Edited by:

ROBERT HOFMANN, WIEBKE KIRLEIS, JOHANNES MÜLLER, VITALII RUD, STANISLAV ŢERNA†, MYKHAILO VIDEIKO

From Ros to Prut:

TRANSFORMATIONS OF TRYPILLIA SETTLEMENTS

VOLUME I

SCALES OF TRANSFORMATION IN PREHISTORIC AND ARCHAIC SOCIETIES | **19.1**

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Foreword of the series 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.

In the last decade, archaeologists from Kiel University carried out intensive fieldwork and collaborative efforts with colleagues from Ukraine and Moldova to analyse population agglomeration in Trypillia mega-sites some 6000 years ago. Multiple monographs and papers have been published on this exciting phenomenon. Still, new aspects of Trypillia societies are to be discovered. The two volumes of STPAS 19 compile – under the title “From Ros to Prut, Transformations of Trypillia settlements” – archaeological, geophysical, archaeobotanical, archaeozoological and geoarchaeological contributions on the economy, settlement patterns, material culture and dating of Chalcolithic societies in the territory of present-day Ukraine and Moldova. Organised across three test regions spanning an East-West transect, the two volumes bring together in-depth investigations of selected key sites and regional reconstructions (Volumes 1 and 2), which are used as the basis for a cross-regional comparison (Volume 2). This comparison, based on the many pieces of the puzzle compiled here for the different test regions, enable a deeper understanding of the particularities, but also the overarching commonalities, in the process of socio-ecological transformations of the Trypillia societies and their environment in diachronic perspective, as well as on spatial scale.

We are thankful to the multiple authors and the graphic designers Esther Thelen, Ralf Opitz and Carsten Reckweg for their deep engagement with the volumes and Sara Krubeck for harmonising the texts and reference lists. We also want to thank Karsten Wentink and Eric van den Bandt from Sidestone Press for their responsive support in realising these volumes and Nicole Taylor for organising the entire publication process in her experienced and high-quality manner.

Wiebke Kirleis and Johannes Müller

To the memory of Stanislav Ţerna,
a cherished colleague and inspiring friend.

Contents

Foreword of the Editors

Since the 6th millennium BCE, the area north-west of the Black Sea between the Carpathians and the Dnieper was a zone of intensive contact between hunter and gatherer communities and Neolithic ones. Human development in this area took place in the context of enormous natural diversity at the interface between the forests of the northern European lowlands and the northern Pontic steppe zone, as well as between the temperate and continental climate zones. Starting from 5300/5200 BCE, the forest-steppe zone was occupied by a network of Linear Pottery communities, and from ca. 4800 BCE by communities labelled as Cucuteni-Trypillia. From 4300 BCE, settlements of a new type, with ring-shaped ground plans, emerged east of the Prut River, some of which reached extents of between 100 and 320 ha after 4000 BCE, making them among the largest prehistoric agricultural settlements in Europe. These so-called Trypillia mega-sites are intensively discussed as an alternative line of development in the context of early urbanism, particularly as they were established at the same time as the early urbanisation of Mesopotamia.

Research into this so-called Trypillia phenomenon has a long tradition dating back to the 19th century. It was intensified in the 1970s by Soviet researchers in connection with the discovery of the enormous size of these settlements, their very rich material culture and their unusually configured settlement plans. This research was continued after 1990 using improved methods by several teams of Ukrainian researchers with the participation of international colleagues. Since the 1970s, the application of geophysical methods, a broad spectrum of scientific analyses and radiometric dating has played a major role in deciphering these unique settlements. This methodological pioneering, in conjunction with the outstanding quality of the archaeological sources, make Trypillia settlements a unique laboratory for a wide range of interpretative approaches.

The twenty-one contributions presented in these two volumes were achieved within an international research network spanning several regions and countries. The overarching aim of these still on-going joint research endeavours is to better understand the processes of formation, transformation, and decline of the Trypillia settlement network and Trypillia mega-sites in a spatio-temporal perspective. To achieve this goal, a research design is applied that integrates local investigations in selected ‘key sites’ with research at regional and inter-regional levels in different ‘test regions’. This multi-scale approach, which targets the reconstruction of processes, is also reflected in the structure of the book.

Researchers from the Institute of Archaeology of the National Academy of Sciences of Ukraine, the Borys Grinchenko Kyiv University, the State Historical and Cultural Reserve ‘Trypillia Culture’ in Lehedzyne, the High Anthropological School in Chișinău, the National Museum of History of Moldova, the Moldova State University, the Romano-Germanic Commission of the German Archaeological Institute in Frankfurt am Main, and Kiel University work closely and intensively together in the aforementioned research network. On the Kiel side, the research is being carried out as part of the Collaborative Research Centre 1266 ‘Scales of Transformations:

Human Environmental interaction in prehistoric and archaic societies' within the sub-project 'Population agglomerations at Trypillia-Cucuteni mega-sites'.

The present two volumes are part of a much broader publication strategy which, in addition to numerous articles in anthologies and journals, so far includes an anthology on Trypillia societies edited by Johannes Müller, Knut Rassmann and Mykhailo Videiko (*Trypilla Mega-Sites and European Prehistory 4100–3400 BCE*) and three monographs, published by Johannes Müller *et al.* (*Maidanetske 2013. New excavations at a Trypillia mega-site*), by René Ohlrau (*Maidanets'ke: Development and Decline of a Trypillia 'Mega-site' in Central Ukraine*) and by Liudmyla Shatilo (*Tripolye Typo-Chronology: Mega and Smaller Sites in the Sinyukha River Basin*). The present two volumes bring together archaeological, geophysical, archaeobotanical, archaeozoological and geoarchaeological contributions on economy, settlement patterns, material culture and dating from three different test regions in the territory of present-day Ukraine and Moldova. The presentation of our new data contributes decisively to a better understanding of both the enormous variability of settlement trajectories characterising this vast area and to connecting developments throughout time.

As archaeology is an undertaking based on cooperation and mutual understanding, we the editors of this work, would like to thank the numerous people who were critical to the success of the fieldwork, subsequent analyses and this publication. In this context, we would like to emphasise the continuous, extremely generous and active support of our research by Vladyslav Chabaniuk, Director of the State Historical and Cultural Reserve 'Trypillia Culture' in Lehedzyne, and Vitalii Vasyliovych Otroshchenko, Head of the Department of Chalcolithic and Bronze Age of the Institute of Archaeology of the National Academy of Sciences of Ukraine. We would also like to highlight the contributions of Knut Rassmann of the Romano-Germanic Commission Frankfurt a. M., who played a key role in the establishment of Ukrainian-German and Moldavian-German cooperation and who created the basis for further research by organising and carrying out geophysical investigations at various key locations and Trypillia mega-sites.

For their constructive and extremely productive collaboration and their manifold contributions we would like to thank our colleagues Norbert Benecke (German Archaeological Institute, Berlin), Natalia Burdo (Kyiv), Erica Corradini (Kiel University). Marta Dal Corso (formerly Kiel University, now Padova University), Stefan Dreibrodt (formerly Kiel University, now State Office for Monument Preservation Baden-Württemberg), Dragana Filipović (formerly Kiel University), Pascal Flohr (formerly Kiel University), Christopher Heilmann (formerly Kiel University), Astrid Holzheid (Kiel University), Svetlana Ibens (Kiel University), Viktor Kosakivskyi (Vinnytsia State Pedagogical University), Cheryl Makarewicz (Kiel University), René Ohlrau (Kiel University), Galyna Pashkevych (National Museum of Natural Sciences of the National Academy of Sciences of Ukraine, Kyiv), Natalie Pickartz (formerly Kiel University, now State Office for Monument Preservation Baden-Württemberg), Wolfgang Rabbel (Kiel University), Liudmyla Shatilo (Kyiv and Kiel University), Frank Schlütz (Kiel University), Ghenadie Sîrbu (Chișinău), Andreea Țerna (Kiel University), Heiko Tiede (formerly Kiel University), Tina Wunderlich (Kiel University), Mariana Vasilache (formerly the National Museum of History of Moldova, now University Lumière Lyon 2), Dennis Wilken (Kiel University), and Olha Zaitseva (Kyiv).

We are very grateful to Elena V. Tsvek† for supporting our investigations in Veselyj Kut and Chyzhivka, and Nina Ses, State Historical and Cultural Reserve 'Trypillia Culture' in Lehedzyne, for generous support during the processing of the finds. We would also like to sincerely thank the numerous unnamed students and colleagues from many European universities who contributed significantly to the success of the project with their dedicated work in the field. We would particularly like to emphasise the special commitment of Lennart Brandtstätter (Tübingen

University), Sophie Juncker (formerly Kiel University), Wiebke Mainusch (Kiel University), Gesa Salefsky (formerly Kiel University), and Vasilisa Tiede (formerly Kiel University). The results would not have been possible without the engagement of Susanne Beyer, Svetlana Ibens, Sara Jagiolla, Tanja Reiser and Karin Winter (all Kiel University) in the field. The field campaigns would not have been successful without the engagement of the many students from Ukraine, Moldova, Romania, Germany, Poland, United Kingdom, Russia, Italy and France.

We would also like to thank our hosts in Cunicea, Stolniceni, and Trinca in Moldova and in Lehedzyne and Kyiv in Ukraine for their friendly welcome and constant support during our field work and find processing campaigns.

Crucial to the success and quality of this publication were Nicole Taylor and Sara Krubeck in Kiel, who we would like to sincerely thank for the scientific editing of this work. We would also like to thank the graphic designers Susanne Beyer, Agnes Heitmann, Sara Jagiolla, Carsten Reckweg and Esther Thelen (all Kiel University) for photographing finds, the graphic realisation of finds drawings, the creation of reconstruction images, the design of the cover image, and the editing of the numerous illustrations. Last but not least, we would like to express our sincere thanks to the two external reviewers of this volume.

With this publication we commemorate our co-editor Stanislav Ţerna (formerly High Anthropological School in Chişinău and Kiel University), who was a key person in the organisation and implementation of the fieldwork in Moldova and Romania, and who unfortunately died tragically in December 2020.

The research presented in this work was funded by the Collaborative Research Centre 1266 'Scales of Transformation: Human-environmental Interaction in Prehistoric and Archaic Societies' of the German Research Foundation – Project number 290391021 – SFB 1266).

Robert Hofmann, Wiebke Kirleis, Johannes Müller, Vitalii Rud, Mykhailo Videiko

TRYPILLIA RESEARCH DECOLONISATION

1. Modern Trypillia Transformation research: decolonising through new research concepts, methods and results

Johannes Müller

Prehistoric research is always also transformation research: the processes of change in societies and environments are recorded in their social, environmental and cultural changes on different spatial and temporal scales (cf. Müller and Kirleis 2019). This also applies to the development of Trypillia societies, which was analysed accordingly in the investigations of CRC 1266 'Scales of Transformations: Human-environmental interaction in prehistoric and archaic societies' (Müller *et al.* 2024).

Since the first discoveries, there has been a fascination with Trypillia (or Tripolye), which has varied through time, as well as due to different aspects that are of course relevant to contemporary history. The important excavations by Vincenc Chvojka (1850–1914) as excavator of the eponymous site Trypillia (Ukraine) 1899, and the excavations by Ernst von Stern (1859–1924) from the Odessa Museum in 1905 in Petreni (Moldova; von Stern 1907), were joined for the first time in the Soviet period by the activities of Tatjana S. Passek (1903–1968) through the Moscow Academy, including the excavations in Kolomistschina (Ukraine) in 1934–1938. Both pre-Soviet research and early Soviet research were characterised by the methodological possibilities that European archaeology as a whole offered scientists at the time. In particular, the formative work of T.S. Passek in 1949 became the standard work for Ukrainian research for many years due to its clear systematics (Passek 1949).

Since the 1960s at the latest, Trypillia research has undergone a development that has proven to be extremely innovative in terms of methodology. These include the early efforts at radiometric dating, but also the considerable progress in the documentation of burnt clay features (Markevich 1981), as well as the aerial archaeological surveys that revealed the dimensions of the mega-sites (*e.g.* Shyshkin 1973). In particular, the large-scale geomagnetic prospections carried out by Valeri P. Dudkin and their interpretation also using aerial photographs (Videiko 2012; Shmaglij 1980) are ahead of the smaller-scale prospections practised in other parts of the world. They enabled the identification of mega-sites, which – at that time – were only occasionally reflected in European archaeology outside the Soviet Union (Narr 1975).

Until the turn of the millennium, Ukrainian, Moldavian and Soviet Trypillia research was characterised by the formulation of research questions that could be tested empirically. From the late 1990s onwards, under new economic and political conditions, it was possible to collect a wide range of archaeological, geoarchaeological and bioarchaeological data using survey and excavation methods that developed with new standards, as well as additional sampling and evaluation methods.

Irrespective of this quantitative and qualitative increase in data (also with the increasing diversification in the social and cultural background of the international scientists involved), Trypillia became a testing ground for the most diverse ideas and hypotheses. Trypillia has been overloaded and partly colonised by lifestyles and ideas that cannot be tested directly on the collected data. This includes the fascination with immigration movements (as well as the fascination with festivals and unstable groups; Gaydarska 2020).

'Decolonising Trypillia' means formulating hypotheses and theses that can be archaeologically verified or falsified. In this sense, habitation practices could be described in their transformation, demographics and economies could be discussed and reconstructed, and cultural developments could be placed in the context of social changes. This book contributes to providing a solid empirical baseline, and a corresponding decolonisation, by presenting the results of numerous field studies and analyses. Together with the results already presented, they lead to probable models of the Trypillia mega-site phase in particular.

Our research strategy was orientated towards special sampling strategies on the one hand, and the excavation of contexts that can provide increased data, *e.g.* on economic issues, on the other. Thus, three test regions were identified in the entire Trypillia area from west to east, in which fieldwork and analyses are concentrated (Fig. 1). Settlement plans of Trypillia settlements are recorded geophysically. In larger settlements, structures are fully excavated and test pits are placed on randomly-chosen features, based on geomagnetic analyses. After sampling, the combination of test pits and larger trenches for the excavation of entire features record data that allow extrapolation from targeted excavations of entire contexts to the entire settlement. With both scales of excavation, a modelled reconstruction of the settlement processes for the entire settlement is thus possible. In the case of smaller settlements that are of great importance, test pits are created in order to date geophysical structures. The results from the test regions, in conjunction with already-known data, enable the reconstruction of transformations on a regional and supra-regional scale; in fact, also for the entire Trypillia distribution area.

In the specific fieldwork concept (Fig. 1), geophysical and archaeological or environmental prospections are used as sampling strategies for targeted excavations. In addition to the off-site works (*e.g.* to obtain environmental data), the excavations increased the data not only on architectural units, but also specifically on pits (cf. Țerna 2021), which are excavated in particular to reconstruct the economy for corresponding sampling and analyses. As a result, data are available for environmental, economic, demographic, cultural and social studies.

Based on data, numerous hypotheses and theses on Trypillia could be tested: decolonising and empirical underpinning through data-based analyses and interpretation that sticks to most probable scenarios provides a deepened and coherent level of understanding of the Trypillia phenomenon.

Within the research of this project, the following topics and their related research questions were, and continue to be, important and are tackled within this publication and additionally in other publications.

The development of settlement hierarchies that include huge sites (at least ten times larger than the smallest known contemporary sites) occurred from the Siret-Dniester interfluve to the Bug-Dnieper interfluve from ca. 4100–3500 BCE. According to our recent interpretation of the available data, social transformations were central for the formation of extraordinary mega-sites, which are unique for the 4th millennium BCE in Europe. To verify the triggers of the development, the following questions represent the focal point of our attempts:

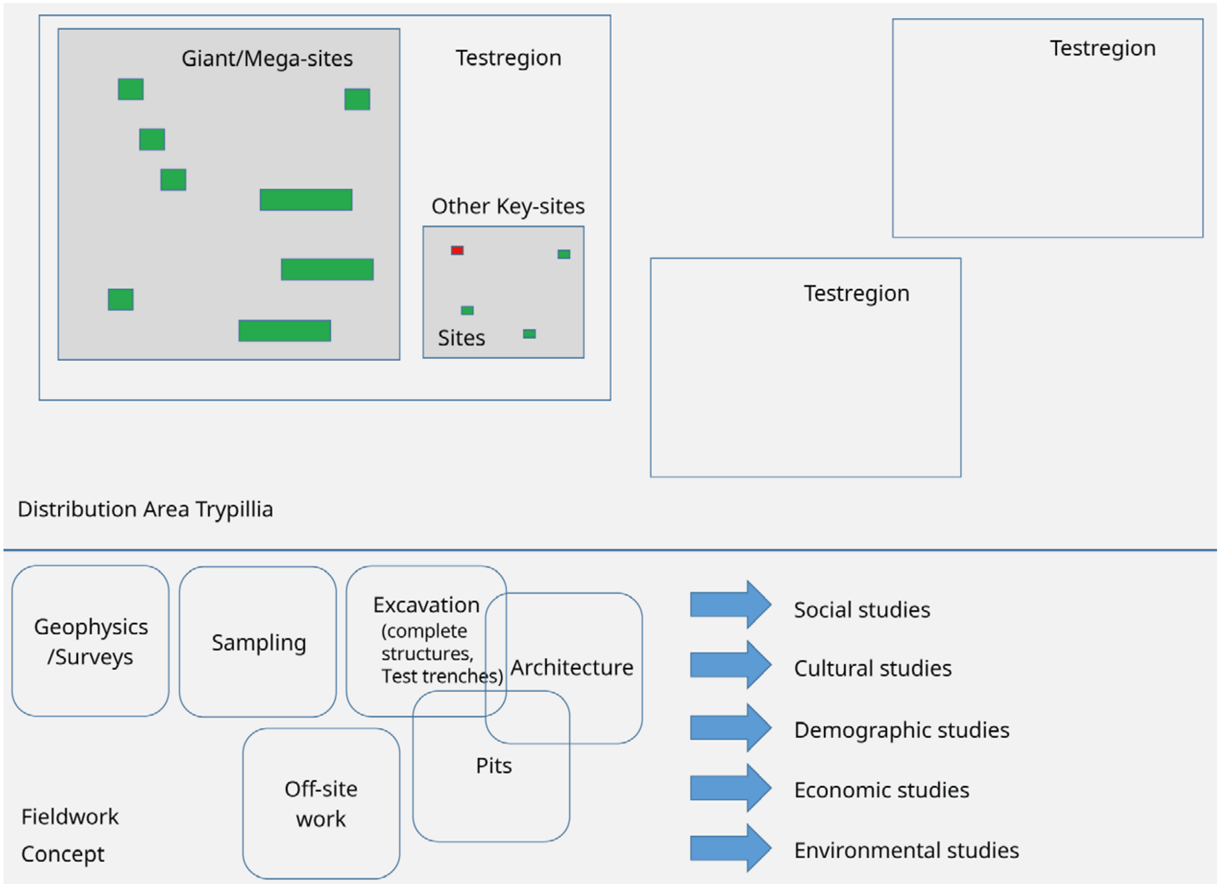


Figure 1. Spatial sampling concepts and the fieldwork concept (graphic: Johannes Müller, Kiel).

1) Which social or political transformations triggered the agglomeration of approximately 15,000 people in Trypillia mega-sites around 4000/3800 BCE?
2) How was social space organised within these proto-urban(?) sites? How was the economy organised?
3) Was the regional natural carrying capacity within the catchment area reached by the agglomeration? Which social factors and components caused and influenced the collapse, which led to a deliberate burning of some mega-sites at ca. 3600 BCE?
4) Was the development of Chernozem anthropogenically triggered by Trypillia economies?
5) How can we understand the development in the Trypillia areas from a trans-regional perspective?

Taking the overall distribution of the phenomenon into account, these questions have to be analysed on a broader geographical scale. As a consequence of similar settlement hierarchies, and in relation to typochronological developments, the structural comparison of three regions from west to east is crucial for the project (Fig. 2): the Sinyukha River Basin (Southern Bug-Dnieper interfluve), the Dniester-Southern Bug interfluve and the Siret-Dniester interfluve.

In each of these test regions, the scales of transformation are important for the reconstruction of the overall patterns:

1) Was the local population agglomeration at mega-sites a result of an agglomeration of the population which was already present in a larger region in smaller sites? Which scale of mobility was integrated in the process?

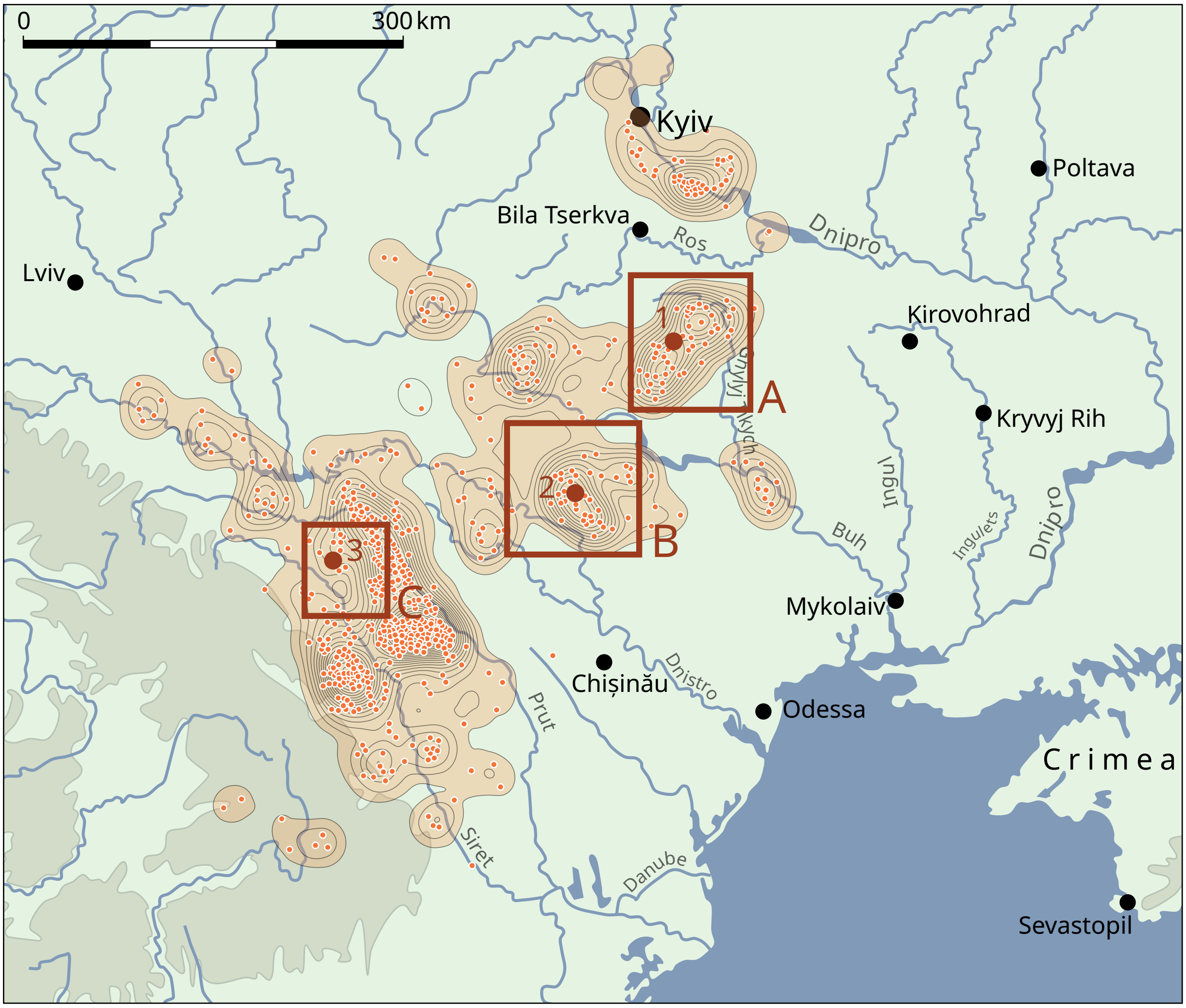


Figure 2. The test regions. A – Sinyukha River Basin (Southern Bug-Dnieper interfluve); B – Dniester-Southern Bug interfluve; C – Siret-Dniester interfluve. Background: The distribution of Trypillia C1 sites from ca. 3900–3650 BCE (Kernel density; KDE radius 30 km; graphic: Robert Hofmann/ Carsten Reckweg, Kiel).

2) Did the communal economy change during the different phases of development (Phase 1: small and medium sized sites; Phase 2: medium and mega-sites; Phase 3: small and medium sites)? How did the practice of subsistence influence the landscape?
3) Did the environmental record underlie a general change or are significant environmental changes linked to societal changes and processes of settlement development?
4) Were the agglomeration processes linked to an increase in social inequalities that were also responsible for the collapse of the mega-sites?

To deal with these research questions, a similar research design was planned for each test region, with a combination of test excavations on selected sites, archaeological and palaeoecological surveys, and an overall evaluation of available data. The application of geophysical surveys, targeted archaeological excavations, a coring program for unexcavated structures, plus archaeobotanical, archaeozoological and palaeopedological analyses, enhanced the archaeological strategy to disentangle even mega-sites and their micro-regions. Additional off-site geotrenches and corings have led to a reconstruction of environmental developments.

The new data contributes decisively to a better understanding of both the enormous variability of settlement trajectories characterising this vast area, and to connecting developments throughout time.

References

Gaydarska, B., ed., 2020. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter. Available from: https://doi.org/10.1515/9783110664959

Markevich 1981: Маркевич, В.И., 1981. *Позднетрипольские племена северной Молдавии*. Кишинев: Штиинца.

Müller, J. and Kirleis, W., 2019. The concept of socio-environmental transformations in prehistoric and archaic societies in the Holocene: An introduction to the special issue. *The Holocene*, 29 (10), 1517–1530. Available from: https://doi.org/10.1177/0959683619857236

Müller, J., Kirleis, W. and Taylor, N., eds., 2024. *Perspectives on Socio-environmental Transformations in Ancient Europe*. Cham: Springer. Available from: https://doi.org/10.1007/978-3-031-53314-3

Narr, K.J., ed., 1975. *Handbuch der Urgeschichte. Vol. 2: Jüngere Steinzeit und Steinkupferzeit. Frühe Bodenbau- und Viehzuchtkulturen*. Bern, München: Francke Verlag.

Passek 1949: Пассек, Т.С., 1949. Периодизация трипольских поселений (*III–II* тыс. до н.э.). Материалы и исследования по археологии СССР (МИА) 10. Москва, Ленинград: Издательство Академии наук СССР.

Shmagliy 1980: Шмаглий, Н.М., 1980. Крупные трипольские поселения в междуречье Днепра и Южного Буга. *In*: И.И. Артеменко, ed. Первобытная археология – поиски и находки. Киев: Издательство “Наукова думка”, 198–203.

Shyshkin 1973: Шишкін, К.В., 1973. З практики дешифрування аерофотознімків у археологічних цілях. Археологія, 10, 32–41.

Țerna, S., 2021. How can we investigate the socio-economic structure of the Cucuteni-Tripolye mega-sites? Houses as Snapshots and Pits as Durable Narratives. *Archäologisches Korrespondenzblatt*, 51 (1), 37–60. Available from: https://doi.org/10.11588/ak.2021.1.86862

Videiko, M.Y., 2012. Comprehensive Study of the Large Settlements of the Tripolye Culture: 1971–2011. *Stratum Plus*, 2012 (2), 225–263.

von Stern, E., 1907. Die „prämykenische“ Kultur in Süd-Russland. Die Ausgrabungen in Petreny, im Bielzer Kreise des Gouvernements Bessarabien; 1902 und 1903. *In*: Countess Уварова, ed. Труды Тринадцатого Археологического съезда в Екатеринославе в *1905* г., Vol. 1. Москва: Типография Г. Лисснера и Д. Собко, 53–95.

MAIDANESTSKE AND SINYUKHA REGION (REGION A)

2. Report on the fieldwork of 2016 in the Trypillia mega-site Maidanetske: Investigations on the development and internal structuring

Robert Hofmann, Johannes Müller, Wiebke Kirleis, Mykhailo Videiko, Hans-Rudolf Bork, René Ohlrau, Natalia Burdo, Liudmyla Shatilo, Vitalii Rud, Stefan Dreibrodt, Knut Rassmann, Mariia Videiko

Abstract

In this chapter, we present results of Ukrainian-German fieldwork of 2016 in the Trypillia mega-site Maidanetske, Ukraine. In addition to the continuation of the archaeomagnetic surveys, these field works included excavations in one of the ditches, the investigation of a communal building and different unbuilt open areas of the settlement. In combination with radiometric dating and various scientific investigations, which are presented in other contributions of this volume, important new results on the internal development of the settlement, the use of space, the function of ditches and the architectural and functional differentiation between residential houses and communal mega-structures were obtained during these explorations.

Introduction

This chapter reports on the 2016 field activities in the Trypillia mega-site at Maidanetske, Talne Raion, which at 200 ha in size represents one of the largest Trypillian settlements. It dates in relative chronology to the period Trypillia C1 (*e.g.* Shmaglij and Videiko 2005; Rassmann *et al.* 2014; Müller *et al.* 2017; Müller and Videiko 2016; Ohlrau 2020a). Our fieldwork builds on extensive earlier surveys and excavations and is embedded within Ukrainian-German research on the large Trypillia settlements framework of the Collaborative Research Centre 1266. In addition to archaeomagnetic surveys and excavations in Maidanetske, we excavated test trenches in the two approximately contemporaneous settlements of Moshuriv 1 and Vijtivka (Chapter 12, this work, Vol. I).

During the 2013 and 2014 campaigns in Maidanetske, systematic investigations focused on uncovering examples of burnt houses (Trenches 51, 92), pits (Trenches 50, 52, 60) and pottery kilns (Trench 80; Müller *et al.* 2017; Müller and Videiko 2016; Ohlrau 2020a). Furthermore, as the backbone of our sampling strategy, we excavated test trenches systematically in order to obtain sampling material for ^{14}C dating, typo-chronological studies, archaeobotanical, archaeozoological and pedological analyses from different parts of the site (Trenches 70–79 and 94–103).

Thus, while these earlier campaigns were focused primarily at the level of individual households, the 2016 excavations investigated various aspects of the settlement as a whole. We attempted to understand the social organisation within a Trypillia mega-site, on the one hand by investigating a presumed collaboratively-built ditch and, on the other hand, through the excavation of a special category of building, a so-called mega-structure. The term 'mega-structure' was introduced by Mykhailo Videiko and John Chapman for a large construction that was investigated in Nebelivka in 2012 (Videiko *et al.* 2013). Within our research at Maidanetske, the term was adopted and used for all large buildings in highly visible positions (Hofmann *et al.* 2019). These could be identified mainly in otherwise unbuilt concentric ring-corridors of the giant settlement, which we interpret as public areas in-between residential domestic zones (Rassmann *et al.* 2014; Ohlrau 2015; Hofmann *et al.* 2019). In addition to this first and most important criterion, two other criteria are hierarchically used in the identification of mega-structures in archaeomagnetic site plans, namely that these buildings display specific architecture in comparison to domestic dwellings and often have extraordinarily large dimensions. The number of mega-structures is many times lower than that of residential houses. Our excavations aimed to reconstruct the architecture and create an inventory of such a building, in order to decipher its functions for the communal integration and social organisation of the community.

The investigation of unbuilt areas in the centre of the settlement and, for comparison, within the ring corridor, aimed to reconstruct the use of public space within the settlement. This should help clarify whether the central unbuilt areas were used for economic purposes such as animal husbandry, gardening/food production or rather for integrative activities. In addition, the excavation offered the opportunity to investigate and date the temporal relationship of different settlement ground plans in a stratigraphic setting.

Fieldwork strategy 2016

In 2016 we continued the sampling and focused mainly on four targets in the northern and central parts of the site:

1. In Trench 111, for the first time in Maidanetske, one of the large building structures was uncovered, situated in a particularly visible position in the main street of the settlement (Figs. 1 and 2A). For this so-called mega-structure, different authors assume public or communal functions, due to the structure's high visibility at regular distances within the public space of the settlement. The investigation of such a building should contribute primarily to the determination of the functions of such buildings.
2. Also in Trench 111, there was the chance to examine older settlement remains below the floor of the mega-structure, which have a different spatial layout and indicate a different course of the ring corridor.
3. In Trench 110 a section of a ditch was excavated which enclosed the inner (main) part of the settlement (Figs. 1 and 2B). The southern part of a burnt house was included in the excavation area, in order to clarify on the one hand the chrono-

Figure 1. Plan of the Maidanetske mega-site with location of the trenches investigated between 2013 and 2016.

logical (stratigraphic) relationship between the ditch and, on the other hand, the house rows which are situated more to the north, outside the enclosed area. The results and analysis of the excavations in Trench 110 were recently published in detail by René Ohlrau (2020a) as part of his dissertation.

4. The excavation in Trenches 113–117 aimed to investigate different kinds of unbuilt areas of the settlement in order to try and establish the purposes for which the large unbuilt space in the centre of settlement was used. To do this, in each case three trenches were excavated in the central unbuilt space (Trenches 116–118) and in the main street of the settlement (Trenches 113–115).
5. At the northern periphery of the settlement, in Trench 112, a gully, visible in the terrain surface and running from northwest to southeast into the valley of the Talianki River (Fig. 1) was investigated by geomorphologists. The primary purpose of this was to investigate colluvial deposits but this was unsuccessful.

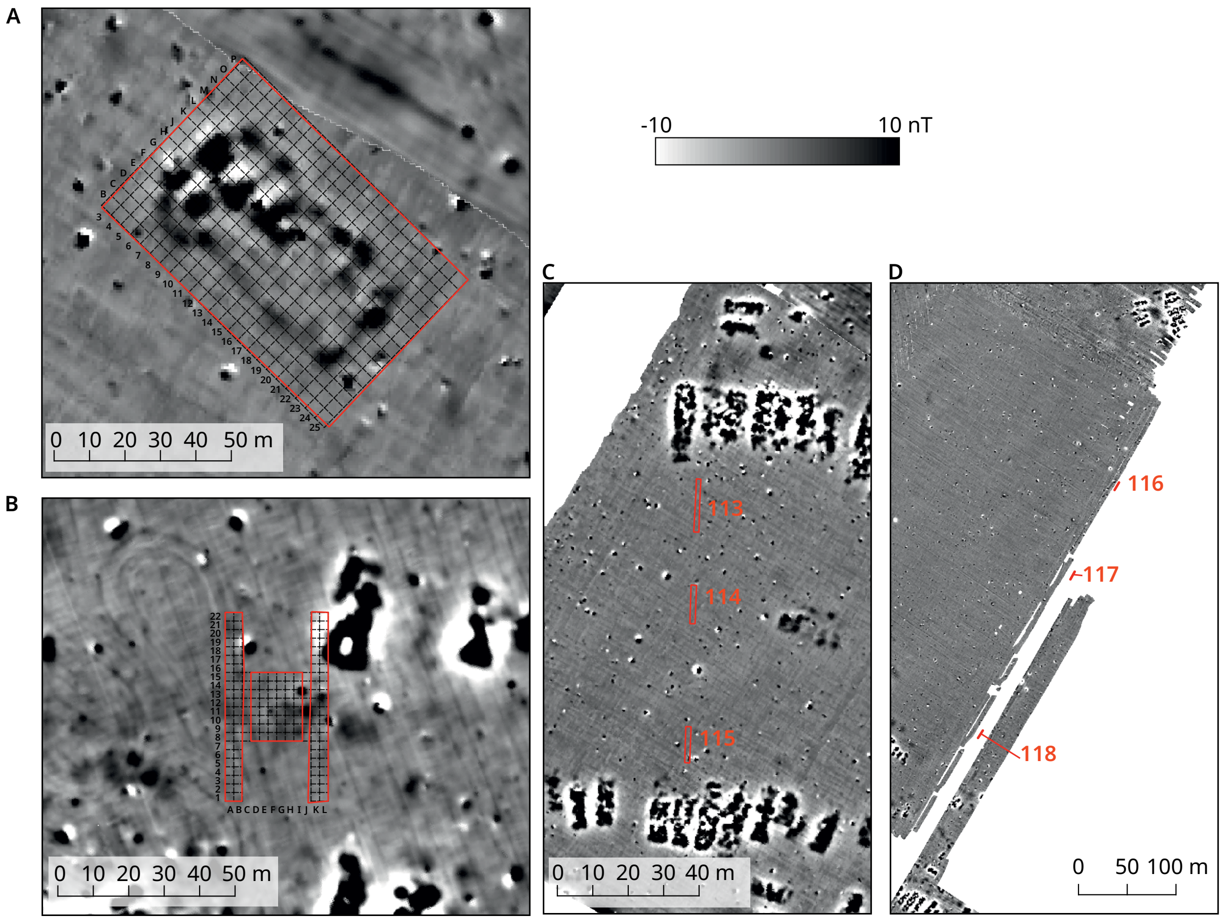


Figure 2. Details of the Maidanetske archaeomagnetic plan with location of anomalies and trenches investigated in 2016: (A) Mega-structure 3 (Trench 111); (B) ditch and house area (Trench 110); (C) within the ring corridor (Trenches 113–115); (D) in the central undeveloped area (Trenches 116–118).

Methods and Materials

Excavation methods and sampling

During the excavations in Maidanetske, we applied a dual excavation strategy based on the results of archaeomagnetic prospection. On the one hand we aimed to investigate examples of selected contexts of different find categories (Chapman *et al.* 2014b; Müller *et al.* 2017, 25–30; Hofmann *et al.* 2018). On the other hand, we sampled systematically different parts of the settlement and different house rings of the settlement, mostly with small test trenches, in order to obtain a representative sample of a Trypillian mega-site for dating, typo-chronological studies and various scientific investigations.

Our excavations were carried out in 'natural layers', which were documented as 'features'. As described in more detail elsewhere, we understand 'features' as units that can be distinguished from one another based on material properties such as the type of soil substrate, their colouring and the type, size and quantity of admixtures contained therein (Hofmann *et al.* 2006, 64–67; Hofmann 2013, 52). The localisation of the finds was performed using xyz coordinates (single finds, samples) and a grid system with a width of one metre. In addition, we assigned finds to features and levels, which usually allows a more precise attribution and interpretation of depositional processes in larger contexts. Descriptions of the properties of features and finds are given in the database of the CRC1266 subproject D1 (Hofmann *et al.* 2023).

In general, a systematic and area-wide sampling of the excavation areas for botanical, zoological and geoarchaeological analyses was carried out, which should enable a reconstruction of activity zones in as much detail as possible and, if necessary, the functional differentiation of the site. The use of the same samples by the different disciplines involved ensures an optimal interdisciplinary synergy of the results. Horizontal sampling for botanical and geoarchaeological investigations took place in every second to fourth quadrat. Selected profiles were vertically sampled in 10 cm steps.

Daub classification

In order to be able to understand the architecture and the materials used for the construction of the buildings, on the burnt daub we documented old surfaces and imprints of woods during our excavations in Maidanetske. The documentation was carried out in two different ways.

On the one hand, we mapped the position, type, direction and dimension of wood imprints on drawings or orthophotos. In addition, we measured the diameters of logs and the width of split wood planks.

However, as focussing on imprints of vanished woods does not adequately consider numerous other types of information on daub such as surface treatments and the thickness of loam covering, we decided to classify the daub fragments further, in addition to the description of features and the documentation of impressions. This kind of documentation of the daub seems to us feasible in terms of the required expenditure of time, and is appropriate for large quantities of daub, which in a Trypillia house can comprise up to several tons. We determined the quantities of the different daub types by weighing and counting them and then used find numbers to link them with further context information. In this way, we were able to assign the quantities to individual quadrats, features, levels and building components. The determined masses contributed to the calibration and advanced analysis of the archaeomagnetic plan of Maidanetske (Pickartz *et al.* 2019; Pickartz *et al.* 2022).

Compared to our earlier attempts, this more flexible classification system of burnt daub that we used in 2016 provides separate classifications of *material types*, on the one hand, and *architectural features*, on the other hand. We assume that the *material types* are the result of specific recipes for the processing of the clay, *e.g.* tempering, *etc.* to prepare for its use in a building. We understand *architectural features* to be any kind of manipulation to a building for architectural reasons. *Architectural reasons* include both technical (construction) and visual requirements (*e.g.* surface finish, imprints, wall decoration).

We defined three material categories and four different architectural features, which could be applied to large quantities of daub within a reasonable time-scale (Tab. 1). Nevertheless, even with this relatively simple classification, one person had to work full-time on the data recording of daub when excavating a burnt building.

From the materials used, we can distinguish compact burnt daub without additives from those that are usually highly porous due to organic tempering. Microscopic and micro-tomographic studies have recently shown that the builders of Trypillia houses added large amounts of cereal chaff to the latter category of material (Chapter 8, this work, Vol. I).

Within this organically tempered category, two variants can be distinguished, which were each used in specific parts of the buildings. For the covering of walls, ceilings and the substructure of floors, the builders usually applied a solid light to medium orange category. A crumbly-yellowish variant was the preferred choice of the builders for podiums and installations. Compact material without macroscopically discernible tempering served for the construction of more heavily stressed surfaces such as floors and fireplaces.

Table 1. Material types of burnt daub: 2016 classification and concordance with the 2013 and 2014 classification (after Müller et al. 2017, 29).

Material type	Type-ID – 2013 and 2014 classification
1. compact (without chaff)	2
2. organic tempered (chaff), light-medium orange	1, 3, 5, 7
3. organic tempered (chaff), yellowish, crumbly	4

Table 2. Classification used for architectural features during the 2016 campaign in Maidanetske.

Architectural features
1 Amorphous
2 Plain surface
3 Two plain surfaces
4 Split wood
5 Log wood
6 Combination: split wood + split wood
7 Combination: split wood + plain surface
8 Combination: 2x split wood + plain surface
9 Combination: split wood + 2x plain surface
10 Combination: split wood + log wood
11 Combination: 2x split wood + log wood
12 Combination: split wood + log wood + plain surface
13 Combination: log wood + plain surface
14 Combination: log wood + 2x plain surface
15 Combination: log wood + log wood
16 Combination: 2x log wood + plain surface
17 Wattle

Five basic types of modifications were considered in the classification of burnt daub which, however, also occur in different combinations (Tab. 2). This included negative imprints of timbers in the form of split wood planks and logs. In addition, flat surfaces and different combinations of surface treatments and negatives of timbers were documented.

Grouping of features

The features were grouped on three hierarchical levels according to a system originally developed for the late Neolithic settlement Okolište in Central Bosnia (Hofmann *et al.* 2006; Hofmann 2013). This system allows comparisons of inventories of certain settlement areas (*layer formations*), the entity of specific feature categories (*layer groups* such as houses, pits, and ditch segments) or parts of specific contexts (*layers* such as part of a house or infilling into a pit). For each context of the grouping level *layers*, the volume of the excavated earth was calculated; this was the basis for the calculation of find densities.

Pottery classification, technology, morphology, and decoration

For classification of Trypillia pottery in the Sinyukha River Basin area, a ceramic typology system is important which was developed in detail by Sergei Ryzhov (1999; 2012) in particular, building on previous works by other authors. This classification system is based on the nomenclature of ancient Greek pottery. In a slightly modified and simplified form, classification systems with comparable systemisation and nomenclature were also used by, for example, Eduard Ovchynnykov (2014), Renè Ohlrau (2020a) and most recently by Liudmyla Shatilo (2021). A nomenclature which is very different in some ways was recently tested on ceramics from Nebelivka (Caswell *et al.* 2020).

When working on the pottery from the Ukrainian-German excavations in Maidanetske, several authors have followed Sergei Ryzhov's classification system; however, those type descriptions have not been published in detail. In this present chapter, the morphological classification of vessels was based on the classification system of Liudmyla Shatilo (2021) which, unlike the typologies of other authors, fits better to the fragmentary character of the find material discussed here. For the technological characterisation of the fabrics, reference is made to the work of René Ohlrau (2020a).

From a technological point of view, so-called kitchenwares, tablewares and 'container wares' are differentiated in the inventory; each one of these was further differentiated according to their temper and surface colour (Tab. 3). While container wares, which scarcely play any role in terms of quantity, are typically organically-tempered, kitchenwares have grey or grey-brown fabrics, are often tempered with crushed shells and moderate to coarse quartz aggregates, and are predominantly fired in a reducing firing atmosphere. These usually comprise less than 10% and a maximum of 20% of the inventories. As demonstrated by their clustered occurrence in burnt contexts (houses or layers over burnt houses), orange-coloured variants are likely to have undergone secondary re-oxidation during the burning of the structures (Fig. 3). Accordingly, so-called 'kitchenwares' are probably not the remains of cooking vessels or pottery used for other pyrotechnic processes.

In contrast to kitchenware, the usually dark-painted and representative tableware was produced under completely oxidising firing conditions. Tableware forms the majority of the inventories, in most cases at more than 90%. Whitish-yellow to reddish surfaces were achieved through the use of kaolin and partly iron-rich white to reddish firing clays. Since the primary firing of the vessels already took place at relatively high temperatures of 800–1200 degrees Celsius in a new type of double-chamber kiln, the additional secondary firing which occurred when the houses burnt down only led to colour changes under certain conditions. Therefore, we cannot exclude the use of tableware as part of pyrotechnical processes.

Nonetheless, from a technological perspective it is remarkable that the ceramic assemblages from Maidanetske and other Trypillia mega-sites consist predominantly of representative painted vessels suitable for use in the context of ritual food consumption. Ceramic vessels, which were clearly used to prepare food and (less representative) vessels for storage, on the other hand, are clearly underrepresented.

Morphologically, according to Liudmyla Shatilo (2021), a distinction was made between six 'types' and ten 'classes' of vessels, to which categories of functions were tentatively assigned according to Rice (1987), taking into account their volumes and their technological properties (Tab. 4). We are aware that functional assignments made in this way can at best allow insight into past category systems of manufacturers and users (Wotzka 1997) and may not be congruent with the actual use of the vessels. In our view, the comparison of frequencies of these functional categories in find inventories does nevertheless offer, under favourable circumstances, the chance to represent and interpret functional differences between contexts.

Bowls, often in a very crudely manner manufactured cups and very representative goblets were most likely used for the serving of food. We consider the following as storage vessels: pear-shaped vessels (including the associated lids as well as large specimens of the categories krater and krater-like), bi-conical and sphero-conical vessels. The generally smaller amphorae and fine ceramic pots as

Table 3. Classification of ceramic fabrics used for ceramics during the 2016 campaign in Maidanetske.

Fabric	Description
Table: fine, white	
Table: fine, reddish	
Table: fine, red	
Table: medium, white	
Table: medium, reddish	
Table: medium, red	
Table: low secondary fired	Surface discoloured, fracture orange or reddish, not sintered
Table: strongly secondary fired	Grey-blue, at least surface sintered
Table: secondary fired (slagged)	Caked with a significant proportion of slag
Kitchen: coarse, grey brown	
Kitchen: coarse, orange	
Kitchen: strongly secondary fired	Dark red, porous
Container ware	Very thick-walled, strongly organically tempered
Indefinite: reduced	
Indefinite: uncleaned	

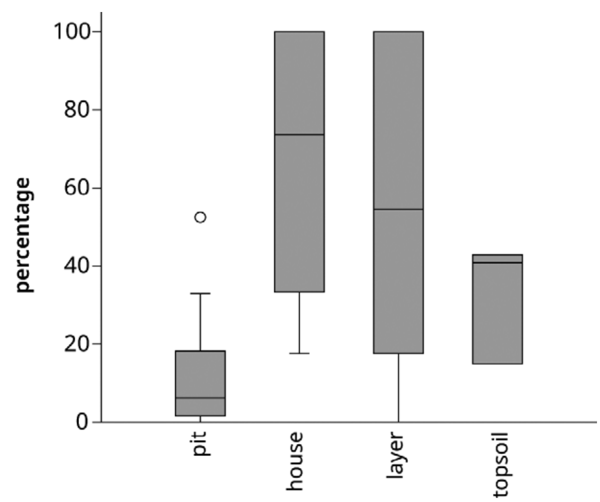


Figure 3. Maidanetske, Trenches 50–111, percentages of orange-coloured so-called kitchenware (among all kitchenwares) in selected types of contexts.

well as smaller bi- and sphero-conical vessels we assume to be serving vessels. Vessels made of kitchenware were probably used to prepare food, although the use of heat can probably be excluded to some extent.

Sergei Ryzhov (1999; 2012) classified decorations at the level of design into so-called ‘decoration schemes’. The relevance of this classification for the long-term relative chronology of the Sinyukha River basin was confirmed by Lennart Brandtstätter (2017; cf. Shatilo 2021). In contrast, ‘micro’ or intrasite chronologies for individual sites have so far relied mainly on the analysis of ^{14}C dating (Rassamakin 2012; Ohlrau 2020a; Shatilo 2021). Attempts to elaborate ‘micro-chronologies’ based on vessel shapes and ‘decoration traits’ have recently been made by René Ohlrau (2020a) for Maidanetske and Liudmyla Shatilo (2021) for Talianki.

Types	Vessel class	Capacity (range in l)	Capacity (median in l)	Kitchenware	Tableware
Bowls		≤2.5 (7)		Processing (without heat)	Transport (serving)
Goblets	Cup	≤0.2			Transport (serving)
	Goblet	0.2–1			Transport (serving)
Kraters/ krater-like v./ pots	Krater/krater-like	0.1–5 5–54	2.6		Small – transport (serving) Large – storage
	Pot		3	Processing (without heat)	Transport (serving)
Pear-shaped v.					Storage
Lids					Storage
Biconical/ sphero-conical v./ amphorae	Bi-conical	0.1–5 5–120	6		Small – transport (serving) Large – storage
	Sphero-conical				Small – transport (serving) Large – storage
	Amphorae	0.3–5 6.6–35	1.4		Transport (serving) Large – storage

Table 4. Classification and proposed function of vessel categories after Shatilo (2021) based on a regional sample of the Sinyukha river basin.

Site formation processes

In order to evaluate the archaeological significance of the find assemblages, we aimed to make a taphonomic reconstruction of the depositional processes. In accordance with the terminology introduced by Ulrike Sommer (1991), an attempt is made to distinguish between primary, secondary and tertiary waste. This classification is based on the logic that, basically, all artefacts remaining in an abandoned settlement constitute ‘waste’ and that ritually deposited artefacts also belong to it. Just as vessels remaining at the site of their use in a burnt house would be classified as *primary waste*, so would, for example, the remains of a ritual meal remaining at the place of deposition. This is contrasted with *secondary* or *tertiary waste* that has been relocated once or several times. An additional category is so-called *foreign waste* deposited from ‘outside’.

The relevant parameters for taphonomic reconstructions in this chapter are, on the one hand, the density of finds in relation to volumes of excavated earth and, on the other hand, the average (mean) artefact weight. The former parameter gives a general impression of where waste was deposited. The average artefact weight serves as a proxy for the degree of fragmentation. Because of their ubiquity, find densities and fragmentations were studied for burnt daub, bones and pottery, while other find categories were too rare to be studied in this way. The combination of find density and fragmentation level potentially allows the identification of primary and secondary waste areas, with the interpretation gaining significance by comparing different find categories. However, one has to take into account that one and the same context may contain different secondary or primary and secondary waste.

Quantification of vessels

Quantifications of vessels are important, since the size of inventories and the percentage of morphological and technological groups within them can provide information on depositional processes and the function of specific contexts. Corresponding quantifications of vessels are a methodical problem especially when – as in the present case – only selective reassembly was performed. In the case of the ceramic assemblages from Maidanetske, an attempt was made to quantify vessels using statistical methods. For this purpose, the preserved percentages of rim, belly and bottom fragments were documented. By summing up these proportions, a minimum number of vessels (MNI) is obtained whereby in each case 100% of the rim, belly or base represents one vessel.

Dating

The dating of Maidanetske is based on the analysis and Bayesian modelling of 93 ^{14}C dates from practically all contexts investigated with participation from the Kiel side (Müller *et al.* 2017; Brandtstätter 2017; Ohlrau 2020a; Chapter 19, this work, Vol. II). The analyses were carried out with the OxCal software (Bronk Ramsey 2009) and the IntCal20 calibration curve (Reimer *et al.* 2020). Modelling by René Ohlrau (2020a) resulted in the differentiation of four settlement phases with a total duration of about 350 years between 3990 and 3640 BCE, which we attempted to assign to the different contexts. Partly chronological fuzziness has to be accepted, which makes aoristic divisions necessary in the chronological interpretations. In terms of absolute chronology, the phases date as follows: Phase 1 – 3990–3935 BCE, Phase 2 – 3935–3800 BCE, Phase 3 – 3800–3700 BCE and Phase 4 – 3700–3640 BCE. The highest building density was in Phase 3, with 1700 apparently coexisting houses.

Results

Trench 110 – Ditch and burnt dwelling

The results obtained through excavations and subsequent analyses in Trench 110 have already been presented in detail elsewhere by René Ohlrau (2020a, 106–117, 212–214). These were supplemented by investigations of depositional processes on bones (Chapter 9, this work, Vol. I). Here, these findings are summarised in brief only, to the extent that they are relevant to the questions addressed in this report. The excavations in Trench 110 included a 12 m long ditch section and a small portion of a dwelling (Figs. 4 and 5).

The ditch investigated in the central area of Trench 110 shows an interruption, approximately 3.5 m long which might therefore be seen to be a causewayed enclosure. Should this interpretation prove to be correct, it would question the defensive character of the enclosure and reveal possible references to contemporaneous complexes in the Central European region (*e.g.* Michelsberg, Funnel Beaker). However, it cannot be ruled out at present that the interruption represents a gateway.

The ditches had maximum widths of 2.5 m, depths of 1.0–1.1 m and u-shaped cross-sections partly tending towards a v-shape. Irrespective of the question of the primary function of the enclosure, the dating and the type and quantity of finds from the two ditch segments reveal different biographies and depositional processes. While the backfilling of the western ditch segment took place between 3955–3810 BCE, so in early phases of the settlement, the eastern ditch segment was filled much later, between 3840–3650 BCE. This potentially longer duration of use is matched by much higher amounts of sterile soil material at the bottom of the eastern segment, washed away from the trench walls, compared to the western ditch segment.

The eastern ditch segment is characterised by moderate densities and fragmentations of bones and pottery and therefore most likely represents the remains of demolished houses and 'normal' household waste. In contrast, the find inventory of the western ditch segment shows some special characteristics:

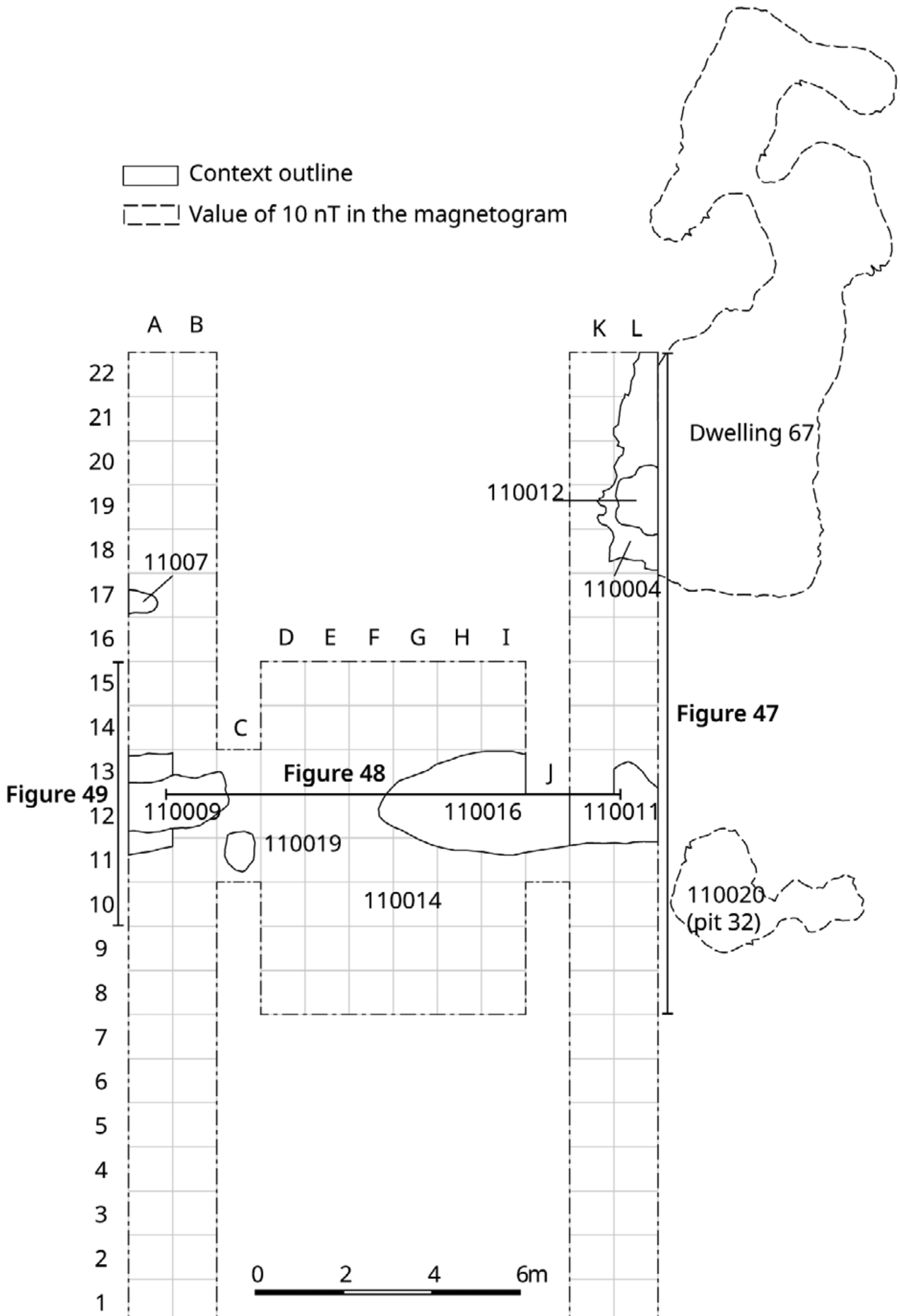


Figure 4. Maidanetske, plan of Trench 110 with location of contexts and profiles (after Ohlrau 2020a, Fig. 46).

the deposition of a *bucranium*, a significantly higher density and lower degree of fragmentation of bones and pottery, and the upside-down deposition of vessels.

The burnt house partly uncovered in the north of Trench 110 over an area of 5 × 1 m differed from other houses in Maidanetske, having an architecture without a platform raised from the ground (Fig. 5). The usage time of this house was dated to between 3700–3635 BCE (68.2%), the final phase of the settlement. Pit 20 associated with this house cut into the fill of the eastern ditch segment of the ditch, indicating that this may have already been backfilled when the house was built.

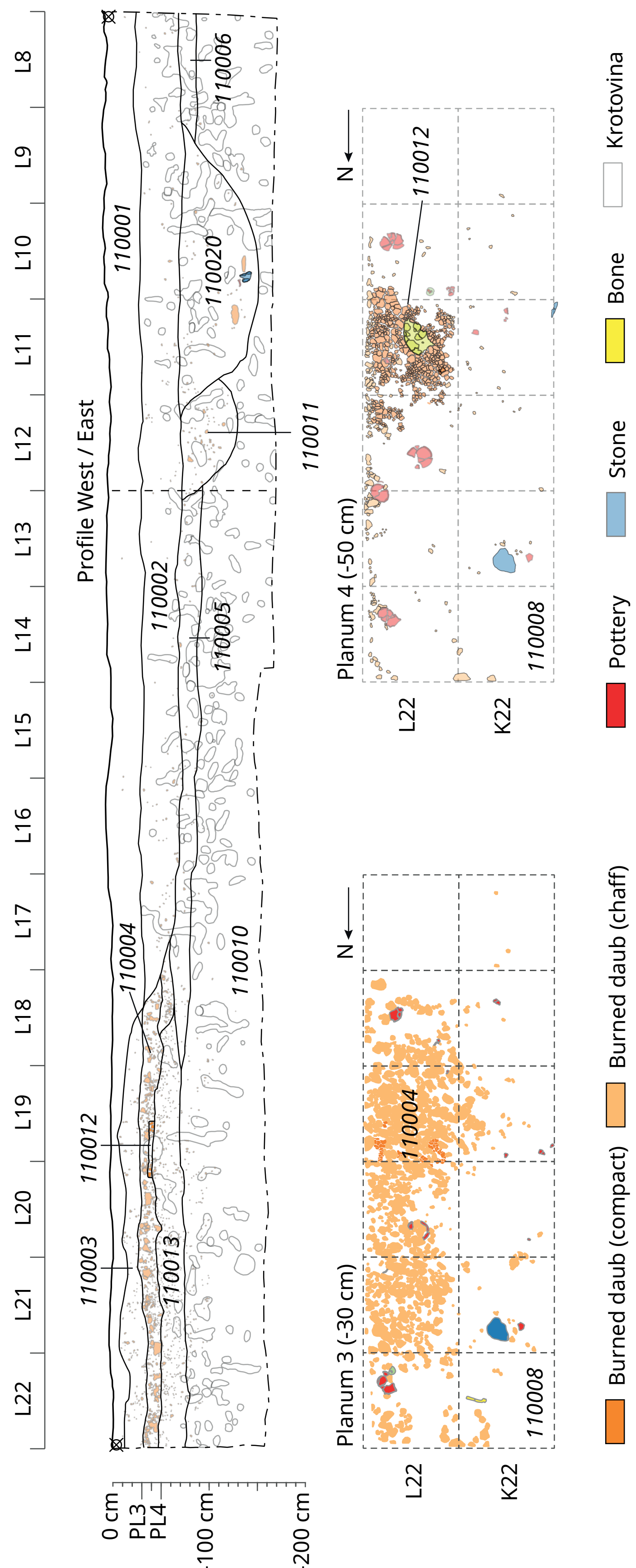


Figure 5. Maidanetske, eastern profile and plana of House 67 in Trench 110 (after Ohlrau 2020a, Fig. 47).

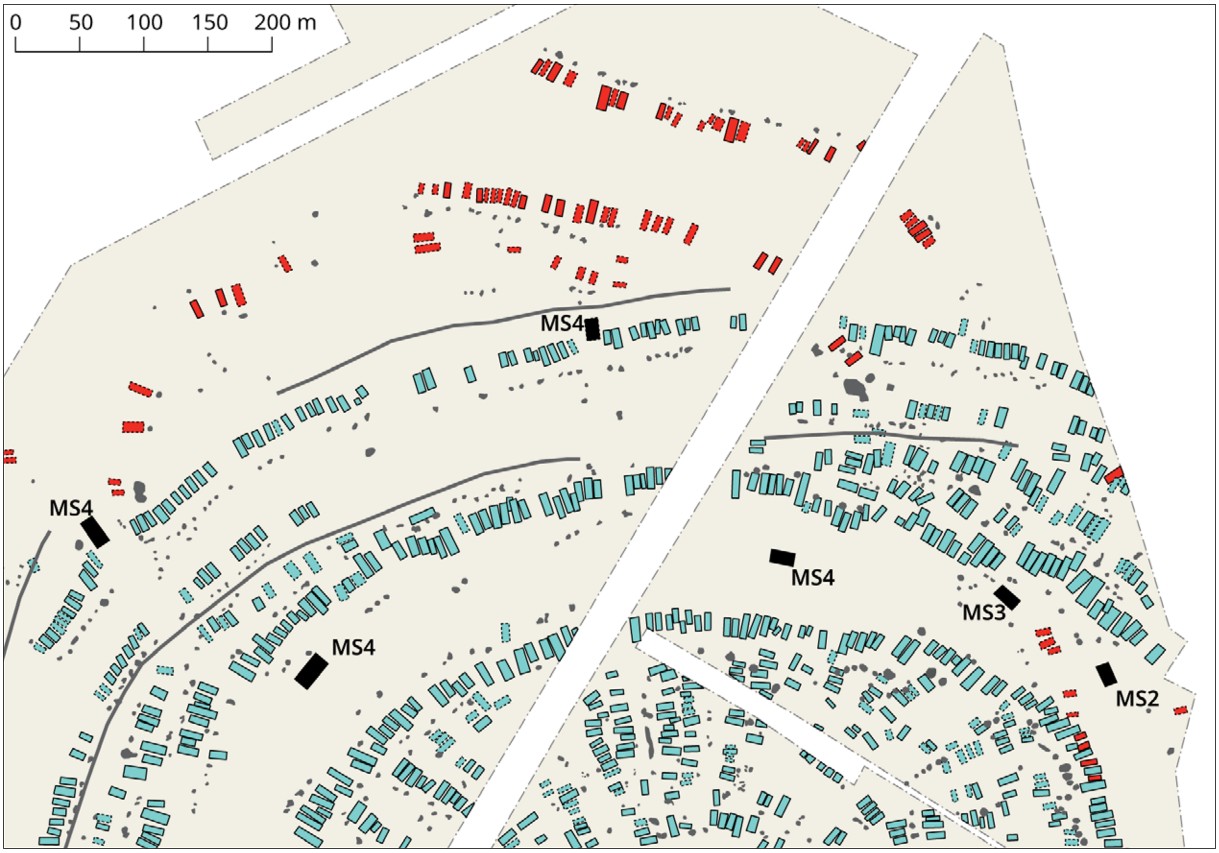


Figure 6. Interpretation of the archaeomagnetic plan of the northern part of Maidanetske. Different colours indicate the affiliation of individual houses to the settlements Maidanetske 1a (red) and 1b (turquoise). Mega-structures are marked in black.

Trench 111 – Excavations in the area of Mega-structure 3 in the ring corridor

Situation in the vicinity of Mega-structure 3

In the north of the Maidanetske 1[1] site, two ring-shaped settlements overlap each other (Fig. 6). To the North of the settlement plan drawn up of Maidanetske 1b there are two parallel rows of houses, which probably represent the ring corridor of an older(?), only partly completed or later partly cleared settlement Maidanetske 1a. Due to the many houses of settlement Maidanetske 1b, the continuation of the rows of houses of this second complex to the south is not easily visible.

Mega-structure 3 is located close to the northern boundary of the 70–90 m wide ring corridor of the presumably younger settlement Maidanetske 1b. Apparently in order to create enough space for the mega-structure, the very irregular northern ‘building line’ of the ring-corridor drop-back at the border of two house clusters northwest of the mega-structure. However, similar drop-backs also occur elsewhere and therefore this does not necessarily have anything to do with the positioning of mega-structures.

Within the ring-corridor of settlement 1b, approximately 25 m southeast of Mega-structure 3, a row of at least six burnt dwellings runs with interruptions in a northwest-southeast direction. Associated with each house is a pit located about 10 metres to the southwest, perhaps defining the back area of each building.

1 While the Trypillia B2/C1 period settlement we investigated is labelled Maidanetske 1, Maidanetske 2 represents an alternative name of the Grebenyukiv Yar site, which lies on the opposite side of the Maidanetske village.

Twenty metres northeast of the houses described, the ruins of another mega-structure, Mega-structure 2, are located within the ring corridor. Judging by its orientation, this mega-structure belonged to the above-mentioned row of houses.

The houses located within the ring corridor of the settlement Maidanetske 1b and the associated Mega-structure 2 most likely represent remains of the older settlement Maidanetske 1a, which have been preserved in unbuilt areas. If one continues the row of houses to the northwest, it can be connected easily to the house rows in the north. This hypothetical connecting line also runs through the area of Mega-structure 3.

In contrast to the northern one, the southern house row of the ring corridor shows a much more consistent structure, although here again one cannot speak of a 'building line' in the strict sense. Anomalies first occur where the row of houses coming from the inside of the ring corridor meets the more southward-turning boundary row of the ring corridor. Anomalies occur at the point where the row of houses coming from the inside of the ring corridor joins the southern boundary of the ring corridor. The houses located here are standing closer together and some of them show a larger offset in the longitudinal direction.

As a preliminary result of the analysis of the plan of the archaeomagnetic survey, we would highlight the overlapping of two different Trypillia settlements in the north of the Maidanetske site, with partly different courses of the ring corridor. While the ring corridors of the two settlements show different courses in the north and west, they join the same course in the east. Unfortunately, we cannot track further to the south the ground plan of the presumably older settlement Maidanetske 1a (which we can in general identify only very fragmentarily). In order to clarify the described anomalies of the settlement ground plan and to date the two settlements of Maidanetske, targeted archaeological excavations were carried out in 2016.

Criteria for the choice of the excavation area

In order to be able to manage the excavation in a reasonable time-scale, we chose to investigate Mega-structure 3, one of the smallest mega-structures, located within the ring corridor of Maidanetske, in the north of the settlement and detected through archaeomagnetic surveying at the beginning of the 2016 field campaign (Fig. 2A).

Besides its size, the shape of the anomaly was a second selection criterion: we deliberately did not choose a mega-structure with empty interior space for excavation, which is the most frequent type in Maidanetske. Instead, with Mega-structure 3 we chose an example which showed in its northwestern part extensive deposition of burnt daub in several spatial concentrations of high magnetisation, in contrast to the 'magnetically empty' southeastern part. In view of the almost find-free mega-structure in the Dobrovody settlement (cf. Korvin-Piotrovskiy *et al.* 2016), which in the plan of the archaeomagnetic survey was indicated only by linear anomalies of the exterior walls, we regarded these remains of overbuilding as a possible location for a more extensive inventory. The obtaining of such a substantial inventory seemed to be useful to determine the functions of such a building.

The third criterion was the spatial proximity of the excavation area and presumed overlap with the above-mentioned remains of the row of houses belonging to a possible older settlement, Maidanetske 1a. Accordingly, this offered a chance to clarify and date the chronological relationship between the two settlements Maidanetske 1a and 1b in a direct stratigraphical manner.

Figure 7. Maidanetske, Trench 111, overview (Planum 2).

Stratigraphy

The excavation area of Trench 111 measured 23 × 15 m and comprised the mega-structure itself and the surrounding open space (Fig. 7). The daub of the mega-structure was buried under a 0.5 m thick Chernozem layer (Feature 111001; Fig. 8). Analogous to other excavation areas, this layer was divided into a thicker black upper part and a thinner more greyish horizon directly above the daub.

The upper and major part of the burnt daub package consisted of small pieces of highly fragmented debris of the rising walls of the mega-structure building. Over the entire area of the mega-structure, this collapse lay on a rammed earth floor with thicknesses ranging from a few millimetres to several centimetres (Feature 111010).

The rammed earth floor of the mega-structure rested on a humus-rich layer embedded in some places with numerous medium-sized pieces of daub and large pottery, ranging from fragments up to complete vessels (Feature 111025). In most parts of the mega-structure this layer could not be clearly distinguished from the more or less sterile buried humus underneath (Feature 111030). The two layers together had a thickness of between 0.4–0.8 m and have been exposed to intensive bioturbation.

In the southwestern section of the excavation area five pits were dug into the ground in the context of pre-mega-site settlement activities. Most of these pits were clearly situated below the floor of the mega-structure. Remarkable from the stratigraphic point of view is, among others, Pit 33 which was located below the central installation platform of the mega-structure (Quadrats J–K/10–12). This pit, which contained a filling of massive lumps of daub, was superimposed by a humus-rich levelling layer which seems to be identical to Feature 111025. Accordingly, there is a high probability that the find-rich layer below the mega-structure is the result of levelling the building ground for the construction of the mega-site. As an alternative interpretation to the theory of a levelling layer, an artificial mounding in the area of the mega-structure may have to be considered (Chapter 5, this work, Vol. I).

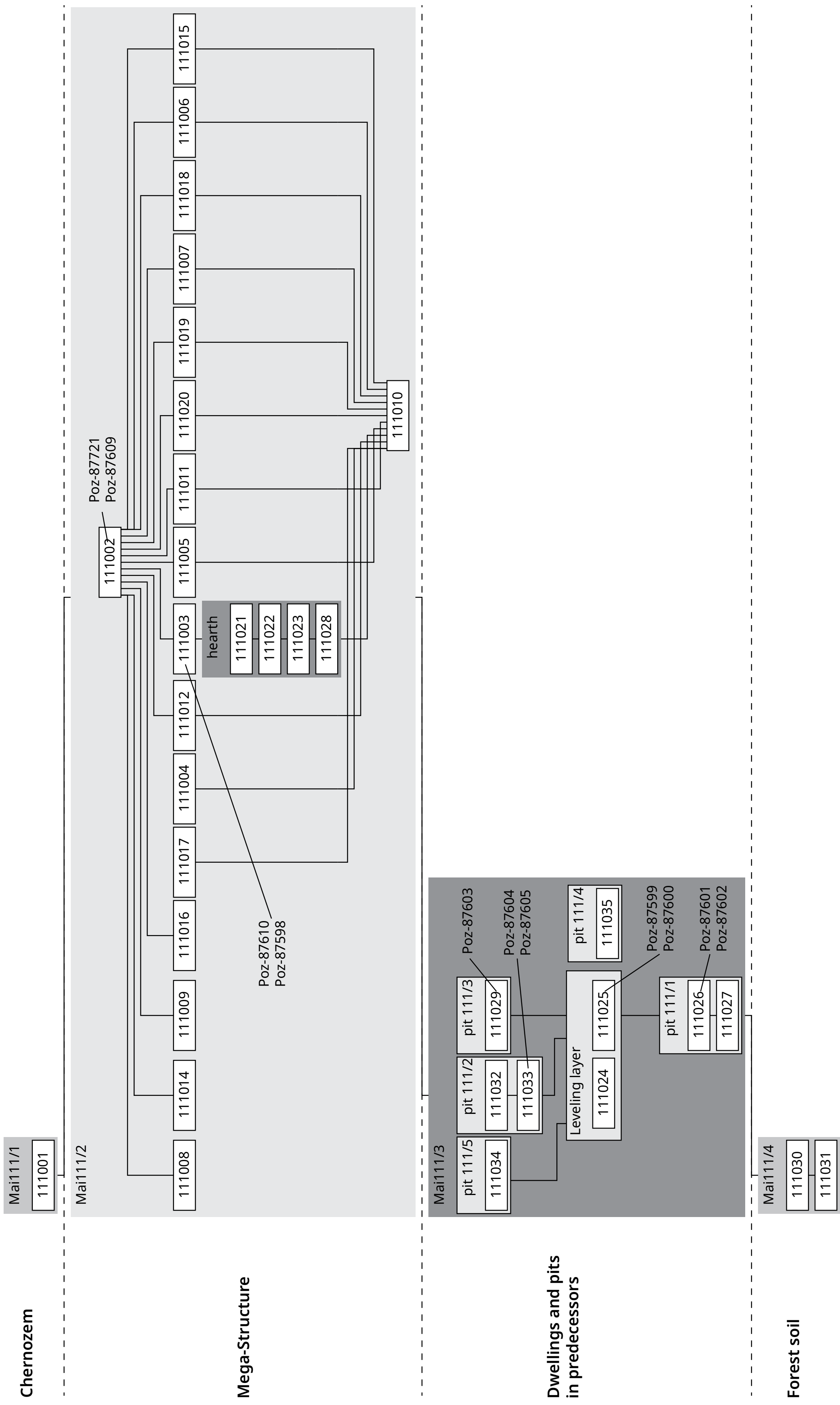


Figure 8. Maidanetske, stratigraphy of Trench 111 shown in a Harris matrix.

Architectural features	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Without material classification
1 Amorphous	438.3	134.3	8.5	
2 Plain surface	208.8	98.7	6.5	0.5
3 Two plain surfaces	88.4	9.7	1.7	
4 Split wood	144.8	3.4	0.5	
5 Log wood	31.0	2.7	1.4	
6 Combination: Split wood + split wood	33.5	1.0		
7 Combination: Split wood + plain surface	58.7	1.2		
8 Combination: 2x split wood + plain surface	18.0			
9 Combination: Split wood + 2 x plain surface (2x)	3.4			
10 Combination: Split wood + log wood	6.0			
11 Combination: 2 x split wood + log wood	0.6			
12 Combination: Split wood + log wood + plain surface	14.7			
13 Combination: Log wood + plain surface	7.8	0.9		
14 Combination: Log wood + plain surface (2x)	0.2			
15 Combination: Log wood + log wood	2.1			
16 Combination: 2 x log wood + plain surface	0.6			
17 Wattle	0.1			
Vitrified daub		1.6		28.7
Non-classified	12.7	12.2	1.0	1.7
Total	**1070.2**	**265.6**	**19.6**	**30.9**

Table 5. Maidanetske, weight (in kg) of material categories and architectural features in burnt daub from features of Mega-structure 3.

However, in the cases of the other pits the stratigraphic relation between the levelling layer or platform mound and the pit filling is not entirely clear because of heavy bioturbation. Indeed, in the case of Pit 35, the height and inclination of ceramic fragments indicate that the pit had been dug into the levelling layer. However, we cannot completely exclude an overlapping of the pit by the levelling layer.

Overall it can be said that Mega-structure 3 was built in an area in which stratigraphic evidence clearly indicates an earlier settlement phase. Pit 111/1, perhaps Pits 111/2–111/5, and a massive levelling layer or platform mound with numerous pottery finds belong to this pre-mega-structure occupation.

Mega-structure 3

Architecture of Mega-structure 3

In the archaeomagnetic plan of the Maidanetske settlement, Mega-structure 3 appeared as a northwest-southeast aligned anomaly with a floor size of approximately 190 m² (dimensions 19 × 10 m; Fig. 2A). Trench 111 opened over this anomaly measured 23 × 15 m and the daub package of Mega-structure 3 was encountered buried under a 0.5 m thick Chernozem layer.

Within the mega-structure, 1.39 tons of daub were documented (Tab. 5); it was not equally distributed, corresponding to the high and low magnetised areas visible

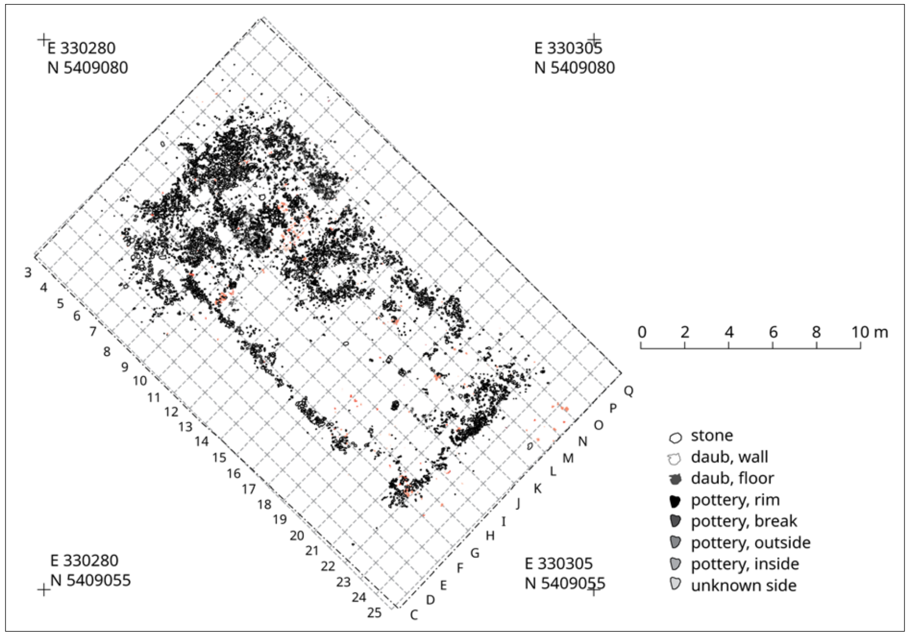


Figure 9. Maidanetske, Mega-structure 3 in Trench 111, drawing of daub from collapsed walls, floor, and pottery.

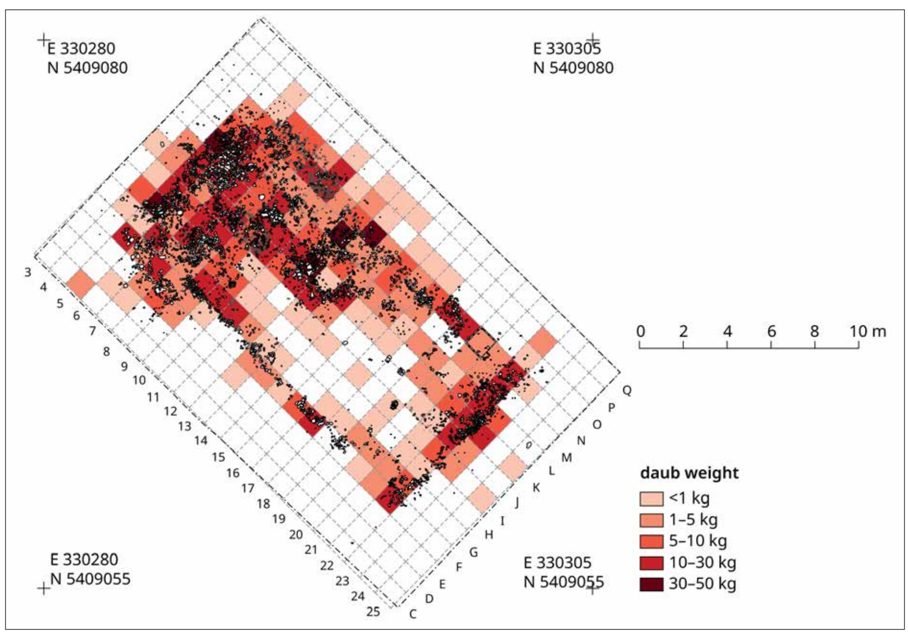
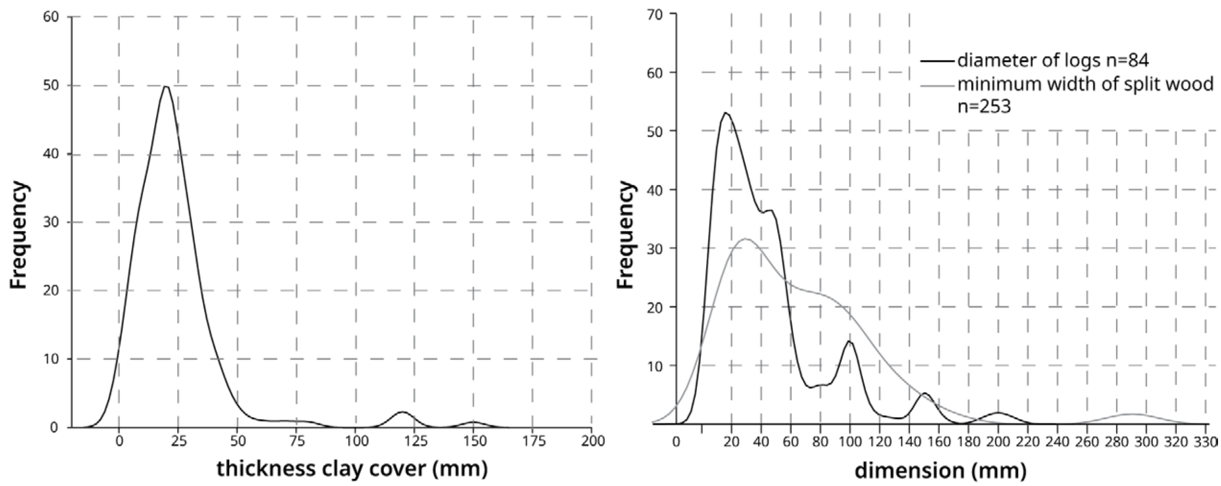


Figure 10. Maidanetske, weight of daub belonging to Mega-structure 3 in Trench 111.

in the archaeomagnetic plan (Figs. 9 and 10; Pickartz *et al.* 2019). In some parts of the exterior walls and in the northwestern half of the building, concentrations in quantities of between 10 and 50 kg/m² were found. In contrast, a particularly low amount of daub in the range of up to 1 kg/m² was documented in the southern quarter of the structure and the surrounding open space. In consequence, an internal division into northwestern and southeastern parts is clearly apparent.

The mega-structure was outlined by a lightweight outer wall made of clay-covered split and logwood timbers. Due to various post-depositional processes, the preservation of this construction was variable in quality. Based on analysis of negative imprints and the measurements of the burnt daub cover, the wall is estimated to have been about 15–20 cm thick (Fig. 11a). As building timber, ash (*Fraxinus* 75%, n=44) and oak (*Quercus* 19%, n=11) were used with dimensions generally less than 10 cm (Fig. 11b; Dal Corso *et al.* 2019). From the wood imprints,



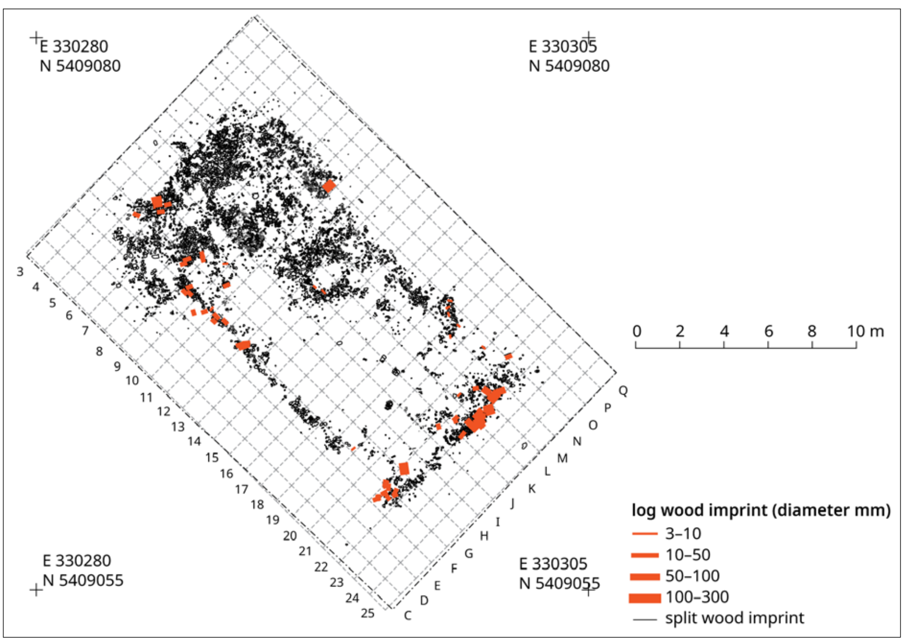


Figure 11 (above). Maidanetske, kernel density distributions of architectural details from Mega-structure 3: left – thickness of the clay covering on construction timbers; right – diameter of logs and minimum width of split wood timbers.

Figure 12. Maidanetske, mapping of type, dimension and direction of split wood imprints within the debris of Mega-structure 3.

both narrow sides and parts of the southwestern longitudinal part of the wall were constructed with log timbers, while the other parts of the wall were constructed mainly with split wood (Fig. 12).

At the southern ends of the longitudinal walls daub-free areas about 1.4 m wide are interpreted as possible entrances. The southeastern narrow side of the mega-structure was particular massive, indicated by the largest diameters of log timbers. A daub concentration 7 m south of the northwestern narrow end might indicate the remains of an interior wall dividing the mega-structure in two parts. The internal wall probably reached 4 m across the house, but 3.50 m remained daub-free, perhaps as a passageway between the two parts of the structure. A small entrance about 1 m wide may also have existed directly north of the interior wall on the northeastern longitudinal side.

The orientation of the negative imprints in the split wood suggests that the timbers were aligned horizontally in the walls of the southeastern part and vertically in the walls of the northwestern part of the mega-structure (Fig. 12). The lack of postholes could indicate a construction with horizontal beams as wall foundations. In the northwestern corner the daub remains with vertically oriented negative imprints might be remains of a gable wall which collapsed into the internal space of the mega-structure. The height of the original external wall can be reconstructed to about 3.5 m. Also, daub remains of the internal wall suggest an original height of 3–3.5 m.

Below small-sized and chaff-tempered wall debris, remains of a burnt rammed earth floor were found in the entire area of the mega-structure (Figs. 9, 13 and 14). This floor layer, mostly only poorly burnt and in parts only 1 cm thick, was preserved exclusively in those places which were also covered by wall debris; it was particularly badly preserved (due to low firing intensity) in the southeastern part of the structure. The floor under the debris of the exterior walls was in better condition and the floor layer was up to several centimetres thick (Figs. 15 and 16). At the outer edge of the wall debris, even in the locations with better preservation, the floor layer suddenly stopped. Here, the floor layer was slightly raised upwards where it would have originally met the outer walls had they been preserved in place. In consequence, it is suggested that all 190 m² of the mega-structure's interior were originally covered with a rammed earth floor. The outer edge of this rammed earth floor marked the position of the exterior walls that are not preserved.

In the northwestern part of the building different installations existed. Within the interior space only a few remains of furnishings were recovered. However, spatial concentrations of a specific yellowish kind of daub in the northwestern part of the building might indicate destroyed furnishing elements. In normal dwellings such as House 44 similar material was used for the construction of bins and podiums (Müller *et al.* 2017, 174).

An oval area 2.2 × 1.3 m, situated within the mega-structure, 3–5 metres away from the northwestern narrow end along the longitudinal axis, marks a fireplace which was raised above the rest of the floor by several extra layers of tamped and burnt earth (Figs. 17 and 18). Corresponding installations are a standard element of Trypillia houses (Pickartz *et al.* 2019). Since they are sometimes decorated, they are frequently interpreted as altars. In the installation of Mega-structure 3 at Maidanetske, at least three successive screed layers lie one above another and testify to a longer-lasting use of the building. In contrast, no signs of floor renewals were determined in the remaining parts of the mega-structure.

The southeastern part of the mega-structure has dimensions of 10 × 7 m, measuring from the base of the interior wall, which probably collapsed in a southeastern direction. No archaeological features could be detected. In this respect, the southeastern part of the mega-structure is empty, but artefact distributions describe different activity zones.

Find inventory of Mega-structure 3

Mega-structure 3 produced a large find inventory including pottery, non-pottery ceramic objects, ground stone and flint artefacts as well as various zoological and plant remains (Tab. 6). The most numerous finds were ceramic vessels, many of which were clearly broken *in situ* on the floor in primary find situations (Fig. 19). We do not see why the view defended by our British colleagues assumes *a priori* that inventories are not functional but 'constructed' (Gaydarska *et al.* 2020)[2]. We rather assume as a preliminary that we can interpret the composition and arrangement of the inventory as a 'living assemblage' in a functional context. Of course, this does not completely exclude the possibility that parts of the inventory represent subsequently deposited so-called 'foreign waste'.

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2 Arguments for this claim are: 1. lack of any functionally coherent pottery groups; 2. overrepresentation of certain vessel parts; 3. too many vessels.

Figure 13. Mega-structure 3 after uncovering the floor plaster (Planum 3b).

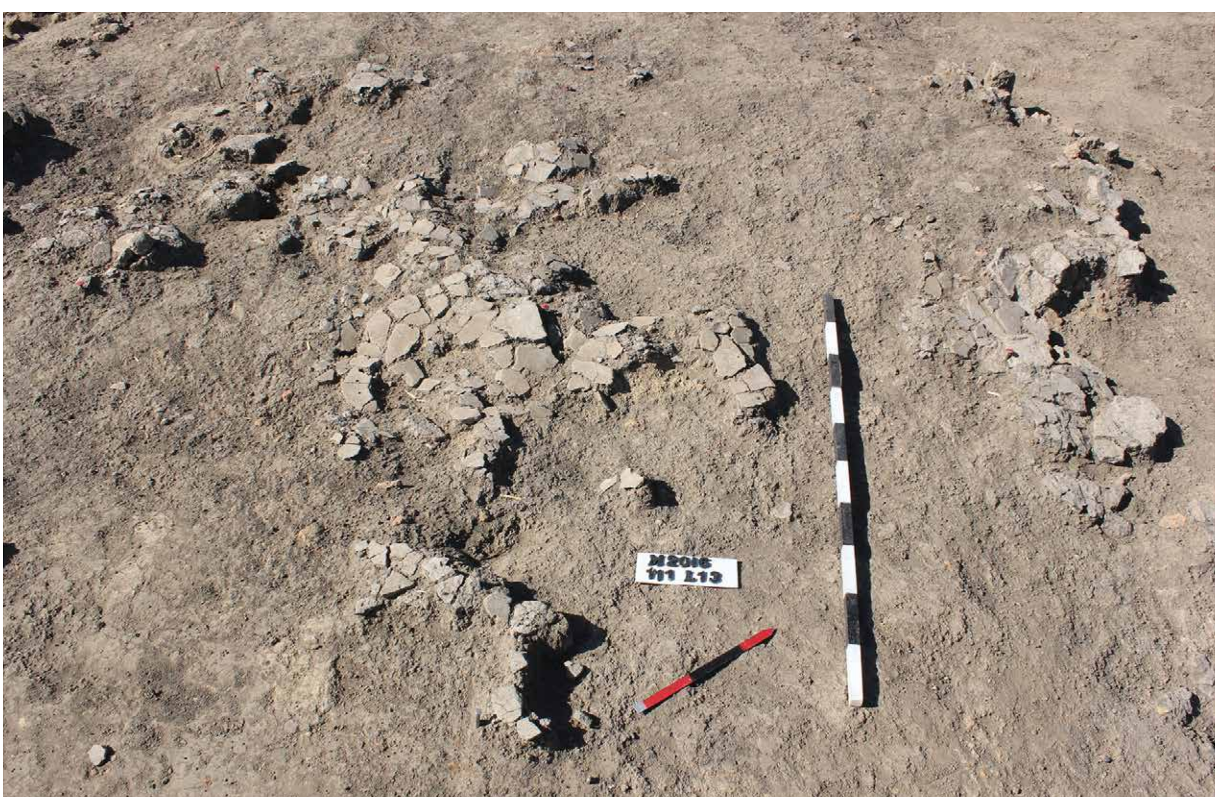


Figure 14. Detail photo of the fragmentarily preserved floor plaster of Mega-structure 3.

Figure 15. Remains of floor preserved under the debris of the south-western longitudinal wall of Mega-structure 3, on the right side stopping abruptly at the position of the former wall.

Figure 16. Maidanetske, central fireplace in Quadrats I–J/8–10 after removal of overlying wall remains.

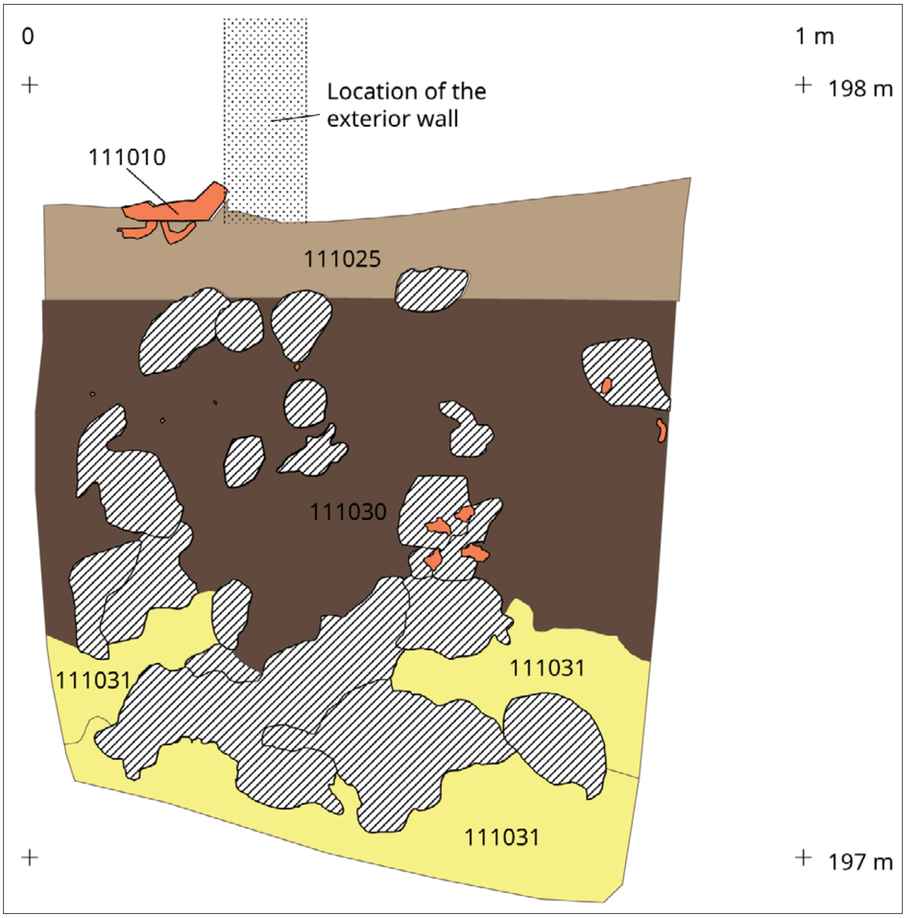


Figure 17. Profile 6 shows the stratigraphic situation at the outer edge of the floor plaster, which here connected to the non-preserved external wall of Mega-structure 3.

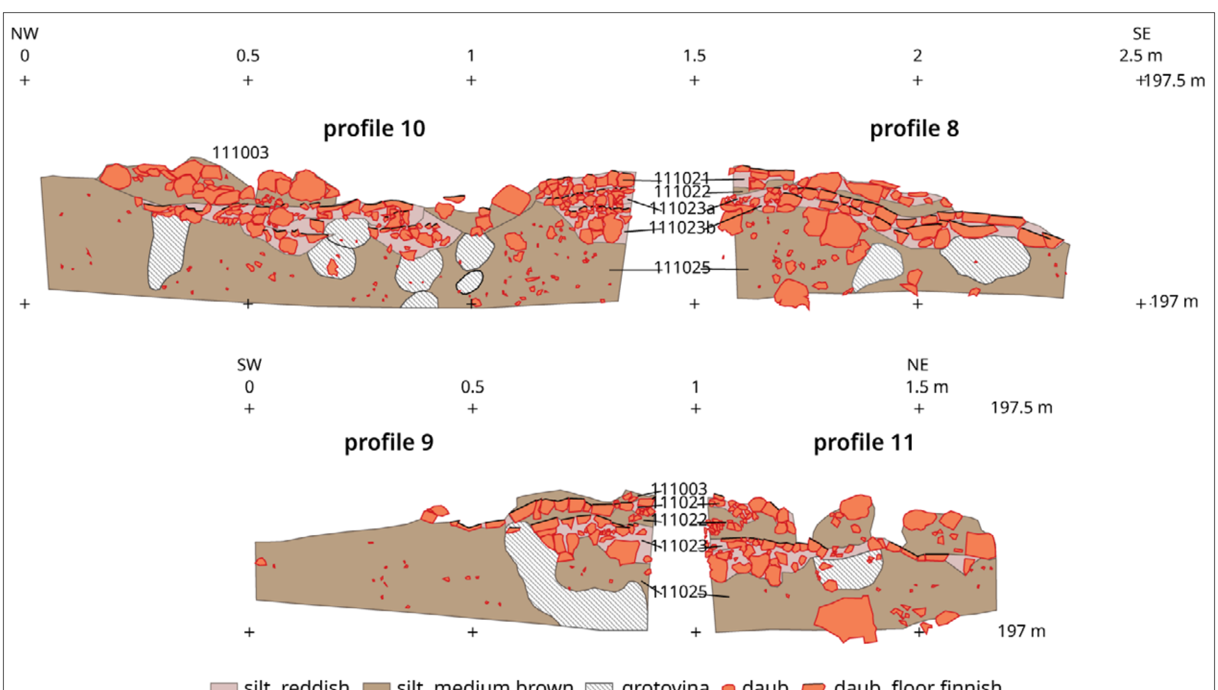


Figure 18. Maidanetske, profile sections through the fireplace of Mega-structure 3 (Profiles 8-11).

	Number (n)	Weight (kg)
Pottery	1821	39.0
Burnt daub	28259	1386.4
Bone	91	1.0
Flint	4	0.02
Ground stone	31	>70.0
Non-pottery ceramic objects	16	0.6

Table 6. Maidanetske, overview of types and quantities of finds in Mega-structure 3.

Figure 19. In situ *situations of vessels on top of the floor plaster of Mega-structure 3.*

Pottery

A total of 3071 pottery fragments weighing 85.4 kg were recovered from Trench 111, of which 1821 fragments weighing nearly 39 kg were from the daub package and other layers associated with the mega-structure. This quantity includes the material that was most likely transported by post-depositional processes, such as frost heave, into the Chernozem layer directly above the daub and which was thereby increasingly fragmented. The ceramic material of the mega-structure shows a relatively low average sherd weight overall of 21.4 g and thus a medium to high degree of fragmentation (Tab. 7). This relatively high level of mechanical damage is further confirmed given that surfaces with painting are not preserved on many of the fragments.

From a technological point of view, the proportion of tableware in the inventory ranges from 86 to 92% and of kitchenware from just under 7 to 12%, depending on whether the calculation is made according to the number of fragments or their weight (Tab. 8). Between the different 'layers', the proportions of wares vary considerably in some places of the mega-structure, as can be demonstrated for

Layer formation	Layer group	Layer	Number (n)	Weight (g)	Fragmentation (g)
Mai 111/4	Topsoil	Chernozem	38	738	19
Mai 111/3	Mega-structure 3	Layer above wall debris	506	8374	17
		Wall debris	1140	29872	26
		Hearth	166	627	4
		Floor	9	123	14
Mai 111/2	Pit 36 (111/4)	Filling	15	567	38
	Pit 35 (111/3)	Filling	260	8878	34
	Pit 34 (111/2)	Filling	286	12926	45
	Pit 33 (111/1)	Filling	84	3757	45
	111-levelling layer	-	519	18209	35
Unknown	Unknown	Unknown	48	1346	28
Total			**3071**	**85417**	**28**

Table 7. Maidanetske, pottery quantities and fragmentation (average sherd weights) in different parts of Trench 111.

	Calculation by number (n)							Calculation by weight (kg)						
Layer	Table	Kitchen	Non-classified	Total number	Table (%)	Kitchen (%)	Non-classified (%)	Table	Kitchen	Non-classified	Total weight	Table (%)	Kitchen (%)	Non-classified (%)
Floor	4		5	**9**	44.4	0.0	55.6	0.1		0.1	**0.1**	49.6	0.0	50.4
Hearth	33	132	1	**166**	19.9	79.5	0.6	0.5	0.1	0.0	**0.6**	82.1	15.5	2.4
Layer above wall debris	467	34	5	**506**	92.3	6.7	1.0	7.4	0.9	0.1	**8.4**	88.5	10.4	1.1
Wall debris	1066	57	17	**1140**	93.5	5.0	1.5	27.3	2.1	0.5	**29.9**	91.5	6.9	1.5
Total	**1570**	**223**	**28**	**1821**	**86.2**	**12.2**	**1.5**	**35.3**	**3.0**	**0.6**	**39.0**	**90.6**	**7.8**	**1.6**

Table 8. Maidanetske, quantity of ceramic wares in different parts of Mega-structure 3.

example by a higher proportion of kitchenware near the central hearth and higher proportions of tableware in other parts of the mega-structure.

The inventory of the mega-structure contained a wide range of vessel categories, which are listed in Table 9. A selection of these are documented by drawings in Figures 20–24.

Kitchenware products are represented by profiled pots decorated with rows of punctures on the rim and shoulder (Fig. 23: 4–6) and a sphero-conical bowl with a strongly inwardly turned rim (Fig. 23: 7).

Open shapes made of tableware are represented by at least five conical bowls, partly decorated with variants of the comet-shaped design (Fig. 20: 2, 4–7). In addition, there was at least one sphero-conical bowl (Fig. 20: 8) and two bowls with four feet (Fig. 20: 1, 3), whose upper parts, however, are not preserved.

Other presumed serving vessels include a minimum of two cups (Fig. 20: 9–10), the painting of which has not been preserved, and a minimum of four goblets, one of which has a handle (Fig. 20: 11–14). The upper part of a bi-conical goblet shows a painting of the metopic scheme (Fig. 20: 11). Two cups decorated with vertical groups of lines are finds whose exact origin within Trench 111 is unclear, as they were recovered unstratified from the excavated earth material (Fig. 24: 6–7).

Vessel classes and type groups	Number (n)	Weight (g)	Summed rim percentages	Summed belly percentages	Summed bottom percentages	Minimum number of vessels
Bowl	22	910	20		330	4
Bowl, conical	93	5959	482.5		287	5
Bowl, sphero-conical	5	88	34			1
Goblet	1	3			25	1
Goblet, cup	2	52	17		70	1
Goblet, goblet	11	255	75.5	65		1
Amphora	66	1865	203	72	100	3
Bi-conical vessel	106	3455		74	100	1
Closed vessel	181	5884	555.5	431.5	377	6
Krater-shaped	2	116		18		1
Sphero-conical vessel	94	4770	36	56	67	1
Pear-shaped vessel	12	356	126			2
Lid	3	72	17			1
Pot	33	1322	218	155	93	3
Binocular vessel	1	80		10		1
Non-classified	71	2782	214.5	86	777	8

Table 9. Maidanetske, quantification of vessels from Mega-structure 3.

Three smaller pots made of tableware seem to be suitable as transport vessels for serving food as well, because the mouths of these vessels are only half-open (Fig. 21: 1–3). One pot is decorated in the rim zone with painting in the leaf-shaped scheme and has a triangular fillet on the neck.

Parts of at least two pear-shaped vessels belong to the group of closed storage vessels. One is painted on the shoulder with festoons, probably according to the metopic scheme (Fig. 20: 15–17). Also, part of this class of pear-shaped vessels are three lid fragments, including the 'cup-shaped' specimen in Figure 20: 16.

The group of closed vessels is also represented by at least two smaller and one slightly larger amphora (Fig. 21: 4, 5, 8, 10), at least one or perhaps two larger bi-conical storage vessels (Fig. 21: 9, Fig. 22: 1) and two sphero-conical vessels (Fig. 22: 2, Fig. 23: 1).

In addition, there are at least six vessels that were classified as 'closed' mainly due to the characteristics of the bottom fragments (no engobe inside).

The remarkable sphero-conical vessel in Figure 22: 2 can clearly be considered as an import because of the greyish colour of the clay and a painting scheme which is unusual for Tomashovka settlements. On the shoulder and belly of this vessel there is a band-like zone located in which vertical and festooned metope-like hatched blocks alternate with zones divided by tangents. The triangular zones which are generated by the tangent have fillings with organically curved bundles of parallel thinner and thicker lines and triangular or nodular connections. On the upper side, the main motif of the painting is bordered by a band of triangles.

Comparable painting schemes are found in the Sinyukha catchment area, for example, in settlements such as Kosenivka (Kruts *et al.* 2005, Fig. 58: 11, Fig. 60: 6) and Vilhovets (Ryzhov 1999; Videiko 2020, Fig. 9), which are attributed to the Kosenivka group.

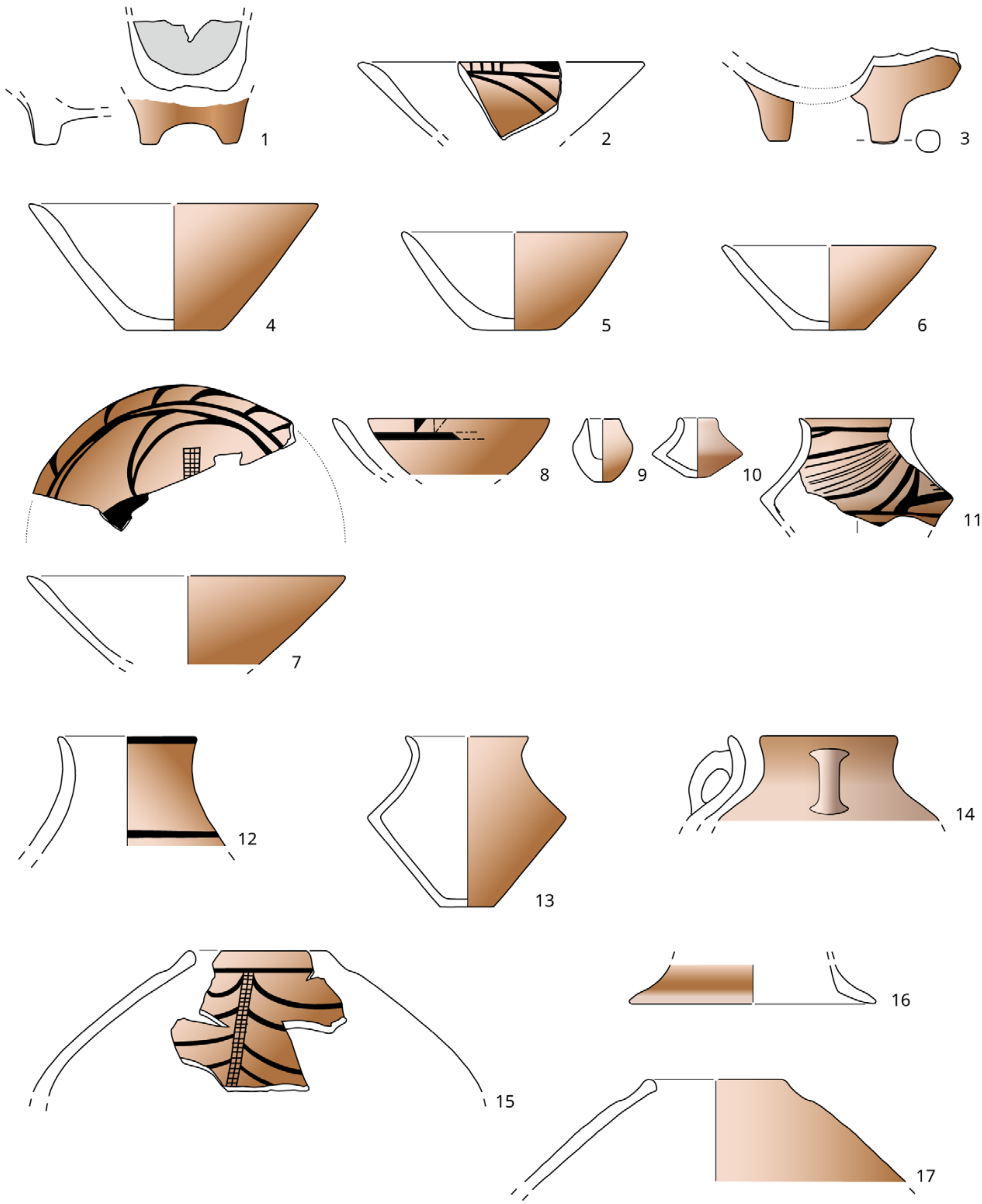


Figure 20. Maidanetske, ceramic inventory of Mega-structure 3: bowls (1–8); miniature vessel (9); cup (10); goblets (11–14); lid (16); pear-shaped vessels (15, 17). Scale 1:4.

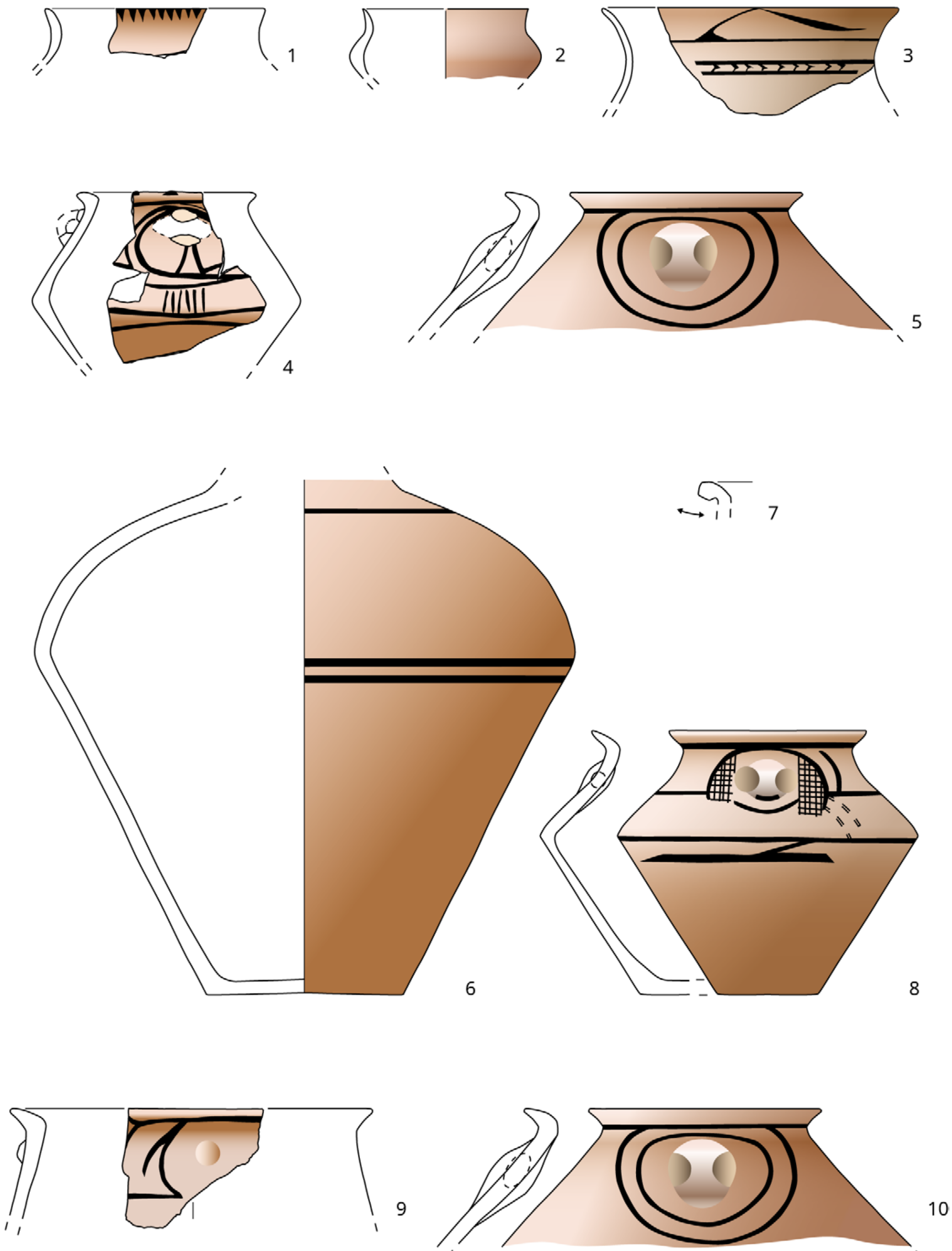


Figure 21. Maidanetske, ceramic inventory of Mega-structure 3: half-open vessels (1–3); amphorae and bi-conical vessels (4, 5, 8–10); sphero-conical vessel (6). Scale 1:4.

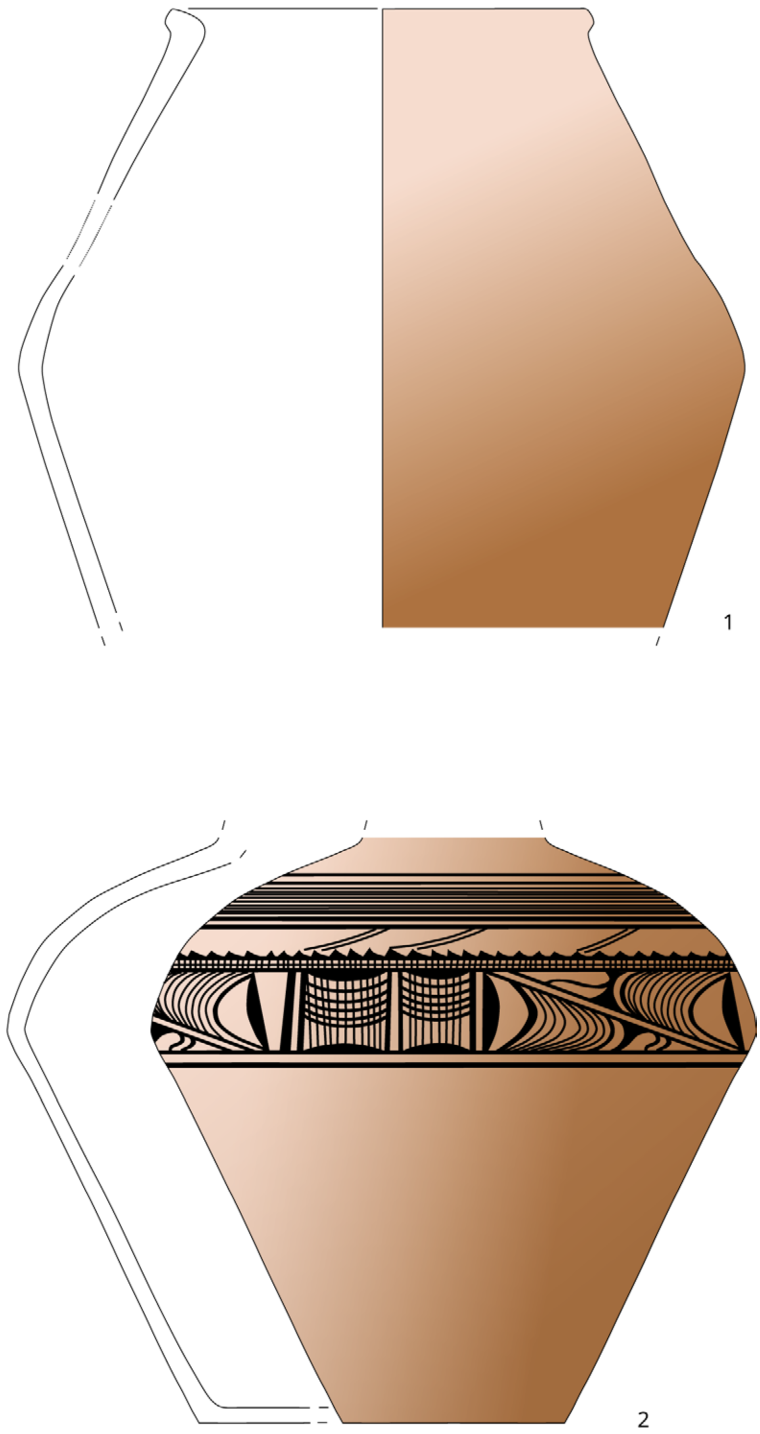


Figure 22. Maidanetske, ceramic inventory of Mega-structure 3: bi-conical vessel (1); sphero-conical vessel (2). Scale 1:4.

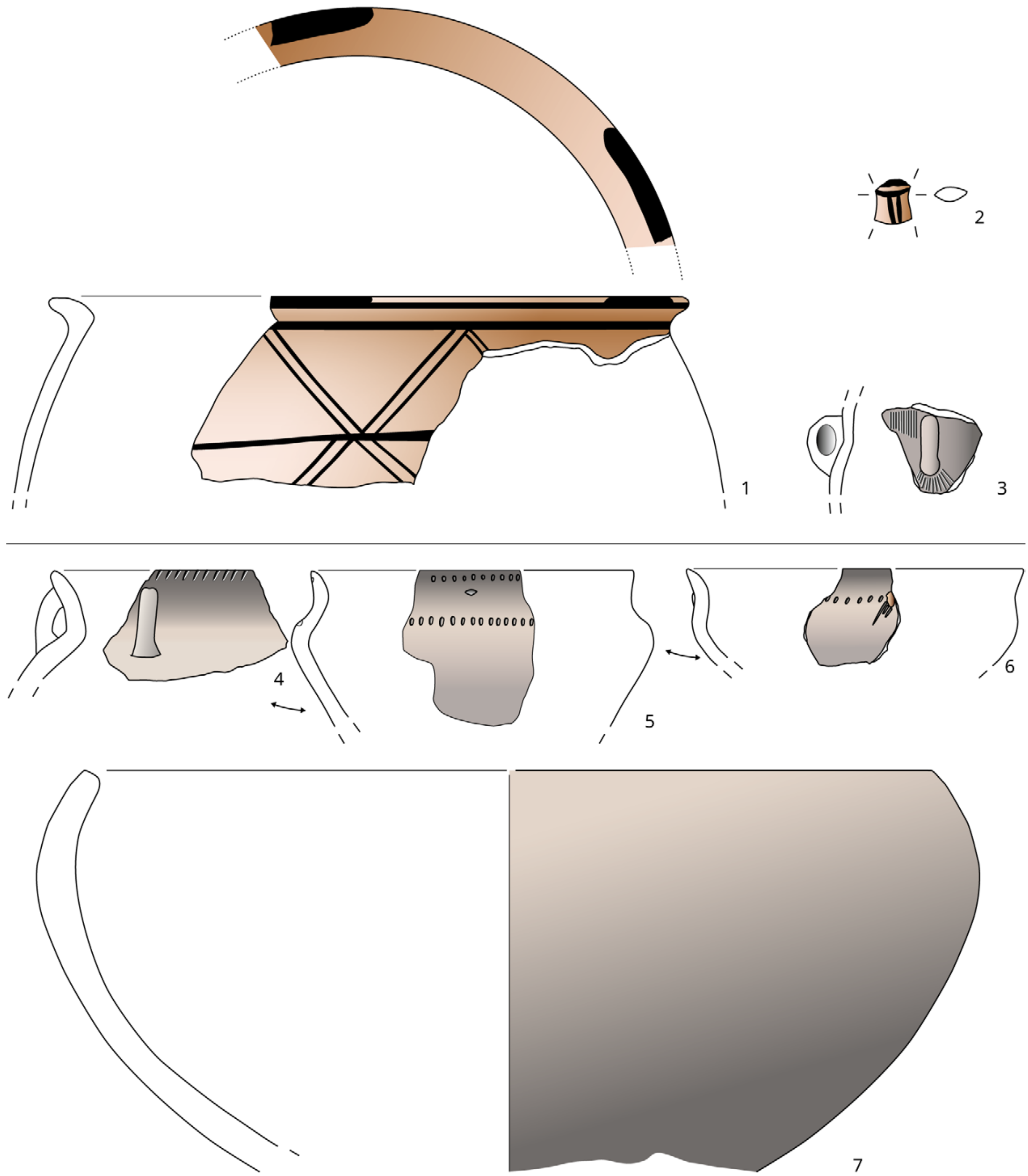


Figure 23. Maidanetske, ceramic inventory of Mega-structure 3: sphero-conical vessel (1); decorated handles (2–3); kitchenware pots (4–6); kitchenware bowl (7). Scale 1:3.

Quarry and ground stone artefacts

A total of 19 quarry and ground stone artefacts of different kinds were found in Mega-structure 3 (Tab. 10). At least four and possibly six or more pieces represent millstones or millstone fragments, while the function of nine of the quarry stones is unclear. In addition, there is a boulder with weathered surface, a rubbing stone, a stone slab and a small whetstone. The quarry and grinding stones are mostly made of granite, while the stone slab and the whetstone are made of fine sandstone. For the quarry stones and millstone fragments it is unclear whether they were in primary position at the place of their use or in secondary position as building material.

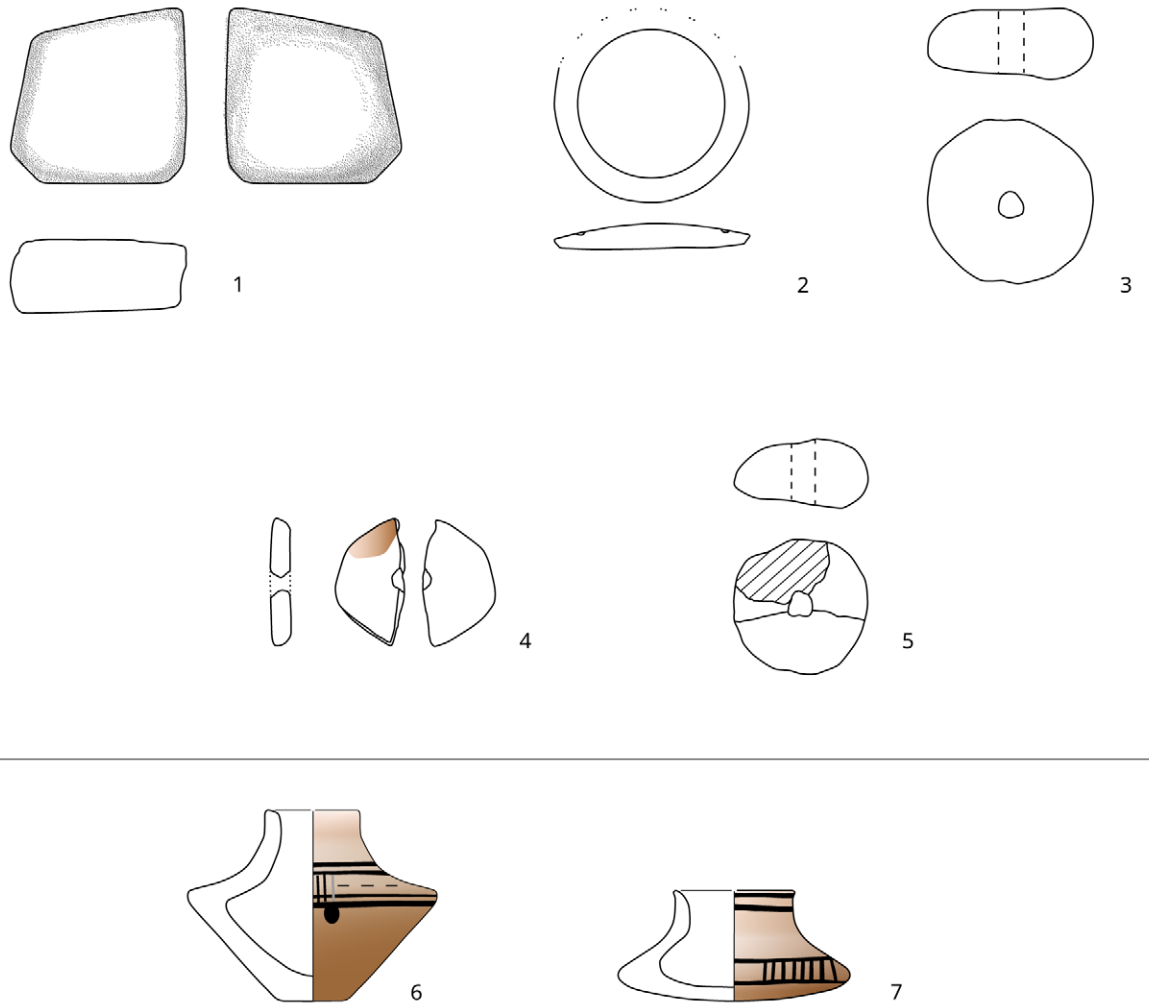


Figure 24. Maidanetske, ceramic and ground stone inventory of Mega-structure 3: whetstone (1); vessel bottom modified into a ceramic disc (2); loom weights (3, 5); spindle whorl (4); cups (6–7). Scale 1:3.

Flint

Within the layers of Mega-structure 3, a small collection of flint artefacts made of a light brown (local?) raw material, partly whitish-discoloured by fire, was found (Tab. 11; Fig. 25). There were one unmodified flake and four pieces of debris, all with portions of cortex. Tools marked by further modifications were not found.

Non-pottery ceramic objects

A total of 14 non-pottery ceramic objects were found in features attributed to Mega-structure 3 (Tab. 12). The largest group is represented by nine mostly fragmentary preserved weaving weights of a round, flattened type with a central perforation (Fig. 24: 3, 5). In addition, a ceramic disc reworked from a vessel bottom (Fig. 24: 2) and an angular-edged pierced sherd with red engobe on one side (closed vessel) were found (Fig. 24: 4). The find inventory furthermore contained three fragments of anthropomorphic figurines. In Quadrat K7 there was a torso of a small female figurine (preserved height 38 mm) with breasts, arm stumps, pierced arms and hips, and clothing indicated by incised lines (Fig. 26: 1). A leg belonging to a considerably larger figurine was found outside the mega-structure in Quadrat M3, broken off at the knee, with carefully sculpted calf and foot (preserved height 55 mm; Fig. 26: 2). An arm fragment was also recovered outside the mega-structure in Quadrat D4.

Find-ID	Feature-ID	Level	Quadrat	Number (n)	Weight (kg)	Category	Material
1110923	111018	3	L22	1	0.24	Boulder (surface weathered)	Granite, fine-grained, red
1111020	111009	4	N9	1	>5	Mill stone fragment (grinder, handstone)	Granite, coarse-grained
1111022	111003	4	I6	1	>5	Mill stone fragment (quern, lower)	Granite, coarse-grained
1111028	111003	4	J3	1	>5	Mill stone fragment (quern, lower)	Granite, coarse-grained
1110546	111002	2	J4	2	0.5	Mill stone fragment (unknown position)	Granite, coarse-grained, red
1110008	111002	2	K9	1	0.04	Quartz cube 40 × 38 × 18 mm	Quartz
1110351	111002	2	M16	1	0.10	Quarrystone	Granite, coarse-grained, red
1110362	111002	2	J3–4	1	0.03	Quarrystone	Limestone
1110362	111002	2	J3–4	1	0.20	Quarrystone (perhaps millstone fragment)	Granite, coarse-grained, yellow
1110441	111002	2	E8	1	0.01	Quartz cube 27 × 18.5 x12 mm	Quartz
1110456	111002	2	E8	1	0.08	Quarrystone	Granite, fine-grained, yellowish-gey
1110679	111009	3	O10	1	0.15	Quarrystone	Granite, coarse-grained, red
1110684	111009	3	O10	1	0.10	Quarrystone, perhaps millstone fragment	Granite, coarse-grained, yellow
1110778	111018	3	F22	1	0.09	Quarrystone	Granite, fine-grained, red
1110778	111018	3	F22	1	0.36	Quarrystone	Granite, fine-grained, red
1111024	111003	4	G4	1	>5	Quarrystone	Granite, coarse-grained
1111026	111003	4	J5	1	>5	Rubbing stone	Granite, coarse-grained
1111016	111003	4	K12	1	>5	Stone slab	Sandstone, fine-grained, red
1110274	111002	2	J7	1	0.22	Whetstone with one flat side, 68 × 70 × 30 mm	Sandstone, fine-grained, grey

Table 10. Maidanetske, list of quarrystone and ground stone artefacts found in features attributed to Mega-structure 3.

Find-ID	Feature-ID	Level	Quadrat	Description	Number (n)	Weight (g)	Raw material
1110230	111002	2	C7	Debris with cortex	1	18	Light brown (regional?)
1110300	111002	2	H15	Debris with cortex – missing in database (only photo available)	1	?	Light brown (regional?) whitish discolouration due to fire exposure
1110318	111002	2	J20	Flake with bulbus and cortex remains	1	1	Light brown (regional?)
1110433	111002	2	N23	Debris with cortex	1	1	Light brown (regional?)
1110439	111002	2	I8	Debris with cortex	1	1.5	Light brown (regional?)

Table 11. Maidanetske, list of flint artefacts found in features attributed to Mega-structure 3.

Artefact distribution patterns of Mega-structure 3

Artefact distribution patterns provide information about the depositional processes and activities which took place within the mega-structure. The overall low degree of fragmentation seems to indicate that pottery was fragmented during a primary context of use (Fig. 27).

Pottery is distributed all over the mega-structure (Fig. 28). For example, bowls, which are generally associated with consumption activities, are evenly distributed across the whole interior space of the mega-structure (Fig. 29). Nevertheless, concentrations are visible in the northwestern and the southeastern areas. This

Figure 25. Maidanetske, flint artefacts from Mega-structure 3. Scale 1:1.

might indicate different activity areas whose character might be detectable by functional differences of the morphological vessel types involved:

- Half-closed and closed vessels, which probably had storage functions, are concentrated in both zones described above (Fig. 30). In the northwestern part of the mega-structure they are situated in the northeastern area, east of the fireplace. In the southeastern part they are concentrated in the southern corner beside the postulated entrance.

Find-ID	Feature-ID	Level	Quadrat	Category	Number (n)	Weight (g)	Type	Degree of preservation (%)	Diameter (mm)	Diameter perforation (mm)	Height (mm)	Thickness (mm)
1110331	111002	2	F6	Spindle whorl	1	11		50	50			8.5
1110474	111002	2	E5	Loom weight (fragment)	1	29	3	25	60		33	
1110576	111003	3	G21	Loom weight	1	63	3	100	55	11	27.5	
1110579	111003	3	I22	Loom weight (fragment)	1	24	3	20	75			
1110579	111003	3	I22	Loom weight (fragment)	1	26	3	20	45		29	
1110611	111003	3	J21	Ceramic disk (fragment)	1	40		65	76			9
1110811	111018	3	I23	Loom weight (fragment)	1	39	3	37	60		25	
1110972	111018	3	H22	Loom weight (fragment)	4	40	3	15	75	6	22.5	
1111571	111018	4a	H23	Loom weight (fragment)	1	83	3	50	75	11	26	
1111572	111018	4a	H23	Loom weight	1	120	3	100	64	9	25	
1111573	111018	4a	H23	Loom weight (fragment)	1	39	3	25	70		28	
1110024	111002	2	K7	Figurine, fragment, torso	1							
1110076	111002	2	M3	Figurine, fragment, leg	1							
1110248	111002	2	D4	Figurine, fragment, arm	2							

Table 12. Maidanetske, list of non-pottery ceramic objects from features attributed to Mega-structure 3.

- Kitchenwares, which are usually associated with food processing activities, occur frequently in the southeastern part but have an additional distribution focus in the northwestern part of the building, mainly southwest of the fireplace (Fig. 31).

In summary, the patterns of pottery distribution indicate food consumption in all parts of the mega-structure (bowls), food processing southwest of the fireplace and along the southern walls of the southeastern part (kitchenware), and food storage northeast of the fireplace and in the southern corner of the southeastern part. The lower fragmentation rate in these zones supports our view that the activities mentioned took place primarily in these parts of the mega-structure (Fig. 27).

Remains of querns are again mainly concentrated in two zones of the mega-structure (Fig. 32). Several fragments were found at the northwestern end of the building partly inside and partly outside the external walls. Another concentration was observed in the central area of the southeastern part of the mega-structure, where the only complete quern was found.

In consequence, the different artefact distribution patterns seem to reflect this dual distribution pattern of the ceramics. We would particularly like to stress the contrast between the only partly preserved querns in the northwestern part and at

Figure 26. Maidanetske, anthropomorphic figurines from Mega-structure 3: (1) Find-ID 1110024; (2) Find-ID 111076. Scale 1:1.

least one complete and several fragmented querns in the central southeastern part. This might indicate that cereal processing only took place in the southeastern part of the mega-structure, where slightly more cereal remains were also found (Fig. 33). We interpret the fragmented querns as secondarily appropriated construction material, as might also hold true for a larger number of quarry stones, a boulder, and two unworked stone slabs (Fig. 32). These are distributed in several accumulations along the external walls and along the central axis of the mega-structure.

The spatial distribution of bones clearly reveals another focused activity area in the northwestern half of the mega-structure (Fig. 34). The detailed bone distribution displays a semi-circular density at some distance from the fireplace along the walls. This could indicate that the consumption of meat was restricted to the northwestern part of the mega-structure.

Other ground-stone artefacts include a polishing stone and a whetstone; both of which were found in the northwestern end of the building. From these artefacts, further activities are identified as taking place in the northwestern part, *i.e.* the polishing and the sharpening of tools (Fig. 32). The distribution of the few flint artefacts (three pieces of debris and one flake) reflects again perhaps the two larger activity zones in the northwest and southeast of the structure (Fig. 35). This also holds true for remnants of textile production (Fig. 36). In one concentration six fragments and one complete loom weight were found in the southern corner of the building. A second concentration consisting of a loom weight fragment and a spindle whorl was found in the western corner. The one fragment (foot and calf) of a large anthropomorphic figurine was deposited outside the building along its narrow

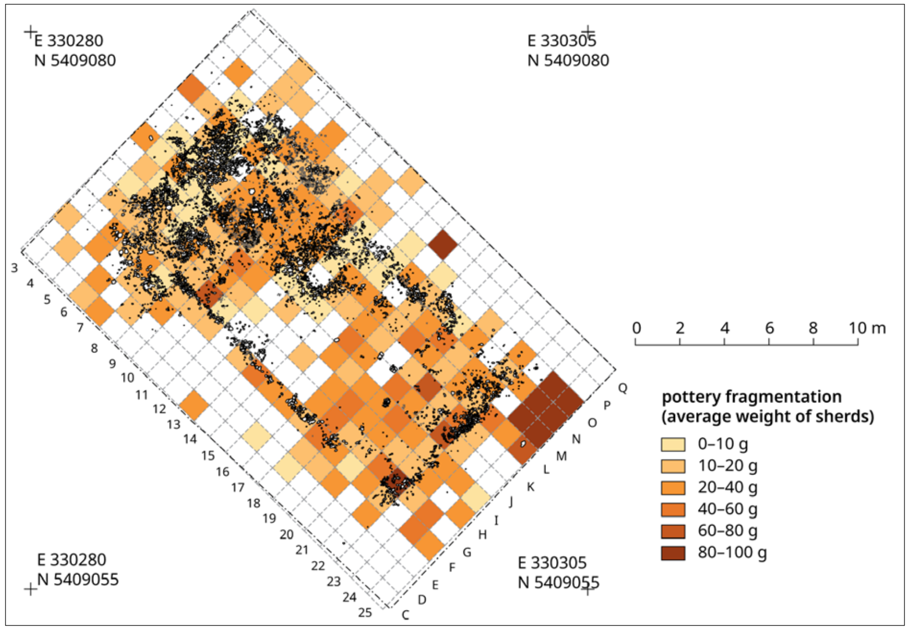


Figure 27. Maidanetske, distribution of ceramic fragmentation (average weight of sherds) in Mega-structure 3.

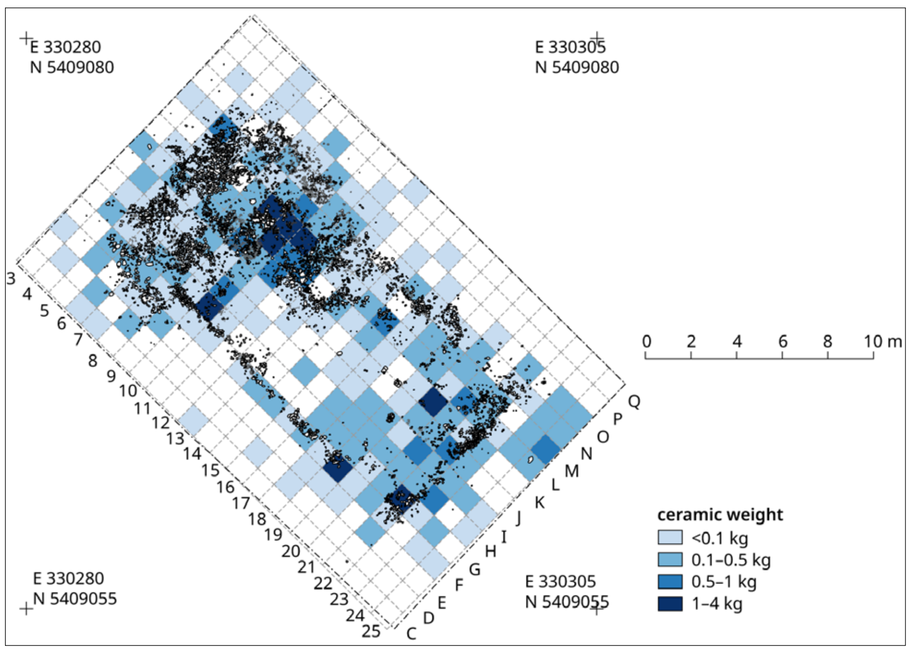


Figure 28. Maidanetske, distribution of ceramics in Mega-structure 3.

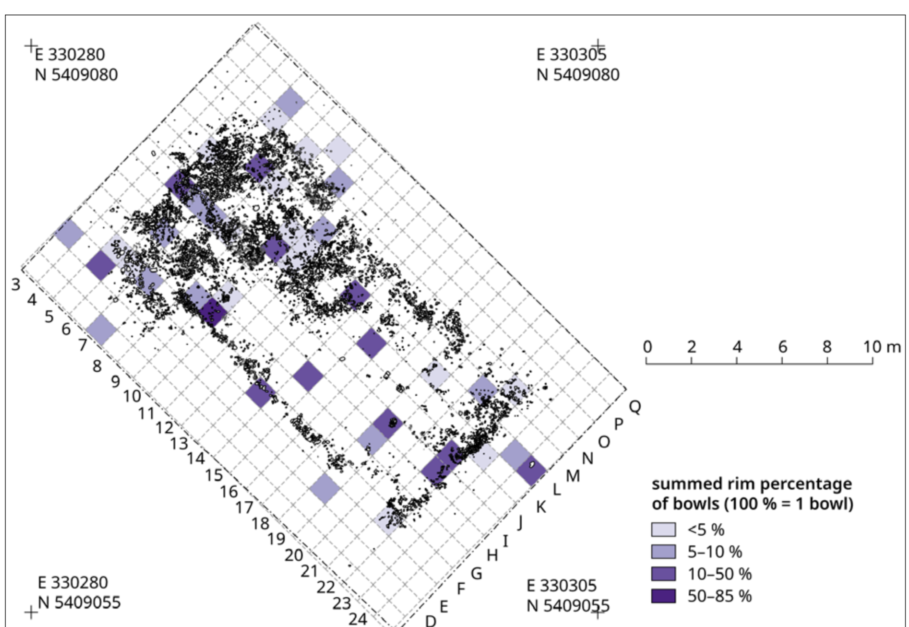


Figure 29. Maidanetske, distribution of ceramic bowls in Mega-structure 3 according to summed rim percentages.

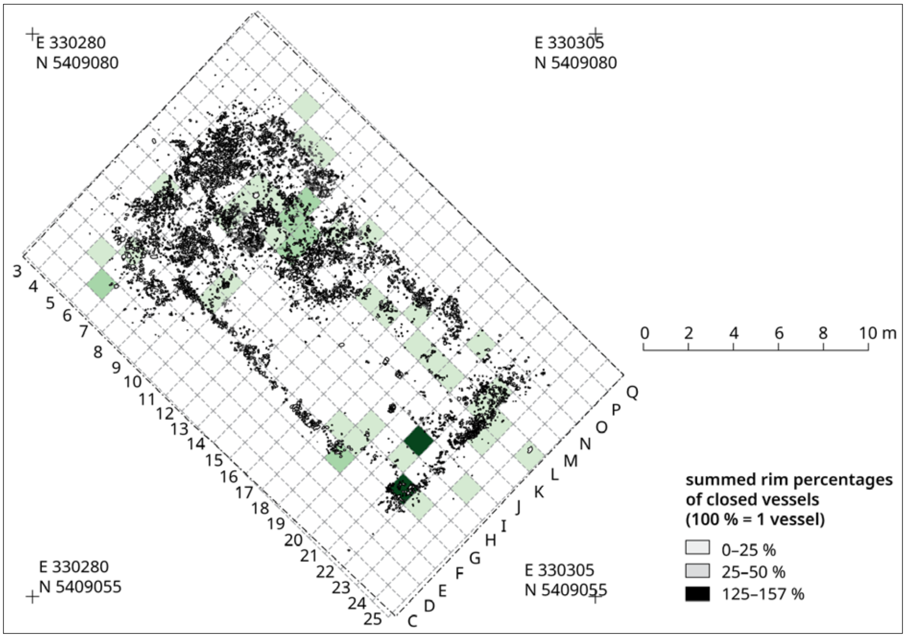


Figure 30. Maidanetske, distribution of closed/half-closed ceramic shapes in Mega-structure 3.

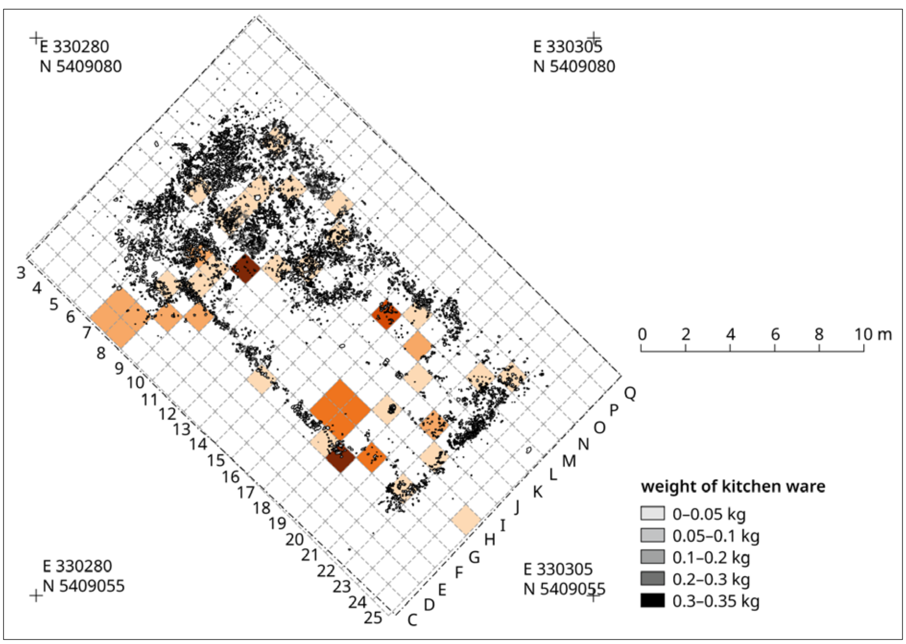


Figure 31. Maidanetske, distribution of kitchenware in Mega-structure 3.

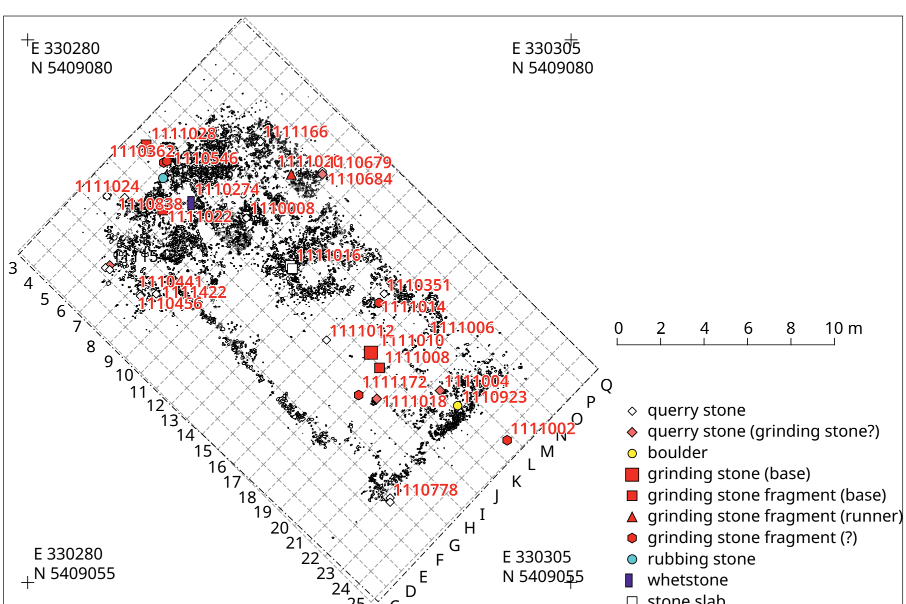


Figure 32. Maidanetske, distribution of ground stone artefacts in Mega-structure 3.

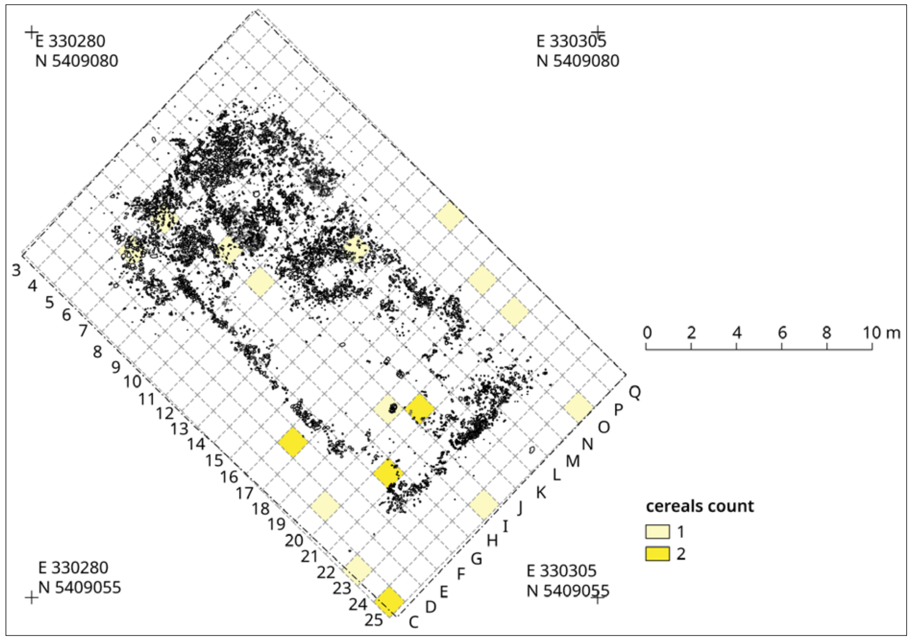


Figure 33. Maidanetske, distribution of charred cereal grains in Mega-structure 3.

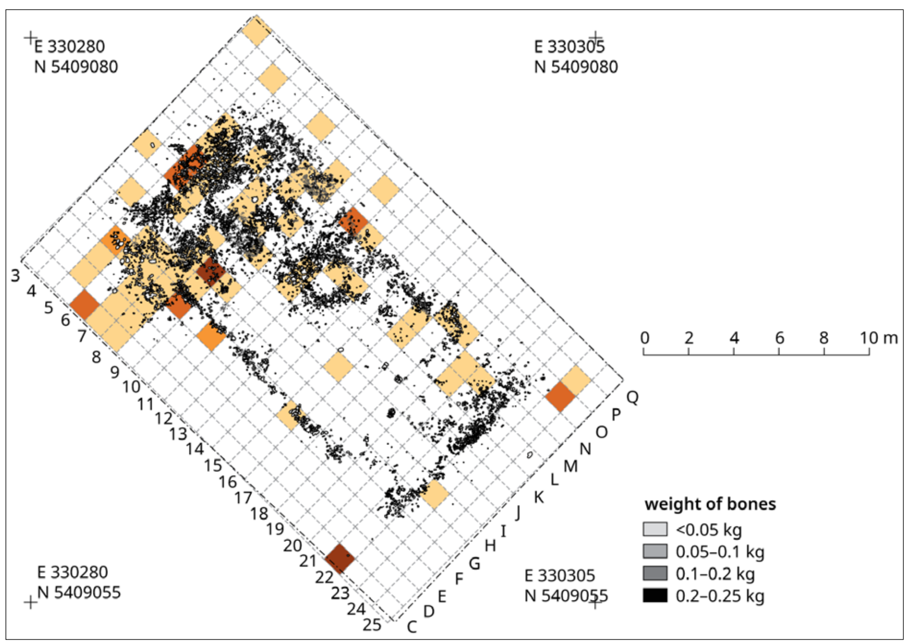


Figure 34. Maidanetske, distribution of animal bones in Mega-structure 3.

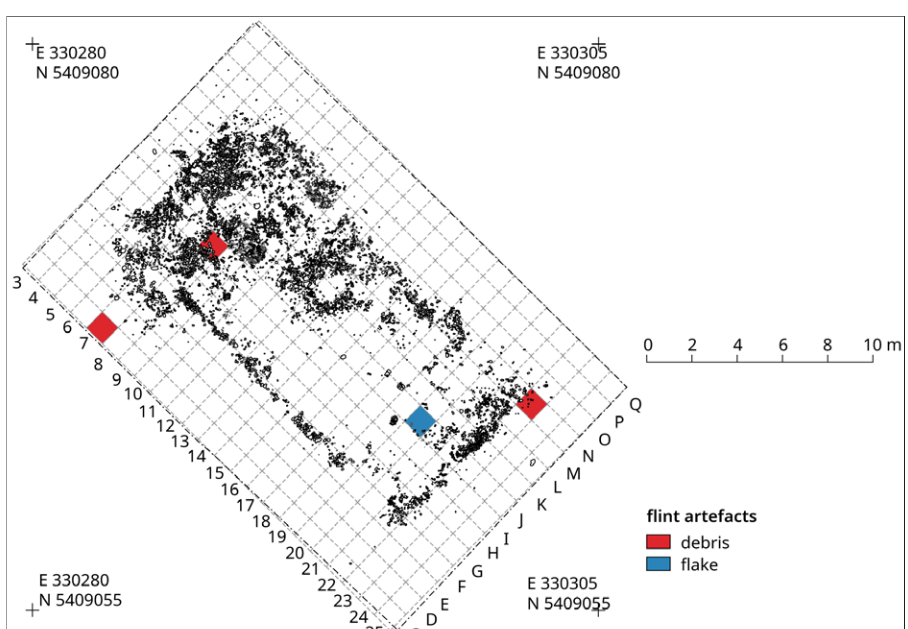


Figure 35. Maidanetske, distribution of flint artefacts in Mega-structure 3.

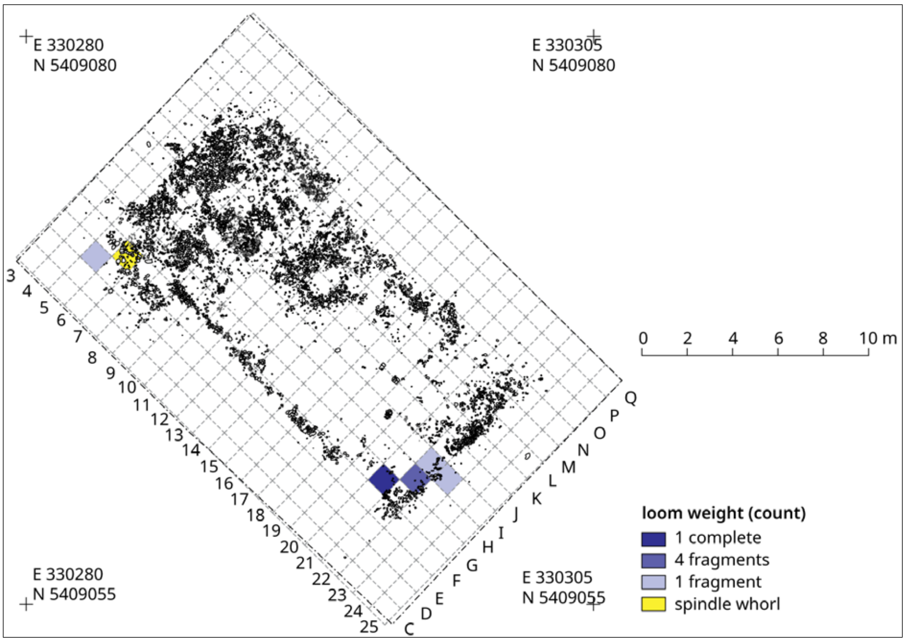


Figure 36. Maidanetske, distribution of remains from textile production in Mega-structure 3.

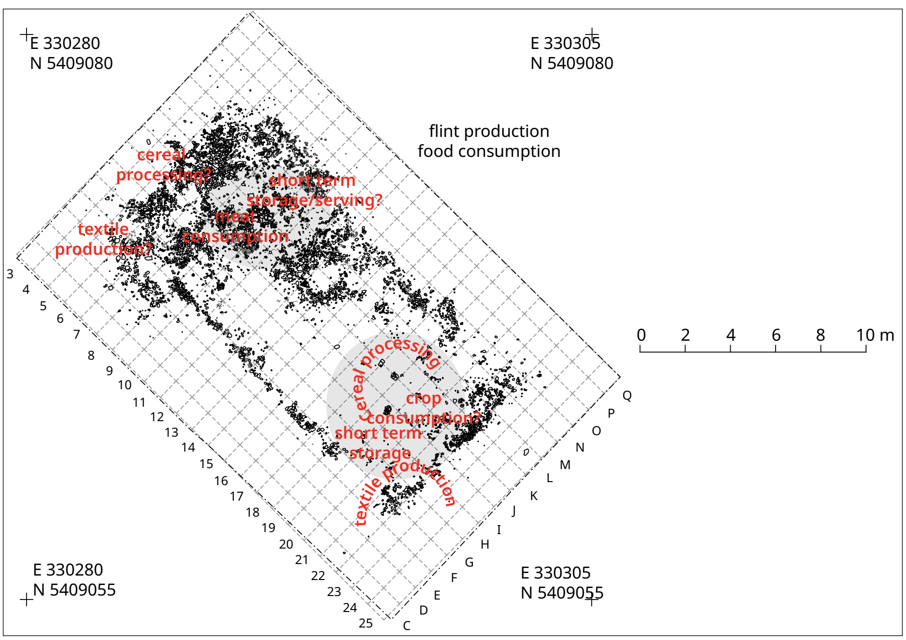


Figure 37. Maidanetske, reconstructed ground plan of Mega-structure 3 with activity zones.

northwestern end and may indicate a certain kind of non-utilitarian practice linked to the northwestern part of the mega-structure.

In consequence, multiple domestic activities could be detected and localised. In the northwestern part of the mega-structure, in addition to pyrotechnical activities at the fireplace, short-term storage, food preparation, meat consumption, textile production, and tool sharpening and polishing were identified. In the southeastern part of the mega-structure cereal processing, short-term storage, food preparation and textile production took place. Food consumption is evident in both areas.

Reconstruction of Mega-structure 3

Comparing the architectural remains and the artefact distribution patterns, the 'dichotomy' between the northwestern and the southeastern part of the mega-structure is evident (Fig. 37).

- The ca. 60 m² of the northeastern part were constructed as a more or less closed space with walls up to 3.50 m in height with possible entrances from the outside and a passageway to the southeastern part of the structure. The fireplace is in a central position within this roofed section. The main activities are linked to consumption of cattle and pork meat, tool-sharpening, and storage.
- The ca. 70 m² of the southeastern part were constructed as an enclosed but unroofed space with lower walls up to 1.5 m in height in which cereal processing, but also food preparation, food consumption, short-term storage and textile production took place.

In principle, our interpretation focuses on the difference between a roofed building in which meat consumption and pyrotechnic activities took place, and an appended unroofed enclosure in which activities including cereal processing were performed. The spatial distribution of vessels (except bowls) with their concentration along the exterior walls probably indicates their original alignment. The difference between the roofed and the unroofed part of the mega-structure is reflected in the presence of charred *Stipa* awns in the southeastern part (Fig. 39). Feather-grass (*Stipa*) is a plant of the steppe and might have entered the archaeological record due to its deliberate collection *e.g.* for matting (Anderson and M'hamdi 2014) or attached to the fur of animals that visited spring-summer (Dannath *et al.* 2019; Körber-Grohne 1987; Rivera Núñez *et al.* 2012). The presence of the tiny, charred, *Stipa* awns could be due to a taphonomical bias such as percolation from upper layers, but a direct radiocarbon date from another context in Maidanetske revealed them to be contemporaneous to the site occupation (3969–3794 BCE; Dal Corso *et al.* 2019).

In consequence, the differences in daub quantities between the northwestern and the southeastern part of the mega-structure definitely have architectural reasons and are not due to different degrees of burning. This interpretation is also supported by significant differences in activities between the two parts of the mega-structure.

Pre-mega-structure occupation

In this section we describe the archaeological layers, structures and associated finds discovered below the floor of the mega-structure. Since the complete excavation of a 0.4–0.8 m thick horizon would have far exceeded the scheduled time for the fieldwork, we conducted a sampling of smaller areas and documented two profiles. Therefore, there may exist further so far undiscovered features within and under the levelling layer and buried soil.

Levelling layer and buried soil

The rammed earth floor of the mega-structure rested on a humus-rich levelling layer or artificial mound into which numerous medium-sized pieces of daub and large pottery items from fragments up to complete vessels were embedded (Features 111024 and 111025). We could trace these layers in different profiles in most parts of the mega-structure but could not clearly distinguish them from the more or less sterile buried humus (Feature 111030) underneath. In some places at least, the layer superimposed clearly the backfilling of pits. In other cases, the stratigraphic relationship between the levelling layer and pits could not be clarified unambiguously due to the strong bioturbation. Taken together, the two layers had a thickness between 0.4–0.8 m.

It is currently difficult to assess the fact that most of the burnt daub under the floor of the mega-structure is classified as compact material without chaff admixture and one plain surface (Tab. 13). In other contexts of burnt houses, in contrast, organically tempered daub with cereal chaff and different kinds of architectural

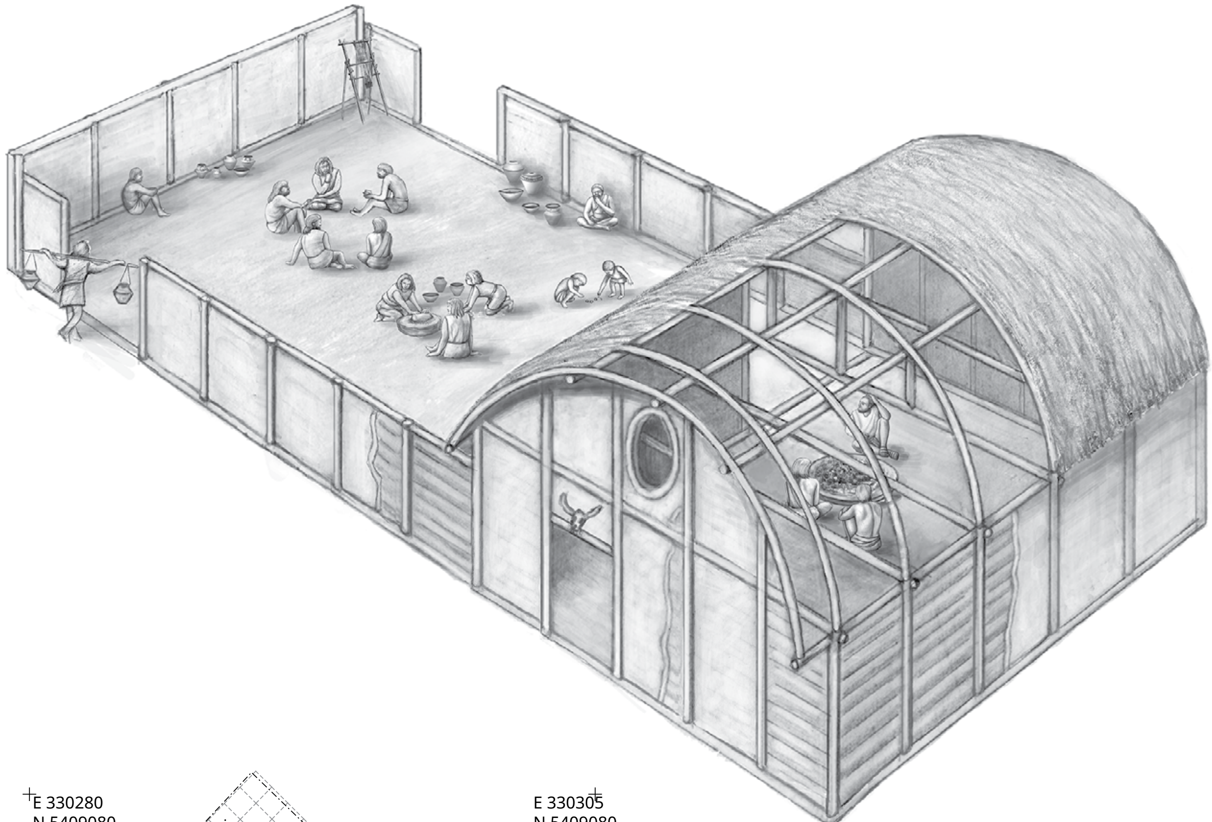


Figure 38 (above). Maidanetske, graphical reconstruction of Mega-structure 3 (graphic: Susanne Beyer, Kiel).

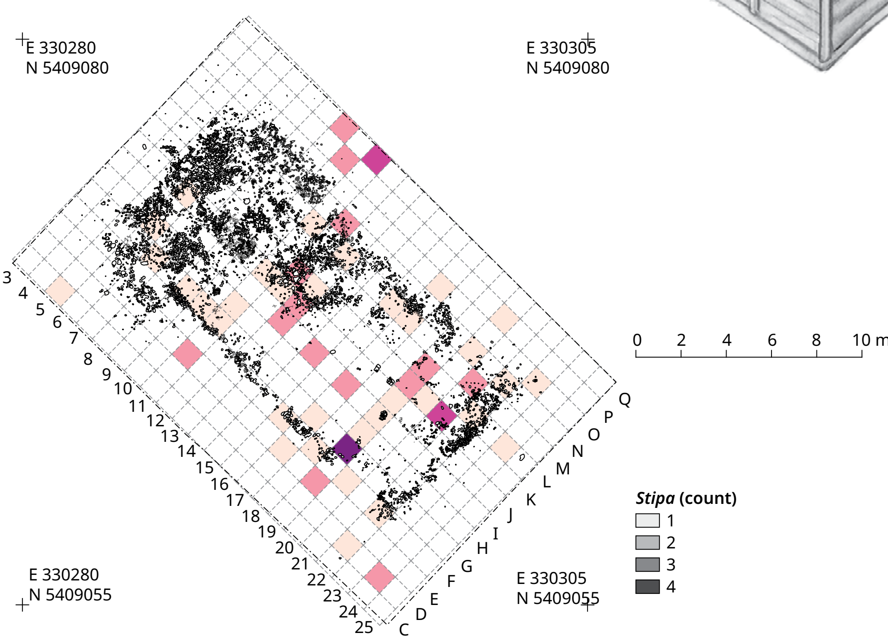


Figure 39. Maidanetske, spatial distribution of Stipa *awns in Mega-structure 3.*

features usually represent the most common material category. It seems most likely that the above-mentioned untempered burnt daub fragments are the remains of the floor of the mega-structure, which we incorrectly assigned to the underlying layer.

In the layer below the rammed earth floor of the mega-structure, chaff-tempered daub represents only 15–20% of the material. The most common architectural features on these pieces are fragments with plain surfaces and imprints of split wood planks, while imprints of logs, and other variants, are very rare. Also, the crumbly yellow material which was used in other contexts for the construction of fixed installed containers and interior components showed mainly imprints of split wood planks.

	Calculation by number (n)						Calculation by weight (kg)					
Architectural features	Compact (without chaff)	Organic tempered (chaff)	Crumbly yellow	Material not specified	Total number	Percentage	Compact (without chaff)	Crumbly yellow	Material not specified	Organic tempered (chaff)	Total weight	Percentage
1 Amorphous	1923	453	16		2392	**55.0**	37.1	0.4		11.2	48.7	**44.8**
2 Plain surface	1608	48			1656	**38.1**	43.9			3.0	47.0	**43.2**
3 Two plain surfaces	1	2			3	**0.1**	0.0			0.1	0.1	**0.1**
4 Split wood	10	38	14		62	**1.4**	1.4	1.4		3.3	6.1	**5.6**
5 Log wood		8			8	**0.2**				0.5	0.5	**0.4**
6 Combination: Split wood + split wood		1			1	**0.0**				0.2	0.2	**0.2**
7 Combination: Split wood + plain surface		4			4	**0.1**				0.8	0.8	**0.7**
10 Combination: Split wood + log wood		1			1	**0.0**				0.1	0.1	**0.1**
Vitrified clay		4		15	19	**0.4**			0.4	0.1	0.5	**0.4**
Non-classified	23	104	2	75	204	**4.7**	0.6	0.1	1.4	2.8	4.8	**4.4**
Percentage	**82**	**15.2**	**0.7**	**2.1**			**76.4**	**1.7**	**1.6**	**20.3**		

Table 13. Maidanetske, frequency of material categories and architectural features of burnt daub in the levelling layer beneath Mega-structure 3.

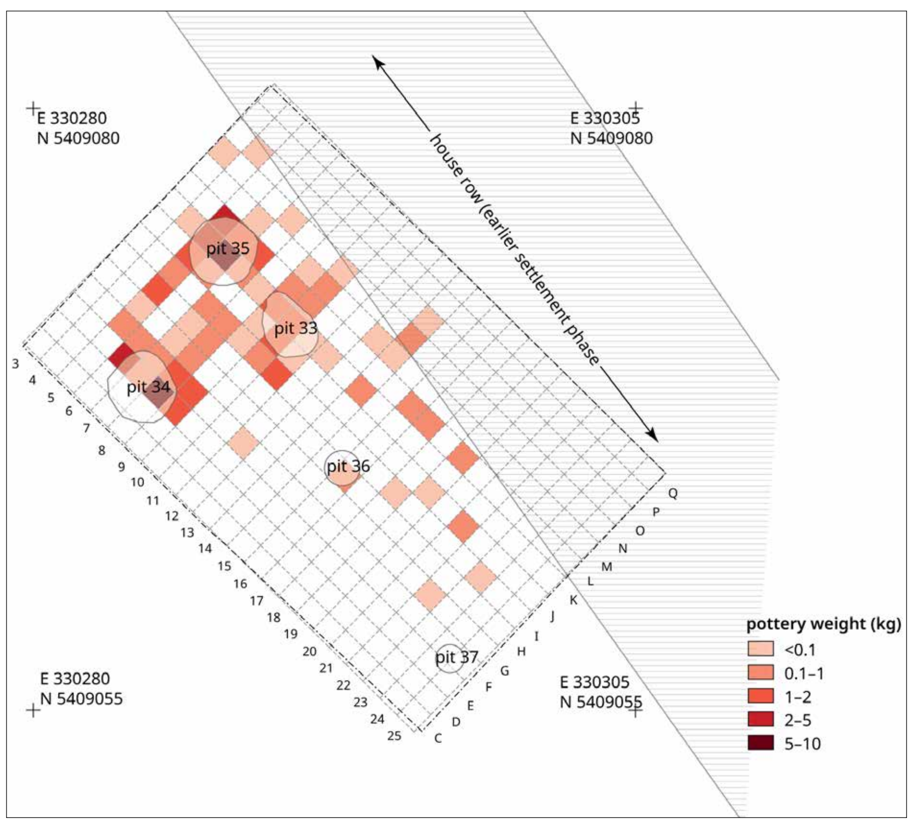


Figure 40. Maidanetske, features of the first building phase in Trench 111 below Mega-structure 3, showing the location of pits and a row of dwellings. Additionally, the distribution of pottery in the layers below Mega-structure 3 is shown.

	Levelling layer		Pit 33		Pit 34		Pit 35		Pit 36	
	Number (n)	Weight (kg)	Number (n)	Weight (kg)	Number (n)	Weight (kg)	Number (n)	Weight (kg)	Number (n)	Weight (kg)
Pottery	519	18.21	84	3.78	286	12.93	260	8.88	15	0.57
Burnt daub	4350	108.68	1616	133.84	118	7.17	116	5.70	43	8.17
Bone (zoology)	80	2.32	3	0.12	237	9.07	31	0.34		
Flint							1	0.06		
Ground stone	10	?			8	1.75				
Non-pottery ceramic objects	3	0.05								

Table 14 (above). Maidanetske, overview of type and frequency of finds of the first settlement phase in Trench 111.

Fabric	Number (n)	Weight (kg)	Number (%)	Weight (%)	Fragmentation (g)
Table	405	12.4	78.0	68.2	31
Kitchen	99	5.1	19.1	28.3	52
Non-classified	15	0.6	2.9	3.5	102
Total	**519**	**18.2**			**35**

Table 15. Maidanetske, frequency (number, weight) and fragmentation (average sherd weight) of ceramic fabrics in the levelling layer below the floor of the mega-structure in Trench 111.

Find distribution analysis consistently shows a zone under the northwestern part of the mega-structure where a large amount of waste was disposed of within and in the surrounding area of several pits (Fig. 40). To the southeast is an adjoining zone of much lower waste disposal intensity.

Table 14 provides an overview of the spectrum and frequency of finds from the layers under the floor of the mega-structure. Apart from burnt daub, ceramics followed by bones represent the most frequent find categories in the levelling layer.

Nearly 20 kg of ceramic vessel fragments were found within Features 111024 and 111025, which corresponds to a rather low find density of 0.88 kg/m². In fact, the material was concentrated in the areas surrounding Pits 33–35 in the northwest of the excavation trench, while on the other hand, there were larger empty areas. In view of a rather low fragmentation degree with an average sherd weight of 35 g, these find concentrations might be understood as only low to moderately relocated material from primary waste contexts.

From a technological point of view, the relatively high proportion of so-called kitchenwares is remarkable. Depending on the calculation method, this amounted to between 20 and 30% (Tab. 15). In total 60 fragments originate from at least three vessels, a large conical bowl with a vertical rim (Fig. 41: 1) and two pots (Fig. 41: 2–3).

Besides the above-mentioned kitchenware vessels, a broad spectrum of vessel categories of tableware is represented in the find assemblage. Most frequent categories are half or completely closed vessels such as amphorae, bi-conical vessels (Fig. 42: 3–5), followed by bowls (Tab. 16). According to the documented percentages of rim, belly and bottom sherds, the quantity of pottery corresponds, purely statistically, to at least 30 vessels.

The spectrum of vessel forms and decorations is illustrated in Figures 42 and 43, as far as we were able to reconstruct it by means of refitting and graphical documentation. Frequently, it shows conical bowls widely used in Tomashovka contexts (Fig. 43: 1–8), which in one case bears painting with a so-called comet-shaped decoration scheme (Fig. 43: 8). Much rarer are bowls with an inwardly bent rim zone like the one shown in Figure 43: 9 which is decorated with the so-called figure-eight-shaped decoration scheme.

Compared to bowls, cups and goblets are generally very rare in Trench 111 whereas they are usually very common in Tomashovka contexts. Only one bi-conical cup,

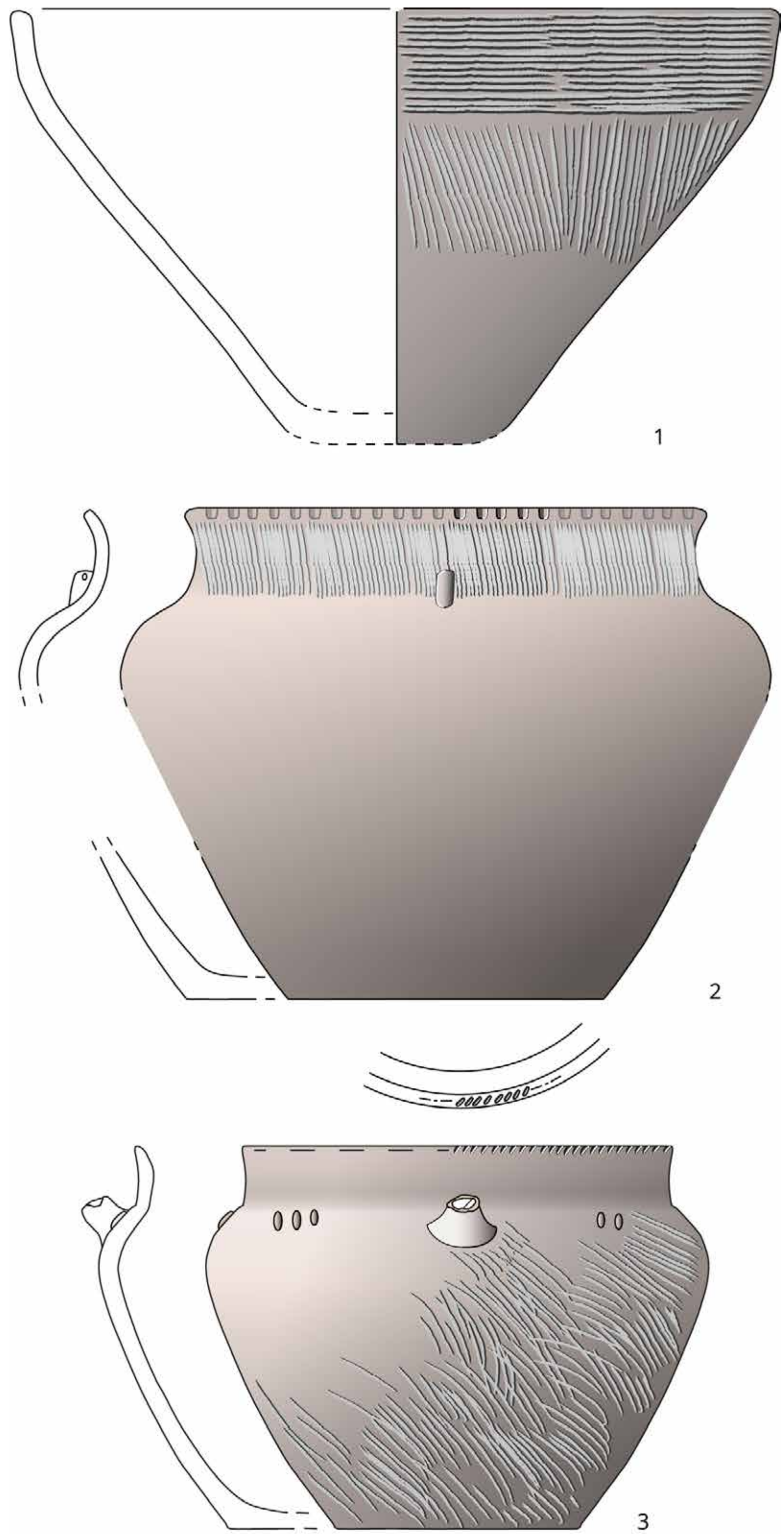


Figure 41. Maidanetske, ceramic inventory of the levelling layer below Mega-structure 3: bowl (1) and pots (2–3) made of kitchenware. (1)–(2) Scale 1:4; (3) Scale 1:3.

Class	Type-group	Number (n)	Weight (kg)	Summed rim percentage	Summed belly percentage	Summed bottom percentage	Minimum number of vessels
Non-classified		132	5.1	146	45	386	4
Amphora		25	1.0	95		200	2
Biconical vessel		4	0.4	15	6		1
Binocular vessel		8	0.3				1
Bowl		14	0.4	13		75	1
Bowl	Conical	30	1.3	318		240	4
Bowl	Sphero-conical	15	0.5	67			1
Closed vessel		214	5.8		125	568	6
Krater		1	0.05	10			1
Krater-shaped		4	0.6		11		1
Goblet		4	0.01	10			1
Goblet	Cup	1	0.1	38		16	1
Goblet	Goblet	4	0.06	10	35		1
Lid		1	0.02	14			1
Pear-shaped vessel		2	0.05	32			1
Pot		60	2.4	85	14	214	3
Total		**519**	**18.2**				**30**

Table 16. Maidanetske, type and frequency of vessel categories in the levelling layer below Mega-structure 3.

shown in Figure 43: 10, can be assigned to the pre-mega-structural settlement. In addition, larger goblets are only represented by a few fragments.

Apart from the serving vessels described, the find inventory included at least four kraters and krater-like vessels (Fig. 43: 11–13, Fig. 42: 2), one of which has a double wavy line on its rim zone. In addition, there are at least four specimens of amphorae and bi-conical/sphero-conical vessels (Fig. 42: 3–5, 9), a tableware 'pot' (Fig. 42: 1), fragments of a pear-shaped vessel (Fig. 42: 8) and a lid.

In addition to pottery, four fragments of weaving weights of a simple round type with central perforation were found in Features 111024 and 111025 (Tab. 17). The two specimens with Find-ID 1111088 occurred in the south-east of the excavation area directly below a concentration of objects for textile processing; these were assigned to the mega-structure. It seems reasonable to assume that the specimens could have been transported to deeper layers through bioturbation and should actually be assigned to the mega-structure. The other two loom weights were found in the north-west of the area in the immediate vicinity of Pit 35.

A total of 10 quarry and ground stone artefacts of different kinds were found in the 'levelling layer' below Mega-structure 3 (Tab. 18).

Pit 33

Pit 33 (111/1) was situated in Quadrats J–K/9–11, slightly off-centre under the fireplace of Mega-structure 3 (Fig. 44). The pit had an irregular oval shape and dimensions of 2.9 m x 2.0 m x 0.3 m (Fig. 40). It was thus more of a shallow depression than a proper pit. The pit had been dug into the buried humus horizon, Feature 111030, which was probably identical with Feature 111027, which was initially documented as the lower part of the pit filling (Fig. 45).

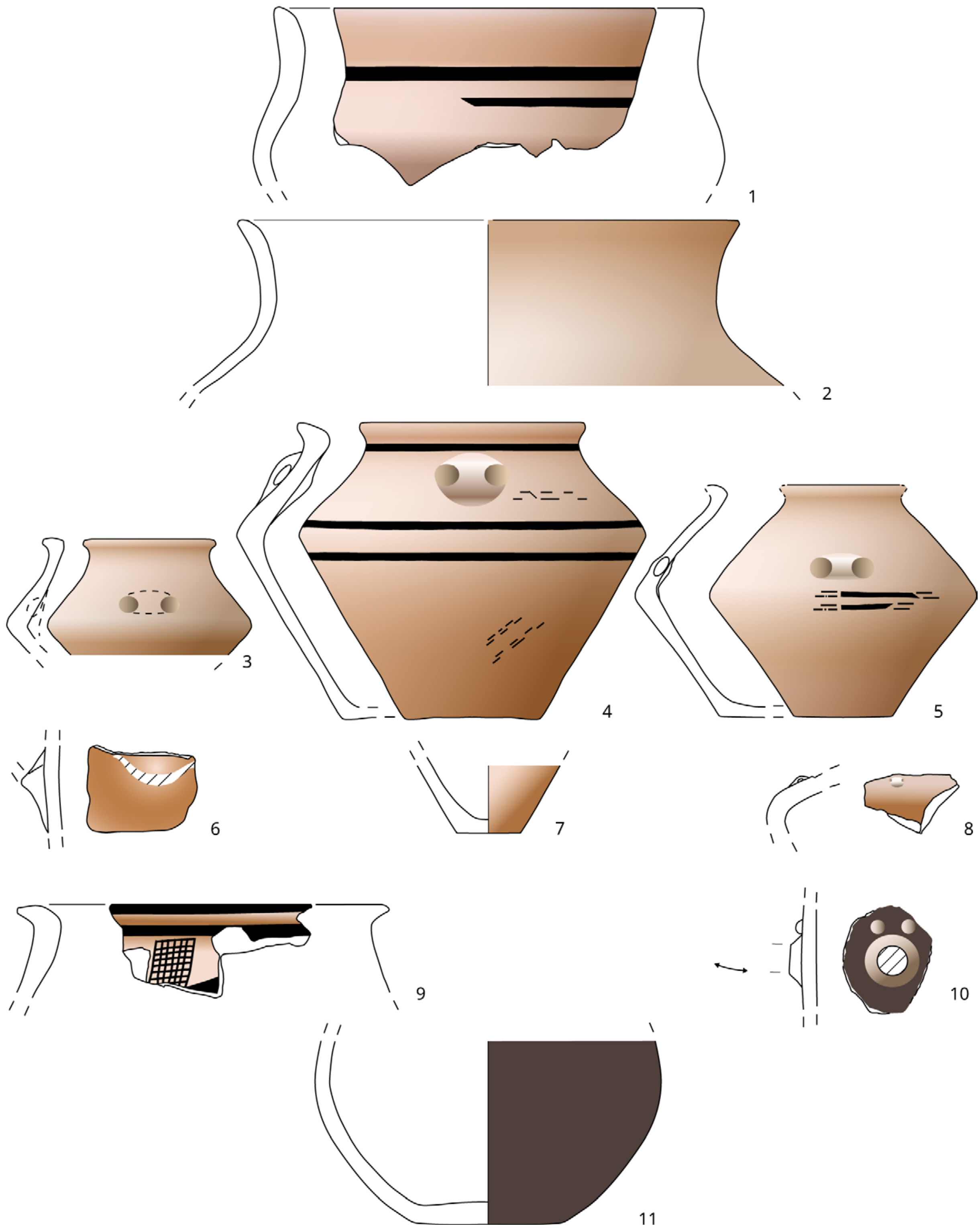


Figure 42. Maidanetske, ceramic inventory of the levelling layer below Mega-structure 3: pot (1); krater (2); bi-conical vessels and amphorae (3–5); handle (6); bottom of a closed vessel (7); bi- or sphero-conical vessel (9); lower part and decorated handle fragment (not Trypillia) of a ceramic vessel (10–11); made of tableware (1–9) and atypical dark burnished black-grey polished ware (10–11). Scale 1:3.

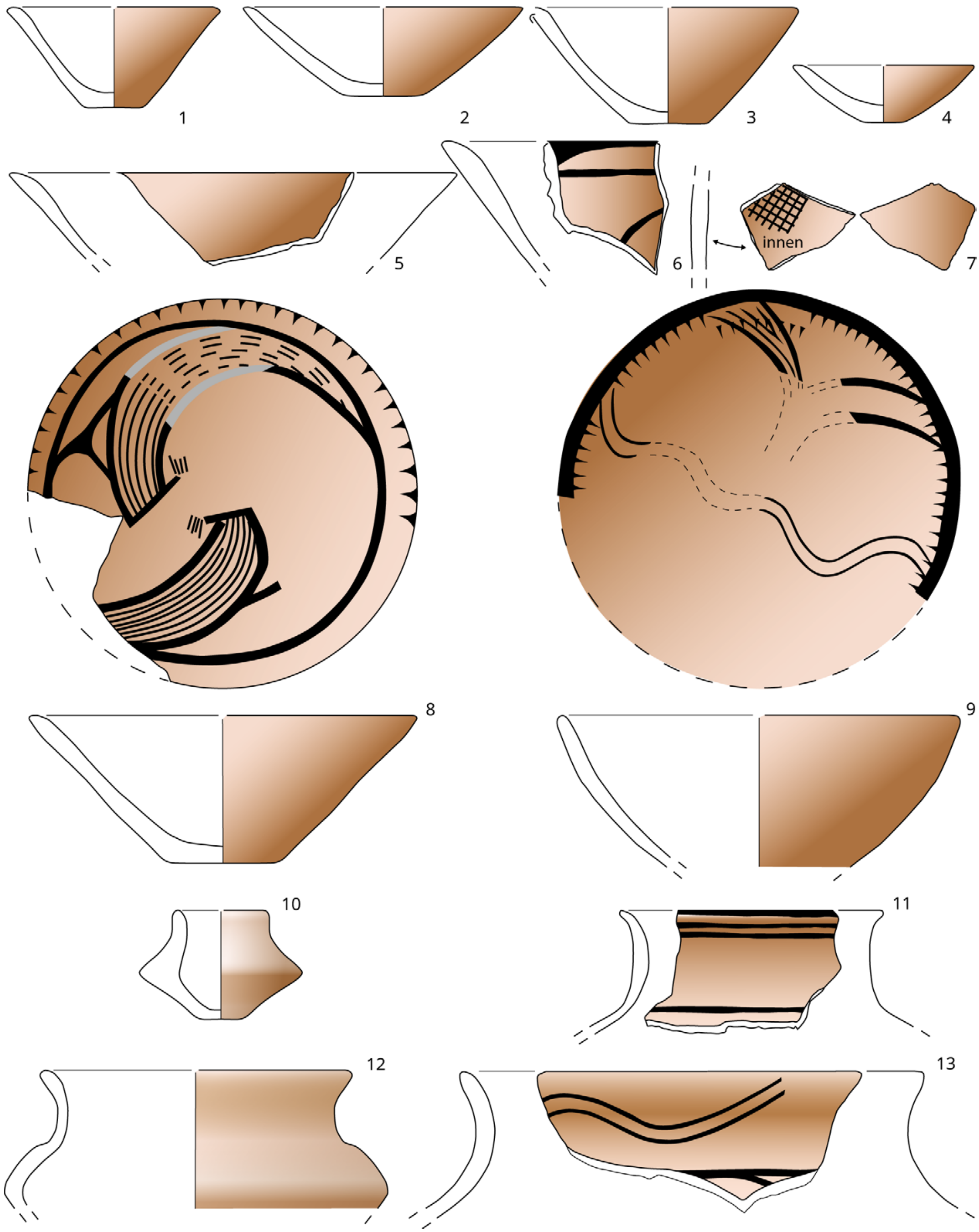


Figure 43. Maidanetske, ceramic inventory of the levelling layer below Mega-structure 3: bowls (1–9); cup (10); kraters (11, 13); krater-shaped vessel (12). Scale 1:3.

Find-ID	Context	Description
1111088	Feature 111025, Level 4b, Quadrat I23	2 loom weight fragments of Type 3, flattened round with central perforation, 26 g, degree of preservation 30%
1111115	Feature 111024, Level 4, Quadrat L6	1 loom weight fragment of Type 3, flattened round with central perforation, 12 g, diameter 50 mm, degree of preservation 25%
1111116	Feature 111025, Level 4, Quadrat L6	1 loom weight fragment of Type 3, flattened round with central perforation, 15 g, diameter 40 mm, height 29 mm, degree of preservation 25%

Table 17. Maidanetske, Trench 111, contextualisation and description of non-pottery ceramic objects.

Find-ID	Feature-ID	Level	Quadrat	Number (n)	Weight (kg)	Cate-gory	Material
1110838	111024	3	H4	1	0.3	Quarrystone	Granite, coarse-grained, red
1111004	111025	4	K21	1	>5	Quarrystone (perhaps millstone fragment)	Granite, coarse-grained
1111006	111025	4	M19	1	>5	Quarrystone	Granite, coarse-grained, red
1111008	111025	4	J18	1	>5	Mill stone fragment (quern, lower)	Granite, coarse-grained
1111010	111025	4	J17	1	>5	Mill stone fragment (quern, lower)	Granite, coarse-grained
1111012	111025	4	J16	1	>5	Quarrystone	Granite, fine-grained, yellowish grey
1111014	111025	4	L16	2	>5	Mill stone fragment (unknown position)	Granite, coarse-grained
1111018	111025	4	I19	1	>5	Quarrystone (perhaps millstone fragment)	Granite, coarse-grained
1111166	111025	4	N7	1	0.1	Quarrystone	Granite, fine-grained, yellowish grey
1111172	111025	4	I18	1	0.02	Mill stone fragment (unknown position)	Unknown

Table 18. Maidanetske, list of quarry stone and groundstone artefacts found in features attributed to the levelling layer below Mega-structure 3.

The filling of Pit 33 consisted mainly of burnt daub, probably from another context, weighing in total about 135 kg (Tab. 19). This burnt daub had been disposed in the pit without any apparent order. The majority of this material (98%!) contained organic temper with cereal chaff, whereas only about 2% showed no visible tempering and only 0.1% had a crumbly yellowish structure. In terms of the number of fragments, almost 75% of the burnt daub was of amorphous shape and gave no indication of the type of architecture. The remaining approximately 400 fragments (corresponding to about 50% of the weight) showed mostly flat surfaces and impressions of split wood planks as architectural features. In contrast, imprints of round timber were much rarer.

Besides burnt daub, the pit contained two bones of large mammals and one of a bovine, as well as 73 ceramic fragments weighing 3.4 kg. From a technological point of view, the small ceramic assemblage showed a usual composition, with about 95% of finer so-called tableware and 5% coarser kitchenware (Tab. 20). A comparatively high average sherd weight of nearly 50 g and a relatively high sherd density of 2.78 kg/m³ indicates that the pit filling represents either primary waste or only slightly relocated secondary waste.

From a morphological point of view, different classes and type groups of vessels were present in the pit (Tab. 21; Fig. 46: 1–2). In terms of the pure number of sherds, closed vessels including bi-conical vessels dominate, followed by conical bowls and pots. However, the minimum number of vessels obtained by measuring the rim, belly and bottom portions tends to show a uniform frequency of the categories identified.

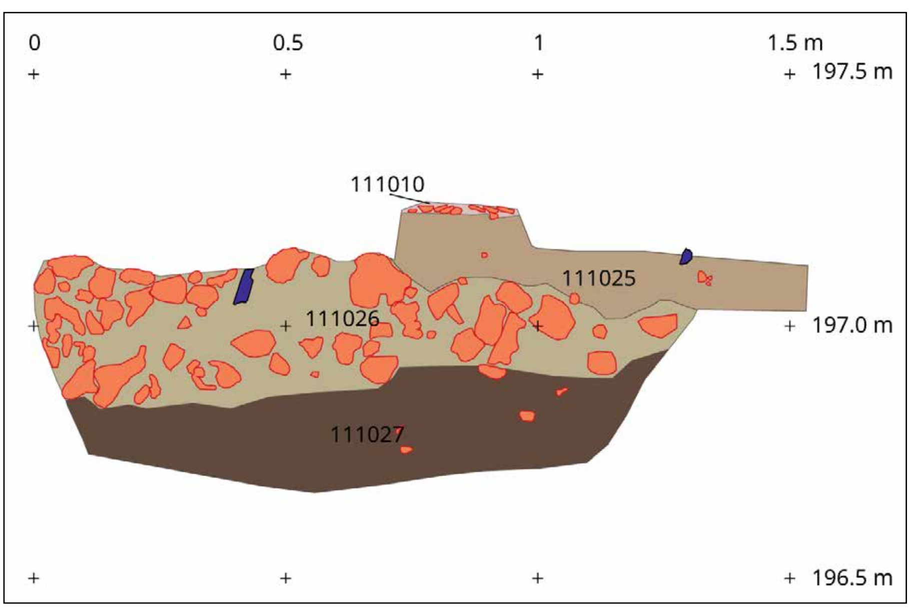


Figure 44 (above). Maidanetske, below the already partially removed central fireplace of Mega-structure 3, the upper edge of Pit 33, filled with burnt daub, is visible.

Figure 45. Maidanetske, profile through Pit 33, the backfill of which is superimposed by the Levelling Layer 111025 and the central fireplace of the Mega-structure 3.

Pit 34

Pit 34 (111/2), situated in Quadrats E–F/8–9, represents one of the larger pits in Trench 111. It was located below the southwestern longitudinal side of the mega-structure (Fig. 40). Here, subsidence of the pit filling led to the displacement of wall debris, which seems to be the reason for the emergence of the apse-like extension on the northeastern longitudinal wall of the mega-structure.

	Calculation by number (n)					Calculation by weight (kg)				
Architectural features	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Total number	Percentage	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Total weight	Percentage
1 Amorphous	1192			1192	**73.76**	63.0			63.0	**47.1**
4 Split wood	131	7		138	**8.54**	21.9	1.4		23.3	**17.4**
2 Plain surface	134	24		158	**9.78**	17.5	1.3		18.8	**14.1**
5 Log wood	67			67	**4.15**	11.2			11.2	**8.3**
6 Combination: Split wood + split wood	22			22	**1.36**	7.9			7.9	**5.9**
8 Combination: 2x split wood + plain surface	20			20	**1.24**	7.4			7.4	**5.5**
3 Two plain surfaces	5			5	**0.31**	0.9			0.9	**0.7**
7 Combination: Split wood + plain surface	2			2	**0.12**	0.6			0.6	**0.4**
10 Combination: Split wood + log wood	2			2	**0.12**	0.5			0.5	**0.4**
Non-classified		7	3	10	**0.62**		0.2	0.1	0.3	**0.2**
Percentage	**97.5**	**2.4**	**0.2**			**97.7**	**2.2**	**0.1**		

Table 19 (above). Maidanetske, frequency of material categories and architectural features of burnt daub in the filling of Pit 33.

Table 20. Maidanetske, frequency (number, weight) and fragmentation (average sherd weight) of ceramic fabrics in Pit 33.

Fabric	Number (n)	Weight (kg)	Number (%)	Weight (%)	Fragmentation (g)
Kitchenware	4	0.2	5.5	5.7	49
Tableware	69	3.2	94.5	94.3	47
Total	**73**	**3.4**			**47**

Class	Type group	Number (n)	Weight (kg)	Summed rim percentage	Summed belly percentage	Summed bottom percentage	Minimum number of vessels
Bowl	Conical	3	0.3	51		65	1
	Sphero-conical	2	0.015	8			1
Goblet		1	0.04		25		1
Bi-conical vessel		5	0.5				1
Closed vessel		48	2.2	27	11	100	1
Pot		3	0.095				1
Non-classified		18	0.37	7		42	1
Total		**80**	**3.52**				**7**

Table 21. Maidanetske, frequency of morphological pottery classes and type groups in Pit 33.

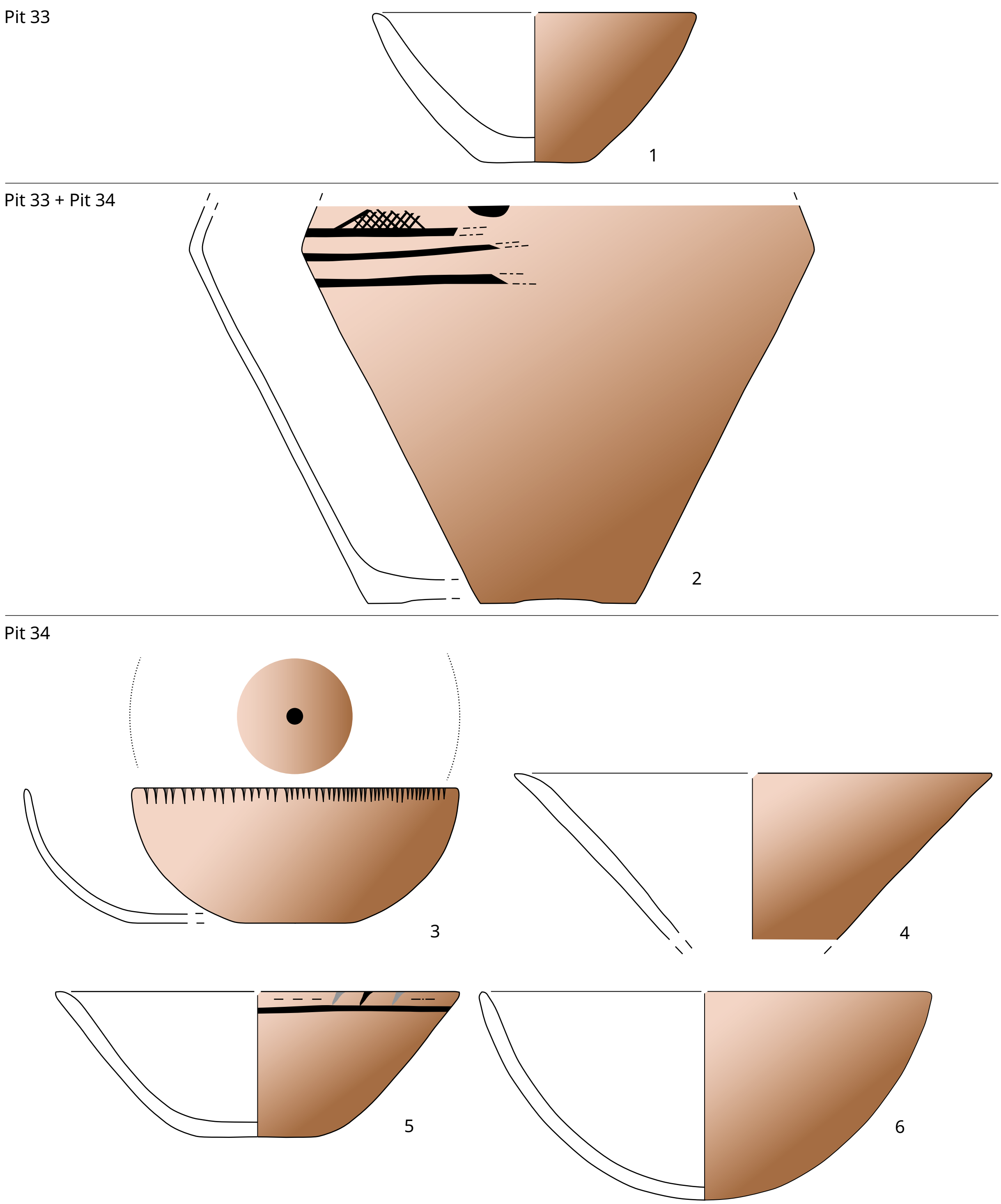


Figure 46. Maidanetske, ceramic inventory of the Pits 33 and 34: bowls (1, 3–6); biconical or sphero-conical vessel (2). (1), (4)–(6) Scale 1:3; (2)–(3) Scale 1:4.

As we discovered the pit only during the last day of the excavation, we could not fully document it. Thus, its size and stratigraphic relationships could only be determined roughly. While the pit was clearly located stratigraphically below the floor of the mega-structure, its relationship to the Levelling Layer 111025 remained unclear.

Pit 34 had a diameter of approximately 3 m. While the upper edge of the pit was situated at a level of about 167.20 m and thus about 0.2 m below the floor of the mega-structure, the lower edge was located beneath 166.60 m. In addition to almost 10 kg

Species	NISP	Weight (kg)
Bos	153	8.34
Indet.	67	0.28
Large mammal	12	0.10
Cervus elaphus	2	0.31
Unio	1	-
Sus	1	0.03
Helix pomatia	1	-
Total	**237**	**9.07**

Table 22. Maidanetske, Trench 111, frequency of animal species in Pit 34 (after Benecke et al.*: Chapter 9, this work, Vol. I).*

Fabric	Number (n)	Weight (kg)	Number (%)	Weight (%)	Fragmentation (g)
Tableware	207	9.5	82.8	89.0	45.8
Kitchenware	43	1.2	17.2	11.0	27.3
Non-classified	36	2.3			63.2
Total	**286**	**12.9**			**45.2**

Table 23. Maidanetske, frequency (number, weight) and fragmentation (average sherd weight) of ceramic fabrics in Pit 34.

of animal bones, the pit contained a large quantity of pottery fragments (about 13 kg), burnt daub (about 7 kg) and a collection of eight ground stone artefacts (Tab. 14).

Pit 34 contained a large collection of 237 animal bones, highly dominated by cattle bones (Tab. 22; Chapter 9, this work, Vol. I). Since elements of the different meat value classes are represented according to the anatomical composition, from the zoological point of view nothing seems to argue against this being normal domestic waste from slaughter. However, the pit stands out because of its extremely high density of bone finds of more than 2 kg/m³ and the low degree of fragmentation, with an average fragment weight of 67 g. In this respect, the assemblage shows characteristics for which a ritual character may be considered.

Comparable to other pits in Maidanetske, pottery in Pit 34 also shows an increased density (3.4 kg/m³) and low fragmentation (45 g average sherd weight). In total, we recovered almost 13 kg which shows a much better preservation of paintings than the material from the mega-structure and the levelling layer. Depending on the calculation basis, 83–89% are so-called tableware and 11–17% are so-called kitchenware (Tab. 23). Thus, the frequency of the fabrics is within the normal range of variability (Shatilo 2021, 158–168).

According to the quantification of the preserved percentages of rim, belly and base fragments, the ceramic inventory comprises at least 23 vessels and represents a wide range of shapes (Tab. 24; Figs. 46–49). This includes at least six conical and sphero-conical bowls (Fig. 46: 3–6, Fig. 47: 1, 3), one of which is decorated with a comet-shaped design scheme (Fig. 47: 1) and another which has a simplified line scheme with central dot and with circumferential ladder band on the periphery (Fig. 47: 3).

Half-open forms are represented by several pots made of different fabrics. There are two tableware pots with short vertical rim and steep shoulder, painted with leaf-shaped design scheme (Fig. 47: 5, 6) and one pot made of kitchenware, decorated with combed decoration groups of round impressions, and plastic applications of animal heads (Fig. 49: 3).

Closed shapes in the inventory include at least one goblet with funnel-shaped rim zone, conical neck, rounded bi-conical belly and leaf-shaped decoration (Fig. 47:

Class	Type group	Number of fragments (n)	Weight (g)	Summed rim percentage	Summed belly percentage	Summed bottom percentage	Minimum number of vessels
Bowl		16	1069	5		132	2
Bowl	Conical	25	1420	185		262	3
Bowl	Sphero-conical	12	237	60.5		65	1
Goblet	Goblet	1	57	26			1
Amphora		9	382	80		100	1
Bi-conical vessel		33	2340	170		100	2
Closed vessel		63	2148	19	31	582	6
Krater		1	55	6			1
Krater-shaped		12	415	37	65	55	1
Container		1	56	6			1
Pot		43	1304	87		8	1
Non-classified		70	3443	210		258	3

Table 24. Maidanetske, frequency of morphological pottery classes and type groups in Pit 34.

7). A krater/krater-shaped vessel has a similar shape, with a handle at the rim and neck. It is painted with a band of hanging triangles at the rim and a segment-shaped shoulder decoration (Fig. 47: 9). In the otherwise undecorated neck area, tree or ear-shaped signs are depicted. Probably also belonging to the category of krater/krater-shaped vessel is the neck shown in Figure 47: 4, on which two hook and ladder bands are shown under a leaf-shaped decoration on the rim.

Closed forms are additionally represented by one small amphora (Fig. 47: 8) and at least three larger vessels of the category amphora/bi-/sphero-conical vessels (Figs. 48, 49: 1). While the latter vessels show typical developed collar-shaped rims, the former amphora has only a rudimentary ridge-shaped thickened rim. The very simple and ephemeral decoration of this vessel with vertical groups of strokes between circumferential lines gives a very archaic impression. In comparison, the 'segment-shaped' decoration of one of the amphora/bi-/sphero-conical vessels is much more complex (Fig. 48: 3).

Overall, it can be shown that the ceramic inventory of Pit 34 is clearly dominated by closed forms, of which there are at least 15 vessels. In contrast, open serving vessels are represented by at least six specimens and semi-open vessels by three specimens.

In addition, eight possibly modified quarry stones derive from Pit 34 (Tab. 25). A fragment of granite could be part of a millstone; in all other cases the artefact character is not determinable.

Pit 35

The funnel-shaped Pit 35 (111/3) was located under the northwestern narrow end of the mega-structure (I–L/4–7; Fig. 40). While the pit was clearly below the floor level of the mega-structure, the determination of the stratigraphic relation to the underlying layer (Feature 111025) was difficult. The round pit had a diameter of 1.5 m at its upper edge; the pointed pit bottom was located 1.25 m below the floor of the mega-structure (Fig. 50).

The pit contained a small collection of burnt daub with a total weight of 5.7 kg (Tab. 26), which was evenly distributed over all levels. As in other contexts, chaff-tempered material predominates, while fragments without temper are much rarer and the 'crumbly-yellow' variant is present only in one piece. The most common

Figure 47. Maidanetske, ceramic inventory of Pit 34: bowls (1–3); pots (5–6); goblet (7); amphora (8); krater/krater-shaped vessel (4, 9); all made of tableware. (1), (3)–(4), (8)–(9) Scale 1:4; (2), (5)–(7) Scale 1:3.

architectural features are flat surfaces, followed by impressions of split wood planks. The accumulation of fragments with a flat surface and without temper in the upper two levels of the pit indicates that they belong to the rammed earth floor of the mega-structure.

A total of 31 animal bones were recovered from the middle part of the pit fill (between 196.47 m and 197.06 m; Tab. 27). Similar to Pit 34, domestic cattle represent the dominant species, followed by two bones of red deer and one of a sheep or goat. From a zoological perspective, nothing contradicts the assumption that this collection represents normal domestic butchery waste (Chapter 9, this work, Vol. I).

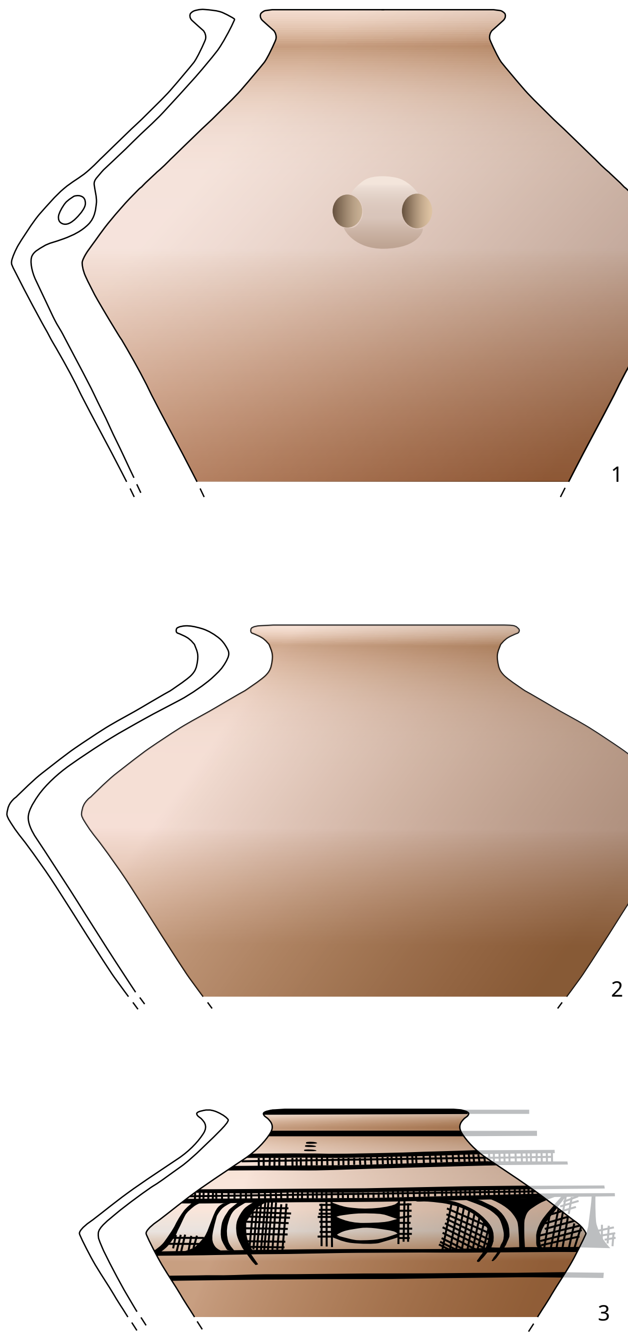


Figure 48. Maidanetske, ceramic inventory of Pit 34: amphora/bi-/sphero-conical vessels (1–3); all made of tableware. Scale 1:4.

Apart from the burnt daub, the animal bones and one flint artefact (Find-ID 1111554, a 6 g point made of dark brown (Volynian?) flint; Fig. 52: 3), the backfilling of the pit comprised a larger ceramic inventory which was distributed over the entire depth of the pit (Fig. 49: 4–7, Figs. 51 and 52). The find density amounted to 3.7 kg/m³ and was similar to that of neighbouring pits, although with an average sherd weight of 34 g the degree of fragmentation was slightly higher.

As in the Levelling Layer 111025, the proportion of tableware is relatively low at 76–77% and that of kitchenware is correspondingly high at 22–23% (Tab. 28). The composition of the pottery assembly, with remains of at least 20 vessels including 5 bowls, 1 pot, 2 goblets, 1 jug, and 7 closed vessels, is also similar to that of other contexts in Trench 111 (Tab. 29).

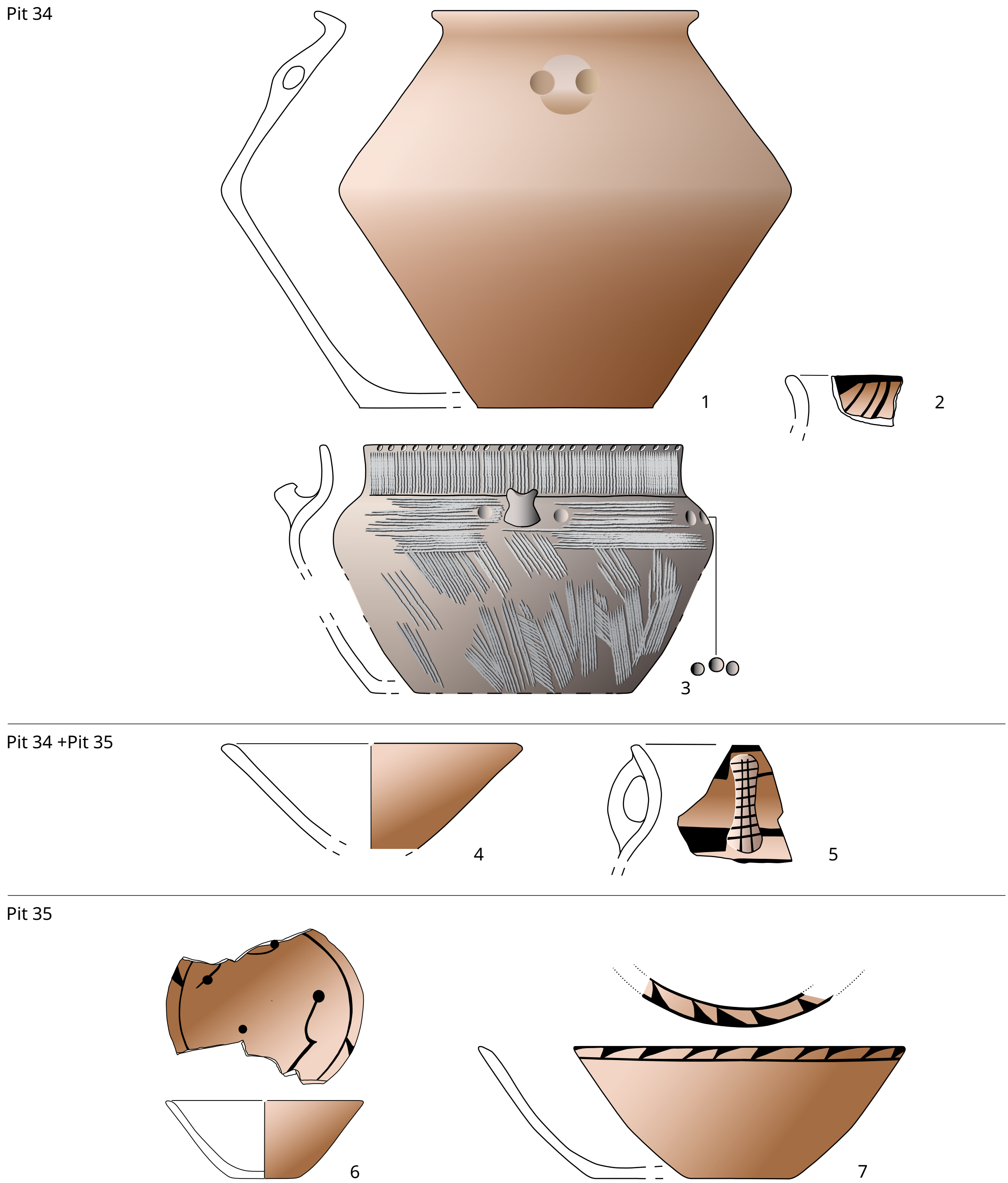


Figure 49. Maidanetske, ceramic inventory of Pits 34 and 35: amphora (1); pot (3); bowls (4, 6–7); goblet (5); made of tableware (1–2, 4–7) and kitchenware (3). Scale 1:4.

The majority of the bowls show open conical shapes, frequently decorated on the rim zone with bands composed of hanging triangles and showing decoration in some places of the comet-shaped scheme and signs (Fig. 49: 6–7, Fig. 51: 5). The bowl in Figure 49: 6 is decorated with a variation of the simplified-line scheme.

Half-open shapes are rare in the inventory and are actually only represented by a kitchenware pot with cattle protomes, round stamps and a perforation at the edge (Fig. 52: 2).

Find-ID	Context description	Category
1111422	Feature-ID 111033, Level 4b, Quadrat E–F/8–9	1 quarry stone, 310 g, material not determined (feldspar?)
		1 quarry stone, 528 g, material not determined
1111542	Feature-ID 111033, from the profile, Quadrat E6	1 quarry stone, 168 g, coarse granite, yellow, perhaps fragment of a grinding stone
		1 quarry stone, 408 g, material not determined, elongated shape 200 × 60 × 26 mm
		4 quarry stones, 338 g, material not determined

Table 25. Maidanetske, Trench 111, list of stone artefacts from Pit 34.

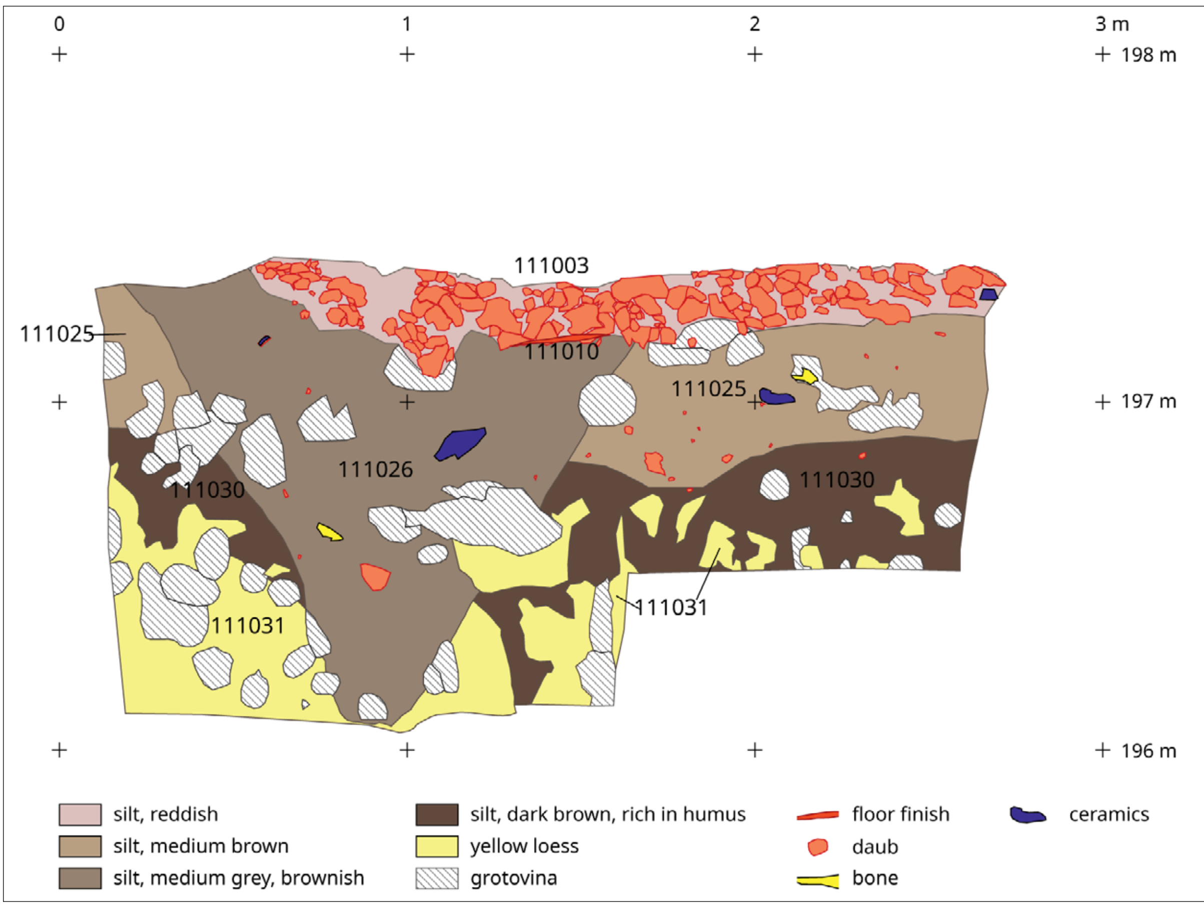


Figure 50. Maidanetske, Profile 32 cutting trough Pit 34 below Mega-structure 3.

The inventory also includes numerous closed shapes such as fragments of a double-conical cup, with leaf-shaped decoration and bands composed of angled triangles and squares in horizontal zones (Fig. 51: 9). The category of closed forms also includes two pear-shaped vessels, one with a bi-conical shape and the other with volute scheme painting (Fig. 51: 6, 8).

The category of amphora/bi-/sphero-conical vessels includes the rim fragment of an amphora with pairs of knobs on the upper shoulder (Fig. 51: 10) and parts of a sphero-conical vessel with tangent scheme painting and ladder bands (Fig. 52: 1). On the other hand, the classification of the closed vessels in Figure 51: 7 and 11, the first of which has leaf-shaped scheme painting, is unclear.

The only chipped stone artefact from Pit 35 is a triangular arrowhead manufactured from a flake of dark brown Volhynian flint, showing on its base a cursory finishing and remains of cortex (Fig. 52: 3). It was found in the centre of the pit halfway down the pit filling.

	Calculation by number (n)					Calculation by weight (g)				
Architectural features	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Total number	Percentage	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Total weight	Percentage
1 Amorphous	83	2		**85**	76.6	3862	62		**3924**	71.1
2 Plain surface	7	9		**16**	14.4	392	208		**600**	10.9
4 Split wood	5	1		**6**	5.4	662	80		**742**	1.4
5 Log wood	2			**2**	1.8	172			**172**	3.1
Non-classified		1	1	**2**	1.8		40	40	**80**	1.4
Total				**109**					**5518**	

Table 26 (above). Maidanetske, Trench 111, frequency of material categories and architectural features of burnt daub in Pit 35.

Table 27. Maidanetske, Trench 111, frequency of animal species in Pit 35 (after Benecke et al.*: Chapter 9, this work, Vol. I).*

Species	NISP	Weight (g)
Cattle	10	206
Large mammal	3	30
Red deer	2	44
Sheep/goat	1	3
Large garden snail	1	-
Indet.	14	56
Total	**31**	**339**

Pits 36 and 37

Further smaller pits or depressions were situated in Quadrats H/16 below the central part (Pit 36 or 111/4) and in E–F/23–25 south-east of the mega-structure (Pit 37 or 111/5; Fig. 40). Pit 36 was discovered only during the final works on the last day of the excavation and could therefore be only partially investigated and only extremely cursorily documented. The dimensions of the pit are therefore largely unclear. The backfill of the pit contained mainly chaff-tempered burnt daub mostly without architectural features (Tab. 30).

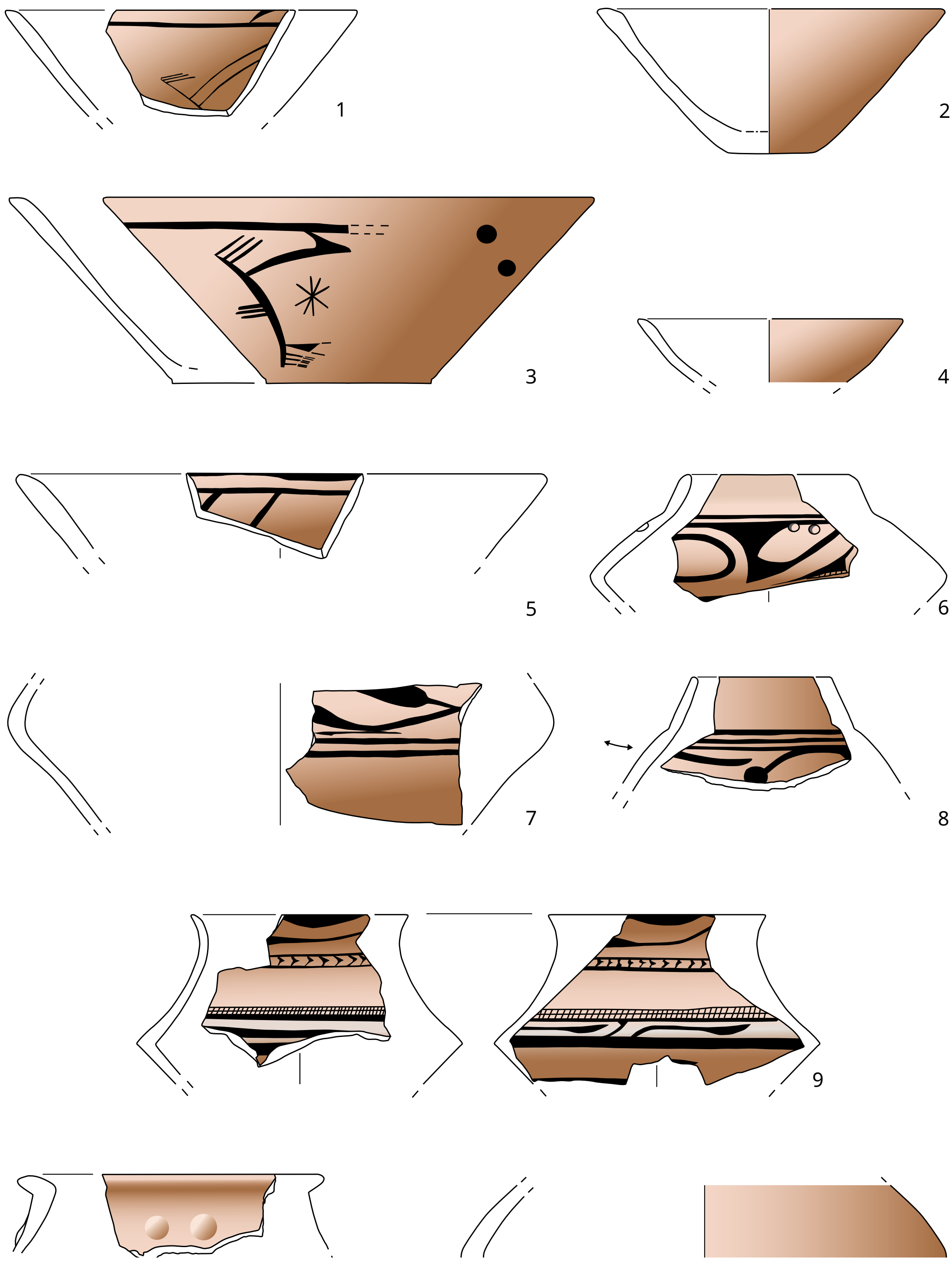
The backfill of Pit 36 contained also a small amount of tableware (Tab. 31) of at least four bowls and closed vessels (Tab. 32). The filling of Pit 37 did not yield any pottery.

Interpretation

Within the investigated area, four of the five pits which presumably belonged to the pre-mega-structure occupation form a row running in a northwest-southeast direction. While the fifth pit (Pit 34) is adjacent, to the southwest, we found no pits northeast of this line.

The distribution of the pits in the excavation area indicates that the supposed older row of houses running within the ring corridor according to the plan of the archaeomagnetic survey would have continued to the northwest. Accordingly, the pits explored in the excavation most probably belong to a pit zone located in the rear area behind houses (Fig. 40). In the pit-free zone to the northeast must have been the location of the associated houses. While to the southeast of the excavation remains of burnt houses are still preserved *in situ*, these were apparently removed in the area of the mega-structure.

As the massive filling of Pit 33 with burnt daub shows, the houses of the earlier phase were at least partly burnt down. The partly find-rich horizon between the



backfill of the pit and the floor of the mega-structure can be explained as a levelling layer to prepare the building ground for the mega-structure. An alternative explanation for the artificial dumping of earth would be the construction of some kind of podium, which may have served to architecturally highlight the building and increase its public visibility (Chapter 5, this work, Vol. I). The finds from this levelling layer, which are characterised by low to moderate fragmentation, might belong to inventories of dwellings that had to make place for the mega-structure or were transported here from the outside.

Figure 51. Maidanetske, ceramic inventory of Pit 35: bowls (1–5); pear-shaped vessels (6, 8); closed vessel (7); goblet (9); amphora (10); all made of tableware. Scale 1:4.

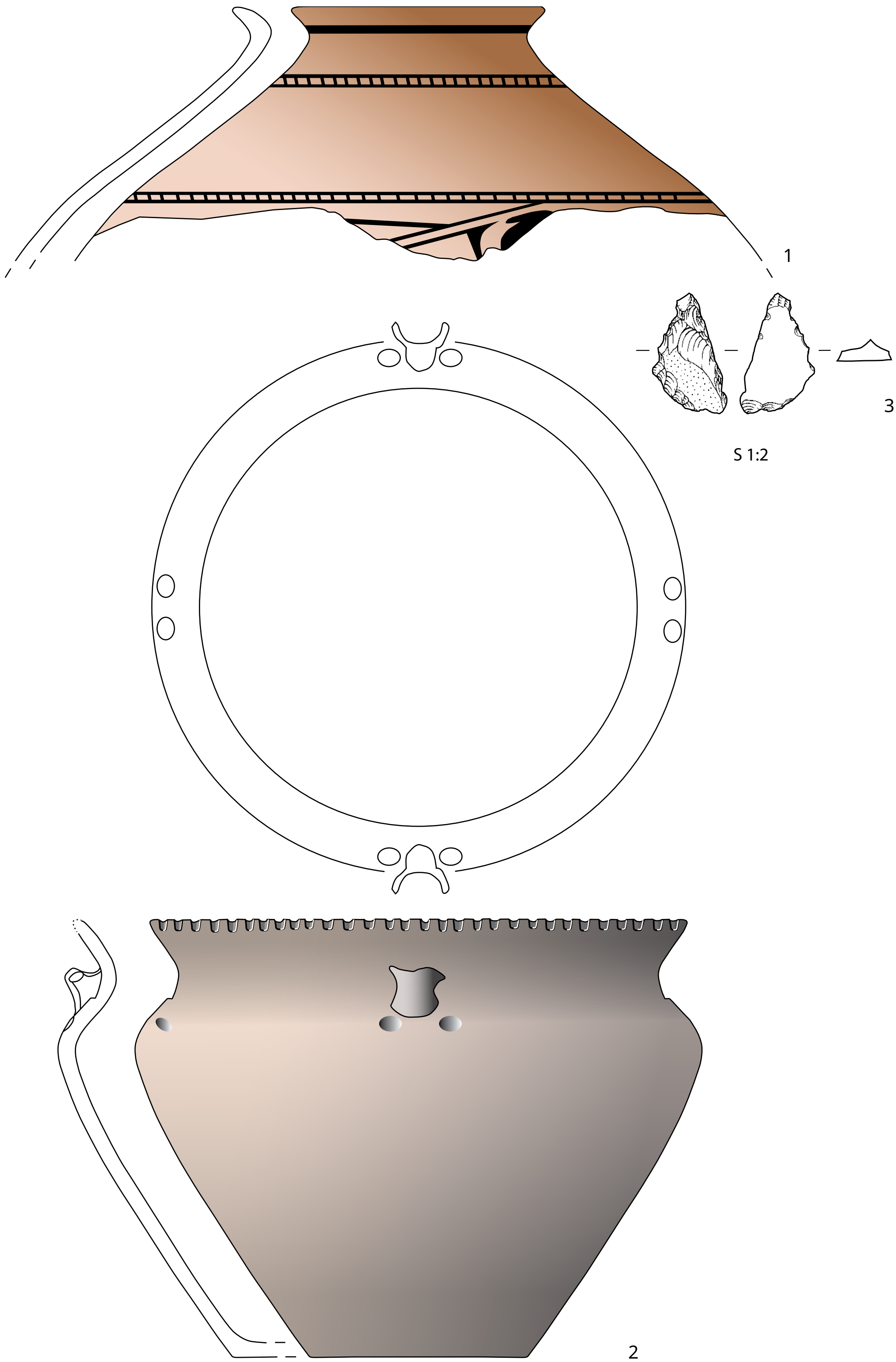


Figure 52. Maidanetske, find inventory of Pit 35: sphero-conical vessel made of tableware (1); pot made of kitchenware (2); chipped stone point (3). Scale 1:3.

Fabric	Number (n)	Weight (kg)	Number (%)	Weight (%)	Fragmentation (g)
Table	197	6.9	75.8	77.3	35
Kitchen	62	2.0	23.8	22.0	32
Indefinite	1	0.1	0.4	0.6	55
Total	**260**	**8.9**			**34**

Table 28. Maidanetske, frequency (number, weight) and fragmentation (average sherd weight) of ceramic fabrics in Pit 35.

Class	Type group	Number (n)	Weight (g)	Summed rim percentage	Summed belly percentage	Summed bottom percentage	Minimum number of vessels
Bowl		10	286			102	2
Bowl	Bowl, conical	27	1280	205		152	3
Bowl	Bowl, sphero-conical	1	12	11			1
Goblet		1	2				1
Goblet	Goblet, goblet	6	92	28	57		1
Goblet	Goblet, jug	1	57	3			1
Amphora		1	51	25			1
Bi-conical vessel		26	1611	100		39	1
Closed vessel		92	2694	91	129	343	4
Four-legged vessel		1	40				1
Pear-shaped vessel		2	110	22			1
Pot		55	1782	50		50	1
Unknown shape		37	861	109	7	71	2

Table 29 (above). Maidanetske, frequency of morphological pottery classes and type groups in Pit 35.

	Calculation by number (n)				Calculation by weight (kg)			
Architectural features	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Total number	Organic tempered (chaff)	Compact (without chaff)	Crumbly yellow	Total weight
1 Amorphous	31			**31**	2.9			**2.9**
2 Plain surface	3	4	2	**9**	0.7	0.5	2.9	**4.1**
4 Split wood	3			**3**	1.2			**1.2**

Table 30. Maidanetske, Trench 111, frequency of material categories and architectural features in Pit 36.

In view of the partially poor preservation of the painted pottery surfaces and the weak relative chronology so far established for the find inventories, absolute dating is of crucial importance for the clarification of the chronological development of the sequence described.

^{14}C dating

From the various stratigraphic contexts of Trench 111, eleven bone-samples were ^{14}C dated by accelerator mass spectroscopy at the Poznan Radiocarbon Laboratory (Tab. 33). Pre-mega-structure activities are dated by Poz-87599 to Poz-87605, derived from Pits 33–35 and the levelling layer below the floor of the mega-structure. The phase of use of Mega-structure 3 is represented by two dates from disarticulated

Table 31. Maidanetske, frequency (number, weight) and fragmentation (average sherd weight) of ceramic fabrics in Pit 36.

Fabric	Number (n)	Weight (kg)	Number (%)	Weight (%)	Fragmentation (g)
Table	15	0.6	100	100	38

Table 32. Maidanetske, frequency of morphological pottery classes and type groups in Pit 36.

Class	Type group	Number (n)	Weight (g)	Summed rim percentage	Summed belly percentage	Summed bottom percentage	Minimum number of vessels
Bowl		4	283	4		85	1
Bowl	Sphero-conical	1	5				1
Closed vessel		9	224	3			1
Goblet	Goblet	1	55		22		1
Total		**15**	**567**				**4**

Laboratory-ID	^{14}C age (BCE)	N (%)	C (%)	Col (%)	Find-ID	Feature-ID	Level	Grid x	Grid y	Material	Taxon	Context
Poz-87721	4900 ± 40	0.9	7.0	1.0	1110275	111002	2	F	9	Bone	Bos	Layer above mega-structure
Poz-87609	5055 ± 35	2.5	10.4	5.6	1110085	111002	2	L	5	Bone	Bos	Layer above mega-structure
Poz-87610	5035 ± 35	2.5	10.9	4.4	1110689	111003	3	F	9	Bone	Bus	Wall debris of mega-structure
Poz-87598	4990 ± 35	2.9	11.0	5.9	1110750	111003	3	M	14	Bone	Bos	Wall debris of mega-structure
Poz-87599	5010 ± 35	4.5	14.5	3.0	1111565	111025	4a	J	13	Bone	Bos	Cultural layer below mega-structure
Poz-87600	4970 ± 30	2.9	11.0	2.0	1110981	111025	3	L	9	Bone	Bos	Cultural layer below mega-structure
Poz-87601	5020 ± 35	1.8	9.7	2.4	1111294	111026	4e	K	9	Bone	Bos	Upper edge of Pit 111/1
Poz-87602	4955 ± 30	1.2	7.9	1.1	1111077	111026	4e	K	9	Bone	Bos	Upper edge of Pit 111/1
Poz-87603	4990 ± 35	4.3	13.6	8.2	1111368	111029	4d	J	5	Bone	Bos	Pit 111/3 below mega-structure
Poz-0	>0	0.3	5.7		1111373	111029	4d	K	5	Bone	Bos	Pit 111/3 below mega-structure
Poz-87604	5000 ± 35	2.4	9.5	3.1	1111542	111033	Profile 30	F	6	Bone	Bos	Lower level of Pit 111/2
Poz-87605	5035 ± 35	2.7	10.9	4.2	1111519	111032/33	Profile 30	F	8	Bone	Bos	Lower level of Pit 111/2

Table 33. Maidanetske, list of ^{14}C dates from Trench 111.

bones which were found inside the wall debris of the mega-structure (Poz-87598, Poz-87610). Post-mega-structure activities are represented by two dates from the layer directly above the wall debris (Poz-87609, Poz-87721).

Overall, the dates fall into a plateau of the calibration curve and the following steep section, covering a long range of about 300 years between 3950 and 3650 BCE. Through application of Bayesian modelling and the use of the function *boundary* with the assumption of two successive occupation phases and several events, the range of dates becomes significantly narrowed, roughly into the 38th century BCE (Fig. 53a). However, the overall probability of this model 1 amounts to only 40% (A_{model}=33.8) due to largely identical dates from the different phases. Higher overall model probabilities of more than 100% can only be obtained by excluding the potential (too old) outliers Poz-87605, Poz-87609, and Poz-87610 (Fig. 53b). The dating results imply that Mega-structure 3 was constructed during Phase 3 of the site chronology suggested by René Ohlrau (2020a). Consequently, Mega-structure 3 at Maidanetske was built related to the rapid population increase of the 38th century and abandoned at the beginning of Phase 4, related to the start of the population decrease.

Trenches 113–117 – Unbuilt open spaces

In two transects with six trenches in total, the central unbuilt area of the settlement and the ring corridor were sampled (Fig. 1). The transect within the ring corridor included Trenches 113 to 115 and stretched in the north of the settlement over a length of 80 m, approximately 35–75 m east of the road in a north-south direction. The trenches were dug using an excavator.

The transect in the central undeveloped area of Trenches 116–118 run along (Trench 116) or within (Trenches 117 and 118) a forest strip which crosses the settlement in a northeast-southwest direction over a total length of approximately 300 m. Here, the trenches were dug by hand. Trenches 116–118 were each 10–15 m long and 1 m wide. The two outer Trenches 116 and 118 were each located at a distance of about 100 m from the nearest burnt Trypillia houses.

The terrain surface in the area of the ring corridor transect slopes very gently from a level of 203.75 m at the northern end of Trench 113 to 204.3 m at the southern end of Trench 115. Along the transect in the central unbuilt area, the terrain surface slopes gently to the southwest from a level of 201.9 m in Trench 116 to 201.0 m in Trench 118.

Stratigraphically, the same natural sequence of layers was found in all examined trenches, as far down as the corresponding depth was reached (Figs. 54 and 55). Below a humic surface horizon of Chernozem with a thickness of between 0.6–1.0 m, partly differentiable into two sub-layers Axh 1 and Axh 2, a relict browning horizon (rBw) with thicknesses of between 0.35–0.45 m was found. This horizon, a buried forest soil, transitioned into the underlying carbonate-bearing rock (Cc), in this case a weakly altered loess. However, this horizon was reached only in Trenches 117 and 116 (?), where it began below an rBw-Cc transition zone 1.4 m below the terrain surface.

Practically none of the trenches showed direct anthropogenic influence. An exception were small pieces of daub and pottery embedded in the rBw horizon of Trenches 113, 115 and 116, situated closest to the houses. However, this material was extremely fragmented and had probably been relocated several times. In view of the otherwise apparently undisturbed stratigraphic sequences, with no intrusions or anthropogenic deposits, these artefacts might have been deposited due to post-depositional processes.

The archaeological excavations were complemented by various scientific analyses. Soil samples were taken and analysed for macrobotanical remains (charcoal, seeds/fruits), soil properties (pedology, geoarchaeology, and geochemistry), biomarkers and snails. Three samples contained charcoal (Trench 114: 2 samples, Trench 117: 1 sample), eight samples contained snails (Trench 113: 2 samples; Trench 114: 2 samples; Trench 115: 2 samples; Trench 117: 2 samples) and three samples contained botanical macroremains (Trench 115: Cerealia indet.; Trench 117: 2 samples with *Stipa* sp.).

Geoarchaeological investigations show differences in the geochemical signature of the sedimentary sequences both between the settlement and its surroundings and between the ring corridor and the central unbuilt area of the settlement (Chapter 5, this work, Vol. I). Accordingly, we can assume different functions for the different settlement areas, possibly of an agricultural nature in the unbuilt centre of the settlement and rather more domestically-oriented in the ring corridor.

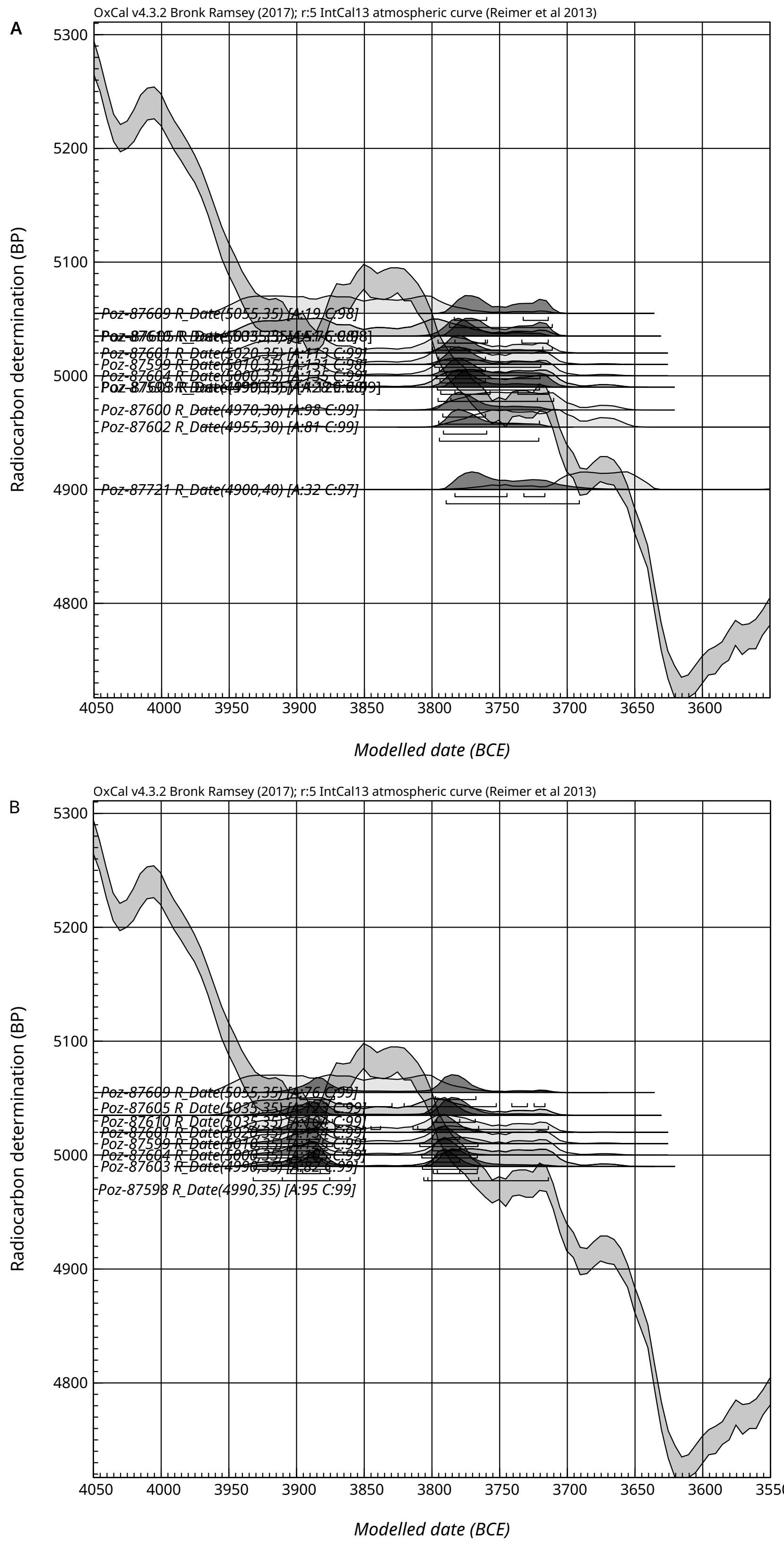


Figure 53. Maidanetske, Bayesian models 1 (a) and 2 (b) of ^{14}C dates from Trench 111 plotted on the calibration curve.

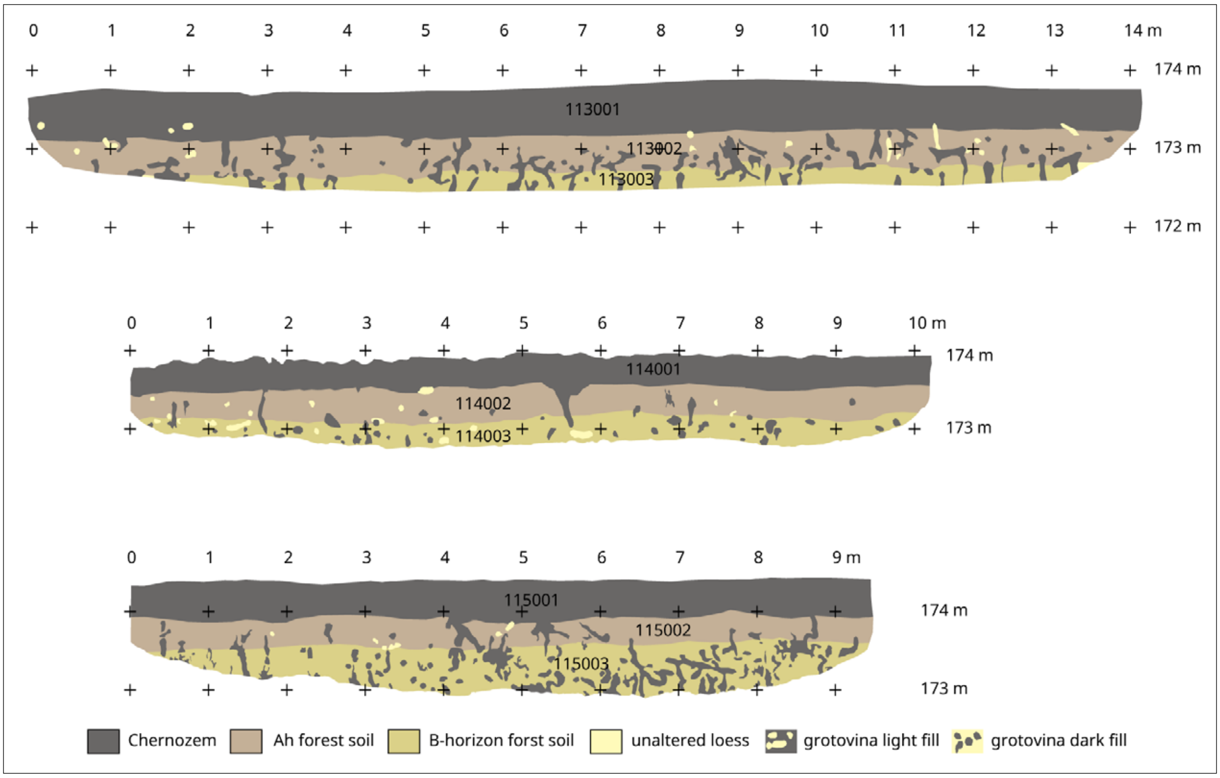


Figure 54. Maidanetske, profiles of the Trenches 113–115.

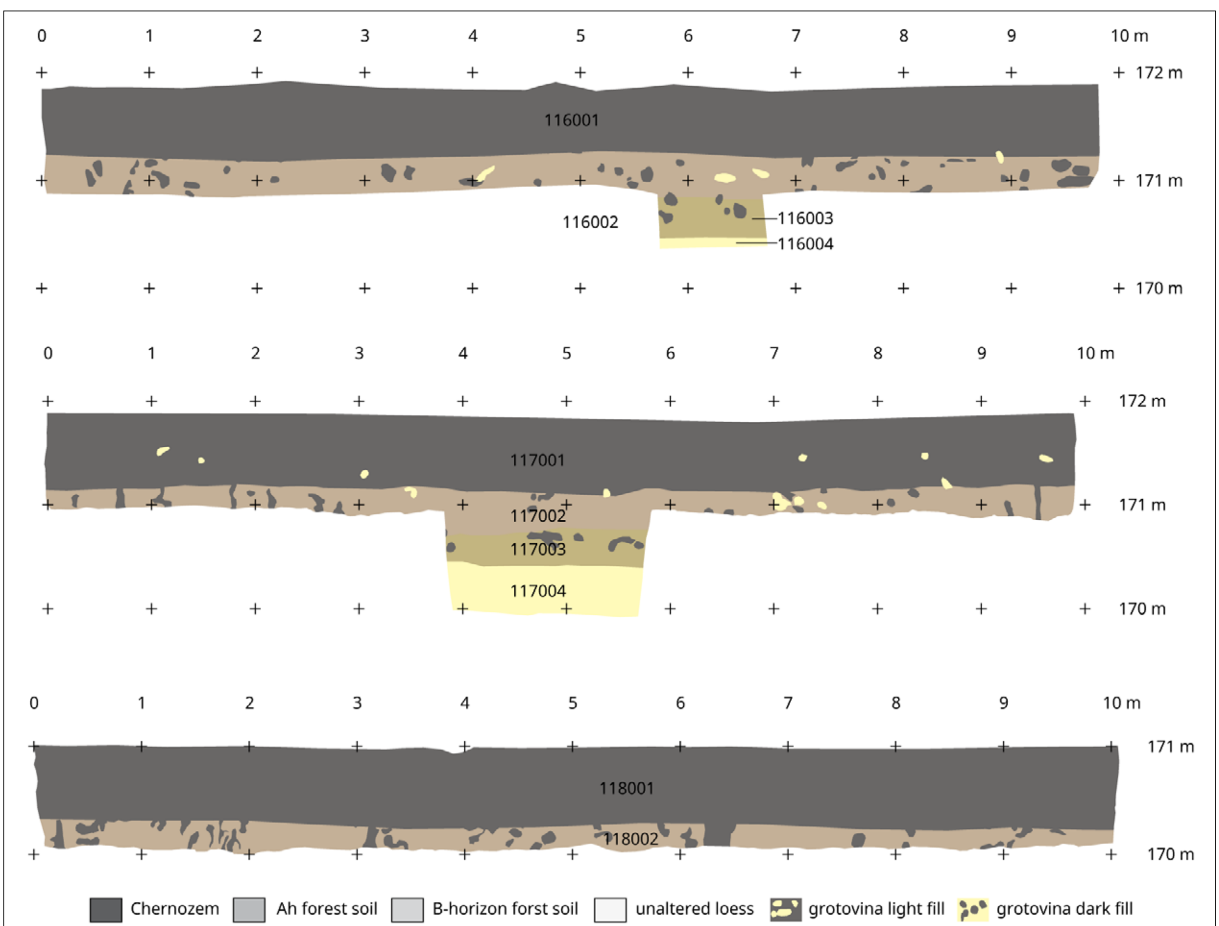


Figure 55. Maidanetske, profiles of the Trenches 116–118.

Discussion

Functional and architectural differentiation within the Maidanetske settlement

In several respects, the fieldwork of 2016 contributes to the functional and architectural differentiation of the mega-site of Maidanetske.

(a) Use of space within the settlement

Through continuation of the archaeomagnetic survey, three new mega-structures were discovered in the northern section of the ring corridor, confirming the predominant placement of such buildings in the ring corridor. Another possible central mega-structure was detected in a rectangular plaza to the east of the settlement, whose size and shape, however, could not be determined due to its proximity to metal objects and a row of trees.

It is hard to overestimate the importance of having found increased phosphate values in open spaces on the site of the settlement, compared to off-site areas. This applies not only to the ring corridor, as the potentially intensively used main street, but equally also to the unbuilt space in the centre of the settlement. The intensive use of the central zone of the settlement, often assumed on the basis of ethnographic analogies (Hale 2020, 127), *e.g.* for the enclosure of cattle or manured gardens, is thus confirmed for the first time.

(b) Architectural differentiation of private dwellings and public mega-structures

In Maidanetske, 82% of the total settlement area has been surveyed by high resolution magnetometry. Among other things, thirteen so-called mega-structures were identified in this plan, which we interpret as communal buildings due to their highly visible location in the public space of the settlement, their specific architecture and their size (Figs. 56 and 57; Tab. 34). Including the excavated Mega-structure 3, seven of these buildings are located within the ring corridor of the settlement. In another five cases they were placed within radial trackways. Lastly, one construction was situated on a rectangular square in the east-northeast part of the settlement. However, only a very small section of this could be recorded. In analogy to integrative architecture in ethnographically investigated non-ranked societies, we consider this decentralised distribution within the settlement as an evidence for the use of these buildings for integrative action by specific sub-groups within the community (Hofmann *et al.* 2019; Ohlrau 2020b). For integrative activities on the level of the whole settlement served likely Mega-structure 1 which is located on a rectangular plaza in the east of the settlement.

In addition to the positioning, the buildings show considerable size differences of between 120 and 580 m² and also a certain degree of architectural variability. In the archaeomagnetic plan of Maidanetske, eleven of thirteen special buildings show an at least partially empty interior surface. Only in the case of Mega-structure 5 is there laminar deposition of daub. In Mega-structures 1, 3, 6 and 9, remains of internal partitions are visible. In eight cases point or pointlike anomalies are visible along the central axis of the structures which most likely represent fireplaces. Thus, in Maidanetske, mega-structures show considerable variability. Besides partly roofed buildings that were investigated at Mega-structure 3, we may also need to consider that some of the mega-structures were completely unroofed and others completely roofed.

Mega-structure-ID	Identified as mega-structure based on size	Identified as mega-structure based on position	Identified as mega-structure based on architecture	Floor area (m²)	Length (m)	Width (m)	Length to width ratio	Type (after Hofmann *et al.* 2019)	Interpretation	Extend of roofing of the interior space	Division in longitudinal direction	Central installation	Position (after Hofmann *et al.* 2019)
1		X	X	>312.0	>26.0	>12.0		?	High-level	Unroofed	?	?	2
2		X	X	175.0	17.5	10.0	1.8	2b	Low-level	Unroofed	One part	yes	3
3		X	X	155.0	18.0	8.6	2.1	3	Low-level	Partly roofed	Two-part?	yes	3
4		X	X	180.0	18.0	10.0	1.8	2b	Low-level	Unroofed	One part?	yes?	3
5		X		378.0	27.0	14.0	1.9	5a	Low-level	Completely roofed	?	?	3
6		X	X	578.0	34.0	17.0	2.0	2a	Low-level	Unroofed	One/two-part?	?	3
7		X		391.0	29.0	13.5	2.1	6c	Low-level	Completely roofed	Two-part	?	3
8		X	X	334.0	23.0	14.5	1.6	2a	Low-level	Unroofed	One part	yes	3
9			X	135.0	15.0	9.0	1.7	2b	Low-level	Unroofed	One/two-part?	yes	6
10			X	162.0	18.0	9.0	2.0	3	Low-level	Unroofed	One/two-part?	yes?	6
11			X	158.0	17.0	9.3	1.8	3	Low-level	Unroofed	One part	yes	6
12			X	258.5	23.5	11.0	2.1	2b	Low-level	Unroofed	One part	yes	4
13			X	122.5	17.5	7.0	2.5	2c	Low-level	Unroofed	One part	?	4

Table 34. Maidanetske, list of mega-structures and information regarding the floor area, dimensions, extent of roofing, interior division, furnishing, and position in the settlement.

Through the excavation of Mega-structure 3, valuable data were obtained on the architecture and inventory of such a building. Accordingly, the architecture of this building (covering ca. 190 m²) differs substantially from that of the Houses 44 (77.5 m²) and 59 (42 m²). Both dwellings are characterized by massive platforms and indications of two 'storeys' (Fig. 58). Partly standardised arrangements of ovens, fireplaces (so-called altars), podiums, storage bins and workplaces appear often, but not always, to be concentrated on top of the elevated platform (Chernovol 2012; Chernovol 2019). Thus, we consider this upper level as main living floor while the lower one might represent subordinate space, for storage purposes, craft activities or for stabling animals. In contrast, Mega-structure 3 represents a one-storey construction, where all activities took place on one level.

Residential buildings are in most cases completely roofed and have a correspondingly stronger magnetisation in contrast to the mega-structures with their partially or completely open floor plans. Due to the different design, much smaller amounts of daub were used for the construction of a mega-structure (House 44: 1–100 kg/m² to Mega-structure 3: <1–50 kg/m²; Pickartz *et al.* 2019).

The remains of the internal architecture also differ. While in Mega-structure 3 only a fireplace is documented, in each dwelling both a fireplace and an oven are present. The absence of ovens suggests that mega-structures were possibly not or not permanently inhabited. Additionally, within the dwellings a podium and a bin were documented, which were missing in the mega-structure. While the division of the mega-structure into two parts could be seen as a reflection of the division of dwellings into two rooms, the aspect of roofing indicates clear differences: an open activity space which is much larger in size cannot be compared to a roofed and much smaller anteroom of a dwelling.

The inventory of the examined Mega-structure 3 show (contrary to earlier findings in Hofmann *et al.* 2019, Tab. 4) less clear differences compared to the fully investigated Houses 44 and 54. Renewed quantitative analyses reveal that the

Figure 56. Maidanetske, redrawing of the plan of the archaeomagnetic survey with positions of mega-structures (after Hofmann et al. *2019); green buildings: dwellings of settlement Maidanetske 1a; white buildings: dwellings of settlement Maidanetske 1b; light red buildings: adjacent dwellings of the primary plaza; red buildings: mega-structures at the primary plaza; yellow buildings: mega-structures in the ring-corridor; blue buildings: mega-structures at different positions of radial pathways.*

density of pottery and the frequency of vessel categories is remarkably consistent between these three contexts (Tab. 35). The frequency of grinding stones is also very similar, although it is generally difficult to distinguish between specimens that were still in use at the time of the abandonment of a house or mega-structure and those that were used secondarily, *e.g.* as building material. Comparing the inventory of the mega-structure and residential houses, some possible differences concern, among other things, artefacts related to the textile production. While such finds in Mega-structure 3 are represented by at least ten objects, they are very rare in both compared dwellings. Certain differences become also apparent when comparing assemblages of charred botanical macro-remains (Chapter 7, this work, Vol. I). Indeed, the proportions of cereal grains and cereal by-products in houses and Mega-structure 3 are very similar. However, the find concentration of charred botanical macro-remains in houses is somewhat higher than in Mega-structure 3.

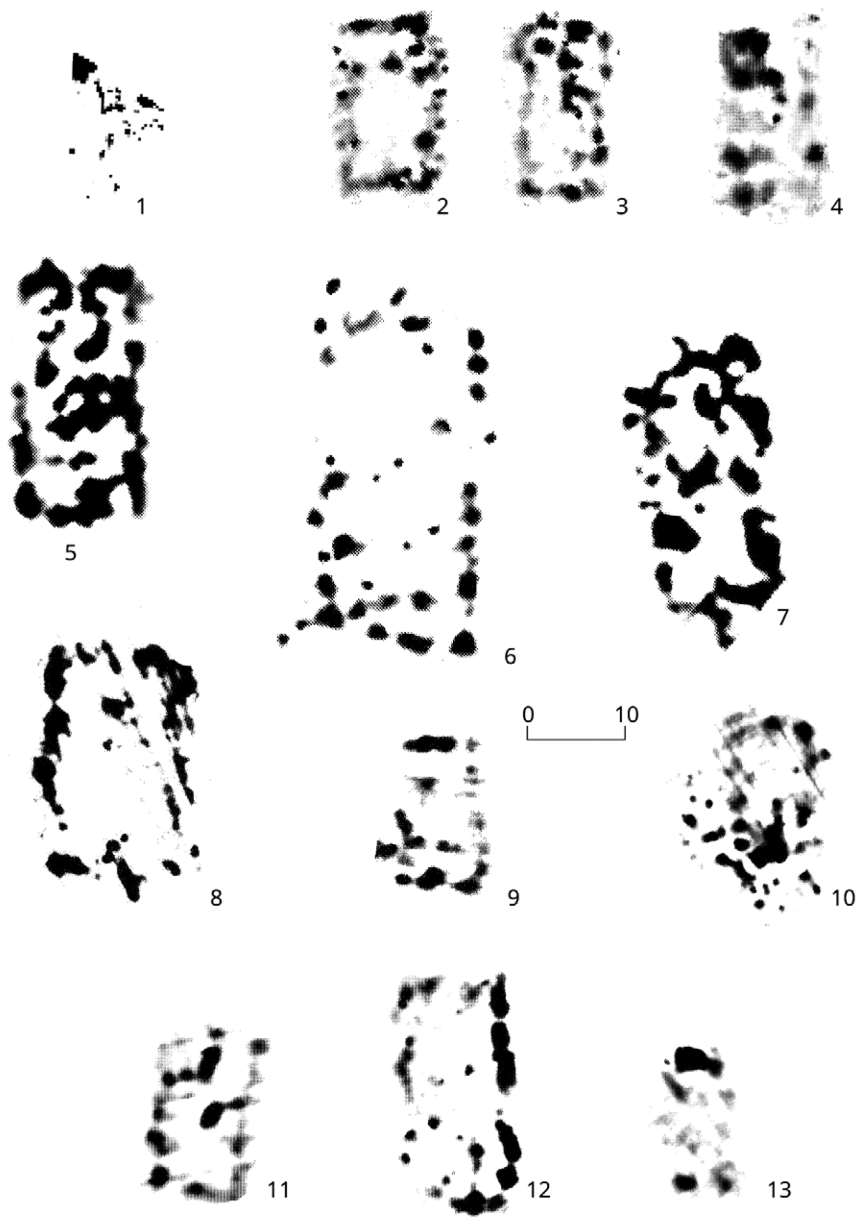


Figure 57. Maidanetske, archaeomagnetic anomalies of Mega-structures 1–13.

Summing up, there are striking differences between dwellings and the investigated Mega-structure concerning architectural design, internal organisation, and to a lesser extent also the kind and intensity of performed activities. Shared aspects of dwellings and mega-structures concern numerous 'domestic' activities which were identified in both types of buildings such as storage, preparation and consumption of food, the milling of grain, the craft production and specific ritual activities, represented by vessel assemblages, animal bones, botanical macro-remains, querns, artefacts for textile production, and anthropomorphic figurines. The absence of ovens suggests that mega-structures were possibly not or not permanently inhabited.

Important for our interpretation of mega-structures is the comparison with integrative buildings in 28 ethnographically documented societies from North America, South America, New Guinea/Oceania, and Africa. In ethnographic situations, a poly-functional character and a frequent use for both ritual and non-ritual activities have consistently been observed (Adler 1989; Adler and Wilshusen 1990). This use can include various aspects such as information sharing, joint decision-making, administrative purposes, body cleansing, stockpiling, or the

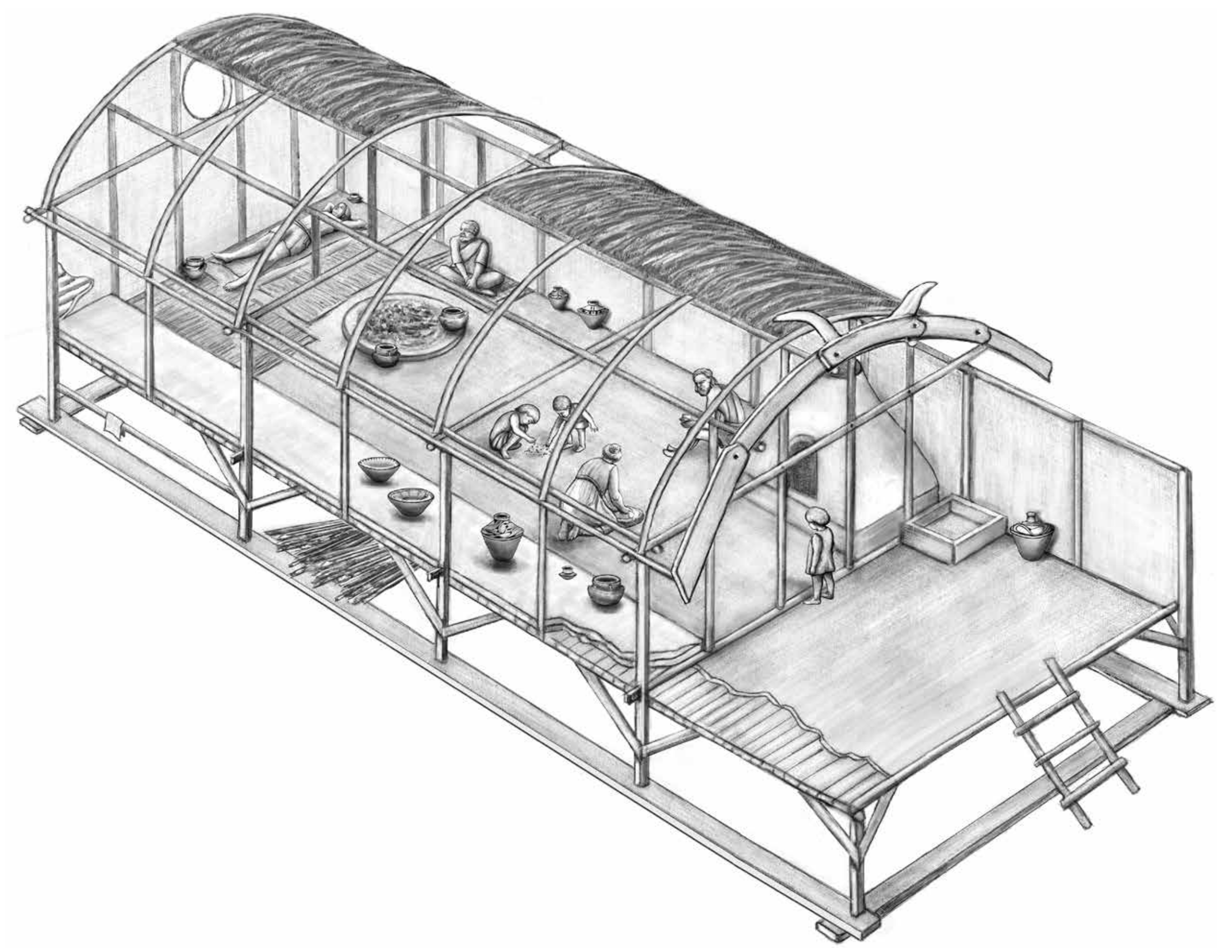


Figure 58. Maidanetske, graphical reconstruction of a Trypillia dwelling based on excavation results from House 44 (cf. Müller et al. *2017), with a raised platform, an anteroom, a main room and numerous details of the inventory and interior (graphic: Susanne Beyer, Kiel).*

redistribution of goods. Consequently, performing day-to-day 'domestic' activities in integrative facilities is the normal state rather than the exception.

Thus, we do not consider the various domestic activities which have been proven for the excavated examples from Maidanetske and Nebelivka (Chapman *et al.* 2014a; Nebbia *et al.* 2018; Gaydarska 2020) as a reason to question the expected public functions. In contrast, in our opinion, the described wide range of activities associated with Trypillia mega-structures completely prevents the interpretation of these constructions as specialized production or central storage facilities, but rather indicates their communal nature as a place for integrative action. Such integrative actions could include feasting during which certain rituals of consumption were performed to share surplus, to acquire prestige and social power, or to maintain existing inequalities (Dietler 1996; Hofmann *et al.* 2024). In another context in Maidanetske feasting activities have already been proven connected with the deposition of two cattle skulls and numerous bowls at the bottom of a pit (Müller *et al.* 2017). Generally, in Trypillia mega-sites we can assume an increased importance of ritual and ceremonial activities that provide a frequently observed mechanism for reducing scalar stress in large human groups (Johnson 1983).

A longer-term perspective on the development and use of mega-structures presented elsewhere could show that these multi-functional buildings probably functioned as institutions in sequential political decision-making processes (Hofmann *et al.* 2019). Indicating a widely distributed participation in political processes and in the collective consumption of surpluses, they probably had a paramount role in the social constitution of Trypillia communities and in the maintenance of social balance (Müller *et al.* 2022; Hofmann *et al.* 2024).

Find category	Interpretation	House 44 (Trench 51)	House 54 (Trench 92)	Mega-structure 3 (Trench 111)
Flint artefacts	Flint production	3 flakes	1 blade	3 debris 1 flake
Anthropomorphic figurines (fragments)	Ritual activities?	3	2	3
Ceramic disk (fragment)	?			1
Spindle whorl	Textile production	1		1
Loom weight (complete)				2
Loom weight (fragment)				8
Whetstone				1
Pounder		1	1	
Rubbing stone				1
Polishing/punching stone			1	
Grinding stone: handstone	Cereal processing? Construction?	2		
Grinding stone: quern, lower		3		1
Grinding stone fragments		6	5	5–6
Quarry stone	Construction?	1	4	21
Stone slab	Construction?		1	1
Amount of pottery*	Food handling	45.1 kg	60.1 kg	39.0 kg
Pottery density (overall)*		0.98 kg/m^3	2.10 kg/m^3	1.83 kg/m^3
Pottery density (range)		0–>5 kg/m^2	0–4.8 kg/m^3	0–4 kg/ m^3
Frequency of bowls: MNI (proportion)	Transport (serving)	20 (26%)	22 (23%)	10 (24%)
Frequency of cups: MNI (proportion)		20 (26%)	9 (9%)	4 (9.5%)
Frequency of closed and half-closed vessels (except of cups/goblets): MNI (proportion)	Transport (serving) or storage	29 (38%)	60 (62%)	23 (55%)
Frequency of kitchenware vessels: MNI (proportion)	Processing (without heat)	7 (9%)	6 (6%)	4 (9.5%)

*Table 35. Maidanetske, comparison of inventories of Mega-structure 3 and Houses 44 and 56. *The ceramic masses and densities refer to both the narrower area of the building and the adjacent waste disposal areas.*

(c) On the question of the function of the ditch

With regard to the function of the causewayed enclosure examined in Trench 110, we would like to highlight two aspects in particular:

As is shown by a compilation of the dimensions of ditches during different Trypillia periods, ditches of the Trypillia B2 and C1 periods are characterised by rather small widths and depths (cf. Chapter 17, this work, Vol. II). In accordance with the results of the investigations in Nebelivka (Hale 2020, 127–128), a defensive function for the ditch in Maidanetske is rather unlikely, due to its dimensions and its interruptions. In this respect, alternative interpretations of the ditches of Trypillia mega-sites as perimeter ditches for the symbolic demarcation of 'inside' and 'outside' (Hale 2020, 127–128) or as 'planning devices to mark the settlement area to be built on' (Ohlrau 2020a, 282) seem extremely plausible. The latter interpretation is substantiated by, among other factors, the dating of the ditches in Maidanetske to the early phase of the settlement.

The evidence of causewayed enclosures in Maidanetske and Nebelivka, which are elsewhere distributed mainly in western and central Europe (Fig. 59), highlights the integration of the mega-sites into a very far-reaching communication and exchange network, possibly associated with certain ritual connotations and practices (Klassen 2014). Accordingly, in the process of filling the ditches, certain

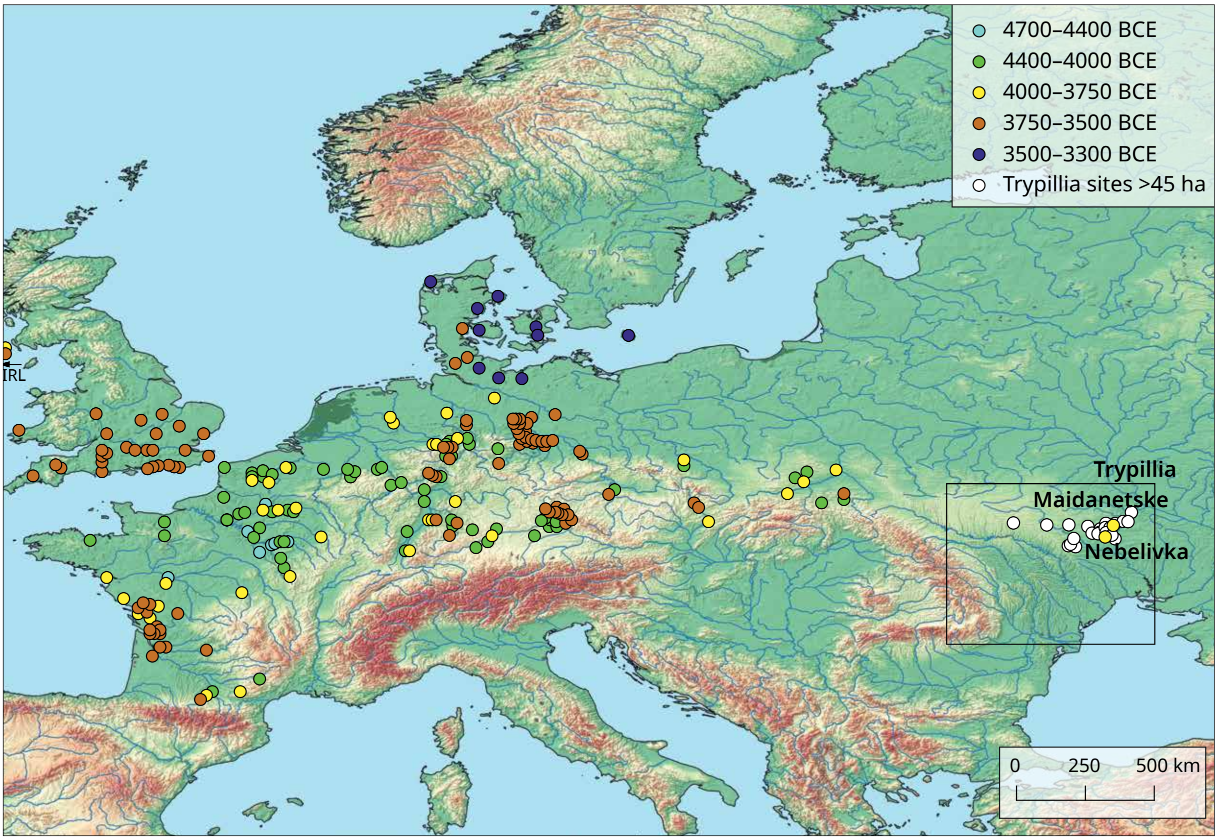


Figure 59. Spatial distribution of so-called causewayed enclosures of the Neolithic and Chalcolithic, often composed of several rows of parallel ditch segments, spread in a longer process from the area of present-day France to the forest-steppe zone of present-day Ukraine and often marking strategic points in an extensive communication and exchange network (extended after Klassen 2014, 214–238, with additions).

ritual activities associated with the deposition of *bucrania* and ceramic vessels also took place in Maidanetske (Ohlrau 2020a, 282).

Internal development of the mega-site of Maidanetske

Regarding the different spatial concepts of the settlements Maidanetske 1a and 1b, our investigations have yielded a stratigraphic sequence of settlement Maidanetske 1a and the Mega-structure 3, probably belonging to settlement Maidanetske 1b. This sequence confirms in principle the sequence that would be assumed from the archaeomagnetic prospection plan based on the fragmentary character of the settlement 1a. The stratigraphic sequence found indicates that the plan of Maidanetske 1a represents the original concept of the settlement, which was modified in the course of the occupation in favour of the new layout of Maidanetske 1b. Our analysis shows that the different concepts possibly only concern the northern part of the site, while the planning in the south seems to be consistent.

Regarding the chronological dimension of the two settlements, it should be emphasised that the remains of settlement Maidanetske 1a found in Trench 111 below the mega-structure certainly do not date only to the beginning of settlement in Maidanetske, but were still in use during Phase 3 in the 38th century. Only shortly afterwards, Mega-structure 3 was built and probably abandoned still in the course of the 38th century BCE. In principle, sample Poz-87542 from House 64 in Trench 101, which also belongs to the Maidanetske 1a plan, dates to the same period (Chapter 19, this work, Vol. II). Unfortunately, only one sample from a hazelnut shell could be dated from this trench, which indicates a considerably longer period of use of this house between roughly 3900 and 3700 BCE (Ohlrau 2020a, 22).

According to our dating, the two different spatial concepts of Maidanetske 1a and 1b thus apparently coexisted for a longer time-span. On the question of this coexistence, René Ohlrau (2020a, 228) had assumed that perhaps not all residents felt committed to Plan 1b and maintained a competing structure. This indicates an inhomogeneous population of the settlement, as is also assumed on the basis of population growth rates (Ohlrau 2020b) and supports our conclusion regarding the fusion of different local units which attempted to maintain their local organisational structure.

When interpreting this, we must take into account the results obtained by Liudmyla Shatilo (2021, 211–216) for Talianki on intra-site micro-chronology, according to which temporal sequences of houses in Trypillia mega-sites are most likely to be located within house clusters. If we date only one house of a house cluster, we obtain a result that does not represent the entire duration of the house cluster but only a part of its real lifespan.

Under the premise of having recorded particularly late houses of Plan 1a beneath the mega-structure, it is entirely plausible, according to this model, not to assume a simultaneity of the two settlement plans, despite similar ^{14}C dating. Instead, we could assume an overall earlier age of settlement Maidanetske 1a. While the new layout concept of Maidanetske 1b had already been actively implemented, residents of individual house clusters in the settlement 1a may have continued to follow the original spatial concept for a longer period.

As René Ohlrau (2020a, 212–214) was able to show, the western trench segment of the inner causeway enclosure was already backfilled between 3955 and 3810 BCE (68.2% probability), while the backfilling of the eastern trench segment took much longer. Consequently, we can assume a temporal overlap and possible competition between the two concepts, long before the final abandonment of Maidanetske 1a.

Conclusions

While the Ukrainian-German field excavations of 2013 and 2014 focused primarily on the study of individual households and the chronological and demographic reconstruction of the mega-site Maidanetske, the 2016 field campaign explored different aspects of the intra-site development, the use of space, and characteristics of facilities belonging to the communal infrastructure. Although questions remain, *e.g.* regarding the architecture of the central mega-structure in the east of the settlement, our investigations contribute decisively to the understanding of the social organisation and the changing history of a Trypillia mega-site.

Investigations within the ring corridor and the central unbuilt area of the settlement confirm the long-supposed intensive use of these parts of the settlement. Very important in several respects is the finding that the investigated ditch represents a causewayed enclosure. Accordingly, ditches did not have a primarily fortificatory significance, but rather served other purposes such as the demarcation of the settlement area or as an instrument of settlement planning. Moreover, the specific structure of the ditch indicates the integration of the Maidanetske settlement into an extensive communication network directed towards Western and Central Europe.

The identification and temporal fixation of two competing concepts of settlement planning constitutes an important argument for the hypothesis, that the formation of Trypillia mega-sites was based on the fusion of previously independent communities. In the public space distributed mega-structures perhaps represent focal points of these communities and probably integrative institutions within a decentrally organised socio-political constitution of mega-sites. The excavation of such a mega-structure demonstrated that these buildings were significantly different from dwellings in architectural terms. The find inventory indicates that a variety of ritual and non-ritual domestic activities were carried out in these buildings, pointing to their multifunctional integrative character in decision-making processes and in the consumption of surplus. Evidence for the existence of a central mega-structure suggests that, similar to ethnographically studied societies, a hierarchical system of high-level integrative buildings for the whole community and different low-level integrative architectures for certain segments of local communities existed in Maidanetske.

Acknowledgements

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Supplementary materials

All primary data in this chapter are freely available online under a CC BY 4.0 licence, in the Kiel University research data repository opendata@uni-kiel.de: https://doi.org/10.57892/100-317.

Appendix

Description and contextualisation of the finds in figures.

Figure	Find-ID	Ceramic-ID	Ceramic-Unit-ID	Fabric	Number (n)	Weight (g)	Feature-ID	Level	Quadrat
20: 1	1110213	15437	520	Table: fine white	1	26	111002	2	H20
20: 1	1110581	15438	520	Table: fine white	1	25	111003	3	H20
20: 2	1110532	15282		Table: medium reddish	1	36	111003	3	L14
20: 3	1110927	15439		Table: medium reddish	1	59	111004	3	M10
20: 4	1110839	15355		Table: medium reddish	6	463	111018	3	J22
20: 5	1110729	15359	508	Table: fine white	1	100	111003	3	F14
20: 5	1111577	15360	508	Table: fine white	1	141	111003	Profile	J11
20: 5	1111417	15361	508	Table: fine white	2	84	111029	4d	K5
20: 6	1111597	15320		Table: fine white	2	63	111018	4a	H23
20: 7	1110873	15159	86	Table: fine white	1	80	111003	3	J5
20:7	1110008	15160	86	Table: medium white	1	8	111002	2	K9
20: 8	1111577	16712		Table: medium reddish	1	14	111003	Profile	J11
20: 9	1110043	15156		Table: undifferentiated	1	40	111002	2	L10
20: 10	1110202	15379		Table: fine white	1	26	111002	2	G6
20: 11	1110405	15433	518	Table: medium reddish	1	23	111002	2	L21
20: 11	1110610	15432	518	Table: medium reddish	1	53	111003	3	
20: 12	1110531	15371		Table: medium reddish	2	133	111003	3	L11
20: 13	1110561	16771		Table: fine white			111003	3	H5
20: 14	1110903	16110		Table: fine white	1	8	111020	3	N20
20: 15	1110927	15852	532	Table: medium reddish	5	67	111004	3	M10
20: 15	1110975	15458	532	Table: fine white	3	63	111012	3	M5
20: 16	1110584	16402		Table: medium white	1	25	111003	3	F16
20: 17	1110957	15428		Table: medium reddish	1	89	111004	3	M8
21: 1	1110049?						111002	2	M12
21: 2	1110555	16507		Table: medium reddish	1	15	111003	3	L9
21: 3	1110940	15388		Table: medium reddish	1	76	111018	3	M22
21: 4	1110395	15397		Table: medium reddish	2	40	111002	2	L19
21: 4	1111161	15398		Table: medium reddish	2	47	111025	4	L19
21: 5	1110781	15829		Table: medium reddish	12	846	111018	3	G22

Figure	Find-ID	Ceramic-ID	Ceramic-Unit-ID	Fabric	Number (n)	Weight (g)	Feature-ID	Level	Quadrat
21: 6	1110781	15819	530	Table: medium reddish	14	490	111018	3	G22
21: 6	1110782	15805	530	Table: medium reddish	70	2344	111018	3	G22
21: 6	1111597	15487	530	Table: medium reddish	8	230	111018	4a	H23
21: 7	1110297	16410		Table: low secondary fired	1	12	111002	2	O8
21: 8	1110782	15791		Table: medium reddish	18	429	111018	3	G22
21: 8	1110781	15823		Table: medium reddish	1	23	111018	3	G22
21: 9	1110869	15369	509	Table: medium reddish	1	71	111002	2	M12
21: 9	1110052	15368	509	Table: medium reddish	1	47	111009	3	M11
21: 10	1110781	15829		Table: medium reddish	12	846	111018	3	G22
22: 1	1110613	15759		Table: fine white	12	1213	111003	3	M–O24–25
22: 2	1110781	15819	530	Table: medium reddish	14	490	111018	3	G22
22: 2	1110782	15805	530	Table: medium reddish	70	2344	111018	3	G22
22: 2	1111597	15487	530	Table: medium reddish	8	230	111018	4a	H22
23: 1	1110353	15380	511	Table: medium reddish	1	126	111002	2	M17
23: 1	1110354	15382	511	Indefinite: uncleaned	1	55	111029	4b	L5
23: 2	1110395	15612		Table: medium reddish	1	2	111002	2	L19
23: 3	1110921	15892		Indefinite: reduced	1	18	111020	3	H10
23: 4	1110725	16433		Kitchen: strongly secondary fired	1	43	111017	3	F18
23: 5	1110966	16079		Kitchen: coarse, orange	1	16	111020	3	J21
23: 6	1110966	15456		Kitchen: coarse, grey brown	9	71	111020	3	J21
23: 7	1110110	16325		Kitchen: coarse, grey brown	1	68	111002	2	I10
24: 1	1110274			Whetstone	1	220	111002	2	J7
24: 2	1110611			Ceramic disk	1	40	111003	3	J21
24: 3	1111572			Loom weight	1	120	111003	3	J21
24: 4	1110331			Spindle whorl	1	11	111002	2	F6
24: 5	1110576			Loom weight	1	63	111003	3	G21
24: 6	1119995	15166		Table: fine white	1	194	Surface find		
24: 7	1119994	15167		Table: medium red	1	164	Surface find		
41: 1	1110896	15903	548	Kitchen: coarse, grey brown	8	1260	111025	3	K20
41: 2	1111083	16035		Kitchen: coarse, grey brown	29	1642	111025	4	L16–17

Figure	Find-ID	Ceramic-ID	Ceramic-Unit-ID	Fabric	Number (n)	Weight (g)	Feature-ID	Level	Quadrat
41: 3	1111089	15179	91	Kitchen: coarse, orange	15	358	111025	4	H8
42: 1	1111253	15384		Table: medium reddish	1	50	111025	4	L7
42: 2	1111139	15377		Table: undifferentiated	2	217	111025	4	L7
42: 3	1111139	15378		Table: medium reddish	1	47	111025	4	L7
42: 4	1111085	15161		Table: fine white	19	616	111024	4	L5
42: 5	1111098	15174	89	Table: medium red	4	356	111025	4	G8
42: 6	1111216	15683		Kitchen: coarse, grey brown	1	37	111025	4	L10
42: 7	1111309	16188		Table: medium white	1	43	111025	4a	L5
42: 8	1111395	16469		Table: fine white	1	16	111024	4b	F7
42: 9	1111232	16372		Table: medium reddish	1	21	111024	4	J5
42: 10	1111230			Not Trypillia?			111024	4	K5
42: 11	1111230			Not Trypillia?			111024	4	K5
43: 1	1111277	15318		Table: fine reddish	1	42	111024	4c	K5
43: 2	1111361	16067		Table: medium reddish	1	56	111024	4a	E7
43: 3	1111309	15317		Table: medium reddish	1	42	111025	4a	L5
43: 4	1111237	19023		No entry			111023	4b	K9
43: 4	1111550	19024		No entry			111029	Profile	J6
43: 5	1111257	15250		Table: medium reddish	1	48	111024	4	K5
43: 6	1111257	15294		Table: fine white	1	20	111024	4	K5
43: 7	1111563	16111		Table: fine reddish	1	17	111025	Profile	J10–14
43: 8	1111091	15363		Table: medium reddish	9	445	111025	4	G8
43: 9	1111284	15362		Table: fine white	8	300	111024	4	N12
43: 10	1111230	15164		Table: fine white	1	120	111024	4	K5
43: 11	1111049	15434		Table: undifferentiated	1	40	111025	4	M18
43: 12	1111253	15372		Table: fine reddish	3	89	111024	4c	L7
43: 13	1111230	15385		Table: medium reddish	1	77	111024	4	K5
43: 13	1111253	15384		Table: medium reddish	2	100	111025	4c	L7
46: 1	1111299	15356	507	Table: medium reddish	2	258	111026	4e	K10
46: 1	1111422	15357	507	Table: medium reddish	1	200	111033	4b	E–F8–9
46: 2	1111421	15181	92	Table: medium white	13	1500	111026	4h	J–K10
46: 2	1111513	15185	92	Table: medium white	3	100	111026	?	J10
46: 2	1111519	15183	92	Table: medium white	1	140	111033	Profile	E8
46: 3	1111422	15162		Table: medium red	9	217	111033	4b	E–F8–9

Figure	Find-ID	Ceramic-ID	Ceramic-Unit-ID	Fabric	Number (n)	Weight (g)	Feature-ID	Level	Quadrat
46: 4	1111519	15323		Table: fine reddish	2	135	111033	Profile	E8
46: 5	1111519	15165		Table: medium white	6	458	111033	Profile	E8
46: 6	1111395	15344	506	Table: fine white	7	193	111024	4b	F7
46: 6	1111519	15345	506	Table: fine white	1	21	111033	Profile	E8
47: 1	1111422	15168	87	Table: medium red	1	100	111033	4b	E–F8–9
47: 1	1111519	15169	87	Table: medium red	1	48	111033	Profile	E8
47: 2	1111541	16228		Table: fine white	1	9	111032	Profile	E6
47: 3	1111519	15187	93	Table: medium red	1	60	111033	Profile	E8
47: 3	1111541	15186	93	Table: medium red	5	200	111032	Profile	E6
47: 3	1110566	15188	93	Table: medium red	1	32	111003	3	G7
47: 4	1111422	16339		Table: medium reddish	1	56	111033	4b	E–F8–9
47: 5	1111422	15394		Table: medium reddish	2	138	111033	4b	E–F8–9
47: 6	1111422	16336		Table: medium reddish	1	71	111033	4b	E–F8–9
47: 7	1111519	15386		Table: fine white	1	57	111033	Profile	E8
47: 8	1111422	15176	90	Table: medium white	9	382	111033	4b	E–F8–9
47: 8	1110566	15177	90	Table: medium white	1	10	111003	3	G7
47: 8	1111519	15178	90	Table: medium white	1	16	111033	Profile	E8
47: 9	1111541	16317	545	Table: medium reddish	11	400	111032	Profile	E6
47: 9	1111542	16318	545	Table: medium reddish	3	40	111033	Profile	E6
47: 9	1111519	16319	545	Table: medium reddish	1	6	111033	Profile	E8
48: 1	1111422	15198	96	Table: fine white	15	1000	111033	4b	E–F8–9
48: 1	1111519	15199	96	Table: fine white	12	680	111033	Profile	E8
48: 2	1111518	15189	94	Table: fine red	8	340	111033	Profile	E8
48: 2	1111519	15191	94	Table: fine red	9	390	111033	Profile	E8
48: 2	1111422	15190	94	Table: fine red	2	150	111033	4b	E–F8–9
48: 3	1111541	15375	510	Table: fine reddish	4	148	111032	Profile	E6
48: 3	1111543	15376	510	Table: fine reddish	1	50	111033	Profile	E6
49: 1	1111361	15196	95	Table: medium red	2	250	111024	4a	E7
49: 1	1111395	15197	95	Table: medium red	2	250	111024	4b	F7
49: 1	1111422	15193	95	Table: medium red	3	338	111033	4b	E–F8–9
49: 1	1111519	15192	95	Table: medium red	9	1000	111033	Profile	E8
49: 1	1111541	15194	95	Table: medium red	2	200	111032	Profile	E6
49: 1	1111542	15195	95	Table: medium red	5	300	111033	Profile	E6
49: 2	1111422	16049		Table: medium reddish	3	56	111033	4b	E–F8–9
49: 3	1111422	15881	535	Kitchen: coarse, grey brown	27	719	111033	4b	E–F8–9

Figure	Find-ID	Ceramic-ID	Ceramic-Unit-ID	Fabric	Number (n)	Weight (g)	Feature-ID	Level	Quadrat
49: 4	1111419	15242	98	Table: fine white	1	66	111029	4b	K6–7
49: 4	1111541	15249	98	Table: fine white	1	44	111032	Profile	E6
49: 5	1111419	15396		Table: medium reddish	1	57	111029	4b	K6–7
49: 6	1111139	15172	88	Table: medium red	1	10	111025	4	L7
49: 6	1111267	15173	88	Table: medium red	1	10	111025	4	I7
49: 6	1111351	15170	88	Table: medium red	2	100	111029	4b	L5
49: 6	1111505	15171	88	Table: medium red	1	14	111029	Profile	K–5–6
49: 7	1111350	15157		Table: medium white	2	248	111029	4b	L5
51: 1	1111359	15335	503	Table: medium reddish	1	40	111029	4d	K6
51: 1	1111421	15337	503	Table: medium reddish	1	26	111026	4h	J–K10
51: 2	1111418	15326	99	Table: fine white	1	50	111029	4c	K6–7
51: 2	1111489	15324	99	Table: fine white	2	79	111029	Profile	K7
51: 2	1111553	15327	99	Table: fine white	1	50	111029	Profile	K6
51: 3	1111553	15163		Table: medium reddish	2	175	111029	Profile	K6
51: 4	1111418	15232	97	Table: fine reddish	1	40	111029	4c	K6–7
51: 4	1111505	15233	97	Table: fine reddish	1	42	111029	Profile	K5–6
51: 5	1111505	15743		Table: medium reddish	1	90	111029	Profile	K5–6
51: 6, 8	1111309	15436	519	Table: fine white	1	10	111025	4a	L5
51: 6, 8	1111505	15435	519	Table: fine white	1	110	111029	Profile	K5–6
51: 7	1111505	15743		Table: medium reddish	1	90	111029	Profile	K5–6
51: 9	1111253	15422	516	Table: fine white	3	133	111025	4c	L7
51: 9	1111274	15407	516	Table: medium reddish	2	20	111025	4c	L7
51: 9	1111312	15408	516	Table: medium reddish	1	10	111029	4c	J5
51: 9	1111362	15406	516	Table: fine white	1	17	111029	4b	L5
51: 10	1111505	15431		Table: fine reddish	1	70	111029	Profile	K5–6
51: 11	1111230	15613	522	Table: medium reddish	1	42	111024	4	K5
51: 11	1111282	15444	522	Table: fine reddish	1	20	111024	4c	K5
51: 11	1111474	15443	522	Table: fine reddish	7	380	111029	Profile	J5
51: 11	1111552	15445	522	Table: fine reddish	3	200	111029	Profile	J6
52: 1	1111282	15882		Table: medium reddish	1	516	111024	4c	K5
52: 1	1111474	15786		Table: medium reddish	1	50	111029	Profile	J5
52: 2	1111372	15893		Kitchen: coarse, grey brown	47	1485	111029	4d	K6
52: 3	1111554			Flint	1	6	111029	Profile	K6

References

Adler, M.A., 1989. Ritual Facilities and Social integration in Nonranked Societies. *In*: W.D. Lipe and M. Hegmon, eds. *The Architecture of Social Integration in Prehistoric Pueblos*. Occasional Papers of the Crow Canyon Archaeological Center 1. Cortez/Colorado: Crow Canyon Archaeological Center, 35–52.

Adler, M.A. and Wilshusen, R.H., 1990. Large-scale integrative facilities in tribal societies: cross-cultural and southwestern US examples. *World Archaeology,* 22 (2), 133–146. Available from: https://doi.org/10.1080/00438243.1990.9980136

Anderson, P.C. and M'hamdi, M., 2014. Harvesting of the Wild Grass Alfa (*Stipa tenacissima* L.) by Pulling in the High Tunisian Steppe: an Unusual Method. *In:* A. van Gijn, J.C. Whittaker and P.C. Anderson, eds. *Exploring and Explaining Diversity in Agricultural Technology.* Early Agricultural Remnants and Technical Heritage (EARTH): 8,000 Years of Resilience and Innovation 2. Oxford, Havertown/Pennsylvania: Oxbow Books, 98–132.

Brandtstätter, L., 2017. *Tripolje-Keramik aus Maidanteske (Ukraine): Auswertung der Grabungskampagne 2013*. [Unpublished Master thesis. Institute of Prehistoric and Protohistoric Archaeology, Kiel University, Germany].

Bronk Ramsey, C., 2009. Bayesian Analysis of Radiocarbon Dates. *Radiocarbon,* 51 (1), 337–360. Available from: https://doi.org/10.1017/S0033822200033865

Caswell, E., Arbeiter, S., Ovchinnikov, E., Gaydarska, B., Nebbia, M. and Chapman, J., 2020. Pottery. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 266–326. Available from: https://doi.org/10.1515/9783110664959-009

Chapman, J., Videiko, M.Y., Gaydarska, B., Burdo, N. and Hale, D., 2014a. Architectural diferentiation on a Trypillia mega-site: preliminary report on the excavation of a mega-structure at Nebelivka, Ukraine. *Journal of Neolithic Archaeology,* 16, 135–156. Available from: https://doi.org/10.12766/jna.2014.4

Chapman, J., Videiko, M.Y., Hale, D., Gaydarska, B., Burdo, N., Rassmann, K., Mischka, C., Müller, J., Korvin-Piotrovskiy, A.G. and Kruts, V., 2014b. The Second Phase of the Trypillia Mega-Site Methodological Revolution: A New Research Agenda. *European Journal of Archaeology,* 17 (3), 369–406. Available from: https://doi.org/10.1179/1461957114Y.0000000062

Chernovol, D., 2012. Houses of the Tomashovskaya Local Group. *In:* F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture Giant-Settlements in Ukraine. Formation, Development and Decline*. Oxford, Oakville: Oxbow Books, 182–209. Available from: https://doi.org/10.2307/j.ctvh1dvmn.13

Chernovol 2019: Черновол, Д., 2019. *Інтер'єр споруд Трипільської культьури*. Автореферат дисертації на здобуття наукового ступеня кандидата історичних наук. [Summary of the unpublished PhD thesis. Національна академія наук України].

Dal Corso, M., Hamer, W., Hofmann, R., Ohlrau, R., Shatilo, L., Knitter, D., Dreibrodt, S., Saggau, P., Duttmann, R., Feeser, I., Knapp, H., Benecke, N., Videiko, M., Müller, J. and Kirleis, W., 2019. Modelling landscape transformation at the Chalcolithic Tripolye mega-site of Maidanetske (Ukraine): Wood demand and availability. *The Holocene,* 29 (10), 1622–1636. Available from: https://doi.org/10.1177/0959683619857229

Dannath, Y., Heske, I. and Kirleis, W., 2019. Ein weiter Blick in die Landschaft. Entdeckungen an einem Standort der Stichbandkeramik. *Archäologie in Niedersachsen,* 22, 50–54.

Dietler, M., 1996. Feasts and commensal politics in the political economy. Food, Power and Status in Prehistoric Europe. *In:* P. Wiessner and W. Schiefenhövel, eds. *Food and the Status Quest: An Interdisciplinary Perspective*. Oxford: Berghahn Publishers, 87–125.

Gaydarska, B., ed., 2020. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter. Available from: https://doi.org/10.1515/9783110664959

Gaydarska, B., Nebbia, M., Chapman, J., Caswell, E., Arbeiter, S., Ovchinnikov, E., Gaskevych, D., Lazăr, C., Ignat, T., Boyce, A., Dolan, A., Newton, J., Kiosak, D., Belenko, M., Craig, O.E., Robson, H.K., von Tersch, M., Lucquin, A., Tóth, Z., Choyke, A., Orton, D., Nottingham, J., Rainsford-Betts, G., Hosking, K., Millard, A. and Pashkevych, G., 2020. The finds. *In*: B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 265–414. Available from: https://doi.org/10.1515/9783110664959-009

Hale, D., 2020. Geophysical Investigations and the Nebelivka Site Plan. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 122–148. Available from: https://doi.org/10.1515/9783110664959-008

Hofmann, R., 2013. *Okolište 2 - Spätneolithische Keramik und Siedlungsentwicklung in Zentralbosnien, Neolithikum und Chalkolithikum in Zentralbosnien.* Universitätsforschungen zur prähistorischen Archäologie 243 (Neolithikum und Chalkolithikum in Zentralbosnien 2). Bonn: Dr. Rudolf Habelt.

Hofmann, R., Kujundžić-Vejzagić, Z., Müller, J., Müller-Scheeßel, N. and Rassmann, K., 2006. Prospektionen und Ausgrabungen in Okolište (Bosnien-Herzegowina): Siedlungsarchäologische Studien zum zentralbosnischen Spätneolithikum (5300-4500 v. Chr.). *Bericht der Römisch-Germanischen Kommission,* 87, 41–212.

Hofmann, R., Shatilo, M., Ohlrau, R., Dal Corso, M., Dreibrodt, S., Videiko, M., Rassmann, K., Kirleis, W. and Müller, J., 2018. Tripolye – Strategy and Results of an ongoing Ukrainian-European Project. *Vita Antiqua*, 10, 146–154. Available from: https://doi.org/10.37098/2519-4542-2018-1-10-146-154.

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Hofmann, R., Müller, J., Kirleis, W., Terna, S., Rud, V., Terna, A., Dal Corso, M. and Schlütz, F., 2023. Database of the Kiel CRC 1266 sub-project D1 'Population Agglomerations at Trypillia-Cucuteni Mega-sites'. [Dataset, status as of 06.10.2023] https://doi.org/10.57892/100-317

Hofmann, R., Müller-Scheeßel, N. and Müller, J., 2024. Trypillia mega-sites: a social levelling concept? *Antiquity*, 98 (398), 380–400. Available from: https://doi.org/10.15184/aqy.2024.18

Johnson, G.A., 1983. Decision-Making Organization and Pastoral Nomad Camp Size. *Human Ecology,* 11, 175–199. Available from: https://doi.org/10.1007/BF00891742

Klassen, L., 2014. *Along the Road. Aspects of Causewayed Enclosures in South Scandinavia and Beyond.* East Jutland Museum Publicatios. Aarhus: Aarhus University Press. Available from: https://doi.org/10.2307/jj.608320

Körber-Grohne, U., 1987. Federgras-Grannen (Stipa Pennata L. s. str.) als Vorrat in einer mittelneolithischen Grube in Schöningen, Landkreis Helmstedt. *Archäologisches Korrespondenzblatt,* 17 (4), 463–466.

Korvin-Piotrovskiy *et al.* 2016: Корвін-Піотровський, О.Г., Пічкур, Є.В., Чабанюк, В.В. and Шатіло, Л.О., 2016. Черкаська область. Роботи Трипільської експедиції. *Археологічні дослідження в Україні*, 2015, 201–203.

Kruts *et al.* 2005: Круц, В.А., Корвин-Пиотровский, А.Г., Рыжов, С.Н., Бузян, Г.Н., Овчинников, Э.В., Черновол, Д.К. and Чабанюк, В.В., eds., 2005. *Исследование поселений-гигантов трипольской культуры в 2002-2004 гг.* Киев: Институт археологии НАН Украины.

Müller, J. and Videiko, M., 2016. Maidanetske: New Facts of a Mega-Site *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehisto-*

ry 4100-3400 BCE. Themes in Contemporary Archaeology 2. London, New York: Routledge, 71–93. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site / Майданецьке 2013. Нові розкопки великого Трипільського поселення*. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Müller, J., Hofmann, R. and Shatilo, M., 2022. Tripolye Mega-Sites: "Collective Computational Abilities" of Prehistoric Proto-Urban Societies? *Journal of Social Computing*, 3 (1), 75–90. Available from: https://doi.org/10.23919/JSC.2021.0034

Nebbia, M., Gaydarska, B., Millard, A. and Chapman, J., 2018. The making of chalcolithic assembly places: Trypillia megasites as materialized consensus among equal strangers? *World Archaeology*, 50 (1), 41–61. Available from: https://doi.org/10.1080/00438243.2018.1474133

Ohlrau, R., 2015. Trypillia Großsiedlungen: Geomagnetische Prospektion und architektursoziologische Perspektiven. *Journal of Neolithic Archaeology,* 17, 17–100. Available from: https://doi.org/10.12766/jna.2015.3

Ohlrau, R., 2020a. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Ohlrau, R., 2020b. Modelling Trypillia 'mega-site' populations. *In*: M. Dębiec and T. Saile, eds. *A Planitiebus usque ad montes: Studia Archaeologica Andreae Pelisiak vitae anno sexagesimo quinto oblata*. Rzeszów: Zimowit, 399–413.

Ovchynnykov 2014: Овчинников, Е.В., 2014. *Трипільська культура Канівського Подніпров'я*. Київ: Видавець Олег Філюк.

Pickartz, N., Hofmann, R., Dreibrodt, S., Rassmann, K., Shatilo, L., Ohlrau, R., Wilken, D. and Rabbel, W., 2019. Deciphering archeological contexts from the magnetic map: Determination of daub distribution and mass of Chalcolithic house remains. *The Holocene*, 29 (10), 1637–1652. Available from: https://doi.org/10.1177/0959683619857238

Pickartz, N., Rabbel, W., Rassmann, K., Hofmann, R., Ohlrau, R., Thorwart, M., Wilken, D., Wunderlich, T., Videiko, M. and Müller, J., 2022. Inverse Filtering of Magnetic Prospection Data—A Gateway to the Social Structure of Cucuteni–Tripolye Settlements? *Remote Sensing*, 14 (3), 484. Available from: https://doi.org/10.3390/rs14030484

Rassamakin, Y., 2012. Absolute Chronology of Ukrainian Tripolian Settlements. *In:* F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture giant-settlements in Ukraine: Formation, development and decline*. Oxford, Oakville: Oxbow Books, 19–69. Available from: https://doi.org/10.2307/j.ctvh1dvmn.7

Rassmann, K., Ohlrau, R., Hofmann, R., Mischka, C., Burdo, N., Videjko, M.Y. and Müller, J., 2014. High precision Tripolye settlement plans, demographic estimations and settlement organization. *Journal of Neolithic Archaeology,* 16, 96–134. Available from: https://doi.org/10.12766/jna.2014.3

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C., van der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A. and Talamo, S., 2020. The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon*, 62 (4), 725–757. Available from: https://doi.org/10.1017/RDC.2020.41

Rice, P.M., 1987. *Pottery Analysis. A Sourcebook*. Chicago, London: The University of Chicago Press.

Rivera Núñez, D., Matilla Séiquer, G., Obón, C. and Alcaraz Ariza, F., 2012. *Plants and Humans in the Near East and the Caucasus: Ancient and Traditional Uses of Plants as Food and Medicine, a Diachronic Ethnobotanical Review*. Vol. 2: *The Plants: Angiosperms*. Murcia: Ediciones de la Unverisdad de Murcia.

Ryzhov 1999: Рижов, С.М., 1999. *Керамiка Поселень Трипiльської Культури Буго-Днiпровського Межирiччя Як Iсторичне Джерело*. [Unpublished PhD thesis. Нацiональна Академiя Наук України].

Ryzhov, S.N., 2012. Tripolian Pottery of the Giant-settlements: Characteristics and Typology. *In:* F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture giant-settlements in Ukraine: Formation, development and decline*. Oxford, Oakville: Oxbow Books, 139–168. Available from: https://doi.org/10.2307/j.ctvh1dvmn.11

Shatilo, L., 2021. *Tripolye Typo-chronology: Mega and Smaller Sites in the Sinyukha River Basin.* Scales of Transformation in Prehistoric and Archaic Societies 12. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/m5457py

Shmaglij and Videiko 2005: Шмаглий, Н.М. and Видейко, Ю.М., 2005. *Майданецкое - трипольский протогород*. Киев: Институт археологии НАН Украины.

Sommer, U., 1991. Zur Entstehung archäologischer Fundvergesellschaftungen: Versuch einer archäologischen Taphonomie. *In:* Mattheusser, E., author. *Die geographische Ausrichtung bandkeramischer Häuser*. Studien zur Siedlungsarchäologie 1 (Universitätsforschungen zur prähistorischen Archäologie 6). Bonn: Dr. Rudolf Habelt, 51–193.

Videiko 2020: Вiдейко, М.Ю., 2020. Дослiдження пiзньотрипiльського поселення Вiльховець. *Археологiя i давня iсторiя України,* 34, 68–79. Available from: https://doi.org/10.37445/adiu.2020.01.05

Videiko *et al.* 2013: Видейко, М., Чапмен, Д., Гейдарская, Б., Бурдо, Н., Овчинников, Э., Пашкевич, Г. and Шевченко, Н., 2013. Исследования мегаструктуры на поселении трипольской культуры у с. Небелевка в 2012 году. *Tyragetia, serie nouă,* 7 [22] (1), 97–124. Available from: https://ibn.idsi.md/sites/default/files/j_nr_file/Tyragetia_1_2013.pdf#page=98

Wotzka, H.-P., 1997. Keramikformen und -funktionen: Wider die systematische Trivialisierung kulturspezifischer Zusammenhänge. *Archäologische Informationen,* 20 (2), 269–299.

3. Geophysical Investigations at Maidanetske

Natalie Pickartz, Tina Wunderlich, Erica Corradini, Knut Rassmann, Dennis Wilken, Wolfgang Rabbel

Abstract

In this chapter we report the results of electric resistivity tomography (ERT), electromagnetic induction (EMI) and ground-penetrating radar (GPR) measurements carried out at the site of Maidanetske in addition to previously conducted magnetic prospection. The aim of this field campaign, which was performed in September 2017, was to test the applicability of these methods on the remains of the burnt houses at Maidanetske. The tests showed that GPR cannot resolve these structures. Also, the apparent conductivity measured with EMI does not show any anomalies that are similar to those in the magnetic map. However, the In-phase component, which is sensitive to the magnetic susceptibility, shows the anomalies of the house remains. Moreover, the cross-section of some house remains are visible in an ERT-profile. Therefore, ERT has to be regarded as the most promising non-destructive prospection method for determining the depth and thickness of the layer containing burnt houses in loess environment such as that found in Maidanetske. In future surveys it should be combined with minimal invasive direct-push conductivity soundings or shallow drillings for further validating and constraining the depths of the settlement layer.

Introduction

Magnetic measurements have been successfully conducted at Maidanetske since the 1970s (Dudkin 1978; Rassmann *et al.* 2016). They have yielded a map with the locations of house remains, pits and kilns as well as estimates of their size based on the magnetic anomalies However, due to the inherent ambiguity of magnetic data, the geometry of a magnetic source body and its magnetic material properties cannot be resolved uniquely from the magnetic data alone (*e.g.* Li and Oldenburg 1996). Complementary additional depth-sensitive geophysical measurements can reduce this non-uniqueness. However, not all geophysical methods are capable to detect a specific structure. It depends on the subsurface conditions whether or not a structure is detectable with a specific measurement setup. Several factors play a role, mainly material property contrasts, but also depth and thickness of the structure, as well as their ratio, the roughness of the surface and coupling of the device and also the distance between the transmitter and receiver in case of EMI.

The anomalies of the majority of the building remains are clearly visible in the magnetic map since they consist of a layer of burnt clay, *i.e.* daub (*e.g.* Müller *et al.* 2017). The archaeological structures are embedded in Chernozem and Loess (Müller *et al.* 2017). We aimed to add additional geophysical data to the existing magnetic map to resolve the geometry of the magnetic anomalies. Therefore, we tested electromagnetic induction (EMI), electrical resistivity tomography (ERT) and ground-penetrating radar (GPR) measurements on different objects in Maidanetske during a field campaign in September 2017 and report the results in this chapter.

For these types of measurements loess turned out to be a challenging environment, because it strongly absorbs the electromagnetic waves of the GPR. Moreover, due to ploughing, GPR shows a rough surface on top and rough interfaces internally, scattering the remaining non-absorbed radar waves. The GPR measurements conducted with a 200 MHZ antenna and a GSSI unit were not able to record reflections from the expected structures. Therefore, the measurements are not shown here. As to the electric measurements, the loess apparently shows only small contrasts between burnt and unburnt fractions in electric conductivity. For the EMI measurements we used a CMD Mini Explorer by GF Instruments but none of the expected structures could be found in the apparent conductivity maps. However, the map of the so-called In-phase EMI component, which is sensitive to the magnetic susceptibility, does show the expected structures. An addition one ERT-profile, measured with the RESECS device by Geoserve, shows the cross-section of house remains.

In the following chapter, we present these results in detail. The chapter is structured as follows: first, we briefly introduce the methods EMI and ERT; next, we present the results and discuss them; finally, we draw a conclusion.

Methods

Electromagnetic induction

Electromagnetic induction (EMI) devices consist of a transmitter and one or several receiver coils. The transmitter coil emits a ‘primary’ oscillating electromagnetic field. Oscillating eddy currents are induced in the soil that depend on the electrical conductivity distribution of the subsurface. These generate a ‘secondary’ electromagnetic field recorded at the receiver coils together with the primary field. EMI devices measure the ‘apparent electrical conductivity’ of the soil, which is the so-called Out-of-Phase component and the In-Phase component, which is a function of the magnetic susceptibility. The sounding depth depends on signal frequency and transmitter-receiver distance.

We used a CMD Mini-Explorer by GF Instruments. The device consists of one transmitter and three receiver coils. The planes of the coils can be oriented horizontally (horizontal coplanar – HCP) or vertically (vertical coplanar – VCP) modes. The distance between the transmitter and receivers are 0.32 m, 0.71 m and 1.18 m leading to theoretical 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 for a homogeneous half-space. Further details on the method and the device can be found in *e.g.* Bonsall *et al.* (2013).

The measurements were performed with 10 Hz sampling frequency using VCP and HCP configuration. The areas were covered in zig-zag mode with a spacing of 0.5 m between parallel profiles.

Data processing included a coordinate shift based on the Mini-Explorer coil configuration, assigning the measurement values to the centre point of each coil pair. Regarding the data as time series based on the sample timing of 10 Hz, a bandpass filter was applied to the raw data to remove noise with high spatial frequencies (above 0.05 1/samples) due to movement of the device while walking, as well as possible drift effects occurring as low frequency signals (below 0.002 1/samples). After this, the data of all six measurement parameters was gridded and linearly interpolated to maps of 0.25 m grid spacing. These maps were then spatially filtered by a 2D Gaussian image filter with a half width of 0.5 m.

Electric resistivity tomography

The principle of an electric resistivity tomography is as follows: electric current is sent into the ground by two current electrodes and the resulting difference in the electric potential is measured between a second pair of electrodes, the potential electrodes. From this, the apparent resistivity can be calculated as the ratio of potential difference and applied current, multiplied by a geometrical factor. The geometrical factor contains the distances of the electrodes as well as their arrangement. A larger distance between the electrodes results in a higher depth of investigation.

To perform an electric resistivity tomography, a larger number of electrodes are placed equidistantly along a profile. Then the measurement device uses for each measurement a set of four electrodes and moves through all possible electrode combinations, resulting in a so-called pseudosection of apparent resistivities. The measured apparent resistivities correspond to a mean value for the subsurface volume that was penetrated by the applied current. So-called inversion calculations determine a subsurface model of resistivity values that is in agreement with the measurements and resemble the true resistivity distribution. Nevertheless, this process is also non-unique and several subsurface models can be found to explain the measured values equally well.

We used the RESECS device by Geoserve with 0.5 m electrode spacing using the dipole-dipole configuration. The inversion calculations were performed with the software BERT (Günther *et al.* 2006).

Results

Figure 1 shows the magnetic map of the site with the measurement locations of EMI and ERT. The magnetic map is discussed in detail by Rassmann *et al.* (2016) and Ohlrau (2020). A method for quantitative interpretation of the magnetic measurements has been presented by Pickartz *et al.* (2019). The dominant features in the magnetic map are the anomalies of more than 2500 burnt remains of houses. Besides these, there is another type of building found in the settlement: the so-called mega-structures. These differ in their floor-plan, placement inside the settlement and function from the residential houses. In this chapter, we present the measurements at one mega-structure and a group of houses.

EMI

We present two areas measured with EMI. For each area, we present the result of one measurement configuration with a figure in comparison to the magnetic map. In addition, we list in a qualitative manner how well the other configurations are in accordance with the magnetic map.

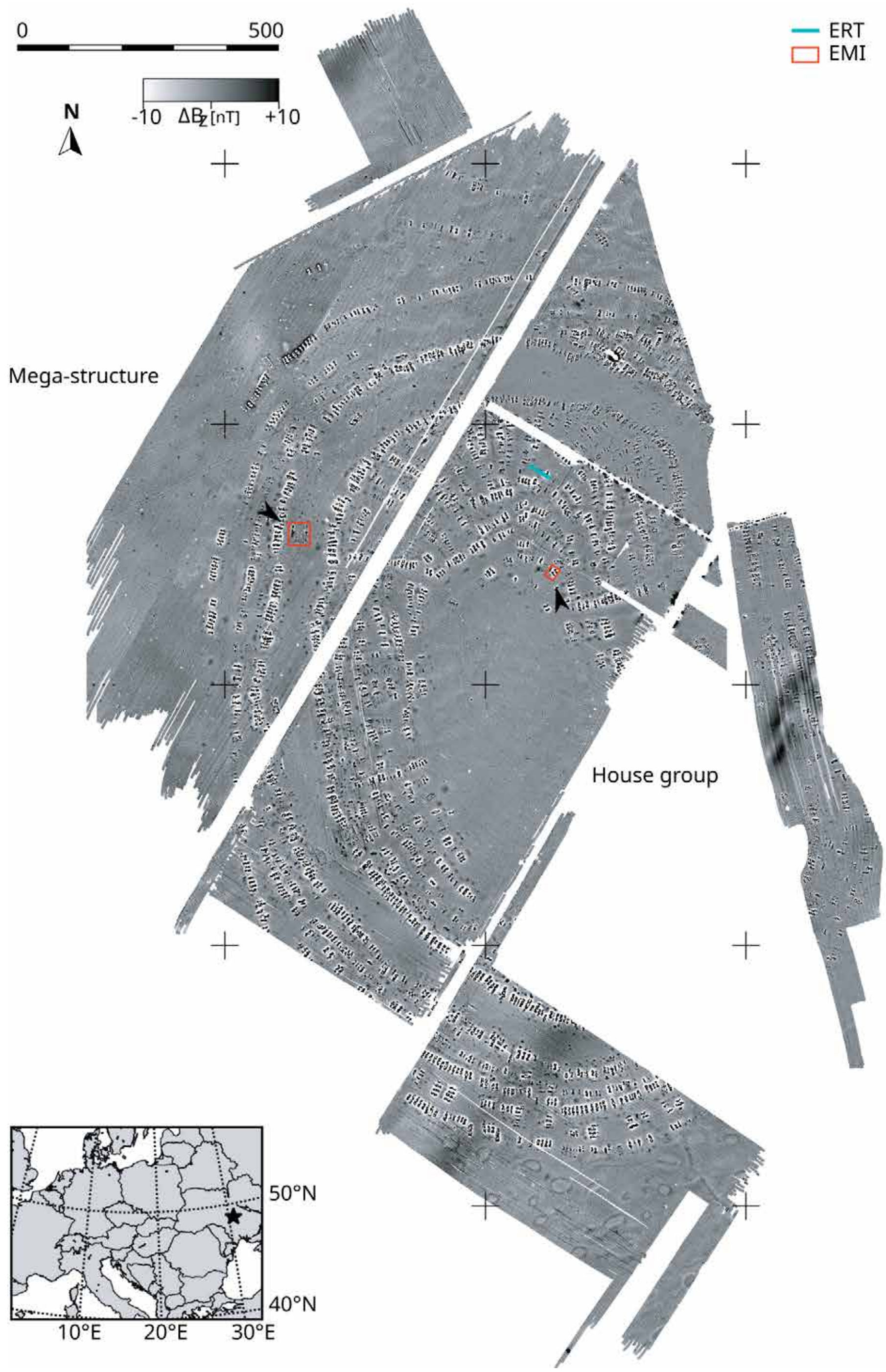

Figure 1. Magnetic map of the site Maidanetske with the location of the areas measured with EMI (red boxes) and the ERT profile (blue line). The insert shows the location of the site in Ukraine.

Mega-structure

Figure 2 shows the comparison of (a) the magnetic map and (b) the In-Phase component (HCP, largest coil separation). The course of the outer walls of the mega-structure is indicated by an apposition of small positive magnetic anomalies. The building was approximately 16 m wide and 35 m long. Outside the building, along the long axis, more positive anomalies of larger scale are visible. Possibly these originate from pits that have been filled with daub. The comparison with the In-Phase values shows that predominantly the anomaly in the northwestern corner of the area is visible as low

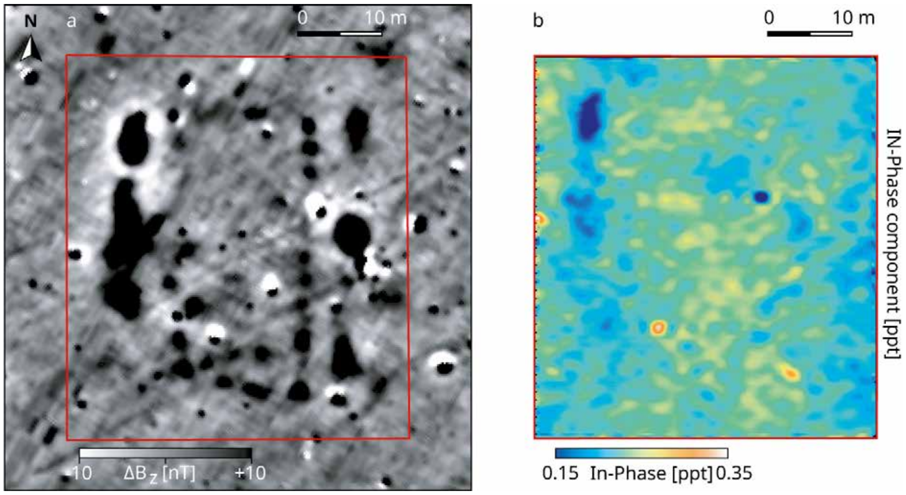

Figure 2. Comparison of (a) the magnetic map and (b) the EMI measurements at a mega-structure in the western part of the settlement. The EMI measurements show the In-Phase values of HCP configuration with the intermediate coil separation.

values. Moreover, this anomaly elongates southwards. However, other structures in analogy to the magnetic anomalies cannot be clearly identified.

The images of the apparent conductivity values show streaky patterns parallel to the traces of ploughing. The traces of ploughing are also visible in the In-Phase values of the smallest coil separation. The In-Phase values of the intermediate coil separation yield a similar image as shown in Figure 2b.

House group

The comparison of the magnetic map and the In-Phase component measured in VCP configuration (intermediate coil separation) are shown in Figure 3. The magnetic map shows the anomalies of three buildings. The two eastern ones have a stronger magnetic anomaly than the western one. Moreover, the orientation of the two eastern houses is rotated by approx. 125°. In the In-Phase measurements, the anomalies of the two houses are visible as decreased values. Also, the western building is visible, however the anomaly is not as distinct as for the two other buildings.

Again, in the apparent conductivity maps no anomalies that correspond to the anomalies in the magnetic map are visible. The map of In-Phase values of the largest coil separation is similar to that of the intermediate coil separation, and that of the smallest coil separation shows the expected anomalies also, but with less contrast.

Additionally, for this area measurements in HCP configuration were performed. Also for this configuration, no corresponding anomalies are visible in the apparent conductivity maps. The In-Phase maps of the HCP configuration show the anomalies of the two eastern buildings: for the two smaller coil separations by decreased values and for the largest coil separation by increased values.

ERT

Figure 4 shows in the upper part the magnetic map with the anomalies of three houses and an unclassified anomaly at the western end. The house in the east has the strongest magnetic anomaly out of the three. The electric profile is indicated by a blue line and cuts across the houses approximately in the middle of their long side. The bottom part of Figure 4 shows the distribution of the resistivity along this profile. The inversion results indicate a three-layer structure consisting of a low resistive top layer, a second layer with increased resistivity values and a layer with low resistivity on the bottom. The top layer has a thickness of approx. 0.5 m and resistivity values lower than 30 Ωm. The second layer extends from about 0.5 m to 1 m in depth with a resistivity values higher than 30 Ωm. Between profile

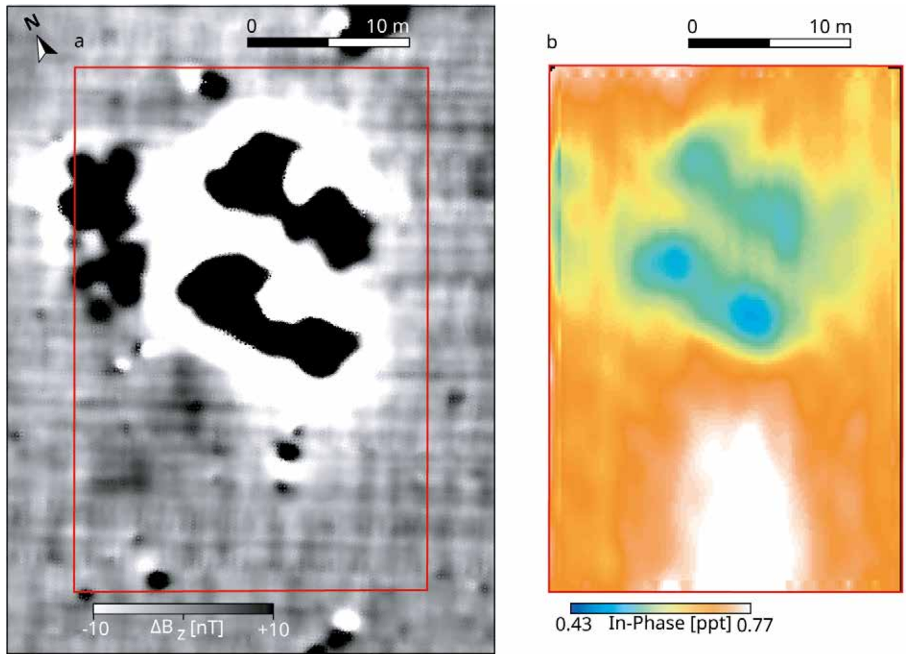

Figure 3. Comparison of (a) the magnetic map and (b) the EMI measurements of three houses in the eastern part of the settlement. The EMI measurements show the In-Phase values of VCP configuration with the intermediate coil separation.

metres 10 to 15 lies a high resistive body with a resistivity up to 50 Ωm. Its vertical extension is slightly increased as it nearly reaches the surface and extends up to 1.2 m in depth. In the bottom layer the resistivity decreases again below 30 Ωm. The comparison of the magnetic map and the ERT profile indicates that the highly resistive body corresponds to the remains of the easternmost house. The magnetic anomaly of the two houses in the centre of the profile have a smaller amplitude. They cannot be identified as resistive structures in the ERT profile. However, there are variations of the resistivity throughout the whole second layer.

Discussion

This study aimed to complement the magnetic map with measurements that provide information about the depth extension and geometry of known archaeological structures. This aim has been partly achieved. We were able to find corresponding anomalies to the magnetic ones in ERT measurements and the In-Phase component of EMI measurements. However, compared to the magnetic map, GPR and EMI conductivity mapping were not able to image these archaeological structures in a satisfactory way.

The ERT profile (Fig. 4) shows that the subsurface is a good electrical conductor. As GPR signals are attenuated in good conducting media, this explains the lack of success of the GPR measurements. Another adverse factor for the GPR measurements was the roughness of the surface. The fields were ploughed and the rough surface leads to a bad coupling between the antenna and the subsurface. Consequently, only a fraction of the signal is transmitted into the subsurface.

The comparison of the ERT profile and the magnetic map suggests that house remains with a strong magnetic anomaly can be located with ERT and those with a less strong magnetic anomaly cannot. This can be explained as follows: The strength of the magnetic anomaly is correlated with the mass and volume of daub in the subsurface: the more daub the stronger the magnetic anomaly. Daub is more compact and less porous than the surrounding soil. Therefore, the daub contains less moisture than the soil around. Since a decrease of the moisture content leads to an increase of the electric resistivity of the soil, volumes containing more daub mass

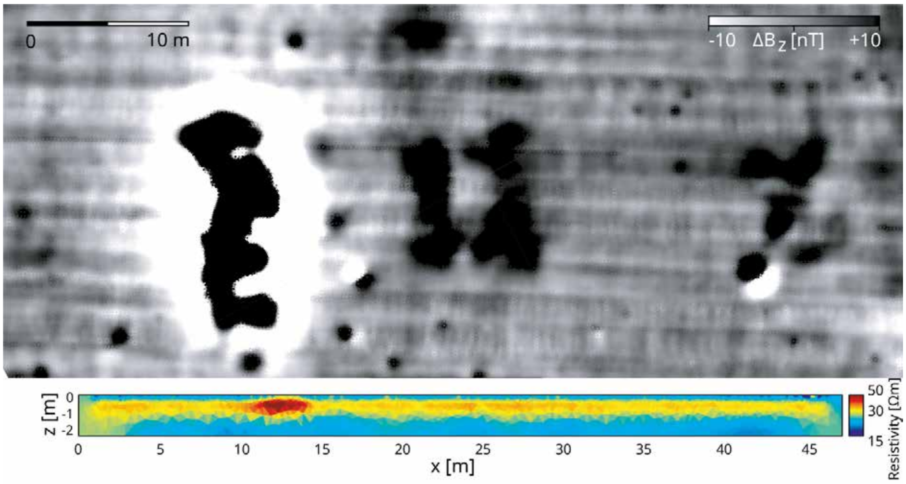

Figure 4. Comparison of magnetic map (top) and ERT profile (bottom). The location of the ERT profile is indicated by the blue line (top). It crosses the remains of three houses. The cross-section of the easternmost house is visible as a high resistive body between 10 m and 15 m in the ERT profile.

than the surrounding show up as a high resistivity anomaly in ERT. This explanation can be supported by additional measurements with similar magnetic signatures or validated by ground-truthing in excavations or corings.

The ERT profile yields an estimate of the depth extension for the easternmost building remains. They start close to the surface, probably directly beneath the ploughing layer at about 30 cm depth and extend to 1.2 m depth. However, since the inversion process is not unique, the depth extension might also be under- or overestimated. This is caused by a loss in resolution with increasing target depth inherent in ERT measurements. Therefore, a combination of ERT profile or areal measurements with minimal invasive direct-push conductivity soundings or shallow drillings appears to be a promising approach for the future.

In addition, the comparison of the magnetic maps and the In-Phase maps show that the structures with a strong magnetic anomaly yield an anomaly in the In-Phase map, too. However, since the structures are visible in all three depth slices, no additional information of the depth extend can be derived.

Conclusion

The rough surface and the conductivity at the site yield challenging conditions for GPR and EMI surveys. Consequently, the GPR measurements did not yield any additional information. Also, the EMI measurements did not contribute depth information of the known structures, since no anomalies are visible in the apparent conductivity distribution and the anomalies in the In-Phase extend over the complete depth range. In contrast, the ERT measurements show that the archaeological structures are located in the uppermost metre under the surface. For further constraining the depth end thickness of the settlement layer, ERT profiling or areal measurements should be combined with minimal invasive direct-push conductivity soundings or shallow drillings in future campaigns.

Acknowledgements

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References

Bonsall, J., Fry, R., Gaffney, C., Armit, I., Beck, A. and Gaffney, V., 2013. Assessment of the CMD Mini-Explorer, a New Low-frequency Multi-coil Electromagnetic Device, for Archaeological Investigations. *Archaeological Prospection*, 20 (3), 219–231. Available from: https://doi.org/10.1002/arp.1458

Dudkin 1978: Дудкин, В.П., 1978. Геофизическая разведка крупных трипольских поселений. *In*: В.Ф. Генинг, ed. Использование методов естественных наук в археологии. Киев: Издательство “Наукова думка”, 35–45.

Günther, T., Rücker, C. and Spitzer, K., 2006. Three-dimensional modelling and inversion of dc resistivity data incorporating topography – II. Inversion. *Geophysical Journal International,* 166 (2), 506–517. Available from: https://doi.org/10.1111/j.1365-246X.2006.03011.x

Li, Y. and Oldenburg, D.W., 1996. 3-D inversion of magnetic data. *Geophysics*, 61 (2), 394–408. Available from: https://doi.org/10.1190/1.1443968

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site* / Майданецьке *2013.* Нові розкопки великого Трипільського поселення. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Pickartz, N., Hofmann, R., Dreibrodt, S., Rassmann, K., Shatilo, L., Ohlrau, R., Wilken, D. and Rabbel, W., 2019. Deciphering archeological contexts from the magnetic map: Determination of daub distribution and mass of Chalcolithic house remains. *The Holocene*, 29 (10), 1637–1652. Available from: https://doi.org/10.1177/0959683619857238

Rassmann, K., Korvin-Piotrovskiy, A., Videiko, M. and Müller, J., 2016. The new Challenge for Site Plans and Geophysics: Revealing the Settlement Structure of Giant Settlements by Means of Geomagnetic Survey. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE*. Themes in Contemporary Archaeology 2. London, New York: Routledge, 29–54. Available from: https://doi.org/10.4324/9781315630731

4. Geoarchaeological analyses on daub pieces from Maidanetske – A treatise on reconstructing burning temperatures of houses and daub processing

Stefan Dreibrodt, Sarah Martini, Robert Hofmann, Marta Dal Corso, Wiebke Kirleis, Johannes Müller

Abstract

44 pieces of daub from the giant Chalcolithic settlement site of Maidanetske, central Ukraine have been analyzed to infer about the burning process of the buildings and on daub processing. A comparison of the data with a large experimental burning experiment has revealed that the investigated domestic house was burnt at higher temperatures (750–850°C) than the communal building of a mega-structure (650–750°C). This could reflect different burning regimes, associated with varying amounts of fuel or different burning processes in general. The chemical composition of the studied daub pieces compared with the local soil imply a loss of clay during the processing in a presumably liquid phase, and an enhancement of phosphorus explainable by the addition of dung to the daub matrix.

Introduction

The analysis of burnt material from archaeological excavations has been carried out to infer about aspects of technology (architecture, ceramic/ metal processing), ancient environments (wood use and availability, cereal imprints) or ideology (ritual burning) to give some examples. The applied approaches varied between archaeological documentation and classification of the burnt material, added by varying analytical techniques. The latter comprise of color measurements (Munsell Scale, colour spectroscometry), neutron activation methods (NAA), XRay fluorescene (XRF), XRay diffractometry (XRD), Fourier transformed infrared analysis (FTIR), the characterization of the magnetic properties of the burnt material, or micromorphological studies (*e.g.* Peters *et al.* 2001; Maki *et al.* 2006; Berna *et al.* 2007; Nodarou *et al.* 2008; Mentzer 2014; Forget *et al.* 2015; Jordanova *et al.* 2019).

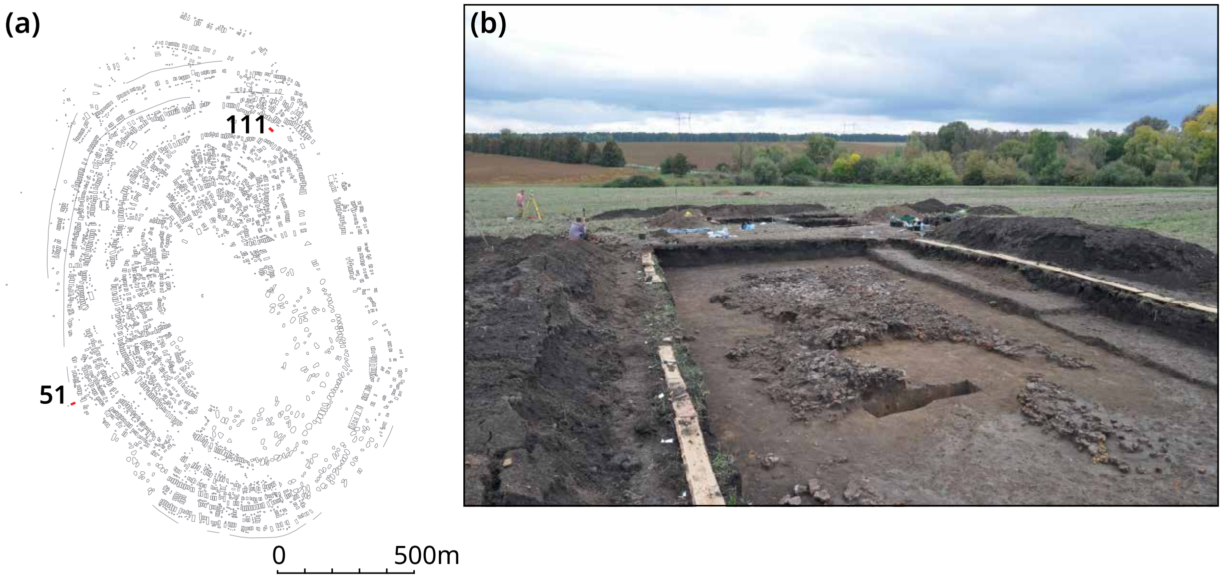


Figure 1. (a) location of the house remains sampled for daub analysis; (b) photograph of the archaeological record, note the dense daub layer in House 44 (Trench 51).

With increased numbers of magnetic maps from archaeological sites, attempts to infer about feature layout and daub masses based on magnetic signatures emerged (Pickartz *et al.* 2019). Additionally, burning experiments are carried out occasionally, to put the analytical data into a controlled context (*e.g.* Bankoff and Winter 1979; Stevanović 1997; Cotiguă 2009; Korvin-Piotrovskiy *et al.* 2012; Burdo *et al.* 2013). In the face of numerous burnt house remains from Neolithic and Chalcolithic sites across Eastern Europe, the question of intentional or unintentional burning has been highly debated among archaeologists during the past decades (*e.g.* Stevanović 1997; Cotiguă 2009; Lichter 2016).

In the presented study, we combined a multi-proxy analytical approach to infer about fire conditions and daub processing at two burnt houses of the Chalcolithic Giant settlement Maidanetske, central Ukraine.

Materials and methods

Site

The investigated giant Trypillia C1 Chalcolithic settlement site of Maidenetske (Müller *et al.* 2016; Müller *et al.* 2017; Hofmann *et al.* 2019) is located at in the district of Talne, central Ukraine (48°48′N, 30°38′E; Fig. 1). Archaeological sites of this type are unique because of their extremely large dimensions. At Maidanetske, on an area of 200 ha approximately 3000 houses arranged in a series of oval structures around an unbuilt central space were inhabited approximately from 3990 to 3640 BCE (*e.g.* Müller *et al.* 2016; Ohlrau 2020; Pickartz *et al.* 2019). Surveys of the many potshards present on the recent surface, magnetic surveys, excavations and exhaustive dating campaigns revealed that about 1500 houses were inhabited contemporaneously by probably 10,000 people (Ohlrau 2020; Pickartz *et al.* 2019). The climate in the region is humid continental (Dfb) today, with hot summers and cold, wet winters. The potential natural vegetation of the region belongs to the climate sensitive forest-steppe transition zone. Where there is no agricultural land use, deciduous forests are present in the landscape today. A mosaic of loess-covered plateaus dissected by small valleys characterizes the recent topography. The surface soils are classified as particularly thick Chernozems in the research area (Atlas of Soils of the Ukrainian SSR: Krupskovo and Polupana 1979).

Sampling

44 samples of daub from one domestic building (28) and one communal building (16) were taken in the field (Fig. 1) and documented according to their macroscopic properties and find situation (Tab. 1). According to macroscopical properties (discrete layering, colours, inclusions), the daub pieces were cut into subsamples. To produce synthetic daub pieces (bricklets) and study their properties reflecting different burning conditions, loess material from the site was taken (Profile 52). As organic temper, einkorn straw and chaff obtained at the archaeobotanical garden at AÖZA Albersdorf has been added.

Methods

For selected daub pieces, their density was estimated in a simple approach dividing their dry weight by the amount of water the daub pieces replaced (as a volume estimate).

Laboratory analysis was carried out after careful disintegration of the daub pieces (subsampled according to visible layering) with mortar and pestle on the air-dried <2 mm fraction.

The RGB-colours of the samples were determined in three replicates on a Voltcraft Plus RGB-2000 Colour Analyser set to display in a 10-bit RGB colour space (*e.g.* Rabenhorst *et al.* 2014; Sanmartín *et al.* 2014). Since RGB colours are internally highly correlated, these data were converted into Light Intensity, Hue, and Colour Saturation according to Viscarra Rossel *et al.* (2006).

The volume specific magnetic susceptibility was measured on three replicates of weighed 10 ml- samples using a Bartington MS2B susceptibility meter (resolution 2*10-6 SI, measuring range 1–9999*10-5 SI, systematic error 10%). Measurements were carried out at low (0.465 kHz) and high (4.65 kHz) frequency. A 1% Fe3O4 (magnetite) sample was measured regularly and the samples susceptibility values were calibrated using this standard before the mass specific susceptibility values were calculated. Mass specific magnetic susceptibility and frequency dependent magnetic susceptibility (Dearing 1999; Clark 1996) were calculated based on the weights of the 10 ml samples and the differences of low and high frequency susceptibilities. The total elemental contents of the samples were measured on a p-ed-xrf device (NITON XL3t 900-series) of Thermo Scientific Analysers. For p-ed-xrf measurements, first, the <2 mm fraction was ground in an Agate mill and placed in a plastic tube covered by a 4 µm thick film. These were then measured in a lead-mantled measurement chamber with He-flotation using the 'mining, Cu/Zn' settings for 300 s with the p-ed-xrf device. As the device has the ability to not just record quantitative elemental concentrations, but also reports measurement errors, all elements with >10% error were discarded from further analysis. The adjustment of the measurement conditions was carried out according to instructions given in previous papers (Lubos *et al.* 2016; Martini *et al.* 2019), that included a calibration of the p-ed-xrf measurements on a wd-xrf data set (Dreibrodt *et al.* 2017). As loess from Maidanetske and organic temper material from the archaeobotanical garden at AÖZA Albersdorf were used in an extensive burning experiment, the elemental content of components was measured with the p-ed-xrf, too. The loess was prepared in the same manner as described above. The organic temper material was burnt to ash at 550°C (2 h), the elemental contents were measured on the ash and converted into values of 105°C dry biomass. Since it was found to deliver an additional value, sensitive to the burning process in previous investigations (*e.g.* Khamnueva *et al.* 2018; Out *et al.* 2021) the content of dithionite soluble iron (Fed) was measured. This was carried out in a cold digestion process of the daub material (<2 mm) according to Blakemore *et al.* (1987) and the iron in the supernatant was measured on an Atomic Absorption Spectrometer. The mineral assemblage of daub pieces

sample number	find_id	material description	modification	Square	feature-id	level	remarks
1	51293		2013-16: 6 foamed clay	L-N/12-13	51004	4	
2	51366		2013-14: 7 without surfaces or imprints	J18	51003	4a	
3	51371		2013-16: 6 foamed clay	J13	51003	4a	
4	51372		2013-16: 6 foamed clay	K11	51003	4a	
5	51373		2013-14: 7 without surfaces or imprints	K11	51003	4a	
6	51373B		2013-14: 7 without surfaces or imprints	K11	51003	4a	
7	51378		2013-16: 6 foamed clay	L11	51003	4a	
8	51379		2013-14: 7 without surfaces or imprints	L11	51003	4a	
9	51386		2013-14: 7 without surfaces or imprints	L15	51003	4a	
10	51387		2013-14: 7 without surfaces or imprints	L16	51003	4a	
11	51390	organic tempered (chaff)	2016: 06 combination Splitwood + Splitwood	K15	51003	4a	
12	51391		2013-14: 7 without surfaces or imprints	I17	51003	4a	
13	51392		2013-14: 7 without surfaces or imprints	I17	51003	4a	
14	51393		2013-14: 7 without surfaces or imprints	I14	51003	4a	
15	51394		2013-14: 7 without surfaces or imprints	I13	51003	4a	
16	51395		2013-14: 7 without surfaces or imprints	H13	51003	4a	
17	51396		2013-16: 6 foamed clay	H13	51003	4a	
18	51400		2013-14: 7 without surfaces or imprints	H10	51003	4a	
19	51402		2013-14: 7 without surfaces or imprints	K15	51003	4a	
20	51409		2013-14: 7 without surfaces or imprints	J13	51009	4b	
21	51413		2013-14: 7 without surfaces or imprints	I12	51009	4b	
22	51416		2013-14: 7 without surfaces or imprints	I15	51009	4b	
23	51613		2013-14: 7 without surfaces or imprints	J17	51017	4b	
24	51613B		2013-14: 7 without surfaces or imprints	J17	51017	4b	
25	51615		Rounded edge of the podium	K15	51017	4b	
26	51617		burned daub with imprints	K11	51011	4b	
27	51620	compact (without chaff)	2016: 03 two plain surfaces	I12	51009	4b	
28	**53391**	**2 samples from house 17, no further information**					
29	1110515	organic tempered (chaff)	2016: 04 split wood	K22	111023		
30	1110517	organic tempered (chaff)	2016: 01 amorphous	M16	111019		
31	1110519	compact (without chaff)	2016: 02 plain surface	M16	111010		
32	1110634A	organic tempered (chaff)	2016: 02 plain surface	G6	111003		
33	1110634B	organic tempered (chaff)	2016: 02 plain surface	G6	111003		
34	1110636	compact (without chaff)	2016: 02 plain surface	G6	111010		
35	1110642	organic tempered (chaff)	2016: 07 Combination Splitwood + Plain Surface	M19	111019		
36	1110644	organic tempered (chaff)	2016: 01 amorph	G20	111020		

Table 1. Archaeological classification of the sampled daub pieces.

sample number	find_id	material description	modification	Square	feature-id	level	remarks
37	1110646	organic tempered (chaff)	2016: 02 plain surface	J10	111003		
38	1110648	compact (without chaff)	2016: 02 plain surface	J10	111010		
39	1111525	organic tempered (chaff)	2016: 02 plain surface	J13	111010		
40	1111526	compact (without chaff)	2016: 02 plain surface	J13	111025		
41	1111535A	organic tempered (chaff)	2016: 02 plain surface	F17	111017		Upper layer "a" oxidising crumbly light yellow material (7-10 mm thick)
42	1111535B	organic tempered (chaff)	2016: 02 plain surface	F17	111017		Lower layer "b" oxidised light orange to light red. Partly the material is bubbly slagged. Underside likely passive even [?]
43	1111574	organic tempered (chaff)	2016: 03 two plain surfaces	N6	111010		
44	1111575	compact (without chaff)	2016: 02 plain surface	N6	111010		

Table 1, continued.

was determined in ground powder samples using conventional xrd measurements (Siemens diffractometer, Cu-α radiation, 2 Theta 4–90°, step size 0.02, 1 s per step). Identification of mineral assemblages was carried out using d-spacings given in mineralogy textbooks (*e.g.* Brindley and Brown 1980).

Results

Daub experiment

Procedure

Prior to the daub experiment the components used were analysed to characterize their geochemical composition. The elemental composition of the loess is given in Chapter 5 (this work, Vol. I). The elemental composition of the studied cereal composition considered as reference for prehistoric organic temper material shows a certain variability. This might be related to different growing conditions (soils, seasonal weather) and differences in harvest stages. The highest concentrations in P are visible in the grains. Additional elements interesting for phytolith research as silica are found higher concentrated in the chaff and straw. Manuring effected the concentrations of nutritional elements. The chaff and straw of einkorn from the archaeobotanical garden Albersdorf were used as organic temper in the daub experiment.

Bricklets of daub were produced as following. A large sample of loess that originated from the base of exposure 52 was dried for 2 days at 40°C. Afterwards, the loess was sieved through a 2 mm mesh to remove stones and to homogenize the material. Chaff and straw of einkorn cultivated at archaeobotanical garden Albersdorf were used as organic temper material. The straw has been cut into pieces of c. 0.5 cm and was dried together with the husks at 40°C for two days prior to the experiment. The mass of daub material was mixed in a volumetric ratio of one to three (organic temper: mineral matter). Straw and chaff were added in a volumetric amount of one to one. About 480 ml of tab water were added while the mixing process to come out with a plastic mass of daub. After thorough mixing to ensure a high degree of homogeneity, the plastic daub mass was rolled into the form of a

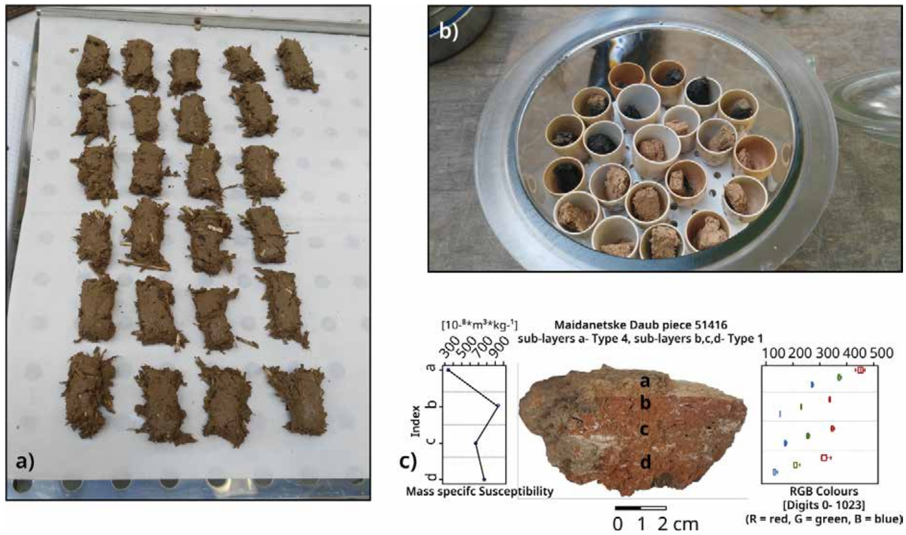


Figure 2. Selected photographs of daub analysis: (a) Bricklets after cutting the mineral-organic daub mass; (b) After burning and cooling in a desiccator; (c) example of one archaeological daub piece, indicating its sub-sampling (center) and measured values of mass specific magnetic susceptibility (left) and colours (right).

Location	Taxon	Component	Treatment	Elemental content ash [ppm] (value, SD)						
				Zn	Fe	Mn	Ca	K	P	Si
Albersdorf	Einkorn	grain	n.s.	1636, 23	1523, 47	887, 52	12692, 368	126425, 678	72521, 234	8504, 145
		straw*	n.s.	957, 27	12713, 201	3721, 129	110313, 1263	224852, 1319	30339, 151	261814, 869
		chaff*	n.s.	260, 12	3837, 84	b.d.l.	36969, 460	31379, 325	11536, 120	585776, 1758
		grain	n.m.	1533, 23	1187, 43	1029, 55	7881, 355	130403, 716	69707, 264	3262, 159
		chaff	n.m.	1079, 34	8373, 186	2555, 130	64623, 1077	214028, 1581	28622, 211	541395, 1368
Tuningen		chaff	n.s.	352, 86	3491, 96	b.d.l.	37520, 572	74480, 644	16234, 414	657760, 1667
Nice		straw	n.s.	b.d.l.	3541, 113	b.d.l.	54208, 663	99656, 713	7494, 91	580385, 1423
Albersdorf	Emmer	chaff	m.	1129, 48	6101, 221	4541, 229	89636, 1875	444759, 3300	81333, 422	410784, 968
Albersdorf	Barley	grain	m.	847, 16	1083, 38	b.d.l.	11006, 349	99656, 639	61141, 234	3178, 149
		grain	n.m.	629, 12	723, 30	b.d.l.	6395, 272	99072, 524	49881, 187	1508, 117
		chaff	m.	1309, 623	6898, 177	2383, 132	95709, 1571	362148, 2207	50441, 265	319251, 879
		chaff	n.m.	1087, 423	3541, 113	1448, 100	38173, 930	291127, 1839	41430, 243	453503, 1046

*Table 2. P-ed-xrf elemental contents measured in the ash (2h at 550°C) of cereal components, * used in the bricklet experiment as organic temper material, Treatments n.s. not specified, n.m. not manured, m. manured).*

c. 1 cm thick plate. 130 bricklet pieces of approximate size of 4 cm * 1.5 cm * 1 cm (x, y, z) were cut with a knife and dried at 40°C for one week.

After the drying process, replicates of the bricklets were burnt in a muffle furnace under different conditions (Tab. 4). Temperatures, duration of burning, and oxygen access were varied in the experiment. The latter was carried out by covering the bricklets by alumina foil during the burning process. All bricklets were dried at 105°C overnight before burning, and cooled to room temperature after burning in a desiccator. The latter resulted in a comparable, limited oxygen access during the cooling process, considered to result in a similar re-oxidation of magnetite to hematite (*e.g.* Le Borgne 1955; Le Borgne 1960), also realistic for field conditions of cooling of the collapsed burnt houses. Each variant of burnt bricklets comprised of at least three replicates.

Location	Taxon	Component	Treatment	LOI 550 (%)	SD (n=3)	Elemental content biomass [ppm] (105 °C dry)						
						Zn	Fe	Mn	Ca	K	P	Si
Albersdorf	Einkorn	grain	n.s.	92.35	0.87	125	116	68	971	9669	5546	650
		straw*	n.s.	97.65	0.37	22	299	88	2596	5292	714	6162
		chaff*	n.s.	84.08	0.72	41	611	b.d.l.	5884	4994	1836	93232
		grain	n.m.	88.34	n.d.	179	138	120	919	15209	8130	381
		chaff	n.m.	96.69	0.11	36	277	84	2136	7076	946	17899
Tuningen		chaff	n.s.	91.41	0.21	30	300	b.d.l.	3223	6398	1395	56505
Nice		straw	n.s.	90.2	0.12	b.d.l.	247	b.d.l.	5313	9767	734	56878
Albersdorf	Emmer	chaff	m.	95.92	0.25	46	249	185	3653	18126	3315	16742
Albersdorf	Barley	grain	m.	86.53	0.92	114	146	b.d.l.	1482	15665	8233	428
		grain	n.m.	87.55	n.d.	78	90	b.d.l.	795	12332	6209	188
		chaff	m.	96.24	0.15	49	259	90	3600	13623	1897	12010
		chaff	n.m.	95.6	0.16	48	156	64	1678	12799	1821	19938

*Table 3. Calculations of biomass elemental components (105°C dry) based on LOI550 values of the samples, * used in the bricklet experiment as organic temper material, Treatments n.s. not specified, n.m. not manured, m. manured, n.d. not determined).*

Exposition time (min)	550°C		650°C		750°C		850°C		940°C	
	ox	red	ox	red	ox	red	ox	red	ox	red
30	Analysis: Determination of colours (RGB), magnetic susceptibility, dithionite-citrate extractable iron, XRD									
60										
120										
240										

Table 4. Overview of the different treatments and analyses on experimental daub (bricklets).

Results of the daub experiment

Figure 3 gives main results of the experimental burning. The complete set of results is given in Appendix 1. Figure 3a shows that the bricklets expose significant changes in colour as a result of exposure to different temperatures for different times and under different burning conditions. For the sake of readability, bricklets burnt under limited/ unlimited oxygen access are addressed to have been burnt under reducing/ oxidizing conditions in the following, although we cannot amount the difference in oxygen access. Considering only the bricklets burnt under oxidizing conditions, the most important changes occurred in the green and blue spectra, whereas the reflectance in red stays at a similar level in all burning variants. Considering the bricklets burnt under reducing conditions, a rapid shift to lower reflectance values (darker) is visible for the samples burnt at 550°C and partly 650°C. This trend disappears or even inverses at temperatures >850°C, when the whole set of bricklets show similar colours. The duration of burning has no (oxidizing) or slight (reducing) unidirectional influence on the change of colours. The latter slight trend towards brighter colours after longer heating duration might indicate the collapse of the alumina foil used to cover the bricklets (visible in the 550°C timeline). Thus, the most pronounced changes in colour are observed under limited oxygen access and lower temperatures.

Figure 3b gives the result of dithionite soluble iron (Fed) standardized against the total iron content of the samples. Compared to the loess material, there is an overall

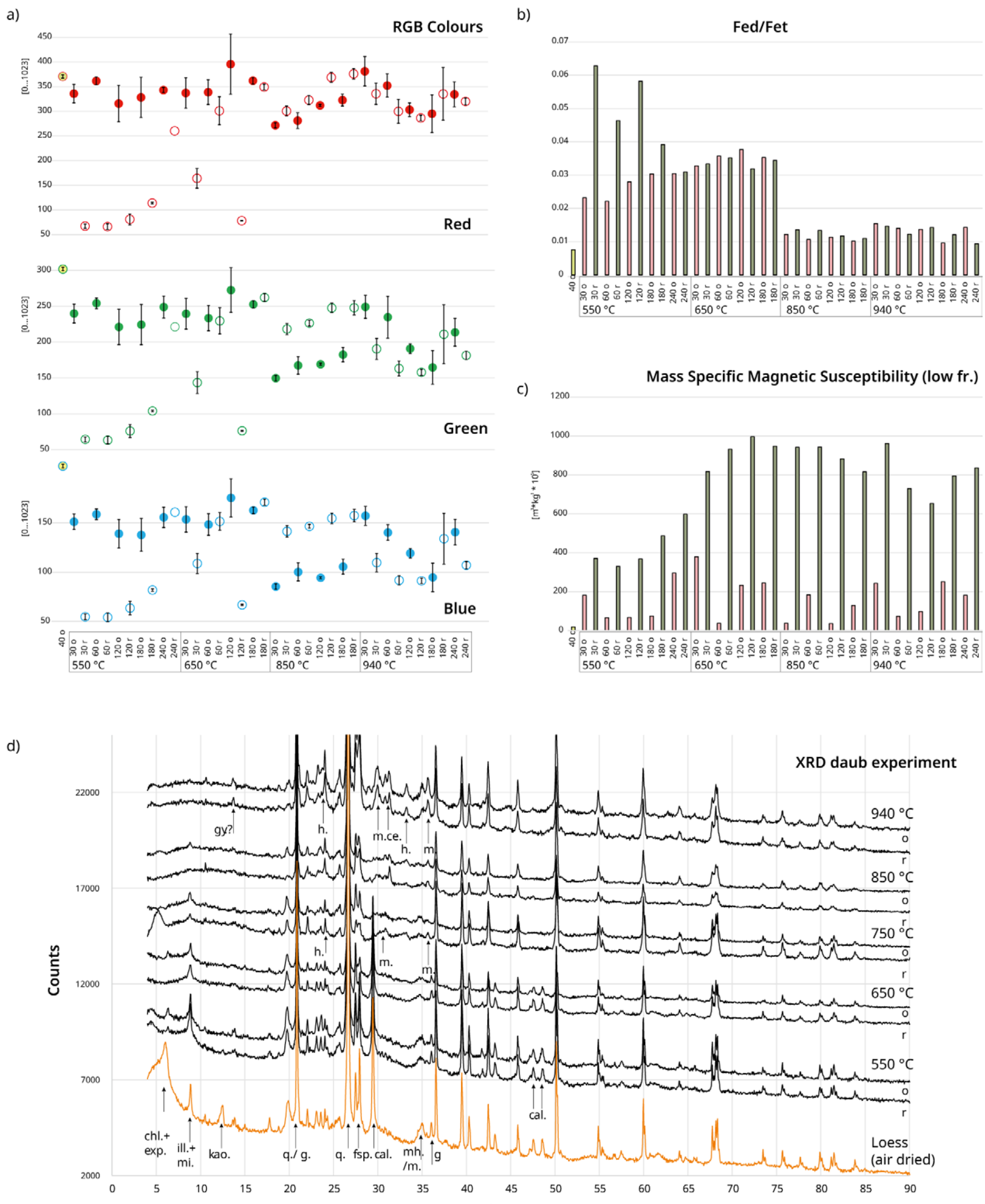


Figure 3. Results of geophysical and geochemical properties of the burning experiment. At the left side, unburnt bricklet values are given (a–c);
(a) RGB colours [0...1023], red, green, blue from top to bottom (oxidized burning- filled circles, reduce burning- open circles);
(b) Fed normalized against the total iron content (oxidized burning – red bars, reduce burning – brown bars);
(c) mass specific magnetic susceptibility (low frequency) (oxidized burning: red bars, reduce burning: brown bars);
(d) xr-diffractograms of the loess and bricklets burnt under oxidizing/ reducing condition for 120 min: chl. + exp. = chlorite + expandable clay minerals; ill. + m. = illite and muscovite; kao. = kaolinite; q. = quartz; g. = goethite; fsp. = feldspars; cal. = calcite; mh. = maghemite; m. = magnetite; h. = hematite; ce. = clinoenstatite; gy. = gypsum.

increase of Fed. At 550°C, a considerable difference between the reducing and oxidizing variants is visible. While the oxidizing samples rise in value with longer duration, the reducing lower. This is probably reflecting the more reducing conditions during the burning process, leading to higher amounts of meta-stable magnetite. The general increase is reflecting the transformation of sedimentary iron compounds (goethite, maghemite) into meta-stable forms ('meta-stable magnetite', hematite) by heating in the presence of organic material (*e.g.* Le Borgne 1955; Le Borgne 1960; Tite and Mullins 1971; Clark 1996). In the 650°C series, all variants reach similar, high values. By the change to 850°C, the values of Fed are all lower and stay at low level after heating to 940°C, too. The most pronounced step in dithionite soluble iron between 650°C and 850°C indicates the transformation of meta-stable iron components ('meta-stable magnetite') into other forms of minerals (magnetite, hematite).

Figure 3c shows the change in mass specific susceptibility as a result of different burning conditions. All bricklets show higher magnetic susceptibility after heating. There are great differences between the bricklets burnt under oxidizing and reducing conditions. After each temperature and duration of burning, the bricklet burnt under reducing conditions show considerably higher values than their oxidizing counterparts do. The absolute values are the lowest at 550°C, and reach high values at temperatures >650°C. At 550°C, a clear trend to increasing magnetic susceptibility values is visible with increasing duration of heating. The bricklets burnt under oxidizing conditions show a certain variability in all variants. A major change (increase) in magnetic susceptibility occurred under reducing conditions between 550°C and 650°C. That points towards magnetite formation during the burning process of organic material under limited oxygen access. Once the organic material has been oxidized completely (temperatures >550°C), no more magnetite (either 'meta-stable' below 850°C or stable above 850°C) is forming and thus magnetic susceptibility is not rising further. The relatively stable (high) magnetic susceptibility values of the bricklets burnt under reduced conditions at temperatures >650°C seen together with the clear decrease in dithionite soluble iron between 650°C and 850°C indicates a complete transformation of the 'meta-stable magnetite' into stable magnetite under the applied experimental conditions.

Figure 3d gives changes in mineral assemblage associated to different burning temperatures. Only samples exposed to heating for 120 min were measured, and a burning variant at 750°C was added. At the base, the loess used as mineral material for the bricklet production is shown. There, a mixture of quartz, feldspars calcite and some clay minerals (chlorite/ expandable clays, illite, kaolinite) and iron oxides (maghemite, magnetite, goethite) are present. After heating at 550°C, the kaolinite has disappeared and the chlorite/ expandable clays are largely reduced. At 650°C, the chlorite/ expandable clays have disappeared, and by 750°C small peaks of hematite and magnetite start to form, while in the same steps the calcite peaks disappear and the illite peaks weaken. At 850°C the illite has disappeared, hematite has grown and perhaps some clinoenstatite started to form. By 940°C hematite, clinoenstatite and magnetite form clearly detectable peaks. The changes of the mineral assemblage occur earlier under reduced conditions. The reflectance of increase in magnetite is visible (see the ratio between magnetite and hematite peaks) but less pronounced than in magnetic properties. A very small increase of magnetite (perhaps in the per Mille dimension) leads to an immense increase in magnetic susceptibility, but the xrd method is considered to be sensitive to changes of the mineral assemblage rather in the percentage dimension.

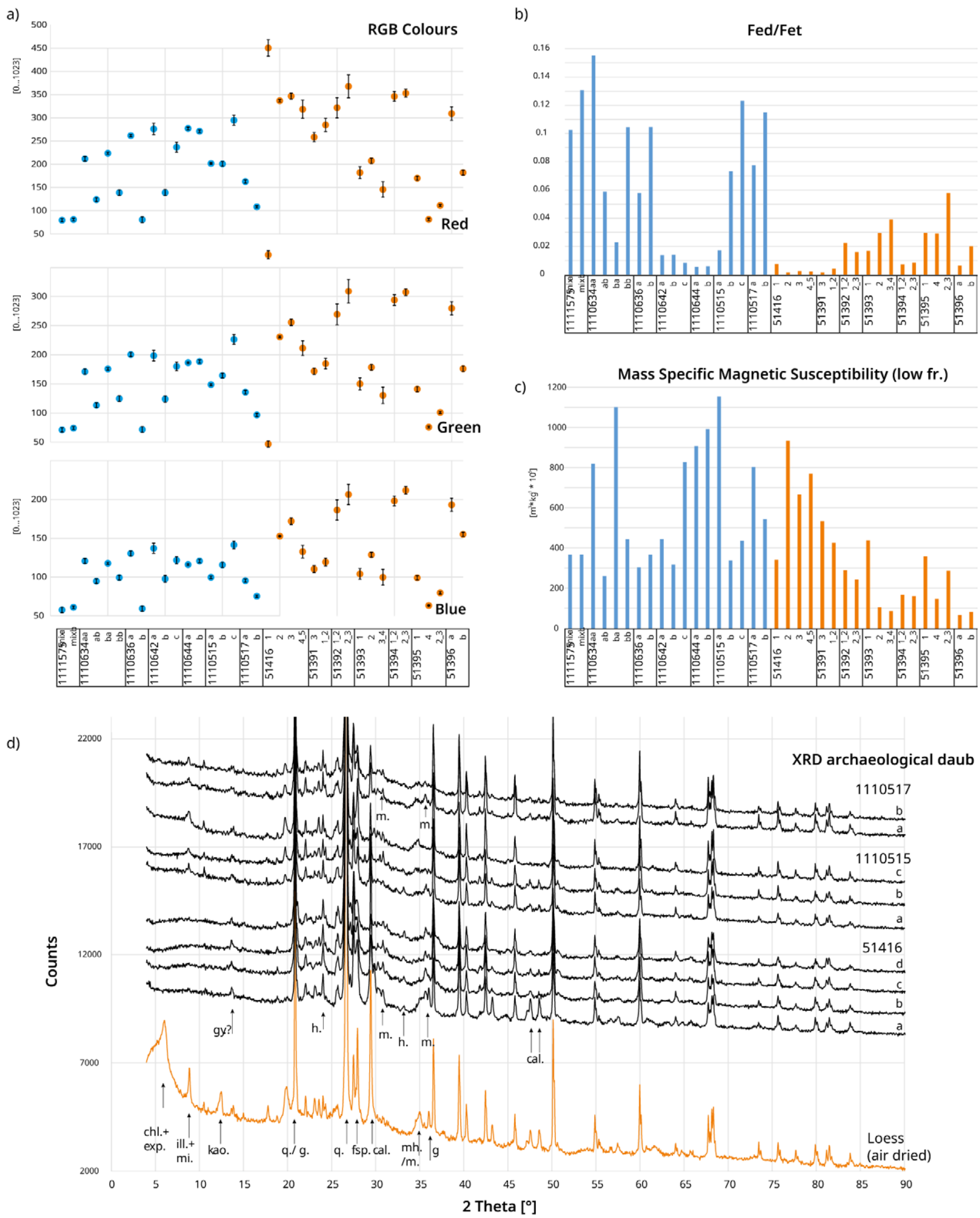


Figure 4. Results of geophysical and geochemical properties of the archaeological daub (communal building 3 – blue bars, domestic building 44 – orange bars);
(a) RGB colours [0...1023], red, green, blue from top to bottom;
(b) Fed normalized against the total iron content;
(c) mass specific magnetic susceptibility (low frequency);
(d) xr-diffractograms of the loess and selected daub pieces: chl. + exp. = chlorite + expandable clay minerals; ill. + m. = illite and muscovite; kao. = kaolinite; q. = quartz; g. = goethite; fsp. = feldspars; cal. = calcite; mh. = maghemite; m. = magnetite; h. = hematite; ce. = clinoenstatite; gy. = gypsum.

Results of archaeological daub analysis

Additionally, to the geochemical and geophysical analysis, for selected archaeological daub samples, their density has been estimated using their dry weight and volume estimations based on their water replacement (Appendix 2). The mean density of the daub pieces from Maidanetske equals 1.97 $g*cm^{-3}$ (SD 0.303, n=33). There are no significant differences between daub pieces from the communal building and daub pieces from the domestic house.

Geochemical and geophysical data of 14 daub pieces (seven from communal building 3 and domestic house 44) are given in Figure 4. The complete data set can be found in Appendix 2.

Figure 4a shows that the daub pieces exposed significantly different colours. An internal variability is also visible within sub-samples from the daub pieces. In the examples selected for the figure, the daub pieces from the communal building are darker than the ones from the domestic house. Compared to the bricklet experiment these darker communal building daub pieces are in similar range than the reducing variants of the lower temperatures (550–650°C).

Figure 4b gives the result of dithionite soluble iron (Fed) standardised against the total iron content of the samples. This standardisation eliminates possible influences of total iron on the amount extractable by the dithionite digestion. Except of two pieces, the daub from the communal building shows higher values of dithionite extractable iron compared to the daub pieces from the domestic house. The observed maximum values in the daub are considerably higher than the ones observed in the bricklet experiment, indicating a possible influence of postdepositional (pedogenic) processes providing a surplus of dithionite soluble iron. Apart from this shift to higher maximum values, the higher amounts of dithionite soluble iron parallels the observation of similarity of the communal building daub with bricklets burnt under reducing condition at lower temperatures (550–650°C). Within single daub pieces, a similar variability of dithionite soluble iron as in the colours is visible.

Figure 4c shows the mass specific susceptibility values of the archaeological daub pieces. The selected daub pieces from the communal building show higher low frequency mass specific susceptibilities than the selected pieces from the domestic house. The susceptibility values from the communal building are all in the range observed for the reduced variants in the bricklet experiment. The displayed samples from the domestic house show different values, much of them with lower susceptibilities.

Figure 4d compares the mineral assemblages of the loess and selected daub pieces. The general similarity of the overall main mineral spectrum indicates that prehistoric settlers used the local loess for daub production. All displayed daub pieces are free from kaolinite what implies burning temperatures >550°C. In the pieces from the communal building (1110517, 1110515), some illite/ muscovite survived the burning process, indicating temperatures <850°C. No illite/ muscovite is present in the sample from the domestic building (51416), where also hematite and magnetite are more clearly present. This indicates that the piece 5416 was exposed to higher temperatures. In addition to the aforementioned minerals, some calcite (not all sub-samples) and gypsum are present. Considering their instability at higher temperatures and their occurrence in the regional soils, a postdepositional (pedogenic) origin of these minerals is probable. While the whole data set (RGB colours, dithionite soluble iron, mass specific susceptibility, mineral assemblage) is used to infer about burning conditions of the analysed houses in a canonical correspondence analysis, calcite and gypsum occurrences in the daub pieces are disregarded in this statistic analysis.

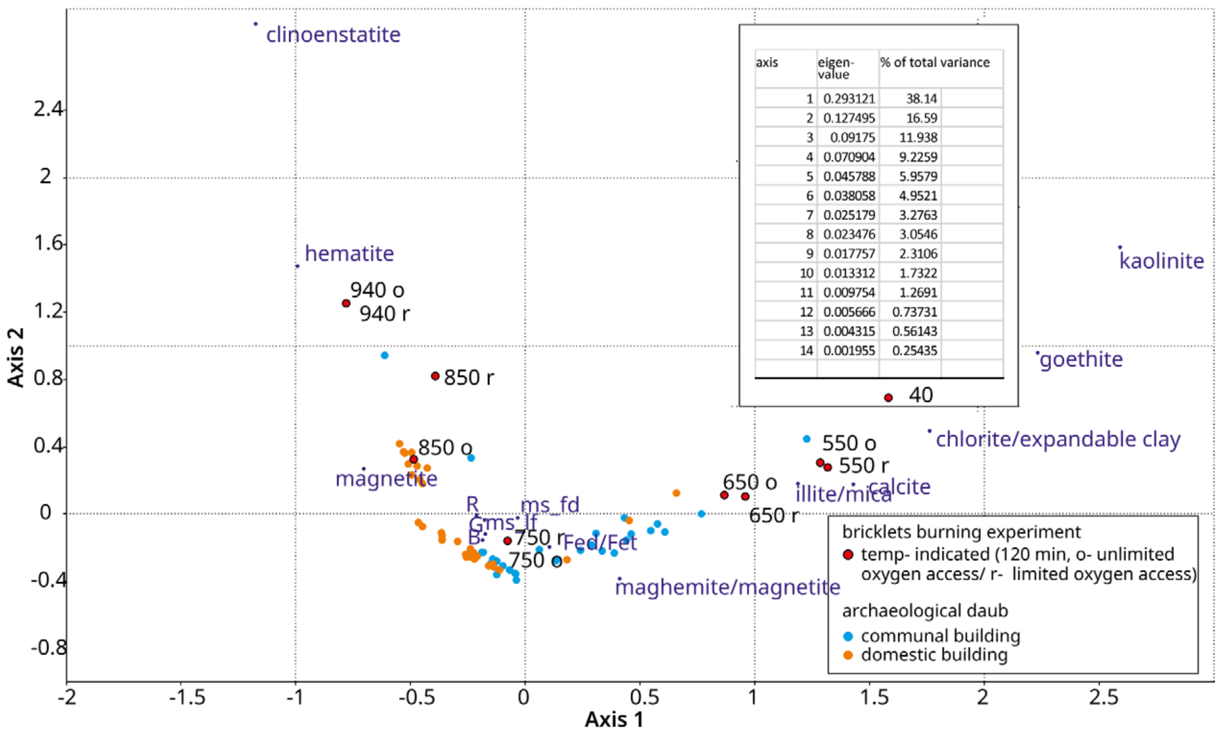


Figure 5. Joint CA plot (axis 1 and 2) of the results of the burning experiment (120 min modes) and the archaeological daub pieces. Considering the displayed variability of the bricklets reflects burning conditions, archaeological daub pieces were probably exposed to similar burning conditions.

Discussion and Interpretation

Daub and fire temperatures

A joint Correspondence Analysis (CA) has been carried out with the results (Fig. 5). There is a clear reflection of the burning temperatures by the clustering of the bricklets within the CA plot, mainly determined by the change of the mineral assemblage. This puts the archaeological daub pieces, assumable produced with the same material (loess from the site), into temperature ranges of between 550°C and 850°C. Furthermore, a difference is visible between the daub from the domestic house (51) burnt at higher temperatures (750°– 850°C), and the communal building (111) burnt at lower temperatures (650°–750°C).

Viewing the results of the CA separately indicating the investigated part of the burnt houses (Fig. 6) backs the results of temperature reconstruction. House parts considered to originate from house floors expose lower temperatures in both buildings. Daub pieces referred to origin form the wall expose rather higher temperatures.

The observed difference between the communal building and the domestic building indicate that these buildings burned down differently. This could reflect differences for fuel available during the fire and/or different burning processes. Whereas the former brings in the question if the compared buildings had a different shape/ architecture, the latter questions an assumed joint process of 'burning down the houses' in the same manner and thus, as a reflection of standardized ritual behaviour.

Daub processing

Some considerations on daub processing based on the geochemical composition of the studied soils and daub pieces are outlined in the following.

Figure 7 shows comparisons of the composition of the daub and the loess from Maidanetske. There are significant differences in the elements considered to reflect

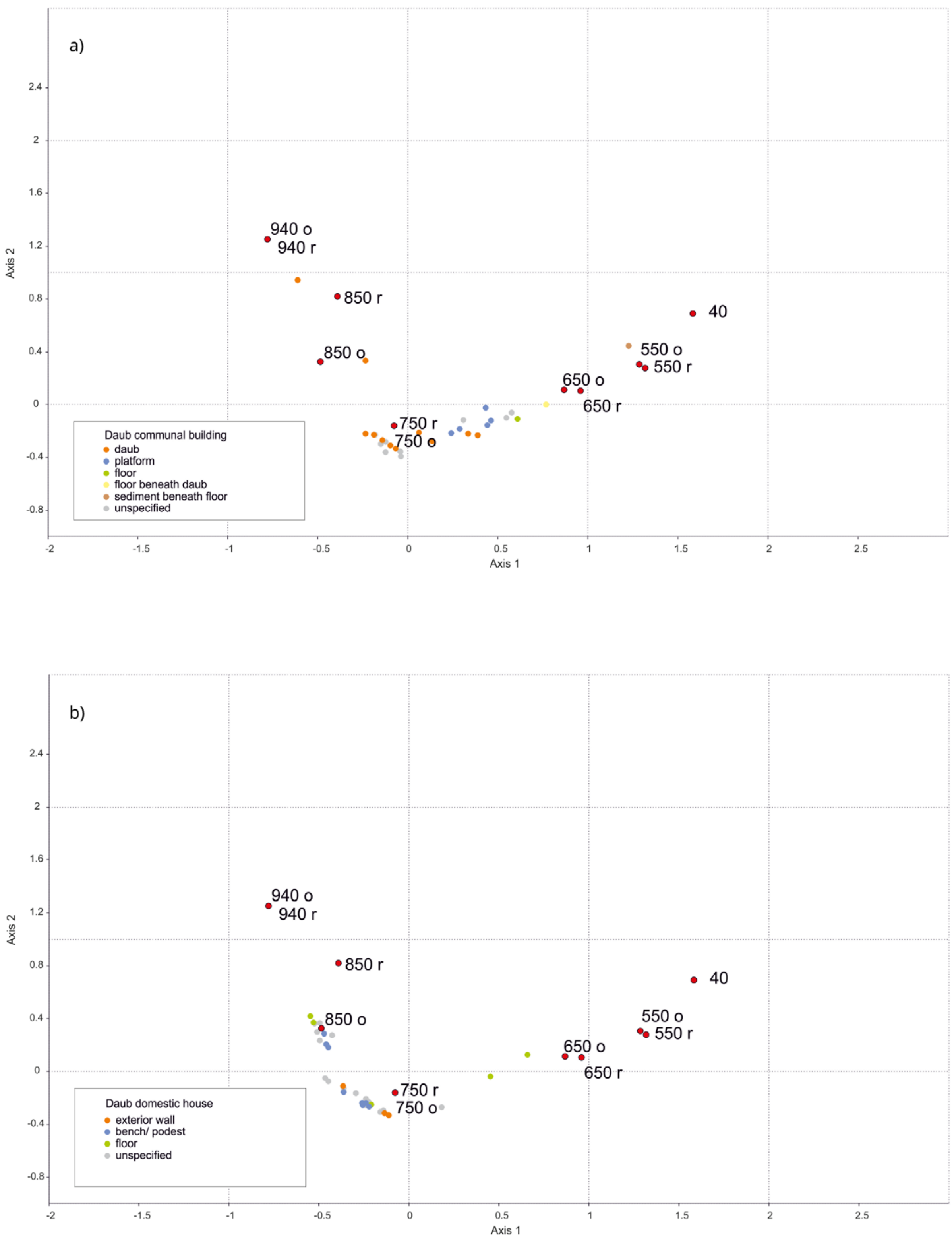
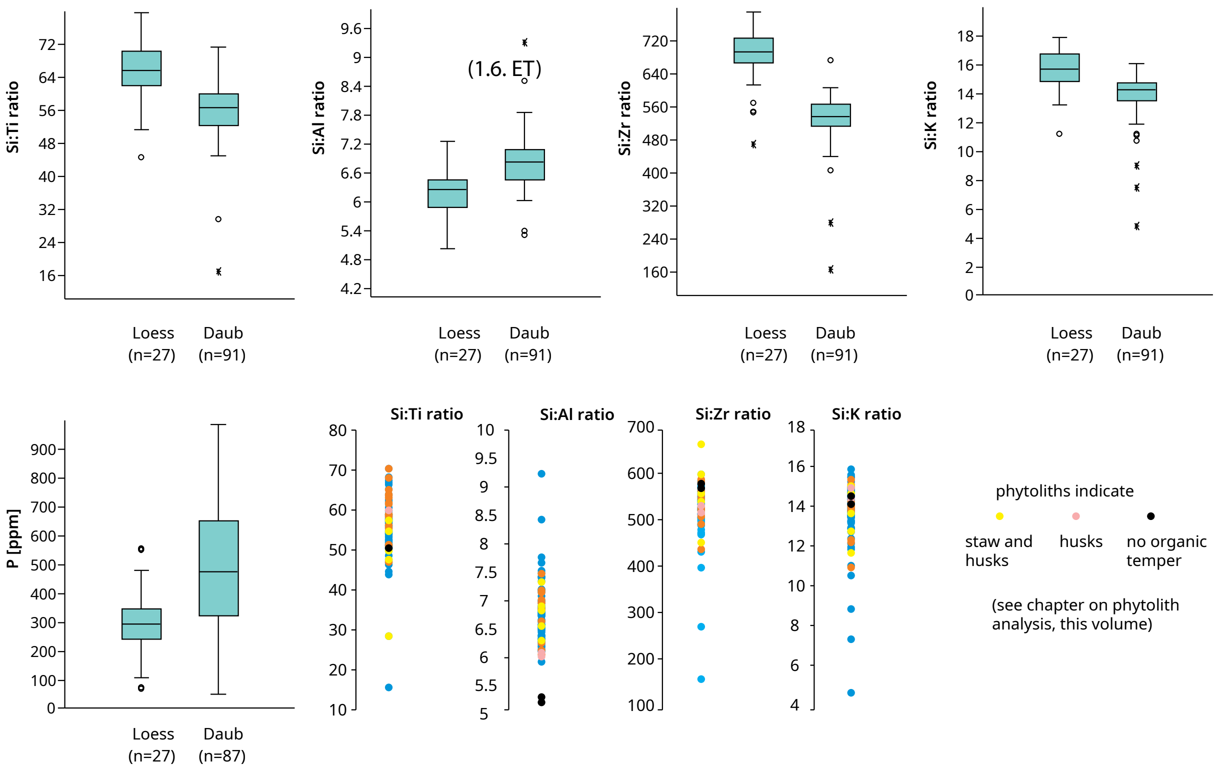


Figure 6. CA plots (axis 1 and 2) for (a) the communal building and (b) the domestic house separately, investigated parts of the house interior are indicated.



Material	Density	P	Si	P	Si	
	g*cm^{-3} (SD, n)	ppm (SD, n)		mg*cm^{-3}		
Loess	1.34 (0.09, 9)	145 (76, 27)	281723 (23292, 27)	0.19	378.2	P difference Daub- Loess: 0.74 mg*cm^{-3}
Daub	1.97 (0.30, 33)	447 (242, 91)	242776 (32211, 91)	0.93	478.3	...equals addition of 5.48 g Einkorn per 1 g Loess
Einkorn*	0.12 (0.04, 8)	1125 (483, 5)	46135 (34771, 5)	0.13	5.54	...leaves a gap in Si of 69.8 mg*cm^{-3} or ca. 70 %

Figure 7 (top). Comparison of boxplots of mean values of mineral elemental contents of daub and loess (upper part), phosphorus (lower left), and the components of organic temper in the daub identified via phytolith analysis (lower right).

*Table 5 (bottom). Calculation of phosphorus and silica contents in the daub compared to the loess and organic temper. *mean values for Einkorn chaff and straw from the garden plot in the Archaeological-Ecological Centre Albersdorf, AÖZA (105 °C dried overnight).*

the mineral components. In the boxplots comparing mean values of elemental ratios, Ti, Zr, and K are enriched in the daub relative to Si, the opposite is true for Al (upper part of the figure). Phosphorous is found to be enriched in the daub compared to the loess (lower left). The organic compartments detected in the daub in the form of phytoliths are displayed in the lower right part of the figure.

The enrichment of elements considered to reflect minerals as zirconium (Zr) or rutile, anatase, ilmenite (Ti) is more pronounced than the enrichment in K, present in feldspars, but also clay minerals of the illite/ mica group. This observation points towards the same direction as the depletion in Al. Together, they indicate a considerable depletion of clay minerals (the main source of Al on earth surface) in the daub compared to the loess. This could be explained by the loss of clay during a daub procedure in a liquid phase. During the mixing of mineral and organic components to produce the plastic daub mass, the clay becomes easily dispersed in the liquid phase, and is lost, when the daub is put onto walls or earthen installations (platforms *etc.*). Apart from Ti, Zr, and K, also Si is probably enriched as a result of the clay flotation, since its main source mineral quartz is present in large amounts in the loess and has a high density.

The enrichment of the daub in phosphorus could be considered further by integrating the elemental contents of the organic temper. The content of Si and

P of straw and chaff of einkorn (archaeobotanical garden at Albersdorf) given in Table 2 were used in the following to estimate if the amount of phosphorus added by plant temper could explain the P surplus of the daub at the site. Because of the very different densities of the compared components, the conversion of weight related elemental contents [ppm] into volume related [g*cm^{-3}] is necessary (Tab. 5).

Considering the outcome of the estimation it becomes clear, that the addition of cereal material as organic temper is not able to explain the P enrichment observed in the archaeological daub. Non-realistic high amounts of organic material would have to be added (about 5.5 g per one gram of loess), and a considerable lag in the silica content would result from that mixture. Whereas this is exemplified based on the einkorn chaff and straw from Albersdorf, it would also account for emmer or barley, mainly because of the given P/Si ratios in the organic remains. Thus, while the surplus Si in the daub compared to the loess is probably reflecting partly the addition of the phytolith rich organic material and partly the enrichment of quartz (Si) via the processing (see above), an additional source must exist for the phosphorous. This is very probably the addition of animal manure (excrements, urine) to the daub mass, known from archaeoethnological work.

References

Bankoff, H.A. and Winter, F.A., 1979. A house-burning in Serbia: What do burned remains tell an archaeologist? *Archaeology*, 32 (5), 8–14.

Berna, F., Behar, A., Shahack-Gross, R., Berg, J., Boaretto, E., Gilboa, A., Sharon, I., Shalev, S., Shilstein, S., Yahalom-Mack, N., Zorn, J.R. and Weiner, S., 2007. Sediments exposed to high temperatures: reconstructing pyrotechnological processes in Late Bronze and Iron Age Strata at Tel Dor (Israel). *Journal of Archaeological Science*, 34 (3), 358–373. Available from: https://doi.org/10.1016/j.jas.2006.05.011

Blakemore, L.C., Searle, P.L. and Daly, B.K., 1987. Methods for chemical analysis of soil. *New Zealand Soil Bureau Scientific Report*, 80. Available from: https://doi.org/10.7931/DL1-SBSR-80

Brindley, G.W. and Brown, G., 1980. *Crystal Structures of Clay Minerals and their X-Ray Identification.* Mineralogical Society of Great Britain and Ireland 5. London: Mineralogical Society.

Burdo, N., Videiko, M., Chapman, J. and Gaydarska, B., 2013. Houses in the Archaeology of the Tripillia-Cucuteni-Groups. *In*: D. Hofmann and J. Smyth, eds. *Tracking the Neolithic house in Europe. Sedentism, Architecture, and Practice*. One World Archaeology. New York: Springer, 95–115. Available from: https://doi.org/10.1007/978-1-4614-5289-8_5

Clark, A., 1996. *Seeing Beneath the soil: Prospecting Methods in Archaeology*, 2nd ed. London: Batsford.

Cotiugă, V., 2009. Experimental Archaeology: the burning of the Chalcolithic Dwellings. *In*: V. Cotiugă, F.A. Tencariu and G. Bodi, eds. *Itinera in praehistoria. Studia in honorem magistri Nicolae Ursulecu quinto et sexagesimo anno*. Iași: Editura Universității “Alexandru Ioan Cuza”, 303–342.

Dearing, J., 1999. *Environmental Magnetic Susceptibility: Using the Bartington MS2 System*, 2nd ed. Bartington Instruments. Available from: https://bartingtondownloads.com/wp-content/uploads/OM0409.pdf

Dreibrodt, S., Furholt, M., Hofmann, R., Hinz, M. and Cheben, I., 2017. P-ed-XRF-geochemical signatures of a 7300 year old Linear Band Pottery house ditch fill at Vráble-Ve’lké Lehemby, Slovakia – House inhabitation and post-depositional processes. *Quaternary International*, 438, 131–143. Available from: https://doi.org/10.1016/j.quaint.2017.03.054

Forget, M.C.L., Regev, L., Friesem, D.E. and Shahack-Gross, R., 2015. Physical and mineralogical properties of experimentally heated chaff-tempered mud bricks: Implications for reconstruction of environmental factors influencing the appearance of mud bricks in archaeological conflagration events. *Journal of Archaeological Science: Reports*, 2, 80–93. Available from: https://doi.org/10.1016/j.jasrep.2015.01.008

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Jordanova, N., Jordanova, D., Barrón, V., Lesigyarski, D. and Kostadinova-Avramova, M., 2019. Rock-magnetic and color characteristics of archaeological samples from burnt clay from destructions and ceramics in relation to their firing temperature. *Archaeological and Anthropological Sciences*, 11, 3595–3612. Available from: https://doi.org/10.1007/s12520-019-00782-y

Khamnueva, S., Mieth, A., Dreibrodt, S., Out, W.A., Madella, M. and Bork, H.-R., 2018. Interpretation of prehistoric reddish pit fillings on Easter Island: A micromorphological perspective. *Spanish Journal of Soil Science*, 8 (2), 236–257. Available from: https://doi.org/10.3232/SJSS.2018.V8.N2.07

Korvin-Piotrovskiy, A.G., Chabanyuk, V. and Shatilo, L., 2012. Tripolian House Construction: Concepts and Experiments. *In*: F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture Giant-Settlements in Ukraine. Formation, Development and Decline*. Oxford: Oxbow Books, 210–229. Available from: https://doi.org/10.2307/j.ctvh1dvmn.14

Krupskovo and Polupana 1979: Крупского, Н.К. and Полупана, Н.И., eds., 1979. Атлас почв Украинской ССР. Киев: Урожай.

Le Borgne, E., 1955. Susceptibilité magnétique anormale du sol superficiel. *Annales de Géophysique*, 11, 399–419.

Le Borgne, E., 1960. Influence du feu sur les propriétés magnétiques du sol et sur celles du schiste et du granite. *Annales de Géophysique*, 16, 159–195.

Lichter, C., 2016. Burning Down the House – Fakt oder Fiktion? *In*: K. Bacvarov and R. Gleser, eds. *Southeast Europe and Anatolia in prehistory: Essays in Honor of Vassil Nikolov on his 65th anniversary*. Universitätsforschungen zur prähistorischen Archäologie 293. Bonn: Dr. Rudolf Habelt, 305–317.

Lubos, C., Dreibrodt, S. and Bahr, A., 2016. Analysing spatio-temporal patterns of archaeological soils and sediments by comparing pXRF and different ICP-OES extraction methods. *Journal of Archaeological Science: Reports*, 9, 44–53. Available from: https://doi.org/10.1016/j.jasrep.2016.06.037

Maki, D., Homburg, J.A. and Brosowske, S.D., 2006. Thermally activated mineralogical transformations in archaeological hearths: inversion from maghemite Fe2O4 phase to haematite Fe2O4 form. *Archaeological Prospection*, 13 (3), 207–227. Available from: https://doi.org/10.1002/arp.277

Martini, S.J., Athanassov, B., Frangipane, M., Rassmann, K., Stockhammer, P.W. and Dreibrodt, S., 2019. A budgeting approach for estimating matter fluxes in archaeosediments, a new method to infer site formation and settlement activity: Examples from a transect of multi-layered Bronze Age settlement mounds. *Journal of Archaeological Science: Reports*, 26, 101916. Available from: https://doi.org/10.1016/j.jasrep.2019.101916

Mentzer, S.M., 2014. Microarchaeological Approaches to the Identification and Interpretation of Combustion Features in Prehistoric Archaeological Sites. *Journal of Archaeological Method and Theory*, 21, 616–668. Available from: https://doi.org/10.1007/s10816-012-9163-2

Müller, J., Rassmann, K. and Videiko, M., eds., 2016. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site / Майданецьке 2013. Нові розкопки великого Трипільського поселення*. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Nodarou, E., Frederick, C. and Hein, A., 2008. Another (mud)brick in the wall: scientific analysis of Bronze Age earthen construction materials from East Crete. *Journal of Archaeological Science*, 35 (11), 2997–3015. Available from: https://doi.org/10.1016/j.jas.2008.06.014

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Out, W.A., Mieth, A., Pla-Rabés, S., Madella, M., Khamnueva-Wendt, S., Langan, C., Dreibrodt, S., Merseburger, S. and Bork, H.-R., 2021. Prehistoric pigment production on Rapa Nui (Easter Island), c. AD 1200-1650: New insights from Vaipú and Poike based on phytoliths, diatoms and ^{14}C dating. *The Holocene*, 31 (4), 592–606. Available from: https://doi.org/10.1177/0959683620981671

Peters, C., Church, M.J. and Mitchell, C., 2001. Investigation of fire ash residues using mineral magnetism. *Archaeological Prospection*, 8 (4), 227–237. Available from: https://doi.org/10.1002/arp.171

Pickartz, N., Hofmann, R., Dreibrodt, S., Rassmann, K., Shatilo, L., Ohlrau, R., Wilken, D. and Rabbel, W., 2019. Deciphering archeological contexts from the magnetic map: Determination of daub distribution and mass of Chalcolithic house remains. *The Holocene*, 29 (10), 1637–1652. Available from: https://doi.org/10.1177/0959683619857238

Rabenhorst, M.C., Schmehling, A., Thompson, J.A., Hirmas, D.R., Graham, R.C. and Rossi, A.M., 2014. Reliability of Soil Color Standards. *Soil Science Society of America Journal*, 79 (1), 193–199. Available from: https://doi.org/10.2136/sssaj2014.10.0401

Sanmartín, P., Chorro, E., Vázquez-Nion, D., Martínez-Verdú, F.M. and Prieto, B., 2014. Conversion of a digital camera into a non-contact colorimeter for use in stone cultural heritage: The application case to Spanish granites. *Measurement*, 56, 194–202. Available from: https://doi.org/10.1016/j.measurement.2014.06.023

Stevanović, M., 1997. The Age of Clay: The Social Dynamics of House Destruction. *Journal of Anthropological Archaeology*, 16 (4), 334–395. Available from: https://doi.org/10.1006/jaar.1997.0310

Tite, M.S. and Mullins, C., 1971. Enhancement of the magnetic susceptibility of soils on archaeological sites. *Archaeometry*, 13 (2), 209–219. Available from: https://doi.org/10.1111/j.1475-4754.1971.tb00043.x

Viscarra Rossel, R.A., Minasny, B., Roudier, P. and McBratney, A.B., 2006. Colour Space Models for Soil Science. *Geoderma*, 133 (3–4), 320–337. Available from: https://doi.org/10.1016/j.geoderma.2005.07.017

Appendices

Appendix 1: Dataset of results from geochemical and geophysical analyses on experimental daub pieces. Cf. Figure 3.

T	Time	oxgen	colors						magnetic susceptibility			Fed		
°C	min	access	R avrg	S	G avrg	S	B avrg	S	mean m lf	S	mean m hf	S	freq dep	mg/kg
40	0	O	348,07	22,22	295,39	17,96	214,46	14,20	17,20	1,83	17,18	2,60	0,06	259,125
550	30	O	335,78	18,67	240,78	13,50	151,00	7,88	156,69	86,19	138,38	74,67	11,68	1213,5
550	60	O	361,44	7,99	255,22	7,65	158,56	5,36	58,36	20,32	51,61	19,29	11,57	1174
550	120	O	315,67	37,02	221,78	25,00	138,89	14,51	55,58	22,97	49,30	19,98	11,30	1475,5
550	180	O	328,22	40,84	225,00	28,49	137,67	16,56	74,81	25,85	67,68	22,73	9,53	1822,5
550	240	O	343,11	5,27	250,00	15,62	155,44	10,36	187,15	70,04	166,45	62,36	11,06	1856
650	30	O	337,11	31,02	240,33	21,70	153,44	12,83	380,55	70,73	338,67	61,60	11,00	1522
650	60	O	338,78	24,88	234,33	17,95	148,22	10,88	44,71	7,72	39,82	6,98	10,94	1632
650	120	O	395,56	61,04	274,00	31,66	175,11	19,39	295,71	66,25	264,89	59,25	10,42	1720
650	180	O	362,00	6,57	253,78	5,42	162,56	3,42	244,77	26,45	218,72	23,67	10,64	1611,333
850	30	O	271,67	5,20	149,22	4,03	85,22	2,83	37,85	1,30	35,00	1,14	7,52	555,75
850	60	O	281,11	15,99	167,22	12,48	100,22	9,34	183,29	54,72	163,69	48,65	10,70	487
850	120	O	312,00	2,00	168,89	1,64	94,22	1,02	36,41	0,82	33,89	0,70	6,92	517
850	180	O	322,67	12,00	182,44	10,22	105,56	7,53	129,51	24,50	115,41	21,32	10,89	464,25
940	30	O	381,00	29,87	250,22	16,25	157,00	9,61	200,15	61,41	178,92	53,89	10,60	704,5
940	60	O	352,22	23,52	235,56	29,73	140,11	7,95	40,09	7,13	36,64	7,52	8,61	640
940	120	O	303,22	13,80	191,00	6,89	119,11	4,86	48,63	9,48	43,54	9,28	10,47	624
940	180	O	295,11	38,24	164,44	23,90	94,56	14,53	251,34	52,66	223,11	45,34	11,23	440
940	240	O	334,33	25,36	214,11	19,57	140,44	13,00	117,36	33,93	104,58	30,11	10,89	653
550	30	R	67,33	4,18	62,56	3,50	54,67	2,85	244,73	77,09	219,76	70,78	10,20	2779
550	60	R	66,33	5,86	61,33	5,29	54,11	4,55	234,16	33,68	212,32	30,60	9,33	2376
550	120	R	81,11	11,10	74,33	9,13	63,44	6,77	238,91	17,98	215,00	16,41	10,01	2672
550	180	R	114,00	1,73	102,67	1,15	81,67	1,15	487,77	108,60	442,30	93,24	9,32	1788
550	240	R	260,33		222,00		160,67		448,11	103,67	397,77	92,80	11,23	1655,5
650	30	R	164,11	19,76	142,89	15,51	108,78	10,19	853,07	28,42	753,67	23,85	11,65	1502
650	60	R	301,06	28,40	230,33	18,53	151,39	8,89	853,07	28,42	753,67	23,85	11,65	1606,4
650	120	R	78,33	0,58	74,67	0,58	66,67	0,58	591,25	303,58	526,57	260,63	10,94	1456
650	180	R	349,22	5,87	263,33	5,49	170,78	3,08	947,91	88,55	833,82	69,80	12,04	1571
850	30	R	300,56	9,97	218,78	7,88	141,33	5,93	941,76	17,67	838,40	16,46	10,98	619
850	60	R	322,78	9,03	227,11	4,03	146,44	1,92	942,07	11,72	836,74	10,64	11,18	611,75
850	120	R	368,89	10,01	248,67	6,77	154,44	5,34	882,10	26,57	781,52	23,51	11,40	535
850	180	R	376,00	10,59	249,00	10,17	157,22	6,35	816,31	28,10	720,26	25,25	11,77	502,25
940	30	R	335,56	21,53	190,56	14,84	109,67	9,33	616,33	69,75	543,15	61,71	11,87	668,5
940	60	R	300,00	24,34	162,89	10,69	91,56	4,74	518,53	77,87	455,64	68,50	12,13	559,5
940	120	R	286,44	5,74	157,44	4,35	91,00	2,65	381,32	42,07	335,34	35,27	12,06	652,5
940	180	R	335,33	53,37	211,33	41,79	133,89	25,72	795,57	40,81	702,62	39,91	11,68	552
940	240	R	320,00	7,22	181,44	5,68	107,11	3,67	519,76	84,47	457,16	76,25	12,05	428

Appendix 2: Dataset of results from geochemical and geophysical analyses on 14 archaeological daub pieces (seven from a communal building, seven from a domestic house). Cf. Figure 4.

Sample ID	Find No.	Structure	ID	Colors						Magnetic susceptibility			Fed		
				Red	S	Green	S	Blue	S	LF MS	S	HF MS	S	Freq dep	mg/kg
1110515a	1110515	mega	1	201,67	1,53	148,67	1,53	99,67	1,53	1154,18	4,39	1054,94	9,41	8,60	480,5
1110515b	1110515	mega	1	200,67	5,13	164,33	4,04	115,67	3,21	337,85	1,29	309,64	1,12	8,35	2040
1110515c	1110515	mega	1	294,67	10,60	226,33	8,50	141,33	5,03	435,91	8,90	389,42	7,43	10,66	3580
1110517a	1110517	mega	2	162,67	3,51	135,67	3,21	95,33	2,08	802,61	5,22	750,86	16,08	6,45	2240
1110517b	1110517	mega	2	108,33	2,52	96,67	2,52	75,33	1,53	544,05	20,51	501,62	20,68	7,81	3136
1110519a	1110519	mega	3	246,00	4,36	194,00	3,46	128,33	3,06	414,47	1,38	374,55	1,34	9,63	1001,5
1110519b	1110519	mega	3	89,67	7,02	80,00	6,56	65,00	4,58	282,96	2,88	258,70	2,62	8,57	1462
1110634Aa	1110634A	mega	4	211,67	4,93	171,00	4,36	120,67	3,21	818,30	12,60	743,55	12,21	9,14	4252
1110634Ab	1110634A	mega	4	124,00	4,36	113,33	4,04	94,67	2,89	260,32	2,37	241,29	2,82	7,31	1597
1110634Ba	1110634B	mega	5	223,67	2,08	175,67	2,08	117,67	1,15	1101,07	3,49	1015,77	2,96	7,75	615,5
1110634Bb	1110634B	mega	5	139,00	6,24	124,67	5,13	99,33	3,06	444,02	3,72	406,36	3,19	8,48	2792
1110636a	1110636	mega	6	261,67	2,52	200,33	3,51	130,33	3,21	303,22	1,81	271,88	1,17	10,34	1557
1110636b	1110636	mega	6	80,67	6,03	71,67	5,03	59,33	3,51	366,54	7,10	332,41	3,03	9,28	2728
1110642a	1110642	mega	7	276,00	12,17	198,33	9,07	137,00	6,56	444,36	2,88	423,18	1,57	4,76	395,5
1110642b	1110642	mega	7	139,00	6,56	124,00	5,57	97,67	4,51	316,82	0,54	284,23	0,63	10,29	403,5
1110642c	1110642	mega	7	236,67	11,02	180,00	7,55	121,67	4,73	827,69	12,64	766,78	11,00	7,36	247
1110644a	1110644	mega	8	277,00	3,00	186,33	1,15	116,00	1,00	907,36	12,58	847,23	10,78	6,63	161
1110644b	1110644	mega	8	271,00	3,00	188,33	2,89	120,67	2,31	992,26	6,72	916,61	5,41	7,62	178
1110646a	1110646	mega	9	264,33	6,51	182,67	5,51	115,33	3,06	1148,60	14,22	1048,57	14,58	8,71	130
1110646b	1110646	mega	9	185,67	8,62	145,67	7,02	99,00	5,57	852,50	7,10	778,16	8,79	8,72	1481
1110648mixa	1110648	mega	10	306,00	14,73	241,67	11,06	152,67	5,51	1056,94	2,73	942,14	3,50	10,86	4450
1110648mixb	1110648	mega	10	251,33	9,45	194,67	7,37	126,67	3,79	518,60	7,70	461,36	6,03	11,04	3370
1111525mixa	1111525	mega	11	152,67	5,03	132,67	4,93	100,33	3,06	324,78	2,81	294,84	2,22	9,22	1832
1111525mixb	1111525	mega	11	229,00	6,24	193,33	4,62	136,67	3,21	522,08	3,27	468,61	2,57	10,24	2264
1111526mixa	1111526	mega	12	108,00	8,89	96,33	8,50	78,33	7,57	290,50	0,77	264,27	0,26	9,03	2174
1111526mixb	1111526	mega	12	100,00	6,24	88,00	5,57	71,33	4,04	218,41	0,96	200,53	0,94	8,18	2508
1111535Aa	1111535A	mega	13	278,33	5,69	240,00	5,20	170,00	3,61	288,40	7,48	281,18	7,22	2,50	535
1111535Ab	1111535A	mega	13	211,00	4,58	165,00	2,65	113,00	1,73	443,08	7,64	429,63	6,77	3,03	922,5
1111535Ac	1111535A	mega	13	208,67	8,50	192,00	7,55	158,33	6,03	199,50	3,87	185,77	4,73	6,89	2672
1111535Ad	1111535A	mega	13	208,67	4,51	154,00	3,00	99,67	1,53	523,05	4,41	505,44	4,19	3,37	262
1111535Ae	1111535A	mega	13	185,33	9,50	155,67	7,64	113,33	5,13	437,32	18,30	405,61	16,19	7,25	687
1111535Ba	1111535B	mega	14	297,00	4,58	202,33	1,53	125,00	1,00	1267,82	4,35	1150,76	4,87	9,23	1193
1111535Bb	1111535B	mega	14	227,00	5,57	170,33	4,04	113,67	2,31	1151,11	0,28	1053,60	1,76	8,47	2260
1111574mixa	1111574	mega	15	195,33	2,31	157,67	2,08	111,00	2,00	523,06	1,31	483,08	0,97	7,64	342
1111574mixb	1111574	mega	15	186,33	5,86	154,00	3,61	111,00	2,65	349,66	5,74	327,46	4,68	6,35	1027,5
1111575mixa	1111575	mega	16	79,67	3,21	71,00	3,61	57,67	3,51	367,04	1,25	336,34	7,11	8,36	2836
1111575mixb	1110575	mega	16	81,00	2,65	74,00	2,65	61,00	1,73	367,39	1,09	329,48	0,73	10,32	3406
51293mix	51293	house	1	140,00	26,46	136,00	24,76	118,33	21,73	29,09	1,97	28,56	1,89	1,82	n.d.

Sample ID	Find No.	Structure	ID	Colors						Magnetic susceptibility				Fed	
				Red	S	Green	S	Blue	S	LF MS	S	HF MS	S	Freq dep	mg/kg
51366mixa	51366	house	2	217,33	9,45	157,33	8,39	107,33	5,86	358,34	23,69	350,73	23,11	2,12	138
51366mixb	51366	house	2	226,67	9,29	159,67	4,93	105,67	3,21	294,79	31,90	284,29	30,03	3,55	140,5
51371a	51371	house	3	210,00	1,73	140,00	1,00	106,33	0,58	133,91	1,39	126,34	1,22	5,65	n.d.
51371b	51371	house	3	85,00	1,00	81,00	1,00	75,00	0,00	462,41	3,41	459,41	3,43	0,65	n.d.
51371c	51371	house	3	210,00	9,64	202,67	9,29	168,33	6,43	78,19	1,51	76,99	1,44	1,54	n.d.
51371d	51371	house	3	186,67	3,51	178,00	3,61	159,00	3,61	146,35	1,01	144,20	0,92	1,46	n.d.
51371e	51371	house	3	172,67	7,09	132,67	4,51	107,00	3,00	194,01	3,18	187,73	3,15	3,24	n.d.
51372mixa	51372	house	4	218,67	1,53	210,00	1,00	182,33	1,15	48,71	1,44	46,67	1,13	4,18	n.d.
51372mixb	51372	house	4	203,00	5,57	196,67	5,03	175,00	4,58	60,71	2,63	56,97	2,19	6,15	n.d.
51373a	51373	house	5	238,67	15,95	218,33	13,58	167,33	9,45	126,55	0,84	121,65	0,86	3,87	n.d.
51373b	51373	house	5	210,00	6,24	203,67	6,11	183,00	6,00	47,19	0,52	46,65	0,54	1,16	n.d.
51373c	51373	house	5	184,33	27,54	179,33	26,01	157,67	23,50	15,87	0,33	15,77	0,38	0,61	n.d.
51373Bmixa	51373B	house	6	142,33	15,89	129,00	13,86	110,67	10,97	252,89	0,73	245,66	0,94	2,86	n.d.
51373Bmixb	51373B	house	6	145,00	13,89	127,67	11,02	103,67	7,51	281,64	0,86	272,39	1,34	3,28	n.d.
51378a	51378	house	7	186,00	5,57	145,00	5,57	102,67	4,16	392,13	1,82	384,18	3,11	2,03	204,5
51378b	51378	house	7	276,67	2,08	241,33	2,31	164,67	2,08	117,40	1,93	112,30	2,11	4,35	129,5
51378c	51378	house	7	124,67	2,08	115,00	1,73	100,00	1,00	97,62	0,67	94,90	0,82	2,79	108,5
51379mixa	51379	house	8	419,00	37,51	329,67	31,66	223,33	22,37	728,25	4,46	637,55	2,89	12,45	1702,4
51379mixb	51379	house	8	379,33	13,01	294,67	10,02	197,67	6,66	907,83	4,47	795,76	4,64	12,34	2433,3
51386a	51386	house	9	388,33	12,58	336,33	10,26	224,33	7,64	170,53	3,45	166,21	3,10	2,53	278,5
51386b	51386	house	9	344,67	7,57	317,33	8,08	230,67	7,57	100,08	0,53	96,15	0,93	3,93	174
51387a	51387	house	10	231,67	9,02	220,67	8,50	192,33	7,09	48,05	0,98	45,78	0,83	4,72	135,5
51387b	51387	house	10	290,67	9,61	264,67	9,07	192,00	7,21	64,65	1,14	60,21	0,50	6,86	196,5
51390a	51390	house	11	367,33	3,06	333,00	3,00	246,33	2,89	97,69	0,86	93,70	1,05	4,08	103
51390b	51390	house	11	314,33	40,65	291,33	35,73	215,67	27,23	79,69	0,13	76,50	0,28	4,00	99
51391a	51391	house	12	258,33	10,07	171,67	5,51	110,33	4,62	532,95	4,20	515,45	2,76	3,28	43,5
51391b	51391	house	12	284,67	14,01	184,67	9,02	119,33	5,03	425,40	1,75	406,47	1,60	4,45	106,5
51392a	51392	house	13	321,67	21,73	269,33	17,90	186,33	13,05	288,69	1,88	275,60	1,70	4,53	n.d.
51392b	51392	house	13	367,67	24,68	309,33	20,53	206,33	13,05	241,97	2,22	234,69	2,15	3,01	n.d.
51393a	51393	house	14	182,00	13,08	150,00	10,39	104,00	7,00	437,95	3,37	399,47	1,08	8,78	1048,5
51393b	51393	house	14	207,33	5,69	178,33	4,73	128,67	3,21	104,67	0,15	97,66	0,33	6,69	790,5
51393c	51393	house	14	145,67	16,50	130,33	14,01	99,67	10,07	85,68	0,45	80,44	0,19	6,12	490,5
51394a	51394	house	15	346,00	10,54	294,00	9,17	198,00	6,24	166,89	1,29	163,71	0,25	1,91	189
51394b	51394	house	15	353,00	8,54	307,67	6,03	211,67	5,03	161,03	1,83	157,95	1,52	1,91	249
51395a	51395	house	16	170,00	4,58	141,00	4,36	99,00	2,65	358,02	0,92	325,53	0,67	9,07	1617
51395b	51395	house	16	81,33	2,52	75,67	1,53	63,33	0,58	146,96	1,23	135,33	0,73	7,91	799,5
51395mix	51395	house	16	111,33	2,08	101,00	1,73	79,67	1,53	286,27	3,90	264,11	2,87	7,74	778
51396a	51396	house	17	309,00	14,53	279,67	11,50	193,00	8,54	64,99	1,06	62,91	0,88	3,21	184
51396b	51396	house	17	182,00	5,57	176,00	4,58	155,00	2,65	80,45	2,97	78,29	2,68	2,69	567,5
51400mixa	51400	house	18	425,00	23,64	356,33	18,15	249,00	13,00	289,24	1,21	270,65	0,92	6,43	n.d.

Sample ID	Find No.	Structure	ID	Colors						Magnetic susceptibility			Fed		
				Red	S	Green	S	Blue	S	LF MS	S	HF MS	S	Freq dep	mg/kg
51400mixb	51400	house	18	454,67	18,50	376,67	16,04	262,67	12,66	296,44	3,14	276,20	2,78	6,83	n.d.
51402a	51402	house	19	406,33	15,37	326,67	11,93	229,33	7,02	332,86	14,80	314,99	14,90	5,38	202
51402b	51402	house	19	393,00	10,39	324,33	8,96	226,67	7,57	448,69	3,52	420,46	2,81	6,29	253,5
51409a	51409	house	20	312,67	20,60	208,33	15,04	140,33	10,07	247,83	6,12	232,30	5,61	6,27	102,5
51409b	51409	house	20	411,00	18,68	334,33	13,65	240,33	10,69	402,52	0,78	374,76	0,63	6,90	14
51413mixa	51413	house	21	356,00	13,75	258,33	12,01	167,00	8,00	461,29	0,06	413,28	1,47	10,41	623
51413mixb	51413	house	21	336,33	16,56	235,33	11,59	151,00	6,56	331,91	2,17	296,53	1,49	10,66	595
51416a	51416	house	22	450,33	17,56	372,00	7,00	271,33	4,04	340,69	16,34	308,99	16,46	9,32	60,5
51416b	51416	house	22	336,67	2,52	230,67	1,53	152,67	0,58	933,22	9,25	832,95	8,16	10,74	43
51416c	51416	house	22	346,67	6,43	255,67	5,69	172,00	4,36	666,94	4,98	584,04	4,92	12,43	68
51416d	51416	house	22	318,33	19,66	211,33	12,70	132,67	8,08	769,35	3,75	706,49	3,09	8,17	179
51613a	51613	house	23	425,67	4,93	371,00	4,36	263,00	3,00	188,75	9,53	181,78	9,48	3,70	47
51613b	51613	house	23	183,67	4,93	147,33	3,79	112,67	2,52	534,18	2,50	525,01	2,35	1,72	179,5
51613Bmixa	51613B	house	24	439,67	9,29	389,67	8,39	271,00	6,24	136,59	2,24	133,04	2,29	2,60	50,5
51613Bmixb	51613B	house	24	454,00	21,17	397,67	18,58	274,00	12,77	140,75	1,22	136,09	1,11	3,31	157,5
51615a	51615	house	25	403,00	38,12	362,33	34,36	255,67	23,69	73,04	1,34	70,87	1,39	2,97	n.d.
51615b	51615	house	25	398,33	23,18	338,33	20,60	231,33	15,04	194,53	1,54	188,98	1,68	2,85	n.d.
51615c	51615	house	25	390,00	15,87	305,33	14,15	216,67	10,21	478,89	1,19	444,91	1,34	7,10	n.d.
51617a	51617	house	26	244,00	2,65	177,00	1,73	114,00	1,73	629,13	3,53	573,41	3,10	8,86	n.d.
51617b	51617	house	26	248,33	10,60	171,33	6,66	110,00	4,00	649,24	3,18	615,86	2,88	5,14	n.d.
51617ox	51617	house	26	267,67	12,01	174,00	8,54	113,00	5,00	529,04	0,71	505,41	1,00	4,47	n.d.
51617red	51617	house	26	220,33	7,09	156,33	5,51	99,00	4,58	586,92	2,41	543,60	2,07	7,38	n.d.
51620a	51620	house	27	261,67	23,03	196,67	17,62	138,33	12,01	285,37	5,46	269,94	4,80	5,40	n.d.
51620b	51620	house	27	438,33	16,77	362,00	13,89	255,67	11,15	225,42	0,87	213,83	1,08	5,14	n.d.
51620c	51620	house	27	304,67	17,24	234,33	12,50	164,00	8,19	322,88	2,46	305,11	2,12	5,50	n.d.
53391a	53391	house	28	252,33	23,07	174,33	15,95	116,67	10,12	554,41	2,34	536,07	2,87	3,31	n.d.
53391b	53391	house	28	247,67	8,14	171,00	5,29	111,67	3,06	599,02	2,48	579,50	1,80	3,26	n.d.

5. The geoarchaeological record of the Chalcolithic Trypillian mega-site Maidanetske, central Ukraine

Stefan Dreibrodt, Sarah Martini, Robert Hofmann, Marta Dal Corso, Wiebke Kirleis, Johannes Müller

Abstract

26 of 40 profiles studied in the field were analysed with geoarchaeological laboratory methods at the Trypillian mega-site of Maidanetske, central Ukraine. Qualitative statistical analysis (PCA) revealed characteristically different signatures of the properties of the archaeological material and the soil (Chernozem) that developed from it on varying settlement compartments. This indicates varying settlement activities and economic processes in different compartments of the settlement. While the results from domestic houses indicate the most intensive everyday settlement activities (fire, waste), the analysed samples from the mega-structure show signatures that indicate much less of these everyday settlement activities or may indicate the restriction of this site for types of activity that leave few or no specific geochemical traces. The unbuilt inner part of the settlement shows a higher P content compared to Chernozems of the surrounding landscape, possible as a result of Chalcolithic agricultural activity, like animal penning. Quantitative approaches to infer population sizes from accumulated P amounts failed, probably because of an alteration of the geochemical record by post-depositional processes. This once more underlines that shallowly buried archaeological contexts are not protected against the attack of plant roots and soil formation processes. The comparison of profiles within a mega-structure feature of Maidanetske revealed a micro-topography probably associated with the architecture of the mega-structure communal building that is not visible in the recent landscape anymore.

Introduction

There has been a growing number of multi-proxy geoarchaeological investigations at archaeological sites focussing on supplying information for a better understanding of site formation processes (*e.g.* Schiffer 1976; Schiffer 1985). Among such studies have been geochemical measurements of archaeo-sediments, often using historical information to relate specific geochemical signatures to distinct features (*e.g.* Wilson *et al.* 2005; Wilson *et al.* 2008; Wilson *et al.* 2009; Davidson *et al.* 2010; Abrahams *et al.* 2010; Entwistle *et al.* 1998; Entwistle *et al.* 2000; Middleton and Prize 1996). Prehistoric multi-proxy approaches have been successfully applied on multi-layered sites to reconstruct overall settlement and environmental histories (*e.g.* Ottaway and Matthews 1988; Lubos *et al.* 2013) or population sizes (*e.g.* Nowaczinski *et al.* 2013; Martini *et al.* 2019). Similar quantitative approaches on shallowly buried sites (flat settlements) failed, however, pointing to a limiting influence of post-depositional alteration on such archaeological contexts (Dreibrodt *et al.* 2017). In this contribution, we explore the potential and limitations of multi-proxy analyses to characterize different compartments of the Chalcolithic Giant Trypillian settlement site of Maidanetske, central Ukraine, and try to explain the origin of different multi-proxy signatures.

Material and methods

Site

The investigated Chalcolithic mega-site of Maidanetske (Müller *et al.* 2016; Müller *et al.* 2017; Hofmann *et al.* 2019) of the Trypillia C1-period is located at Majdanetskoe, district of Talne, central Ukraine (48°48′N, 30°38′E; Fig. 1a, b). Archaeological sites of this type are unique because of their large dimensions. Approximately 3000 houses arranged in a series of oval structures around an unbuilt central space were inhabited approximately from 3990 to 3640 BCE, at Maidanetske (*e.g.* Müller *et al.* 2016; Ohlrau 2020; Pickartz *et al.* 2019). Surface surveys, magnetic surveys, excavations and dating revealed that about 1500 houses were inhabited contemporaneously by probably 10,000 people (Ohlrau 2020; Pickartz *et al.* 2019). The climate in the region is humid continental (Dfb) today, characterized by hot dry summers and cold wet winters. The topography is made of loess-covered plateaus dissected by small valleys. The recent surface soils are classified as particularly thick Chernozems in the research area (Atlas of Soils of the Ukrainian SSR: Krupskovo and Polupana 1979). The potential natural vegetation of the region is the forest-steppe transition zone. Without agricultural land use, deciduous forests are present in the landscape today. The investigated archaeological site, sitting on a loess plateau, is used for large agricultural fields, subdivided by wind-breaking tree lines, and unpaved roads.

Profile documentation and sampling

All profiles were documented in the field applying usual methods (digital photography, scaled drawings/ sketches). 40 soil profiles were documented in the field, 26 soil profiles have been analysed with laboratory methods at the Giant Chalcolithic settlement site of Maidanetske (Fig. 1c). The latter were located crossing different archaeological contexts (mega-structure: 3, domestic houses: 14, pit fills: 2) or the unbuilt space (radial street: 3, unbuilt centre: 3, slope: 1). Samples were taken in continuous depth increments, comprising the Chernozem A-horizon, the archaeological record (where present) and subsoil horizons (relict Bw, loess).

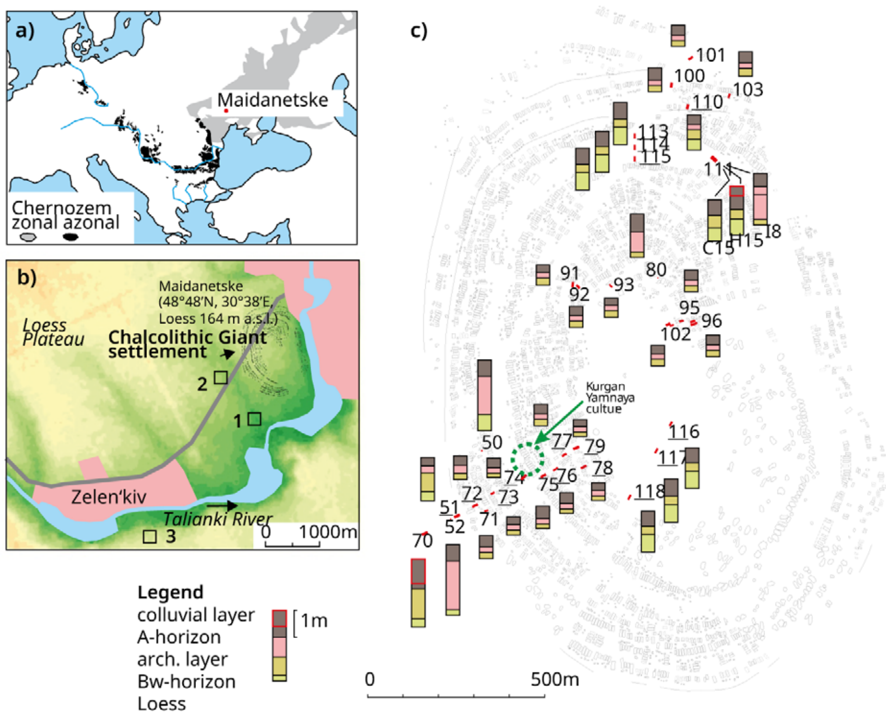


Figure 1. (a) Location of Maidanetske in central Ukraine within the zonal Chernozem gurdle; (b) location of the giant Chalcolithic settlement site in the recent landscape, numbers indicate the surface Chernozem sites compared with the soil at the site; (c) gradiometer plan of the site indicating the stratigraphy of the investigated profiles.

Methods

At four profiles, samples for bulk density analysis were taken. Bulk density was calculated from the weights of three replicates of 100 cm3 samples taken with steel cylinders and dried at 105°C overnight.

Laboratory analysis was carried out on the air dried <2 mm fraction of the samples. Sample pre-treatment included a careful disintegration of the dry samples (room temperature) with the help of mortar and pestle, and sieving through a 2 mm mesh. During this step, visible artefacts, bio-remains, and stones were extracted and weighed separately.

The RGB-colours of the samples were determined in three replicates on a Voltcraft Plus RGB-2000 Color Analyser set to display in a 10-bit RGB colour space (*e.g.* Rabenhorst *et al.* 2014; Sanmartín *et al.* 2014). Since RGB colours are internally highly correlated, these data were converted into Light Intensity, Hue, and Colour Saturation according to Viscarra Rossel *et al.* (2006) before statistical analysis.

The volume specific magnetic susceptibility was measured on three replicates of weighed 10 ml- samples using a Bartington MS2B susceptibility meter (resolution 2*10-6 SI, measuring range 1-9999*10-5 SI, systematic error 10%). Measurements were carried out at low (0.465 kHz) and high (4.65 kHz) frequency. A 1% Fe3O4 (magnetite) sample was measured regularly and the samples susceptibility values were calibrated using this standard before the mass specific susceptibility values were calculated. Mass specific magnetic susceptibility and frequency dependent magnetic susceptibility (Dearing 1999; Clark 1996) were calculated based on the weights of the 10 ml samples and the differences of low and high frequency susceptibilities.

Organic matter and carbonate contents were estimated by loss on ignition (LOI) at 550°C and 940°C (Dean 1974) after two hours heating of formerly dried samples (105°C overnight).

The total elemental contents of the samples were measured on a p-ed-xrf device (NITON XL3t 900-series) of Thermo Scientific Analysers. For p-ed-xrf measurements, first, the <2 mm fraction was ground in an Agate mill and placed in a plastic tube covered by a 4 µm thick film. These were then measured in a lead-mantled measurement chamber with He-flotation using the ‘mining, Cu/Zn’ settings for 300 s with the p-ed-xrf device. As the device has the ability to not just record quantitative elemental concentrations, but also reports measurement errors, all elements with >10% error were excluded from further analysis. The adjustment of the measurement conditions were carried out according to instructions given in previous papers (Lubos *et al.* 2016; Martini *et al.* 2019), that included a calibration of the p-ed-xrf measurements on a wd-xrf data set (Dreibrodt *et al.* 2017).

For selected profiles, the grain size distribution of the <2 mm fraction was determined using a combined wet sieving (sand) and Atterberg (silt, clay) method (*e.g.* Müller 1964).

For samples at Profile 117 ground powder samples were analysed with xrd (Siemens diffractometer, Cu-α radiation, 2 Theta 4–90°, step size 0.02, 1 s per step). Identification of present mineral assemblages was carried out using characteristically d-spacing patterns given in mineralogy textbooks (*e.g.* Brindley and Brown 1980).

For statistical comparison of the profiles, 19 parameters were selected. Those comprise of colour values (Hue, Light Intensity, and Chromatic Information), LOI550/940, magnetic susceptibility (low frequency, mass specific), frequency dependent magnetic susceptibility, and p-ed-xrf-total elemental contents (P, Zr, Y, Sr, Rb, Zn, Fe, Ti, Ca, K, Al, Si). All percentage values were logarithmised prior to the application of PCA to reduce the effects of relative scaling (*e.g.* Filzmoser *et al.* 2009).

Results

Selected data and profiles

Bulk density values from four profiles are displayed in Figure 2. Although there is a certain variability, a general trend to slightly increasing density values from the loess (~ 1.3 g*cm^{-3}) into the Chernozem (~ 1.4 g*cm^{-3}) is visible. Maxima in bulk density occur in the shallower part of the Chernozem and might reflect recent plough pans. XRD measurements of the samples of one profile are shown in Table 1. The main mineral assemblage is in accordance with Chernozems from the region. Quartz, feldspars and mica, together with clay minerals (chlorite/ expandable clays, illite, kaolinite) and pedogenic iron oxides (maghemite/ magnetite) make up the general mineral assemblage, together with traces of gypsum. The loess contains higher amounts of calcite and in the surface sample of the Chernozem perhaps some hematite is present.

Examples for selected profile data are given in Figures 3 and 4. The grain size distribution of Profile H15 (yard of the Mega-structure 111) and above and beneath a domestic Dwelling 77 (a, b) are given in Figure 3. Since the site is situated on a loess plateau, the overall grain size distribution is dominated by silt. The increase in fine particles (clay, fine silt) within the Chernozem that formed by earthworm casts as a result of landscape transformation by the Chalcolithic settlers (Dreibrodt *et al.* 2020; Dreibrodt *et al.* 2021; Dreibrodt *et al.* 2023) is visible in all profiles. The deeper Profile H15 indicates a further decrease in sand within the Chernozem (0–55cm) compared with the loess (>110cm).

Selected additional results from the profiles are given in Figure 4. LOI550 values show an increase in the Chernozem and small-scale colluvium compared to the buried incipient early Holocene forest soil and the loess. The LOI940 values indicate a small amount of pedogenic carbonates within the Chernozem while maxima in depths larger than 100 cm (Profile H15) expose the primary carbonate content of the loess. Varying amounts of daub pieces indicate the proximity of H15 to the building of the mega-structure. The profile within the domestic house (77a) contains more daub

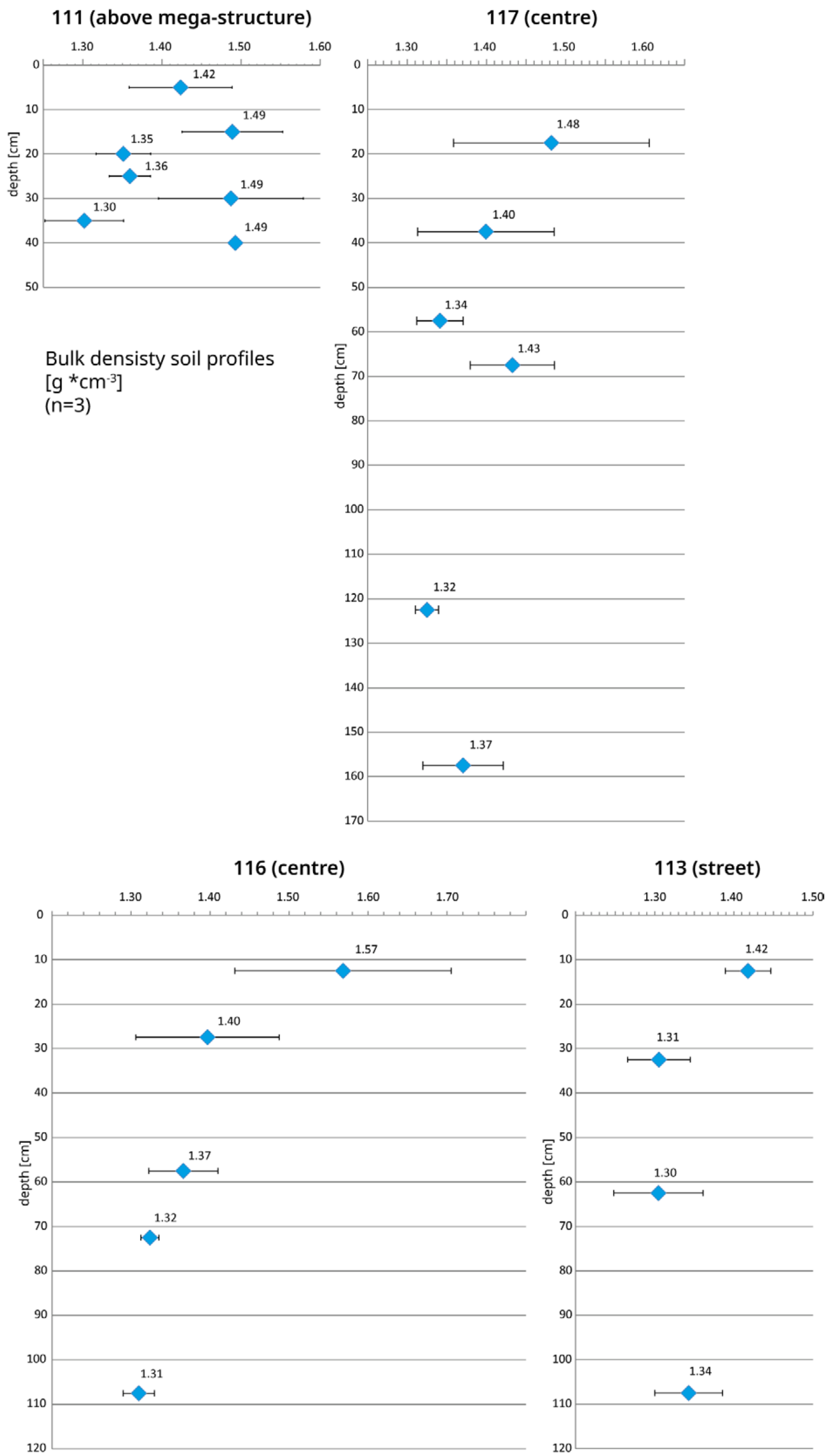


*Figure 2. Bulk density values [g*cm⁻³] of four profiles of the site (Profile I8 at the Context 111, see Fig. 1).*

Mineral / -group	165	144	125	105	85	65	45	25	5	Surface casts
Quartz	++	++	++	++	++	++	++	++	++	++
Feldspars	+	+	+	+	+	+	+	+	+	+
Calcite	++	++	++	++	+	(+)	(+)	(+)	(+)	(+)
Illite/ Muscovite	+	+	+	+	+	+	+	+	+	+
Chlorite/ Expandables	++	++	++	++	++	++	++	++	+	+
Kaolinite	++	++	++	++	++	+	+	+	+	+
Gypsum	+	+	+	+	+	+	+	+	+	+
Maghemite/ Magnetite	+	+	+	+	++	++	++	++	++	++
Hematite									+?	
Dolomite		+?	+?	+?						

Table 1. Illustrating the mineral assemblage present in Profile 117 from the surface to 165 cm depth. Relative abundances of different minerals: ++ = dominant; + = present; (+) = traces present.

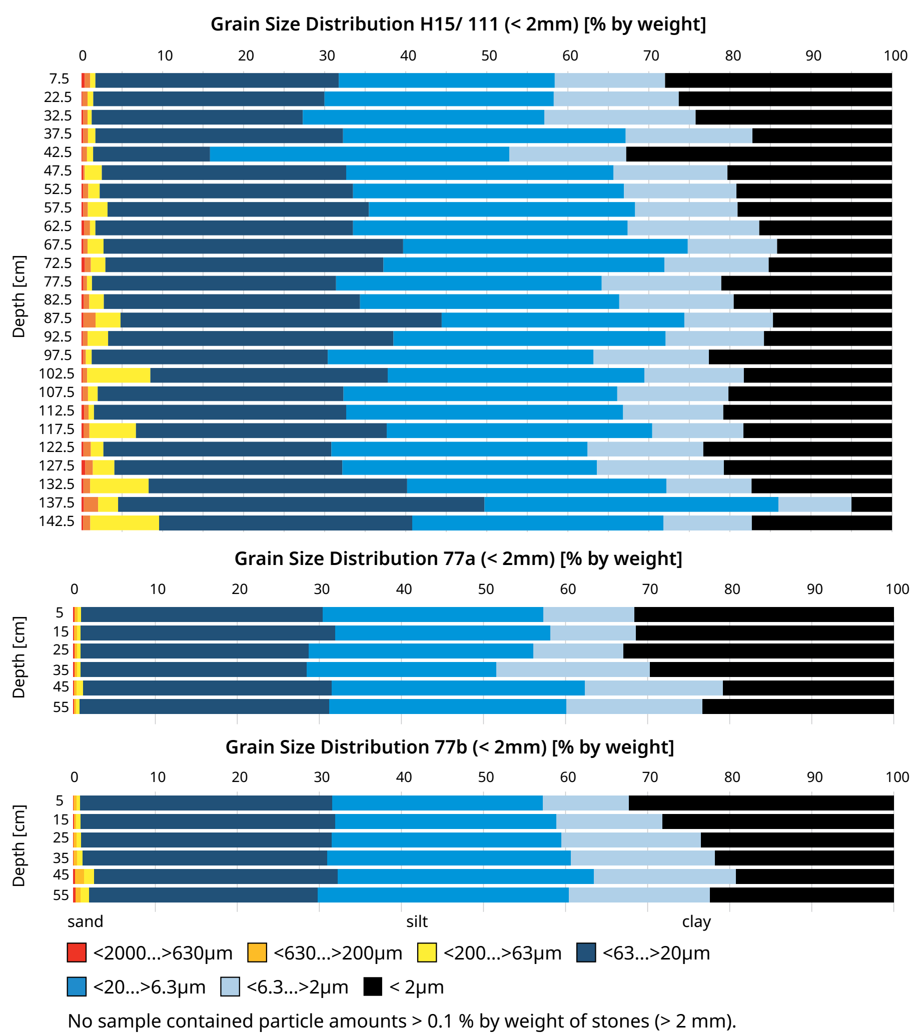


Figure 3. Grain size distribution of the Profiles H15 (Context 111) and House 77; 77a is a profile that cuts the archaeological record, 77b is located near the dwelling; pedostratigraphy of 77a: 0–40cm = Chernozem; 40–50cm = archaeological record; 50–60cm = relict forest soil (rBw); pedostratigraphy of 77b: 0–40cm = Chernozem; 40–60cm = relict forest soil (rBw); for Profile H15 see Fig. 5.

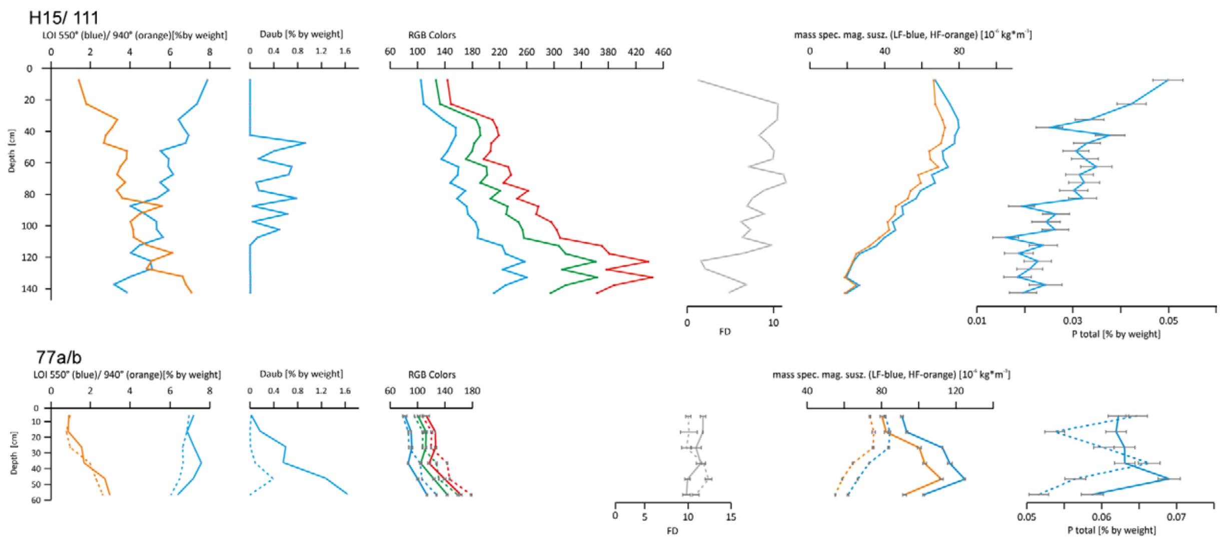


Figure 4. Shows selected laboratory results of the Profiles H15 (Context 111) and House 77 (for pedostratigraphy see Figs. 3 and 5). RGB colors [0 to 1023], frequency dependency (FD) in [%].

compared to the profile outside the building (77b). The darker colours of the upper parts of all profiles are ascribable to the recent Chernozem. A transition beneath in H15 to ca. 80 cm is related to a small-scale colluvium. Below, ca. 80 to 100 cm, the buried forests soil shows a tendency to paler colours. The maxima in RGB values in H15 (in depths > ca. 110 cm) are indicative for the loess. The transition to paler colours in 77 are ascribable to the archaeological record (77a) and the buried forest soil (77b). The magnetic properties are reflecting both, the pedogenic enhancement and the archaeological record. The former is more pronounced in H15 with an increase of ca. 160% in the buried forest soil and ca. 260% in the Chernozem (and small scale colluvium) compared to the loess. The large difference in magnetic properties visible within Profile 77 of the domestic house reflects the existence of a large amount of burnt particles in 77a compared to the situation beneath the house (77b). This is even visible the Chernozem that formed above the findings. The frequency dependent susceptibilities are values of at ca. 10% for the Chernozem, also slightly higher above the dwelling (77a) compared to the profile beneath (77b). The total phosphorous values show an increase within the Chernozem/ small-scale colluvium and the archaeological record compared to the loess. The maxima of total phosphorous are visible in the domestic Dwelling 77a.

Figure 5 compares results of three deep profiles located at a so-called mega-structure (111). LOI, colours and magnetic susceptibility indicate a surprising small-scale variability within and around the archaeological feature. In Profile I8, a comparably thin Chernozem (ca. 45 cm) has formed above two thick archaeological layers. The daub layer of the mega-structure building superposes another layer, probably a levelling layer that contains considerably high amounts of phosphorous. Below, the early Holocene relict forest soil (rBw) is buried in a thickness of at least 80 cm. This is very similar to the thickness of the rBw buried below the colluvium in exposure 70 (Kirleis and Dreibrodt 2016; Dreibrodt *et al.* 2020; Dreibrodt *et al.* 2021). The unaltered loess is not attained in Profile I8. Profile H15 cuts through what has been addressed to have been a yard within the mega-structure. There, an unusually thick Chernozem horizon forms the surface (ca. 85 cm). Its lower portion probably represents a small-scale colluvium. Below the Chernozem, the early Holocene relict forest soil is preserved in a thickness of ca. 30 cm. The base of the profile is made up by the unaltered loess. Profile C15 is a cut through the soil developed in unbuilt area adjacent to the mega-structure. The Chernozem has a thickness of ca. 55 cm, underlain by a remnant of the relict early Holocene forest soil (ca. 45 cm thick), and the unaltered loess at the base.

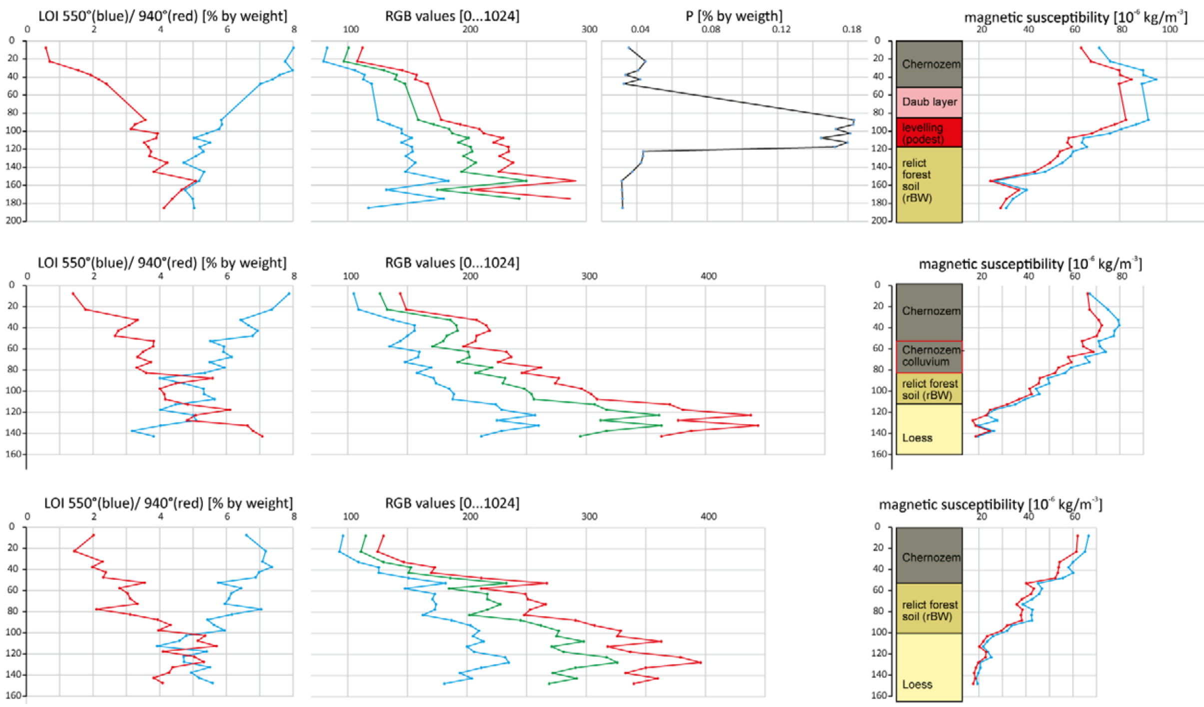


Figure 5. Illustrates the small-scale variability related to the stratigraphy within the Mega-structure 111, visible in the laboratory data from the Profiles I8, H15 and C15 (top to bottom).

Comparison of different settlement compartments

For the statistical analysis of the geoarchaeological data from different compartments of the site, the samples from the archaeological record and the overlying Chernozem horizon were combined. The soil which had formed above the archaeological record was included since its properties indicate an inheritance from the underlain archaeological record (Dreibrodt *et al.* 2021).

Boxplots of results are given in Figures 6 and 7. There are a lot of measurements without a significant difference between different profile groups. Among these data are contents of stones, colour values and content of organic matter (LOI550). Exceptions are the Light intensity and Chromatic information values. The mega-site profiles and the Pit 52 profile show higher values, indicating paler soil colours. Organic matter contents (LOI550) of the findings and the Chernozem developed above show little variability. The carbonate contents (LOI940) indicate higher values in the mega-structure profiles. Another significant difference appears in the magnetic properties of the samples. The low frequency mass-specific magnetic susceptibility and frequency dependent magnetic susceptibility are both enhanced above former domestic houses. Within the suite of measured elements, P, Al and Si are significantly enhanced within the domestic house profiles, too. Ca shows higher values within the mega-structure profiles. To infer the P contents of the whole site, a comparison of the Chernozem in on- and off-site profiles has been carried out, additionally. The latter sampling sites are located in the surrounding landscape (Fig. 1b). The results imply a significantly higher P content of all on-site profiles (including the unbuilt centre part of the settlement) compared to off-site Chernozem (Fig. 8).

A PCA carried out on the on-site data is given in Figure 9. It is based on laboratory results from 158 samples (profiles from: houses – 77, mega-structure – 29, pit fill – 15, unbuilt centre – 18, unbuilt street – 19). The correlation matrix indicates some positively correlating parameters (colours, Ca and LOI940, Al and Si) and some negatively correlating ones (LOI550 and colours, Ca with Rb and Zr, LOI940 with Rb). The first three components explain about 67% of the variability of the compared

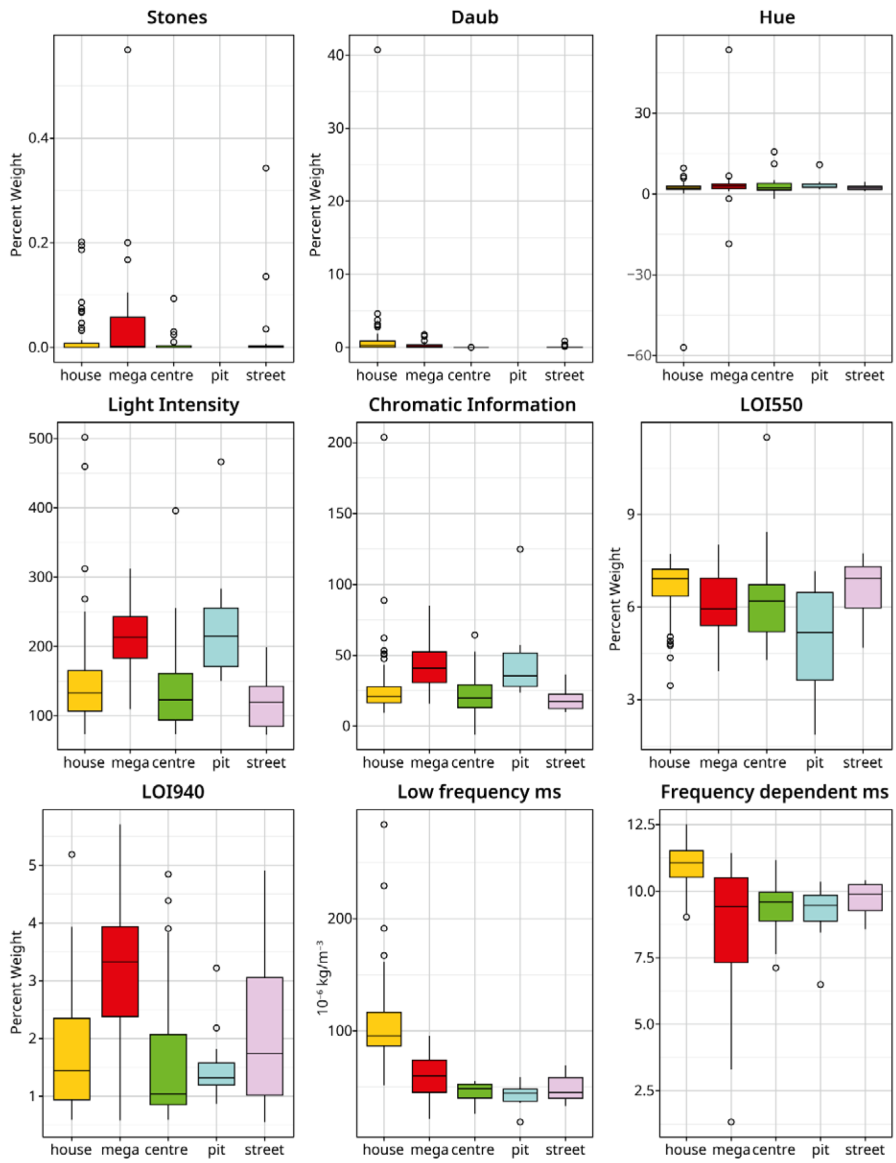


Figure 6. Box plot of results of the investigated profiles grouped according to different settlement compartments (geophysical and geochemical composition); built structures: house (domestic houses) and mega (mega-structures incl. communal buildings) vs. *unbuilt sections: centre, pit, street (for settlement layout see Fig. 1).*

samples. With some overlapping, the group of dwellings (domestic houses, mega-structure) is separated from the unbuilt profiles (street, centre, pit) in the PC1 *vs.* PC2 plot. Additionally, the domestic houses plot in a separate cluster compared to the mega-structure. A look on the loading of the parameters within the first component reveals that the colours, LOI940, Sr and Ca are negatively correlated with PC1. With PC2, LOI550, Zr, Rb, and Ti are negatively correlated. An additional Plot of PC1 *vs.* PC3 divides the samples from profiles on unbuilt ground in separate clusters. LOI550, magnetic susceptibility, frequency dependent susceptibility, Sr and Ca are negatively correlated with PC3.

Discussion and interpretation

The varying geochemical and geophysical patterns of the different compounds of the Giant Trypillia settlement Maidanetske are discussed in the following on a qualitative level (PCA) in a first step and on a quantitative level (mass calculation of phosphorus) in a second step.

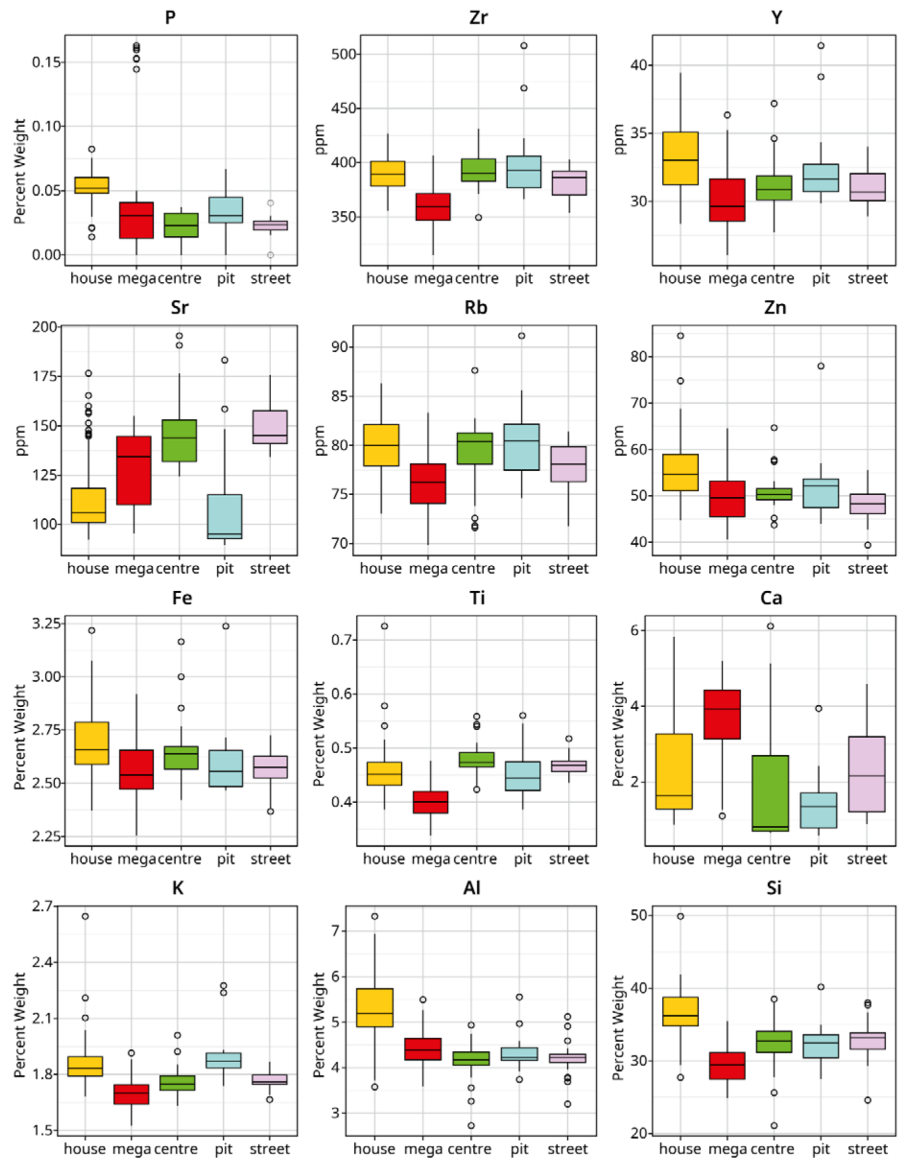


Figure 7. Box plot of results of the investigated profiles grouped according to different settlement compartments (geochemical composition; total elemental composition); built structures: house (domestic houses) and mega (mega-structures incl. communal buildings) vs. *unbuilt sections: centre, pit, street (for settlement layout see Fig. 1).*

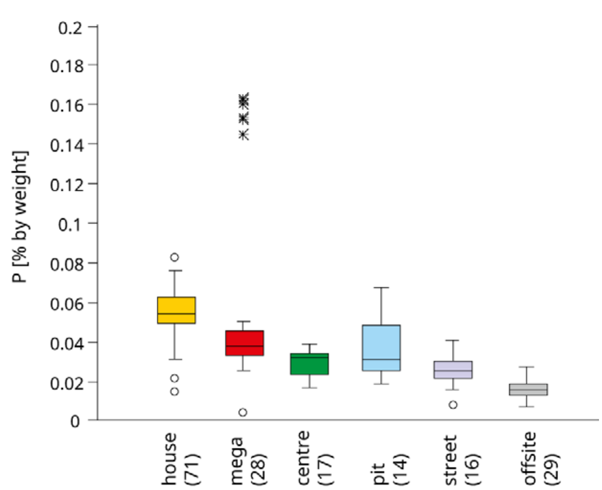
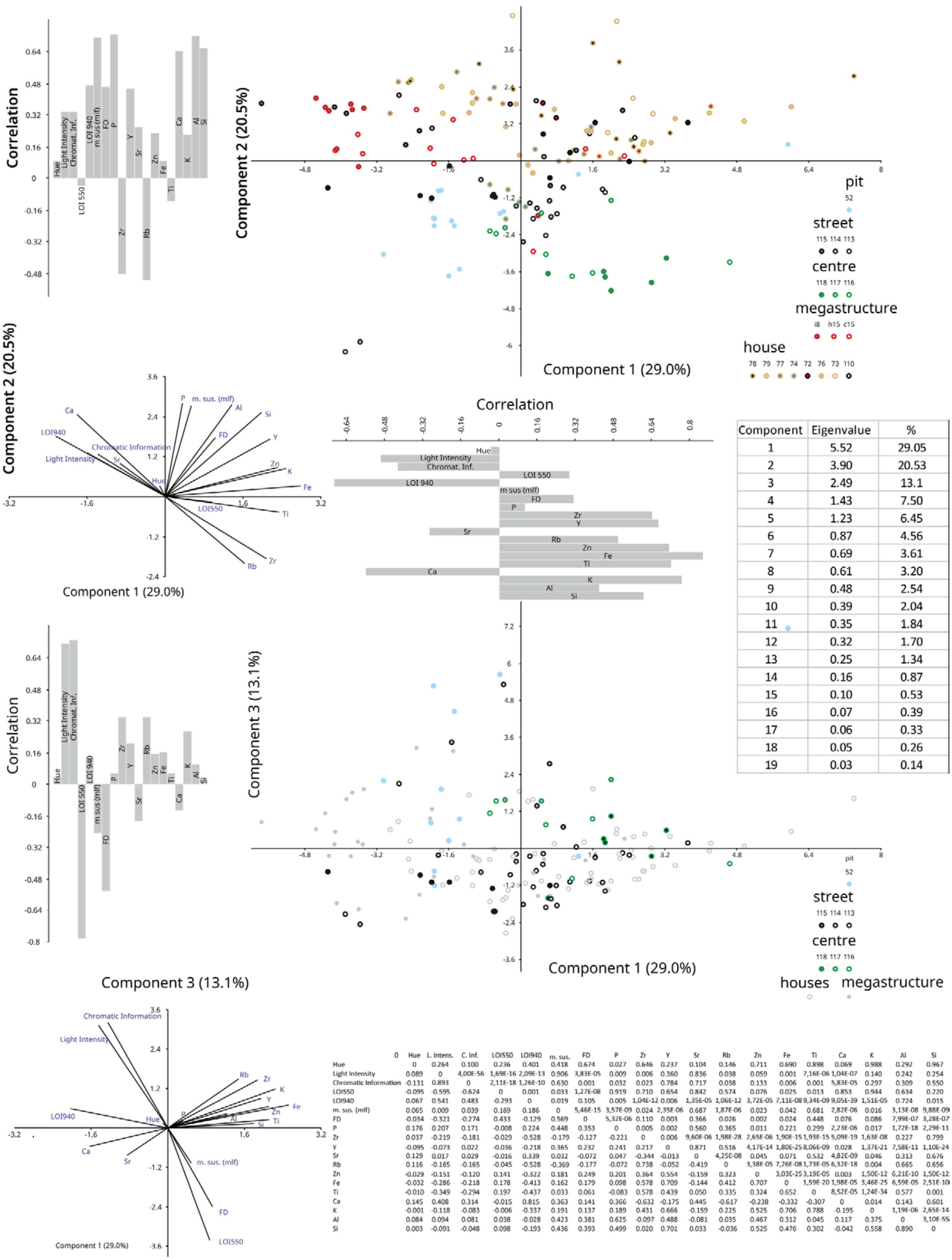


Figure 8. Boxplots of the total phosphorous content of off-site Chernozem profiles compared to the the Chernozem at Maidanetske; in parentheses: number of samples.



Component	Eigenvalue	%
1	5.52	29.05
2	3.90	20.53
3	2.49	13.1
4	1.43	7.50
5	1.23	6.45
6	0.87	4.56
7	0.69	3.61
8	0.61	3.20
9	0.48	2.54
10	0.39	2.04
11	0.35	1.84
12	0.32	1.70
13	0.25	1.34
14	0.16	0.87
15	0.10	0.53
16	0.07	0.39
17	0.06	0.33
18	0.05	0.26
19	0.03	0.14

0	Hue	L. Intens.	C. Inf.	LOI550	LOI940	m. sus.	FD	P	Zr	Y	Sr	Rb	Zn	Fe	Ti	Ca	K	Al	Si
Hue	0	0.264	0.100	0.236	0.401	0.418	0.674	0.027	0.646	0.237	0.104	0.146	0.711	0.690	0.898	0.069	0.988	0.292	0.967
Light Intensity	0.089	0	4,00E-56	1,69E-16	2,09E-13	0.906	3,83E-05	0.009	0.006	0.360	0.836	0.038	0.059	0.001	7,16E-06	1,04E-07	0.140	0.242	0.254
Chromatic Information	-0.131	0.893	0	2,11E-18	1,26E-10	0.630	0.001	0.032	0.023	0.784	0.717	0.038	0.133	0.006	0.001	5,83E-05	0.297	0.309	0.550
LOI550	-0.095	-0.595	-0.624	0	0.001	0.033	1,27E-08	0.919	0.710	0.654	0.842	0.574	0.076	0.025	0.013	0.853	0.944	0.634	0.220
LOI940	0.067	0.541	0.483	-0.293	0	0.019	0.105	0.005	1,04E-12	0.006	1,35E-05	1,06E-12	3,72E-05	7,11E-08	9,34E-09	9,05E-39	1,51E-05	0.724	0.015
m. sus. (mlf)	0.065	0.009	0.039	0.169	0.186	0	5,46E-15	3,57E-09	0.024	2,35E-06	0.687	1,87E-06	0.023	0.042	0.681	2,82E-06	0.016	3,13E-08	9,88E-09
FD	-0.034	-0.321	-0.274	0.433	-0.129	0.569	0	5,32E-06	0.110	0.003	0.366	0.026	0.002	0.024	0.448	0.076	0.086	7,99E-07	3,28E-07
P	0.176	0.207	0.171	-0.008	0.224	0.448	0.353	0	0.005	0.002	0.560	0.365	0.011	0.221	0.299	2,23E-06	0.017	1,72E-18	2,29E-11
Zr	0.037	-0.219	-0.181	-0.029	-0.528	-0.179	-0.127	-0.221	0	0.006	9,60E-06	1,98E-28	2,65E-06	1,90E-15	1,93E-15	5,09E-19	1,63E-08	0.227	0.799
Y	-0.095	-0.073	0.022	-0.036	-0.218	0.365	0.232	0.241	0.217	0	0.871	0.516	4,17E-14	1,80E-25	8,06E-09	0.028	1,37E-21	7,58E-11	1,10E-24
Sr	0.129	0.017	0.029	-0.016	0.339	0.032	-0.072	0.047	-0.344	-0.013	0	4,25E-08	0.045	0.071	0.532	4,82E-09	0.046	0.313	0.676
Rb	0.116	-0.165	-0.165	-0.045	-0.528	-0.369	-0.177	-0.072	0.738	-0.052	-0.419	0	3,38E-05	7,26E-08	1,73E-05	6,32E-18	0.004	0.665	0.656
Zn	-0.029	-0.151	-0.120	0.141	-0.322	0.181	0.249	0.201	0.364	0.554	-0.159	0.323	0	3,03E-25	3,19E-05	0.003	1,50E-12	6,21E-10	1,50E-12
Fe	-0.032	-0.286	-0.218	0.178	-0.413	0.162	0.179	0.098	0.578	0.709	-0.144	0.412	0.707	0	1,59E-20	1,98E-05	3,46E-25	6,59E-05	2,51E-10
Ti	-0.010	-0.349	-0.294	0.197	-0.437	0.033	0.061	-0.083	0.578	0.439	0.050	0.335	0.324	0.652	0	8,52E-05	1,24E-34	0.577	0.001
Ca	0.145	0.408	0.314	-0.015	0.815	0.363	0.141	0.366	-0.632	-0.175	0.445	-0.617	-0.238	-0.332	-0.307	0	0.014	0.143	0.601
K	-0.001	-0.118	-0.083	-0.006	-0.337	0.191	0.137	0.189	0.431	0.666	-0.159	0.225	0.525	0.706	0.788	-0.195	0	1,19E-06	2,65E-14
Al	0.084	0.094	0.081	0.038	-0.028	0.423	0.381	0.625	-0.097	0.488	-0.081	0.035	0.467	0.312	0.045	0.117	0.375	0	3,10E-55
Si	0.003	-0.091	-0.048	0.098	-0.193	0.436	0.393	0.499	0.020	0.701	0.033	-0.036	0.525	0.476	0.302	-0.042	0.558	0.890	0

Figure 9. PCA of the geophysical and geochemical record of Maidanetske.

Different geochemical and geophysical patterns – Hints to Chalcolithic land use?

The majority of samples from the archaeological record plots in different clusters compared to samples from the unbuilt space within Maidanetske (Fig. 9). This is mainly explained by the second axis. The positive correlations of elements like P, Sr, Zn, K, Ca, considered to reflect anthropogenic activity, with the second axis explains a part of that clustering. Al and Si and the magnetic properties of the samples make up another part, which reflects the remnants of architecture at Maidanetske. Pale colours are also in accordance with that latter component of the samples, regarding the paler colour of burnt mineral material compared to the natural Chernozem. The separation of the clusters of the mega-structure and the domestic houses is explained by the first axis. With the first axis, there is a negative correlation of the colours, Ca, Sr and LOI940. At historical sites, Ca and Sr are considered to be related to anthropogenic activities (*e.g.* houses, hearths; *e.g.* Wilson *et al.* 2005; Abrahams *et al.* 2010; Zimmermann 1992; Manzanilla 1996; Entwistle *et al.* 2000; Middleton 2004). At Maidanetske, large amounts of Ca and Sr reflect the (paler) calcareous material of the loess and the Chernozem additionally to the indication of anthropogenic activity. Thus, the separation of mega-structure (rather negative values) and the domestic houses (rather positive values) on the first axis indicates the contribution of much more intensive 'everyday' anthropogenic activities (*e.g.* fire, food preparation, craft *etc.*) to the remnants of domestic houses compared to the mega-structure. Additionally, higher values of magnetic properties, Al and Si indicate another type of architecture within domestic houses compared to the mega-structure, providing more material (probably daub) to be altered by the burning process. The mega-structure was probably a place restricted for activities that occurred comparatively seldom or that were completely different in nature ('non-economic activities').

A PCA plot of the PC1 *vs.* the PC3 axis results in a clearer separation of the unbuilt profiles. With the third axis, P and Zn are positively correlated. The observed elemental patterns could indicate that rather agricultural activities were ongoing in the centre of the settlement (*e.g.* Clark 1996; Ottaway and Matthews 1988; Wilson *et al.* 2005) whereas the geochemical and geophysical patterns of the streets are more similar to activities attributed to the domestic houses (magnetic properties, Ca, Sr). A comparison of the total phosphorus content of settlement compartments of Maidanetske and 'off-site' Chernozems from the surrounding landscape (Fig. 8) exhibits the phosphorus enrichment of all Chernozems of Maidenetske (including unbuilt centre) in comparison to the natural background values. Thus, the cluster visible in the PC1 *vs.* PC3 plot might indicate agricultural land use, perhaps animal penning, as a possible form of land use for the unbuilt centre of Maidanetske.

Budgets of phosphorous – Hints to Chalcolithic demography?

The estimation of prehistorical population sizes has been a hot topic in archaeology since the mid-20th century and is quite difficult in the absence of written records. Various approaches based on materials assessable by archaeological excavations. Examples include skeletal/mortuary remains (*e.g.* Chamberlain 2009; Chamberlain 2006), quantifications of assemblages (*e.g.* Cook 1972a; Gallivan 2002; Marsden and West 1992; Phillips 1972; Schiffer 1976; Turner and Lofgren 1966), settlement/house sizes (*e.g.* Casselberry 1974; Kolb *et al.* 1985; LeBlanc 1971; Naroll 1962; Plog 1975; Schacht 1981; Wiessner 1974), or radiocarbon dates (*e.g.* Barton *et al.* 2003; Bocquet-Appel and Demars 2000). Other approaches have been based on paleo-environmental records (*e.g.* Feeser *et al.* 2019) and resource limitations (*e.g.* Cook 1972b; Hassan 1978; Vita-Finzi *et al.* 1970; Zorn 1994).

Calculation of P budget	Area of built space		Mean thickness arch. layer	Volume arch. layer	Mean bulk density	Mass of arch. sediment	Mean P content	Mass of P in arch. sediment
	[ha]	[m²]	[m]	[m³]	[t*m⁻³]	[t]	[% by weight]	[t]
	134.5	1,344,615	0.61	817,612	1.4	1,144,656	0.054	615.6
Estimation of population size	**Diet type**	**P/yr [kg]**	**Sum Inhabitants [n]**	**Settlement period [yrs]**	**Mean Inhabitants [n] (this approach)**		**Mean Inhabitants [n] (estimation Ohlrau et al., 2016)**	
	cereal rich	1.047	588,011	300	1,960		11,150	
	meat rich	1.116	551,656	300	1,839			

Table 2. Calculation of population size of Maidanetske based on the amount of phosphorous (P) stored at the site.

Some authors tried to use the amount of phosphorous stored within the archaeo-sediment to deduce the number of prehistorical inhabitants of settlements. Nowaczinski *et al.* (2013) and Martini *et al.* (2019) have applied this approach successfully at multi-layered sites, where it was backed by comparisons with results of 'traditional' archaeological methods of palaeo-demography. The application of a similar approach failed at a flat settlement, indicating a significant influence of post-depositional processes on the shallowly buried archaeological record (Dreibrodt *et al.* 2017).

The following calculations have been applied to the laboratory results at Maidanetske (Tab. 2). As it was realized that the Chernozem has formed as a result of local redistribution of subsoil at the surface most probably by the action of anecic earthworms (casts; Dreibrodt *et al.* 2021; Dreibrodt *et al.* 2023), the sum of the archaeo-sediment of the houses and the overlain Chernozem were used as a base of total phosphorus accumulation. The area of domestic houses was calculated based on the gradiometer plan of the site (Fig. 1c). The mean thickness of the archaeological layer and the Chernozem were calculated on the base of available profiles from the site. The volume of the layer considered to reflect the remnant of the archaeological record was calculated by multiplication of mean thickness (archaeological layer + Chernozem) and the area of built space. The mean bulk density of the Chernozem at the site has been applied to convert this volume into a mass value. Afterwards, the mean phosphorus percentage measured on the samples of the domestic houses was converted into the stored mass of phosphorus. In a last step, this mass of phosphorus has been divided by model amounts of phosphorous content of human nutrition/excrements per annum borrowed from the model of Nowaczinski *et al.* (2013). The resulting values indicate that the phosphorus, accumulated at the houses of Maidanetske, would explain in total between ca. 550,000 to 590,000 human individuals assuming a rather cereal rich diet or a meat rich diet, respectively. However, dividing these values by 300 years, assumed to reflect the occupation period of Maidanetske, mean population numbers of 1,840 to 1,960 individuals result for the different dietary models. This is much less than assumed by archaeological estimations (see Ohlrau *et al.* 2016): ca. 11,150 people. This is an enormous disagreement considering that other P sources (namely cattle) have not been considered so far in this simple P based palaeo-demography estimation model.

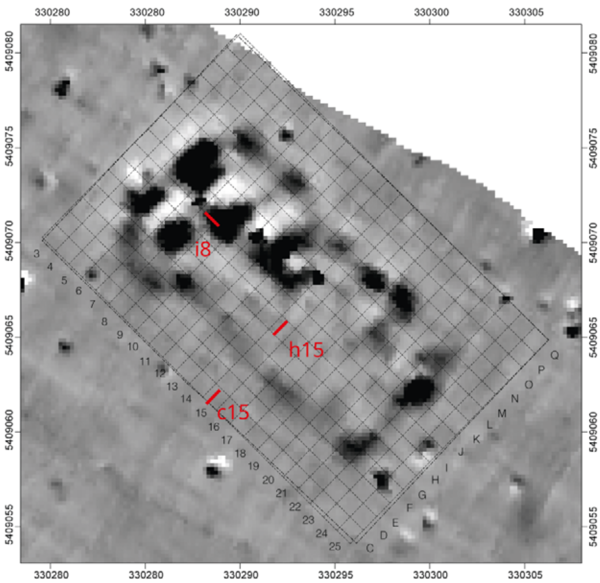
As it has been discussed for the example of Neolithic houses in Vrable (Dreibrodt *et al.* 2017), the postdepositional site history has to be considered. Taking into account only the last 100 years of industrial agricultural land use, a considerable amount of P could have left the site via the harvest. Since it is known that a sugar refinery was present from ca. 1900 to 2000 CE in Maidanetske, the possible P loss of the Chernozem at Maidanetske is estimated assuming beetroot as a main cultivated crop. According to agronomical measurements, beetroots extract ca. 36 kg of P per annum and hectare from the soil (DLG 1973). Beetroot cannot be cultivated permanently due to depriving effects on the soil. If we consider the period between 1900 and 2000 CE, the beet may have been cultivated only every other year (total 50 years), alternating with another crop. Here, we assume cereals (wheat) to have played that role. Wheat is characterized by a P uptake of ca. 19.5 kg per annum and hectare (DLG 1973). Assuming no compensation by manuring, the export of P from the site (134.5 ha) would sum up to ca. 372.2 t. A conversion of this phosphorous amount into prehistoric inhabitants would add 1,112 to 1,185 additional individuals to the mean number of inhabitant model estimation (300 years settlement duration) given in Table 2. However, the outlined correction fails to deliver a population size in a similar dimension like the archaeological expectation. A significantly longer time period-approximately 1,000 years of preindustrial agricultural use at the site, based on the diachronic settlement history of Maidanetske (Dreibrodt *et al.* 2020) could explain the phosphorus draw from the archaeological context. But there is a lack of reliable data that would allow such a calculation. At the Chalcolithic site of Maidanestke, as in the Neolithic contexts of Vrable (Dreibrodt *et al.* 2017): the geochemistry of shallowly buried archaeological contexts is highly exposed to change through post-depositional processes.

Revealing hidden micro topography of the mega-structure feature

At the communal building ('mega-structure') three deep profiles were studied. These characteristic features of Trypillian mega-sites have been discovered by comparison of gradiometer plans from a number of sites in central Ukraine (Hofmann *et al.* 2019). One profile (I8) is located in the mega-structure communal building, one is located in the yard (H15), and one is located outside of the enclosure associated with the mega-structure (Fig. 10).

Sediment properties are given in Figure 5. The most obvious are the over-thickened Chernozem in Profile H15 and the depth of the pre-Trypillian soil and loess below the mega-structure communal building (I8) compared to the profiles in the yard (H15) and the adjacent unbuilt area (C15). Since the border between the relic early Holocene soil and the loess should be expected in a similar depth, in profiles located that closely together, the observed offset of at least 60 cm needs an explanation.

One scenario that is based on the thickness and depth of characteristic soil horizons is outlined in the following and illustrated in the sketch of Figure 10. The differences in Chernozem thickness and the varying burial depths of pre-mega-structure soils and loess are best explained, considering the leveling layer as at least partly sub-aerial feature ('podium'; Fig. 10B). On top of this podium, the communal building was erected (Fig. 10C). The floor of the building was thus elevated above the yard and the enclosure by ca. 40–50 cm. This would result in a greater height and might qualify the communal building as a special one compared to the domestic houses. After the abandonment of the settlement and the communal building (Fig. 10D), Chernozem has overgrown the house remains (Fig. 10E). Slow small-scale erosion processes during the subsequent prehistoric times (heavy rainfalls, snowmelts; Fig. 10F) and faster erosion processes during historical and modern times (erosion, ploughing; Fig. 10G) would explain the even surface present nowadays, the varying thicknesses of surface Chernozem (+ small-scale colluvium) and buried pre-Trypillian soil and loess. The analysis of additional mega-structure profiles and high resolution, small-scale relief data (Lidar, high-resolution satellite data) might prove the reliability of the outlined scenario.



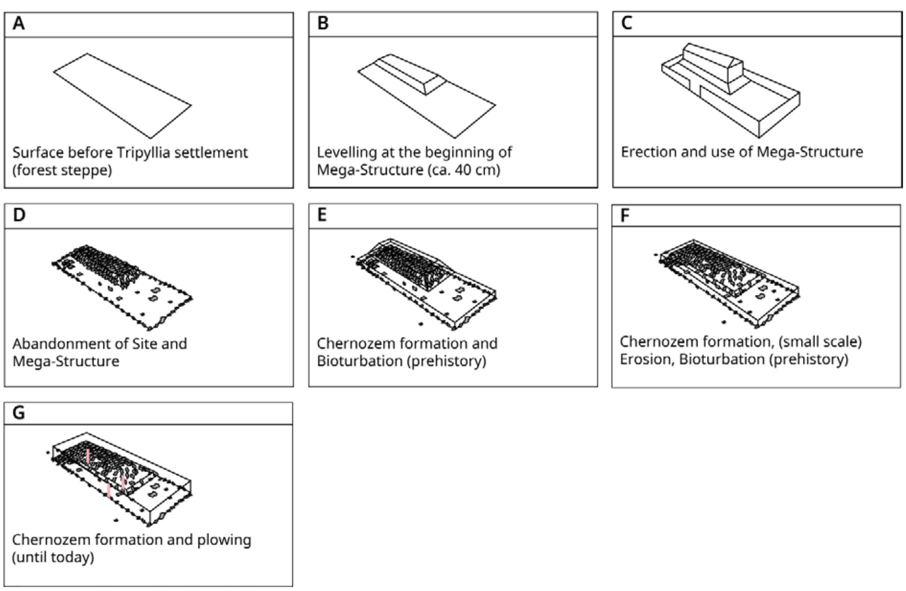


Figure 10. Model of the structure and evolution of the mega-structure (111) based on interpretation of the geoarchaeological data (Fig. 5).

References

Abrahams, P.W., Entwistle, J.A. and Dodgshon, R.A., 2010. The Ben Lawers Historic Landscape Project: Simultaneous Multi-element Analysis of Former Settlement and Arable Soils by X-ray Fluorescence Spectrometry. *Journal of Archaeological Method and Theory*, 17, 231–248. Available from: https://doi.org/10.1007/s10816-010-9086-8

Barton, R.N.E., Jacobi, R.M., Stapert, D. and Street, M.J., 2003. The Late-glacial reoccupation of the British Isles and the Creswellian. *Journal of Quaternary Science*, 18 (7), 631–643. Available from: https://doi.org/10.1002/jqs.772

Bocquet-Appel, J.P. and Demars, P.Y., 2000. Neanderthal contraction and modern human colonization of Europe. *Antiquity*, 74 (285), 544–552. Available from: https://doi.org/10.1017/S0003598X00059901

Brindley, G.W. and Brown, G., 1980. *Crystal Structures of Clay Minerals and their X-Ray Identification.* Mineralogical Society of Great Britain and Ireland 5. London: Mineralogical Society.

Casselberry, S.E., 1974. Further refinement of formulae for determining population from floor area. *World Archaeology*, 6 (1), 117–122. Available from: https://doi.org/10.1080/00438243.1974.9979593

Chamberlain, A., 2006. *Demography in Archaeology*. Cambridge: Cambridge University Press. Available from: https://doi.org/10.1017/CBO9780511607165

Chamberlain, A., 2009. Archaeological Demography. *Human Biology*, 81(3), 275–286. Available from: https://doi.org/10.3378/027.081.0309

Clark, A., 1996. *Seeing Beneath the soil: Prospecting Methods in Archaeology*, 2nd ed. London: Batsford.

Cook, S.F., 1972a. Can pottery residues be used as an index to population? *Contribution of the University of California Archaeological Research Facility,* 14, 17–40.

Cook, S.F., 1972b. *Prehistoric Demography*. McCaleb Module in Anthropology 1. Reading/Massachusetts: Addison-Wesley.

Davidson, D.A., Wilson, C.A., Lemos, I.S. and Theocharopoulos, S.P., 2010. Tell formation processes as indicated from geoarchaeological and geochemical investigations at Xeropolis, Euboea, Greece. *Journal of Archaeological Science,* 37 (7), 1564–1571. Available from: https://doi.org/10.1016/j.jas.2010.01.017

Dean, W.E., 1974. Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss on ignition: comparison with other methods. *Journal of Sedimentary Petrology,* 44 (1), 242–248. Available from: https://doi.org/10.1306/74D729D2-2B21-11D7-8648000102C1865D

Dearing, J., 1999. *Environmental Magnetic Susceptibility: Using the Bartington MS2 System*, 2nd ed. Bartington Instruments. Available from: https://bartingtondownloads.com/wp-content/uploads/OM0409.pdf

DLG, 1973. *DLG-Futterwerttabellen: Mineralstoffgehalte in Futtermitteln*. Arbeiten der DLG 62. Frankfurt: DLG-Verlag.

Dreibrodt, S., Furholt, M., Hofmann, R., Hinz, M. and Cheben, I., 2017. P-ed-XRF-geochemical signatures of a 7300 year old Linear Band Pottery house ditch fill at Vráble-Ve'lké Lehemby, Slovakia – House inhabitation and post-depositional processes. *Quaternary International*, 438, 131–143. Available from: https://doi.org/10.1016/j.quaint.2017.03.054

Dreibrodt, S., Hofmann, R., Sipos, G., Schwark, L., Videiko, M., Shatilo, L., Martini, S., Saggau, P., Bork, H.-R., Kirleis, W., Duttmann, R. and Müller, J., 2020. Holocene soil erosion in Eastern Europe-land use and/or climate controlled? The example of a catchment at the Giant Chalcolithic settlement at Maidanetske, central Ukraine. *Geomorphology*, 367, 107302. Available from: https://doi.org/10.1016/j.geomorph.2020.107302

Dreibrodt, S., Hofmann, R., Dal Corso, M., Bork, H.-R., Duttmann, R., Martini, S., Saggau, P., Schwark, L., Shatilo, L., Videiko, M., Nadeau, M.-J., Grootes, P.M., Kirleis, W. and Müller, J., 2022. Earthworms, Darwin and prehistoric agriculture-Chernozem genesis reconsidered. *Geoderma*, 409, 115607. Available from: https://doi.org/10.1016/j.geoderma.2021.115607

Dreibrodt, S., Langan, C.C.M., Fuchs, M. and Bork, H.-R., 2023. Anthropogenic impact on erosion, pedogenesis and fluvial processes in the central European landscapes of the eastern Harz mountains forelands (Germany). *Quaternary Science Reviews*, 303, 107980. Available from: https://doi.org/10.1016/j.quascirev.2023.107980

Entwistle, J.A., Abrahams, P.W. and Dodgshon, R.A., 1998. Multi-Element Analysis of Soils from Scottish Historical Sites. Interpreting Land-Use History Through the Physical and Geochemical Analysis of Soil. *Journal of Archaeological Science,* 25 (1), 53–68. Available from: https://doi.org/10.1006/jasc.1997.0199

Entwistle, J.A., Abrahams, P.W. and Dodgshon, R.A., 2000. The Geoarchaeological Significance and Spatial Variability of a Range of Physical and Chemical Soil Properties from a Former Habitation Site, Isle of Skye. *Journal of Archaeological Science,* 27 (4), 287–303. Available from: https://doi.org/10.1006/jasc.1999.0453

Feeser, I., Dörfler, W., Kneisel, J., Hinz, M. and Dreibrodt, S., 2019. Human impact and population dynamics in the Neolithic and Bronze Age: Multi-proxy evidence from north-western Central Europe. *The Holocene*, 29 (10), 1596–1606. Available from: https://doi.org/10.1177/0959683619857223

Filzmoser, P., Hron, K. and Reimann, C., 2009. Principle component analysis for compositional data with outliers. *Environmetrics,* 20 (6), 621–632. Available from: https://doi.org/10.1002/env.966

Gallivan, M.D., 2002. Measuring Sedentariness and Settlement Population: Accumulations Research in the Middle Atlantic Region. *American Antiquity*, 67 (3), 535–557. Available from: https://doi.org/10.2307/1593825

Hassan, F.A., 1978. Demographic Archaeology. *In*: M.B. Schiffer, ed. *Advances in Archaeological Method and Theory*. New York, San Francisco, London: Academic Press, 49–103. Available from: https://doi.org/10.1016/B978-0-12-003101-6.50009-3

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Kirleis, W. and Dreibrodt, S., 2016. The Natural Background: Forest, Forest Steppe or Steppe Environment. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 171–180. Available from: https://doi.org/10.4324/9781315630731

Kolb, C.C., Charlton, T.H., DeBoer, W., Fletcher, R., Healy, P.F., Janes, R.R., Naroll, R. and Shea, D., 1985. Demographic Estimates in Archaeology: Contributions From Ethnoarchaeology on Mesoamerican Peasants. *Current Anthropology*, 26 (5), 581–599. Available from: https://doi.org/10.1086/203348

Krupskovo and Polupana 1979: Крупского, Н.К. and Полупана, Н.И., eds., 1979. Атлас почв Украинской ССР. Киев: Урожай.

LeBlanc, S., 1971. An Addition to Naroll's Suggested Floor Area and Settlement Population Relationship. *American Antiquity*, 36 (2), 210–211. Available from: https://doi.org/10.2307/278676

Lubos, C.C.M., Dreibrodt, S., Robin, V., Nelle, O., Khamnueva, S., Richling, I., Bultmann, U. and Bork, H.-R., 2013. Settlement and environmental history of a multilayered settlement mound in Niederröblingen (Central Germany) – a multi-proxy approach. *Journal of Archaeological Science*, 40 (1), 79–98. Available from: https://doi.org/10.1016/j.jas.2012.07.022

Lubos, C., Dreibrodt, S. and Bahr, A., 2016. Analysing spatio-temporal patterns of archaeological soils and sediments by comparing pXRF and different ICP-OES extraction methods. *Journal of Archaeological Science: Reports*, 9, 44–53. Available from: https://doi.org/10.1016/j.jasrep.2016.06.037

Manzanilla, L., 1996. Soil analyses to identify ancient human activities. *Canadian Journal of Soil Science*, 76 (2), 107–108. Available from: https://doi.org/10.4141/cjss96-016

Marsden, P. and West, B., 1992. Population Change in Roman London. *Britannia*, 23, 133–140. Available from: https://doi.org/10.2307/526107

Martini, S.J., Athanassov, B., Frangipane, M., Rassmann, K., Stockhammer, P.W. and Dreibrodt, S., 2019. A budgeting approach for estimating matter fluxes in archaeosediments, a new method to infer site formation and settlement activity: Examples from a transect of multi-layered Bronze Age settlement mounds. *Journal of Archaeological Science: Reports*, 26, 101916. Available from: https://doi.org/10.1016/j.jasrep.2019.101916

Middleton, W.D., 2004. Identifying Chemical Activity Residues on Prehistoric House Floors: A Methodology and Rationale for Multi-Elemental Characterization of a Mild Acid Extract of Anthropogenic Sediments. *Archaeometry*, 46 (1), 47–65. Available from: https://doi.org/10.1111/j.1475-4754.2004.00143.x

Middleton, W.D. and Price, D.T., 1996. Identification of Activity Areas by Multi-element Characterization of Sediments from Modern and Archaeological House Floors Using Inductively Coupled Plasma-atomic Emission Spectroscopy. *Journal of Archaeological Science*, 23 (5), 673–687. Available from: https://doi.org/10.1006/jasc.1996.0064

Müller, G., 1964. *Methoden der Sediment-Untersuchung*. Sediment-Petrologie 1. Stuttgart: Schweitzerbart'sche Verlagsbuchhandlung.

Müller, J., Rassmann, K. and Videiko, M., eds., 2016. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site / Майданецьке 2013. Нові розкопки великого Трипільського поселення*. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Naroll, R., 1962. Floor area and settlement population. *American Antiquity*, 27 (4), 587–589. Available from: https://doi.org/10.2307/277689

Nowaczinski, E., Schukraft, G., Rassmann, K., Hecht, S., Texier, F., Eitel, B. and Bubenzer, O., 2013. Geophysical-Geochemical Reconstruction of Ancient Population Size – the Early Bronze Age Settlement of Fidvár (Slovakia). *Archaeological Prospection*, 20 (4), 267–283. Available from: https://doi.org/10.1002/arp.1460

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Ohlrau, R., Dal Corso, M., Kirleis, W. and Müller, J., 2016. Living on the Edge? Carrying Capacities of Trypillian Settlements in the Buh-Dnipro Interfluve. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 207–220. Available from: https://doi.org/10.4324/9781315630731

Ottaway, J.H. and Matthews, M.R., 1988. Trace element analysis of soil samples from a stratified archaeological site. *Environmental Geochemistry and Health*, 10 (3/4), 105–112. Available from: https://doi.org/10.1007/BF01758678

Phillips, P., 1972. Population, economy and society in the Chassey-Cortaillod-Lagozza cultures. *World Archaeology*, 4 (1), 41–56. Available from: https://doi.org/10.1080/00438243.1972.9979519

Pickartz, N., Hofmann, R., Dreibrodt, S., Rassmann, K., Shatilo, L., Ohlrau, R., Wilken, D. and Rabbel, W., 2019. Deciphering archeological contexts from the magnetic map: Determination of daub distribution and mass of Chalcolithic house remains. *The Holocene*, 29 (10), 1637–1652. Available from: https://doi.org/10.1177/0959683619857238

Plog, F., 1975. Demographic Studies in Southwestern Prehistory. *Memoirs of the Society for American Archaeology*, 30, 94–103. Available from: https://doi.org/10.1017/S0081130000003841

Rabenhorst, M.C., Schmehling, A., Thompson, J.A., Hirmas, D.R., Graham, R.C. and Rossi, A.M., 2014. Reliability of Soil Color Standards. *Soil Science Society of America Journal*, 79 (1), 193–199. Available from: https://doi.org/10.2136/sssaj2014.10.0401

Sanmartín, P., Chorro, E., Vázquez-Nion, D., Martínez-Verdú, F.M., Prieto, B., 2014. Conversion of a digital camera into a non-contact colorimeter for use in stone cultural heritage: the application case to Spanish granites. *Measurement*, 56, 194–202. Available from: https://doi.org/10.1016/j.measurement.2014.06.023

Schacht, R.M., 1981. Estimating Past Population Trends. *Annual Review of Anthropology*, 10, 119–140. Available from: https://doi.org/10.1146/annurev.an.10.100181.001003

Schiffer, M.B., 1976. *Behavioral Archaeology*. New York: Academic Press.

Schiffer, M.B., 1985. Is There a “Pompeii Premise” in Archaeology? *Journal of Anthropological Research*, 41 (1), 18–41. Available from: https://doi.org/10.1086/jar.41.1.3630269

Turner II, C.G. and Lofgren, L., 1966. Household Size of Prehistoric Western Pueblo Indians. *Southwestern Journal of Anthropology*, 22 (2), 117–132. Available from: https://doi.org/10.1086/soutjanth.22.2.3629190

Viscarra Rossel, R.A., Minasny, B., Roudier, P. and McBratney, A.B., 2006. Colour space models for soil science. *Geoderma*, 133 (3–4), 320–337. Available from: https://doi.org/10.1016/j.geoderma.2005.07.017

Vita-Finzi, C., Higgs, E.S., Sturdy, D., Harriss, J., Legge, A.J. and Tippett, H., 1970. Prehistoric Economy in the Mount Carmel Area of Palestine: Site Catchment Analysis. *Proceedings of the Prehistoric Society*, 36, 1–37. Available from: https://doi.org/10.1017/S0079497X00013074

Wiessner, P., 1974. A Functional Estimator of Population from Floor Area. *American Antiquity*, 39 (2), 343–350. Available from: https://doi.org/10.2307/279593

Wilson, C.A., Davidson, D.A. and Cresser, M.S., 2005. An evaluation of multielement analysis of historic soil contamination to differentiate space use and former function in and around abandoned farms. *The Holocene*, 15 (7), 1094–1099. Available from: https://doi.org/10.1191/0959683605hl881rr

Wilson, C.A., Davidson, D.A. and Cresser, M.S., 2008. Multi-Element soil analysis: an assessment of its potential as an aid to archaeological interpretation. *Journal of Archaeological Science*, 35 (2), 412–424. Available from: https://doi.org/10.1016/j.jas.2007.04.006

Wilson, C.A., Davidson, D.A., Cresser, M.S., 2009. An evaluation of the site specificity of soil elemental signatures for identifying and interpreting former functional areas. *Journal of Archaeological Science*, 36 (10), 2327–2334. Available from: https://doi.org/10.1016/j.jas.2009.06.022

Zimmermann, W.H., 1992. *Die Siedlungen des 1. bis 6. Jahrhunderts nach Christus von Flögeln-Eekhöltjen, Niedersachsen: Die Bauformen und ihre Funktionen*. Probleme der Küstenforschung im südlichen Nordseegebiet 19. Hildesheim: Verlag August Lax.

Zorn, J.R., 1994. Estimating the Population Size of Ancient Settlements: Methods, Problems, Solutions, and a Case Study. *Bulletin of the ASOR*, 295, 31–48. Available from: https://doi.org/10.2307/1357103

6. Worked osseous materials from the site of Maidanetske: is that all there is?

Andreea Țerna

Introduction

The long-term research on the Cucuteni-Trypillia phenomenon has widely benefitted in the last decades from advances in field archaeology and material culture studies, which has led to a better understanding of the social, economic and environmental transformations that shaped its two millennia of existence. However, there is a lack of systematic approach in the investigations of certain categories of artefacts. This is the case with objects made of osseous materials *i.e.* bone, antler, dentine, shells, which have received little attention due to the relatively small number of finds but also due to a sort of scepticism about their potential use as proxies for cultural change.

The data on this subject is more generous for the early stages of Cucuteni-Trypillia, *i.e.* 4900–4200 BCE, where assemblage sizes range from dozens to around 200 items per site (Bibikov 1953; Zbenovici 1980; Ţurcanu and Bejenaru 2012; Vornicu 2014). For the period between 4200–3600 BCE, which corresponds to the formation and development of the mega-sites, two regional patterns can be observed. Large-scale excavations at sites in the Bug-Dnieper interfluve revealed a surprisingly low number of finds made of osseous materials (Shmagliy and Videiko 2005; Kruts *et al.* 2008; Kruts *et al.* 2010; Kruts *et al.* 2011; Kruts *et al.* 2013; Ohlrau 2020; Tóth and Choyke 2020). On the other hand, for the region between the Carpathians and the Dniester River, most publications, although they refer to old excavations and some of them lack quantitative data, indicate a good representativity of worked osseous materials (Cucoş 1999, 67–71; Bolomey and Marinescu-Bîlcu 2000; Sorochin 2002). Recent research at the site of Stolniceni (Republic of Moldova), which benefitted from extensive sediment screening (Țerna *et al.* 2019) supports this information. The assemblage recovered here yielded almost 230 objects. Only in the second part of the 4th millennium BCE, during the late Trypillia phase, can one see an outburst in the manufacturing of bone and antler implements, together with the appearance of standardisation in the production of bone daggers and heavy antler axes (Dergachev 1980; Markevich 1981).

Returning to the mega-sites of the Bug-Dnieper region, the poverty of worked osseous materials appears surprising, when considering the scales of production and consumption required to sustain such large communities. The published assemblage of worked osseous materials from the excavation campaigns from 1971 to 1991 at Maidanetske consists of fewer than 15 tools. On the other hand, a large collection of 210 pieces of adornments was recovered from two contexts that demonstrate hoarding practices (Shmagliy and Videiko 1987, 63–64; Shmagliy and Videiko 2005, 102). Only two objects were discovered during the Ukrainian-German excavations from 2013 to 2016: an antler axe and a bone bead (Ohlrau 2020, 84). In searching for an explanation of the scarcity of finds, the first question that should be addressed concerns the quality of the recovered assemblage. The archaeological record is frequently subject to perturbing factors and biases at various stages during its formation, taphonomic life, recovery and research. Systemic errors in the excavation methodology, sampling and collection strategies may result in only partial recovery of finds. Particularly for the worked osseous materials, the size and quality of the assemblage can be greatly affected by the on-site identification of human-modified items. During excavations, most often only easily recognisable objects are collected, while expedient tools, preforms, blanks, production wastes, or any other types of products with a lower degree of volume or surface modification can be easily ignored and mixed in with the faunal assemblage. As a result, the screening of faunal remains is critical for recovering potentially lost records and can be especially useful for sites with very small assemblages such as Maidanetske, because it can provide a better estimate of the true importance of worked osseous materials within the settlement's economy. This paper presents the small collection of bone implements recovered during the screening of faunal remains from the excavations at Maidanetske from 2013 to 2016.

Material and methods

The reassessment of faunal remains was carried out for the material recovered from different features in Trenches 50, 51, 52, 60, 80, 110 and 111. In total, the assemblage contained approximately 900 fragments (for more information on the frequency of faunal remains in each trench, see Chapter 9, this work, Vol. I).

The main limitation in identifying the worked osseous materials, which may also affect to some degree their frequency within the assemblage, is the poor preservation of the skeletal elements. A large part of the faunal remains was affected by various taphonomic agents, resulting in partial or complete degradation of the surface. The majority of the bones show exfoliation, root etching, mineral crust and corrosion. These factors should not have a significant impact on the recognition of highly modified implements, but they can be decisive in the identification of expedient tools, fragmented objects or products made from bones of small mammals, which are more prone to dissolution (Lyman 1994).

The fragments which showed traces of manufacturing or use were examined under a Keyence digital microscope at magnifications ranging from 5x to 100x. For the classification and interpretation of the micro-traces we used as reference the substantial set of publications available on the subject (Peltier and Plisson 1986; Sidéra 1993; Legrand 2007; Averbouh 2000).

Results

Despite the preservation constraints, it was possible to identify four modified bone fragments: two finished products, a debitage waste, and a fragment of undetermined manufacturing stage. Aside from those, two other fragments have modifications that may or may not be the result of human intervention.

All the finds come from two trenches: 50 and 60. Both were opened over pits that corresponded to houses from rings 4 and 5 (Müller *et al.* 2017, 51–59).

Find № 50134 is a tool made from the quartered metapodial of a large ruminant (Fig. 1). Because both ends of the implement are broken, the reconstruction of the initial morphology is difficult. A large transversal fracture runs deeper on the anterior face of one extremity, most likely the distal end of the implement. A small abraded area is visible on one edge, near the fracture line (Fig. 1A). Judging by the convergent edges, one can assume that the tool was initially pointed. The opposite end has a longitudinal break. On the anterior face, it preserves a portion of a bevel-like end (Fig. 1B). The deep chipping on the top and the large flaking on the front of the bevel are characteristics of wear developed during use. While the flaking could have been caused by incorrect manipulation of the tool, the chipping at the end was most likely caused by repeated strikes with a hard surface. All of this points to the possibility that the object was used as an intermediate tool, a punch-like object. As regards the manufacturing process, the uneven aspect of the edges indicates that the technique used for blank extraction was percussion. The shaping was done by abrasion and was limited to the extremities.

Find № 50131 is a fragment of an undetermined type of implement and shows fractured areas at both ends (Fig. 2). It was obtained by the fracture of a long bone diaphysis from a cattle-size animal. The proximal end of the object was modified, as evidenced by the abrasion traces, which are weakly visible on a small area on the extremity. The distal end has a Y-shaped fracture and narrow areas of wear located primarily at the fracture line's base (Fig. 2B). The edges of the fracture are rounded at the highest points (Fig. 2A), indicating that the object was used for a short period of time after its initial breakage. The artefact is covered in ochre, which has mostly adhered to the bone surface at the distal end. Based on the location of the residue, it is less likely that the colouration occurred as a result of deposition in sediment rich in ochre, but rather that it may be connected to the use of the tool. Aside from the well-known use of ochre as pigment and its symbolic value in prehistory, several other utilitarian functions were assumed such as ingredients for obtaining the adhesives used for hafting (Lombard 2006) or the additives for hide tanning (Keeley 1980; Rifkin 2011).

Find № 60189 is a debitage waste from the bipartition of a large ruminant metapodial (Fig. 3). This is a common method of debitage that allows the raw material block to be divided in two symmetrical blanks. The two rods were separated from one side of the bone by grooving longitudinally with a flint tool, a technique that allows for more control over the finished product's morphology. As a result, the edge is straight and regular, and it preserves longitudinal parallel striations from the contact with the flint implement (Fig. 3). Percussion was used as a secondary technique for completing the separation on the opposite side of the bone. In this case, the resulting edge is uneven and has a rough aspect.

Find № 50151 is a medial fragment of an object whose surface has been partially destroyed but which retains traces of shaping by scraping and fracturing (Fig. 4). It was obtained by fracturing a long bone from a sheep-sized animal. The fragment lacks sufficient features to allow us to identify the manufacturing stage or morpho-functional category to which it belongs.

Aside from the above four objects that show clear traces of manufacturing or use, there are two other fragments that could be considered pseudo-tools. The first, *find № 50152*, is a long bone fragment with the edges converging in a pointed end (Fig. 5.1). The surface is heavily altered, with calcareous crust covering nearly half of the length. The only modifications observed were on the apex. Under high magnifications, the apex shows a flattened surface with superficial striations and darker colouration. If we consider that the modifications are the result of use, then one should imagine a very short event and only marginal contact with the worked material. Nonetheless, there are several other surface modification agents that are likely to produce wear similar to that found on the archaeological object. We

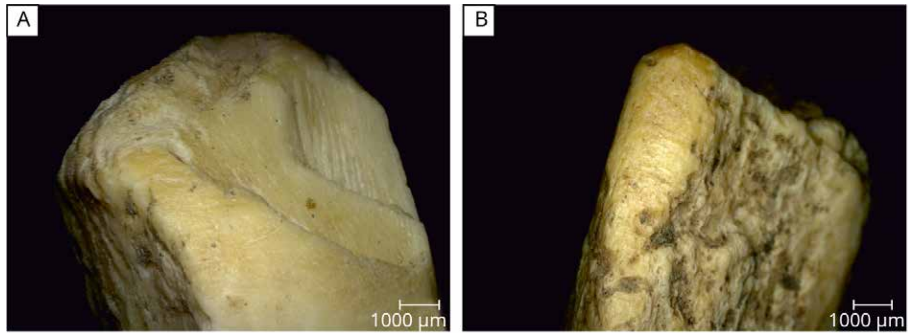


Figure 1. Find № 50134: (A) the distal end showing worn traces of abrasion; (B) close-up of the bevelled-like proximal end of the tool.

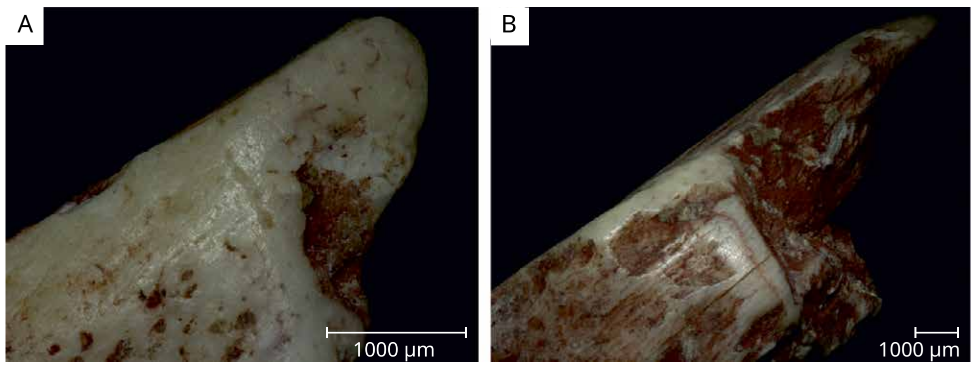


Figure 2. Find № 50131: (A) the distal end showing rounding of the fractured tip; (B) small areas of use wear near the fracture line.

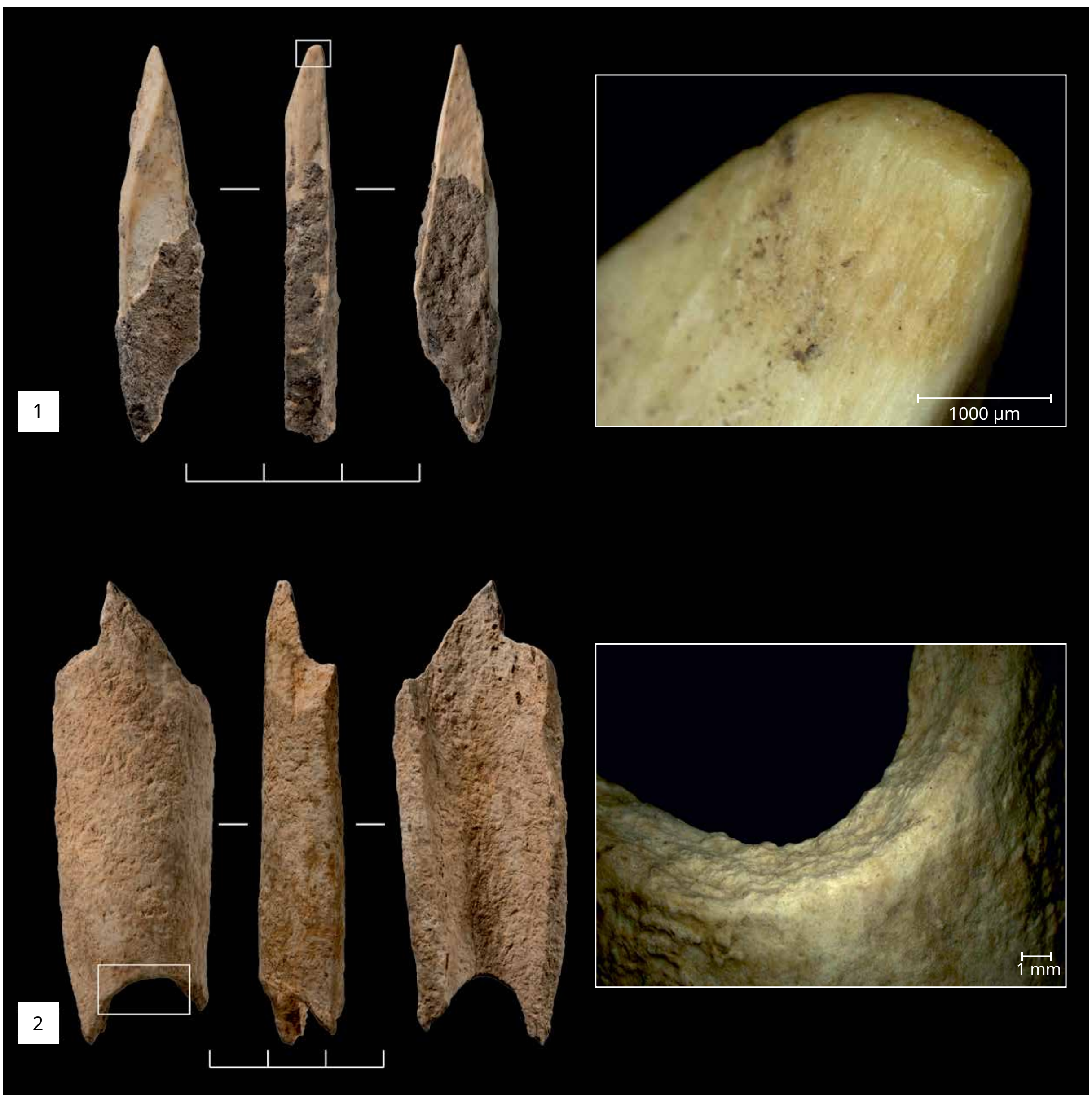
Figure 3. Find № 60189: Traces resulting from the longitudinal partition of a metapodial by grooving: longitudinal striations on the groove's wall and surplus material from the detachment, on the bottom.

considered taphonomic processes such as trampling (Lyman 1984; Lyman 1994), but also human activities other than tool production; for example, it has been shown that boiling bone fragments in pottery vessels can result in modifications such as rounding, bevelling and striations at the ends (White 1992, 120–129).

The last object, *find № 60184*, is a longitudinal segment from a long bone, with one end displaying a rounded concavity, similar to a human-made perforation (Fig. 5.2). Because the bone surface has been completely eroded, it is impossible to distinguish any manufacturing traces and thus determine whether the modification is the result of a technological action.

Figure 4 (left). Find № 50151: Longitudinal striations produced by scraping.

Figure 5 (below). Two possible pseudo-tools: (1) find № 50152 and a close-up of the apex; (2) find № 60184 and a close-up of the concavity's inner wall.



Discussion and Conclusion

The very small size of the assemblage allows only a few observations on the production of implements from osseous materials at the site of Maidanetske. All implements found in the faunal remains are made of long bones from large or small ruminants. We observed that the inhabitants of the site were familiar with both expedient and more elaborated methods of producing blanks. Fracturing and the selection of bones with useable breaks from butchering wastes are quick methods for blank acquisition but they have the disadvantage of allowing less control over the final product shape. Alongside this, we see the use of bipartition by grooving, a method that requires a greater investment of time and careful planning of technological sequences but, in return, it provides blanks of predetermined shape. The presence of a debitage waste within the assemblage indicates that, at least for some types of products, manufacturing occurred at the site.

Due to the high fragmentation of the objects, little can be said about the types of objects produced at Maidanetske. We identified what appears to be a punch-like implement and a presumed awl that had been re-used for a short time after its initial breakage. Both objects are similar to items commonly found at Cucuteni-Trypillia sites.

The low frequency of implements made from osseous materials remains a subject open to discussion.

The research strategy at Maidanetske, based on target excavations and test pits, allowed for the investigation of various categories of archaeological features (burnt houses, pits, pottery kilns), which should provide a representative sample of finds. At the same time, the sieving of sediment from various contexts ensured the collection of even small size remains. By screening the faunal assemblage, we were able to recover a small number of artefacts that had escaped identification on-site. Still, even after excluding the presumed biases related to the excavation and recovery methods, the number of finds remains surprisingly low. Therefore, it is reasonable to ask if there is a missing assemblage that one should search for, or is that all there is? One possible explanation is that the density of finds reflects their actual economic value. Thus, the scarcity of worked osseous materials translates into a low demand of such goods and, as a result, a small scale of production. Another explanation could be that there was a presumably complex spatial distribution of production, consumption and refuse activities. Here we are considering different scenarios that could result in the aggregation of finds in specific locations within or outside the settlement, the identification of which by means of excavation would be purely a matter of chance. To name a few examples, specialised production or consumption of worked osseous materials could have occurred in workshops or activity areas located in specific neighbourhoods of the site. In terms of refuse practices, the cumulative disposal of objects has already been documented at Maidanetske in the case of adornments (Shmagliy and Videiko 1987, 63–64; Shmagliy and Videiko 2005, 102). Hoarding has been observed at other Cucuteni-Trypillia sites and this primarily consists of non-utilitarian objects (Dumitrescu *et al.* 1954; Sergeev 1963; Ursachi 1991; Sztáncsuj 2005). Nonetheless, there are also cases of hoards composed of tools, which are usually interpreted as accumulations of objects of symbolic value or sets of semi-finished products for exchange (Pichkur 2017). Any of these scenarios will require additional research in order to be validated.

Seen in a wider context, other mega-sites of the region like Nebelivka and Talianki have provided assemblages of osseous materials of similar size (Kruts *et al.* 2008; Kruts *et al.* 2010; Kruts *et al.* 2011; Kruts *et al.* 2013; Tóth and Choyke 2020). What we consider to be even more relevant is that the low intensity of discarded goods is not limited to worked osseous materials, but has also been documented for the chipped stone industry (Shmagliy and Videiko 2005; Kiosak *et al.* 2020). Flint is known to be the main raw material used for the production of tools at the Cucuteni-

Trypillia sites. In comparison to contemporary settlements west of the Dniester river, the mega-sites provide not only a small number of finds but also very little evidence of on-site production of goods (Shmagliy and Videiko 2005, 101). Therefore, the small size of the worked osseous materials assemblage matches the overall low density of tools and weapons at Maidanetske and other mega-sites.

References

Averbouh, A., 2000. *Technologie de la matière osseuse travaillée et implications paléotechnologiques. L'exemple des chaînes d'exploitation du bois de cervide chez les Magdaléniens des Pyrenées*. [PhD thesis. Université de Paris I – Panthéon – Sorbonne].

Bibikov 1953: Бибиков, С.Н., 1953. *Раннетрипольское поселение Лука-Врублевецкая на Днестре: К истории ранних земледельческо-скотоводческих племен на юго-востоке Европы*. Материалы и исследования по археологии СССР (МИА) 38. Москва, Ленинград: Издательство Академии наук СССР.

Bolomey, A. and Marinescu-Bîlcu, S., 2000. The Bone and Antler Industry. *In*: S. Marinescu-Bîlcu and A. Bolomey, eds. *Drăgușeni. A Cucutenian Community*. București: Editura Enciclopedică, 63–90.

Cucoş, Ș., 1999. *Faza Cucuteni B* în *zona subcarpatică a Moldovei*. Bibliotheca Memoriae Antiquitatis VI. Piatra-Neamţ: Muzeul de Istorie Piatra-Neamț.

Dergachev 1980: Дергачев, В.А., 1980. Памятники позднего энеолита (опыт систематизации). Кишинев: Штиинца.

Dumitrescu, V., Dumitrescu, H., Petrescu-Dîmboviţa, M. and Gostar, N., 1954. *Hăbășești. Monografie arheologică*. București: Editura Academiei Republicii Populare Române.

Keeley, L.H., 1980. *Experimental Determination of Stone Tools Uses: A Microwear Analysis*. Prehistoric Archeology and Ecology series. Chicago: University of Chicago Press.

Kiosak, D., Belenko, M.M. and Chapman, J., 2020. Chipped Stone. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 352–369. Available from: https://doi.org/10.1515/9783110664959-009

Kruts *et al.* 2008: Круц, В.А., Корвин-Пиотровский, А.Г., Менотти, Ф., Рыжов, С.Н., Черновол, Д.К. and Чабанюк, В.В., eds., 2008. Трипольское поселение-гигант Тальянки. Исследования *2008 г / Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2008*. Киев: Институт археологии НАН Украины.

Kruts *et al.* 2010: Круц, В.А., Корвин-Пиотровский, А.Г., Менотти, Ф., Рыжов, С.Н., Черновол, Д.К. and Чабанюк, В.В., 2010. Керамика, пластика, орудия /Ceramic, figurines, tools. *In*: А.Г. Корвин-Пиотровский and Ф. Менотти, eds. Трипольское поселение-гигант Тальянки. Исследования *2010* г / *Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2010*. Киев: Институт археологии НАН Украины, 20–31.

Kruts *et al.* 2011: Круц, В.А., Корвин-Пиотровский, А.Г., Рыжов, С.Н., Черновол, Д.К. and Чабанюк, eds., 2011. Трипольское поселение-гигант Тальянки. Исследования *2011* г / *Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2011*. Киев: Институт археологии НАН Украины.

Kruts *et al.* 2013: Круц, В.А., Корвин-Пиотровский, А.Г., Чабанюк, В.В. and Шатило, Л.А., 2013. Трипольское поселение-гигант Тальянки. Исследования *2012* г / *Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2012*. Киев: Институт археологии НАН Украины.

Legrand, A., 2007. *Fabrication et utilisation de l'outillage en matières osseuses du Néolithique de Chypre: Khirokitia et Cap Andreas-Kastros.* BAR International Series 1678. Oxford: Archaeopress.

Lombard, M., 2006. Direct evidence for the use of ochre in the hafting technology of Middle Stone Age tools from Sibudu Cave. *Southern African Humanities*, 18 (1), 57–67.

Lyman, R.L., 1984. Broken Bones, Bone Expediency Tools, and Bone Pseudotools: Lessons from the Blast Zone around Mound St. Helens, Washington. *American Antiquity*, 49 (2), 315–333. Available from: https://doi.org/10.2307/280021

Lyman, R.L., 1994. *Vertebrate Taphonomy*. Cambridge: Cambridge University Press. Available from: https://doi.org/10.1017/CBO9781139878302

Markevich 1981: Маркевич, В.И., 1981. *Позднетрипольские племена северной Молдавии*. Кишинев: Штиинца.

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site* / Майданецькe *2013.* Нові розкопки великого Трипільського поселення. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Peltier, A. and Plisson, H., 1986. Micro-tracéologie fonctionnelle sur l'os. Quelques résultats expérimentaux. *In*: M. Patou-Mathis, ed. *Outillage peu élaboré en os et en bois de cervidés II. 3ème réunion du groupe de travail numéro 1 sur l'industrie de l'os préhistorique*. Artefacts 3. Viroinval: Editions du C.E.D.A., 69–80.

Pichkur 2017: Пичкур, Е.В., 2017. Индикаторы «импортов» в трипольской культуре (по материалам «кладов» кремневых пластин). *Vita Antiqua*, 9, 206–221. Available from: https://doi.org/10.37098/VA-2017-9-206-221

Rifkin, R.F., 2011. Assessing the Efficacity of Red Ochre as a Prehistoric Hide Tanning Ingredient. *Journal of African Archaeology*, 9 (2), 131–158. Available from: https://www.jstor.org/stable/43135547

Sergeev 1963: Сергеев, Г.П., 1963. Раннетрипольский клад у с. Карбуна. Советская археология, 1963 (1), 135–151.

Shmagliy and Videiko 1987: Шмаглій, Н.М. and Видейко, М.Ю., 1987. Пізньотрипільське поселення поблизу с. Майданецькоґо на Черкащиии. *Археологии*, 60, 58–71.

Shmaglij and Videiko 2005: Шмаглий, Н.М. and Видейко, Ю.М., 2005. Майданецкое - трипольский протогород. Киев: Институт археологии НАН Украины.

Sidéra, I., 1993. *Les assemblages osseux en bassins parisien et rhénan du VIe au IVe millénaires B.-C. Histoire, techno-économie et culture*. [PhD thesis. Université de Paris I – Panthéon – Sorbonne].

Sorochin, V., 2002. *Aspectul regional cucutenian Drăguşeni-Jura*. Bibliotheca Memoriae Antiquitatis XI. Piatra-Neamţ: Editura Constantin Matasă.

Sztáncsuj, S.J., 2005. The early Copper Age hoard from Ariușd (Erősd). *In*: G. Dumitroaia, J. Chapman, O. Weller, C. Preoteasa, R. Munteanu, D. Nicola. and D. Monah, eds. *Cucuteni. 120 ans de recherches. Le temps du bilan*. Bibliotheca Memoria Antiquitatis XVI. Piatra Neamț: Editura Constantin Matasă, 85–106.

Țerna, S., Vornicu-Țerna, A., Hofmann, R., Dal Corso, M., Shatilo, L., Vasilache-Curoşu, M., Rud, V., Knapp, H., Kirleis, W., Rassmann, K. and Müller, J., 2019. Stolniceni – Excavation results from the 2017 campaign. *Journal of Neolithic Archaeology*, 21, 209–282. Available from: https://doi.org/10.12766/jna.2019.9

Tóth, Z. and Choyke, A., 2020. Worked Bone. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 370–377. Available from: https://doi.org/10.1515/9783110664959-009

Ţurcanu, S. and Bejenaru, L., 2012. Industria materiilor dure animale. *In*: C.-M. Lazarovici and G. Lazarovici, eds. *Ruginoasa – Dealul Drăghici.* Monografie arheologică. Suceava: Editura Karl A. Romstorfer, 173–190.

Ursachi, V., 1991. Le dépôt d'objects de parure énéolithique de Brad, com. Negri, dép. de Bacău. *In*: V. Chirica and D. Monah, eds. *Le Paléolithique et le Néolithique de la Roumanie en contexte Européen*. Bibliotheca Archaeologica Iassiensis IV. Iași: Institut d'Archéologie, 335–386.

Vornicu, A., 2014. Technological behavior in the manufacturing of bone pointed tools: a case study on the Chalcolithic settlement from Târgu Frumos (Iaşi county, Romania). *In*: M. Mărgărit, G. Le Dosseur and A. Averbouh, eds. *An overview of the exploitation of hard animal materials during the Neolithic and Chalcolithic*. Târgoviște: Editura Cetatea de Scaun, 137–154.

White, T.D., 1992. *Prehistoric cannibalism at Mancos 5MTUMR-2346*. New Jersey: Princeton University Press.

Zbenovic 1980: Збенович, В.Г., 1080. Поселение Бернашевкана Днестре *(k* происхождению *Трипольской* культуры*)*. Киев: Академия Наук Украинскои ССР.

7. Plant economy and local environment at the Trypillia mega-site Maidanetske from botanical macro-remains

Marta Dal Corso, Wiebke Kirleis

Introduction

Archaeological and environmental setting

Population agglomeration of thousands of inhabitants in Chalcolithic mega-sites (or giant settlements) of the Trypillia culture is an extraordinary phenomenon of the late 5th and early 4th millennium BCE in southeastern Europe. The Maidanetske site in the central part of the Bug-Dnieper interfluve consists of ca. 3,000 houses built around an oval open space of ca. 25 ha. Overall, the site covers an area of about 200 ha. The houses and mega-structures are arranged in up to eight circles, some being separated by open space of 70–100 m. Clusters of 50–150 structures are interpreted as distinct neighbourhoods, each being associated with a mega-structure. An intensive dating programme shows that the Maidanetske site was inhabited for a relatively short time period from 3990–3640 BCE which is about five to six generations. During this period other mega-sites were present a few kilometres away, such as Talianki and Nebelivka (Shatilo 2021).

Although situated nowadays in a humid continental forest-steppe landscape with hot summers and cold wet winters (Dfb climate class according to Köppen and Geiger 1939), a patchy environment can be expected to have existed in the vicinity of the site (Fig. 1) with open grasslands, groups of trees on the plateau and riverine woodland in the valley of the adjacent Talyanka River (Dal Corso *et al.* 2019). The woodland patches are likely to have been dominated by fast-growing ash, oak and elm (Dal Corso *et al.* 2019). Such diversified landscape offered multiple ecological niches suitable for crop cultivation as well as animal husbandry and was esteemed valuable and probably very appealing for Trypillia settlers. The relevance of crop cultivation for the Maidanetske settlers amongst others is proven by the massive use of cereal by-products for earthen architecture (*e.g.* in house building) as attested by cereal chaff phytoliths, as well as imprints, in daub (Dal Corso *et al.* 2018). Cereal by-products were used also as animal fodder. Indeed, according to the stable isotope data on faunal remains (Makarewicz *et al.* 2022), Trypillia animal husbandry strategies at Maidanetske were diverse, probably reflecting a conscious management of the space by the community, also in respect of the exigencies of other nearby communities. Most of the domesticated herbivores in Maidanetske, which included mainly cattle followed by sheep and goats, grazed on extensive well-watered grassy pastures. However, some cattle were herded in intensively-grazed restricted pastures, thus manure-enriched, possibly located in the centre of the settlement (Makarewicz *et al.* 2022). This practice would have guaranteed easy access to milk for dairy products and to dung for manure of arable plots. Direct grazing on arable fields may have been possible as well. Pigs received different treatment and were mainly kept within the settlement area and fed with nitrogen-enriched plant-based food waste (Makarewicz *et al.* 2022). Over the course of 150 years of settlement occupation such intensive land use and clearing of woody patches resulted in the formation of Chernozem soils (black soils; Kirleis and Dreibrodt 2016; Dreibrodt *et al.* 2022).

Brief history of research in Trypillia archaeobotany

To understand the phenomenon of Trypillia mega-sites it is crucial to explore the relevance of agriculture since this provides the backbone for the survival of such large population agglomerations. The onset of farming and sedentism furthered population growth. Plant cultivation and animal husbandry therefore provided the necessary food security. When the Trypillia mega-sites developed in the 4th millennium BCE, agriculture was already well established around the Black Sea (*e.g.* Monah 2007; Motuzaitė Matuzevičiūtė 2013; Motuzaitė Matuzevičiūtė and Telizhenko 2016; Salavert *et al.* 2015). Preceding archaeological groups such as the LBK (Motuzaitė Matuzevičiūtė and Telizhenko 2016) in western Ukraine and the Pre-Cucuteni and Gumelniţa groups in Romania (*e.g.* Carciumaru 1990; Golea *et al.* 2014; Hovsepyan *et al.* 2020; Monah and Monah 2002) based their economy on crops and domestic animals. The knowledge about plant cultivation and seedlings was available to the Trypillia settlers, and the plant evidence shows that they made use of these. Alongside the direct evidence from plant micro- and macro-remains, large, immobile storage vessels (‘*phitoi*’ with chaff-tempered thick walls, estimated as up to 1.2 m high and over 50 l in volume) are known in the area of Maidanetske (Shatilo 2021, 196; Shumova 1988), that indicate a distinct organisation for handling of staple foods. According to house models, such large containers were located on the podium in the main floor of Trypillia houses. Fragments have been found in Maidanetske, Nebelivka and Talianki (Maidanetske House 44: Müller *et al.* 2016, 256; Nebelivka House A9 and Mega-structure B5: Burdo and Videiko 2016, 110), although more often smaller vessels of 30–40 l in volume were found.

The study of plant exploitation in Trypillia-Cucuteni archaeology has a long research history that is based mainly on the analysis of plant imprints in clay artefacts like vessels and daub plus fortunate cases of ceramic vessels found filled with charred plant remains (Kirleis and Dal Corso 2016, Tab. 1, 198; Pashkevych and Videiko 2006; Yanushevich 1978; Yanushevich 1989). The focus on daub and its organic temper is in accordance with the archaeological strategy of excavating the houses as main units in order to explore the everyday life of the settlers in the Trypillia mega-sites. The analysis of charred plant remains derived from soil samples only started in the early 2000s with excavations by the Ukrainian archaeological team around Kruts in Talianki. It marked a shift from qualitative data on the occurrence of different plant species towards the identification of human activities related to the cultivation, usage and processing of plants (Chapman *et al.* 2020, 409–412; Dal Corso *et al.* 2019; Kirleis and Dal Corso 2016; Kirleis *et al.* 2024; Kruts *et al.* 2008; Kruts *et al.* 2009; Pashkevych 2012).

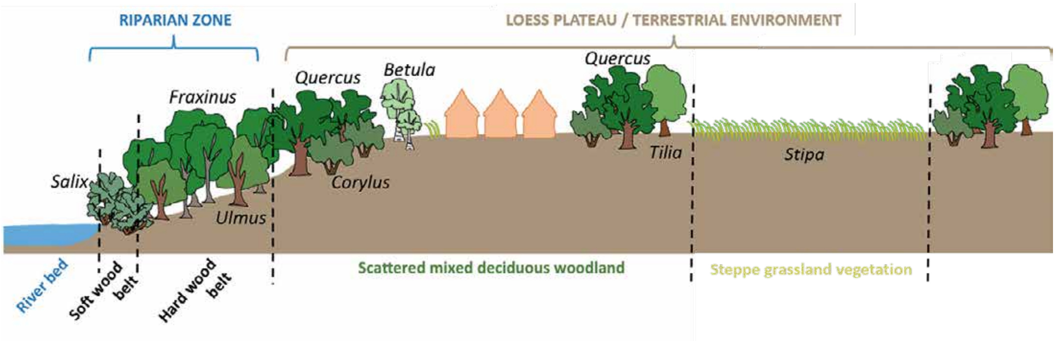


Figure 1. Scheme of Chalcolithic vegetation zones in the vicinity of Maidanetske based on archaeobotanical records (after Dal Corso et al. *2019).*

While extremely low find concentrations in Talianki discouraged the archaeobotanical team from IPNA Basel to continue beyond a pilot study (Kruts *et al.* 2008; Kruts *et al.* 2009), soil sampling for archaeobotanical analyses was carried out by the British-Ukrainian excavations at Nebelivka on a regular basis for house structures, the mega-structure, a pit close to a house and one close to a kiln-like structure labelled as 'industrial feature'. Since the use of a flotation tank next to low find concentrations resulted in mechanical damage of the few findings from the mega-structure, bucket flotation was then applied, but this still resulted in extremely low find concentrations (Chapman *et al.* 2020, 409–414).

For the Trypillia mega-sites one main issue is the preservation of the house structures close to the modern soil surface, the overall archaeological material being sometimes heavily damaged by ploughing. For the archaeobotanical record, such deposition near to the modern surface heavily affects the preservation of the charred plant remains. The deeper in the ground, the more plant remains are preserved and in even better conditions, as the find concentration has shown.

Research questions and aims

With this paper we are providing the final data on the systematic study on the plant economy of the Maidanetske mega-site and are updating preliminary records published to date (Dal Corso *et al.* 2019; Kirleis and Dal Corso 2016). The main aim of our investigation of plant remains is the characterisation of the proto-urban subsistence economy in a mega-site of the early 4th millennia BCE. Furthermore, in order to better understand organic preservation conditions at the site and to provide better orientation for future research, we applied a sampling strategy that includes and differentiates between ten different kinds of archaeological features, including some test samples from the natural stratigraphy above and below the *in situ* archaeological record.

Methods

Sampling strategy and archaeological features

During three years of fieldwork campaigns (2013, 2014, 2016), for the analysis of botanical macro-remains 732 samples were systematically collected in 10 litre lidded buckets. Each trench was provided with a grid of 1 m^2. Sampling density varied according to the features (Tab. 1). In the uppermost layers of the stratigraphy, hereafter called 'topsoil', samples were taken in random distribution on a quarter of the squares. This part of the stratigraphy corresponds to the soil horizon below the modern arable horizon, *i.e.* the lowermost portion of Chernozem (see Chapter 5,

Category of archaeological features and their abbreviations		Sample (n)	Volume (l)	Trench №	№ of archaeological feature
Ditch fill	D	14	140	1	1
Pit fill	P	110	892	6	12
House	H	168	1400.5	19	19
House debris	H	129	1215		
Fireplace	H	7	70		
Platform (upper house floor)	H	2	20		
House entrance	H	2	16		
Unburnt installation	H	7	62		
Burnt house floor	H	38	366		
Burnt wall debris	H	25	229		
Occupational layer	O	86	763	11	11
Kiln	K	8	80	1	1
Kiln, construction	K	4	40		
Kiln, not specified	K	4	40		
Kiln end	KE	11	97	1	1
Levelling layer	L	27	270	1	1
Mega-structure 3	MS	202	2025	1	1
Topsoil	T	95	816	12	12
Buried soil	S	11	80	7	7
Total		**732**	**6563.5**		

Table 1. Botanical macro-remain samples per feature at Maidanetske, excavations 2013–2016. The abbreviation of the category has been used in the histograms and correspondence analysis in the results section.

this work, Vol. I), where few archaeological materials were present but likely to be reworked. In the deeper *in-situ* archaeological stratigraphy, every second square was sampled. In addition, specific contexts, such as fireplaces, were always sampled, in some cases with smaller sample volumes to respect the stratigraphic unit. The archaeological stratigraphy sampled included the inside of buildings (*i.e.* 19 dwellings and one mega-structure) and their direct outside vicinity where different kinds of activities could have taken place (referred to as 'occupational layer' and sampled in 11 cases). Among the dwellings, House 44 in Trench 51 has been excavated entirely (Müller *et al.* 2017). Several other houses have been investigated partially through test trenches, usually 1 m wide and a few metres long: even though botanical samples were collected as well in test trenches, these houses are less represented in the record than House 44. Usually, one pit occurs in association to a house: five pits were sampled in such cases. The Mega-structure 3 in Trench 111 was entirely excavated and densely sampled on 100% of the squares. Four pits were present below it, preceding the mega-structure. These pits were covered by a sediment platform, which formed a so-called 'levelling layer' that is associated with the establishment of the mega-structure (Hofmann *et al.* 2019). Finally, in Trench 80 a three-chambered kiln for pottery production was sampled according to its three phases of use (Müller and Videiko 2016; Ohlrau 2020). The third phase corresponds to the deposition of a layer of waste on the kiln and is unrelated to its original function ('kiln end' in Tab. 1, named after Ohlrau 2020). Three pits were found very close to the kiln: one of them was rich in ceramic and is likely to be connected to the kiln's primary function as a pottery furnace (Pit 1 in Trench 80); the other pits contained more heterogeneous waste and were most likely associated to a house adjacent to the kiln (Pits 2 and 3 in Trench 80).

Figure 2. Preparation for bucket flotation (photo: M. Dal Corso, UFG Kiel).

Sample processing

Bucket-flotation was carried out near the site, on the shore of an artificial lake (fish pond) adjacent to the River Talyanka (Fig. 2). Bilge pumps (RULE, model 24DA, 360 GPH/1363LPH, 12V) powered by a solar panel (Prevent Germany, module PV-3x45-M-ETFE-SH) and a car battery provided the water that then flowed back into the river. Each regular 10 l sample was distributed across five buckets, covered with water and carefully stirred by hand to dissolve the sediment. Most of the samples consisted of loamy sediment that easily disaggregated; clayey samples were left to soak for some minutes before proceeding with flotation. The floating parts were then carefully washed into a metal sieve with 300 µm mesh width. For each bucket this procedure was repeated three times, in order to retrieve all carbonised materials trapped in the sediment. After a final check, the remaining sediment was discarded. The material obtained from flotation was hung inside light cloth and air-dried in the field. Sorting and taxonomic and anatomic identification of the plant remains were carried out at the Microscopy Laboratory of Archaeobotany at Kiel University.

For the presentation of data in this chapter Office Excel was used. Multivariate statistics has been applied using Office Excel and its CAPCA add-in for correspondence analysis (Madsen 2016).

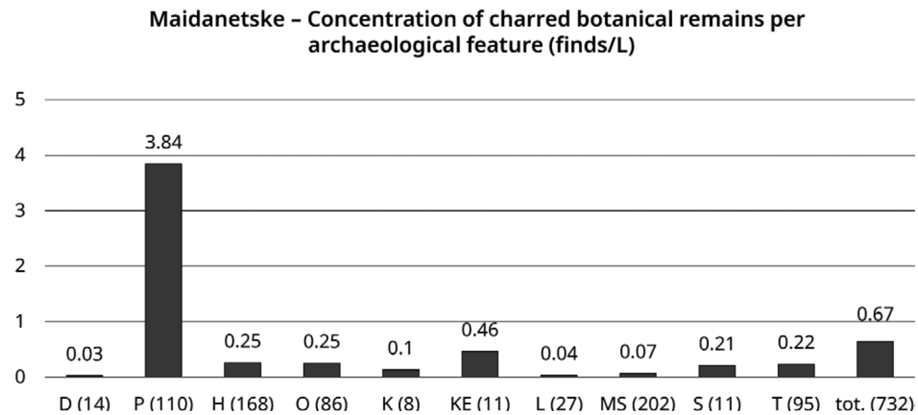


Figure 3. Find concentrations for the Maidanetske charred botanical macro-remains per litre of sediment according to archaeological context. Numbers in brackets along the x axis indicate the number of samples analysed per category of features, which are: D = ditch fill; P = pit fill; H = houses; O = occupational layer around houses; K = kiln; KE = waste disposal at the end of kiln use; L = levelling layer below the mega-structure; MS = mega-structure; S = buried soil; T = topsoil. The abbreviation 'tot.' means total.

Results

Taphonomy: finds preservation and concentration in different archaeological features

In terms of preservation conditions (Fig. 3), most of the taxa is preserved as charred remains (4402 finds). The average find concentration of the charred botanical macro-remains for the Maidanetske site is low, less than one find per litre of soil (0.7 finds/litre, Fig. 3 column 'tot.'), which is comparable with that of central European Neolithic sites (Bogaard and Jones 2007; Kirleis *et al.* 2012; Müller *et al.* 2017, 65) but still provides solid evidence of the ancient plant assemblage. However, the picture on finds concentrations becomes different when comparing the record obtained from different categories of archaeological features (Fig. 3). Pits provide almost four finds per litre of sediment. In contrast, houses and palaeo-surfaces surrounding houses (here 'occupational layers') showed a concentration of finds of only around 0.2 per litre. The value for buried soil below the archaeological stratigraphy and for the topsoil above is also 0.2 finds per litre, which suggests a minor movement of finds due to bioturbation. The slightly higher concentration of botanical remains in the post-abandonment context of the kiln (0.4 finds/litre), not related to its use as ceramic furnace, fits the archaeological interpretation of this feature as a waste heap, where more charred plant remains could be expected.

An important result for future Cucuteni-Trypillia research is that from a taphonomic point of view, organic preservation is favoured inside the pits. One reason therefore is that they reach deeper into the ground than the typical Trypillia houses that are found subsurface, often exposed to disturbance *e.g.* by modern ploughing. The pits reaching from the palaeo-surface into the underlying Cambisol horizon and Loess substrate provide a suitable microclimate for organic preservation. Humidity and temperature can be compared to the cellars of modern houses in the study area, which are dug into the Loess substrate and used to store foodstuffs.

Since house-pit combinations are considered to be representative for a mega-site household as a socio-economic unit, the finds from pits should reflect the activities of the respective households (Ţerna 2021). Furthermore, the infillings of some of the pits represent the biography of a single household since the full house inventory entered

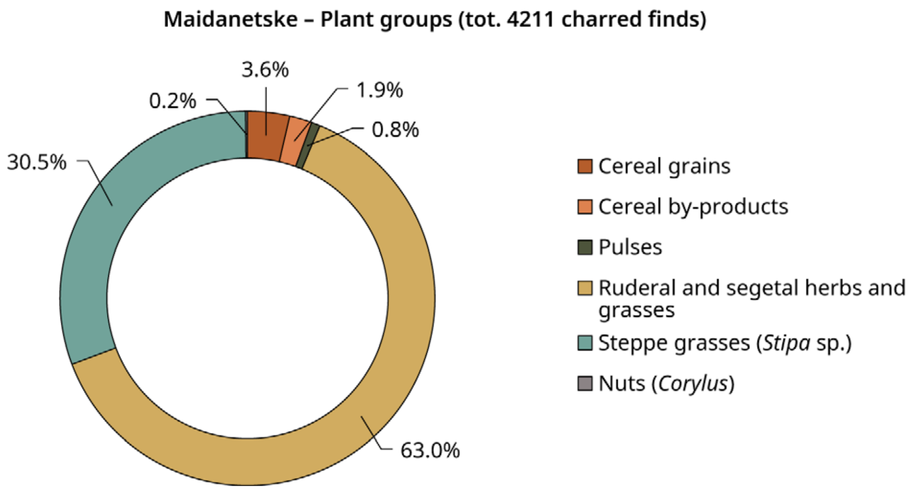


Figure 4. Relative proportions of different plant groups in the charred assemblage from Maidanetske (excluding finds from topsoil and mineralised material).

the pit after burning (Müller *et al.* 2016). In Maidanetske, pits next to the botanical assemblage also contain a concentration of fragmented ceramic sherds and animal bones derived from domestic waste, and sometimes parts of dismissed and broken architecture, represented by large quantities of daub fragments (*e.g.* in Maidanetske Pit complex 27 in Trench 60). The high concentration of charred botanical remains in the Maidanetske pits can be considered secondary deposition (Schiffer 2010), related to discarding of waste from diverse household related activities.

Mineralisation of botanical remains at Maidanetske was rare. The mineralised remains are 3478 seeds of Chenopodiaceae and of *Chenopodium album* (white goosefoot) from the fill of Pit complex 27 in Trench 60. Since they come from one feature only, they are not representative of the overall site record but of an exceptional micro-environment. The mineralisation could relate to the high density of animal bones in that same pit that may have chemically affected the botanical assemblage (Müller *et al.* 2017).

The archaeobotanical assemblage from Maidanetske

Overview

Altogether, 4402 charred finds (seeds, fruits, threshing remains, slaggy remains; 4211 charred finds excluding those from topsoil; Fig. 4) plus 3478 mineralised fruits of Chenopodiaceae were identified at Maidanetske from the archaeological features excavated between 2013–2016 (Tab. 2). The plant record comprises cultivated crops, *i.e.* cereals and pulses, several wild herbs of ruderal and segetal habitats (especially of the fat hen and wild spinach family of the Chenopodiaceae), steppe vegetation (mainly feather-grass awns) and fragmented nutshells from hazel gathered from woodland borders.

Fragments of wood charcoal were retrieved as well, which have been published previously (Dal Corso *et al.* 2019).

The crops: cereals and pulses

In the record of charred botanical macro-remains of Maidanetske, 233 finds belong to cereals. In the cereal record, grains account for 65% and by-products for 35% of the remains (Fig. 5A). This evidence indicates that cereals were processed and probably cultivated by the inhabitants of the site. When looking at the proportions of grains *versus* cereal by-products in different kinds of archaeological features (Fig. 5B), both

Maidanetske (Ukraine), Botanical macro-remains			D	P	H	O	K	KE	L	MS	S	Tot.	T	Tot. + T
		Samples (n)	14	110	168	86	8	11	27	202	11	**637**	95	**732**
		Volume (L)	140	892	1401.5	763	80	97	270	2025	80	**5747.5**	816	**6563.5**
Plant group	**Plant taxa**	**Plant part**	**D**	**P**	**H**	**O**	**K**	**KE**	**L**	**MS**	**S**	**Tot.**	**T**	**Tot. + T**
Cereal grains												**152**	**8**	**160**
	Triticum dicoccum	Seeds/ fruits	0	14	7	3	0	0	0	0	2	**26**	1	**27**
	Triticum monococcum	Seeds/ fruits	0	12	2	0	0	0	0	0	0	**14**	0	**14**
	Triticum monococcum/ dicoccum	Seeds/ fruits	0	22	0	0	1	0	0	0	0	**23**	0	**23**
	Triticum aestivum s.l.	Seeds/ fruits	0	0	1	0	0	0	0	0	0	**1**	2	**3**
	Triticum sp.	Seeds/ fruits	0	0	0	0	0	0	0	3	0	**3**	0	**3**
	Cerealia indet.	Seeds/ fruits	0	31	28	7	0	1	2	14	2	**85**	5	**90**
Cereal by-products												**81**	**2**	**83**
	Triticum dicoccum	Glume bases	0	52	7	1	0	0	0	0	0	**60**	1	**61**
	Triticum monococcum	Glume bases	0	8	1	0	0	0	0	0	0	**9**	0	**9**
	Triticum monococcum/ dicoccum	Glume bases	0	10	2	0	0	0	0	0	0	**12**	1	**13**
Pulses												**32**	**7**	**39**
	Lens culinaris	Seeds/ fruits	0	1	0	0	0	0	0	0	0	**1**	0	**1**
	Pisum sativum	Seeds/ fruits	1	20	3	0	0	0	0	1	3	**28**	2	**30**
	Fabaceae p.p. (cult.)	Seeds/ fruits	0	1	1	0	0	0	1	0	0	**3**	5	**8**
Ruderal, segetal and grassland vegetation												**2638**	**26**	**2664**
	Anagallis sp.	Seeds/ fruits	0	0	0	0	0	0	0	0	0	**0**	1	**1**
	Chenopodium album	Seeds/ fruits	0	1823	4	3	0	0	1	29	0	**1860**	8	**1868**
	Chenopodium polyspermum	Seeds/ fruits	0	0	0	0	0	0	0	1	0	**1**	0	**1**
	Chenopodium sp.	Seeds/ fruits	0	157	2	1	0	0	0	0	1	**161**	11	**172**
	Chenopodiaceae p.p.	Seeds/ fruits	0	565	1	0	0	0	0	13	0	**579**	3	**582**
	Trifolium-type	Seeds/ fruits	0	0	0	0	0	0	0	0	0	**0**	1	**1**
	Vicia sp.	Seeds/ fruits	0	0	0	0	0	0	0	1	0	**1**	0	**1**
	Galium aparine	Seeds/ fruits	0	17	0	0	0	0	0	0	0	**17**	0	**17**
	Lamiaceae	Seeds/ fruits	0	1	0	0	0	0	0	0	0	**1**	0	**1**
	Polygonum aviculare	Seeds/ fruits	0	1	0	0	0	0	0	0	0	**1**	0	**1**
	Polygonum convolvulus	Seeds/ fruits	0	1	0	0	0	0	0	0	0	**1**	0	**1**
	Polygonum sp.	Seeds/ fruits	0	0	1	0	0	0	0	0	0	**1**	0	**1**
	Rosaceae	Seeds/ fruits	0	1	0	0	0	0	0	0	0	**1**	0	**1**
	Silene sp.	Seeds/ fruits	0	0	0	0	0	0	0	0	0	**0**	1	**1**
	Hyoscyamus niger	Seeds/ fruits	0	2	0	0	0	0	0	0	0	**2**	0	**2**
	Solanum nigrum	Seeds/ fruits	0	1	0	0	0	0	0	0	0	**1**	0	**1**
	cf. *Avena* sp.	Seeds/ fruits	0	0	0	0	0	0	1	0	0	**1**	0	**1**
	Bromus secalinus-type	Seeds/ fruits	0	2	0	0	0	0	0	0	0	**2**	0	**2**
	Bromus sp.	Seeds/ fruits	0	2	0	0	0	0	0	0	0	**2**	0	**2**
	Echinochloa crus-galli	Seeds/ fruits	0	0	2	1	0	0	0	0	0	**3**	1	**4**

Maidanetske (Ukraine), Botanical macro-remains			**D**	**P**	**H**	**O**	**K**	**KE**	**L**	**MS**	**S**	**Tot.**	**T**	**Tot. + T**
	cf. Panicoideae	Seeds/ fruits	0	0	0	0	0	0	0	1	0	**1**	0	**1**
	Poaceae p.p.	Seeds/ fruits	0	1	0	0	0	0	0	1	0	**2**	0	**2**
	Setaria viridis	Seeds/ fruits	0	0	0	0	0	0	0	0	0	**0**	1	**1**
Steppe vegetation (*Stipa* sp.)												**1280**	**139**	**1419**
	Stipa sp.	Awns	3	674	292	171	10	44	5	72	9	**1280**	139	**1419**
Fruits and nuts												**7**	**0**	**7**
	Corylus avellana	Pericarps fragments	0	4	3	0	0	0	0	0	0	**7**	0	**7**
Ruderal and segetal vegetation (mineralised)												**3478**	**0**	**3478**
	Chenopodium album	Seeds/ fruits	0	978	0	0	0	0	0	0	0	**978**	0	**978**
	Chenopodium sp.	Seeds/ fruits	0	976	1	0	0	0	0	0	0	**977**	0	**977**
	Chenopodiaceae p.p.	Seeds/ fruits	0	1523	0	0	0	0	0	0	0	**1523**	0	**1523**

Table 2. The botanical macro-remains from Maidanetske, Ukraine (excavations 2013–2016). Abbreviations indicate the categories of features: D = ditch fill; P = pit fill; H = houses; O = occupational layer around houses; K = kiln; KE = waste disposal at the end of kiln use; L = levelling layer below the mega-structure; MS = mega-structure; S = buried soil; T = topsoil. The plant remains are all charred if not differently specified. Detailed data is stored and accessible at the Kiel ArboDat-D1, IUFG Kiel.

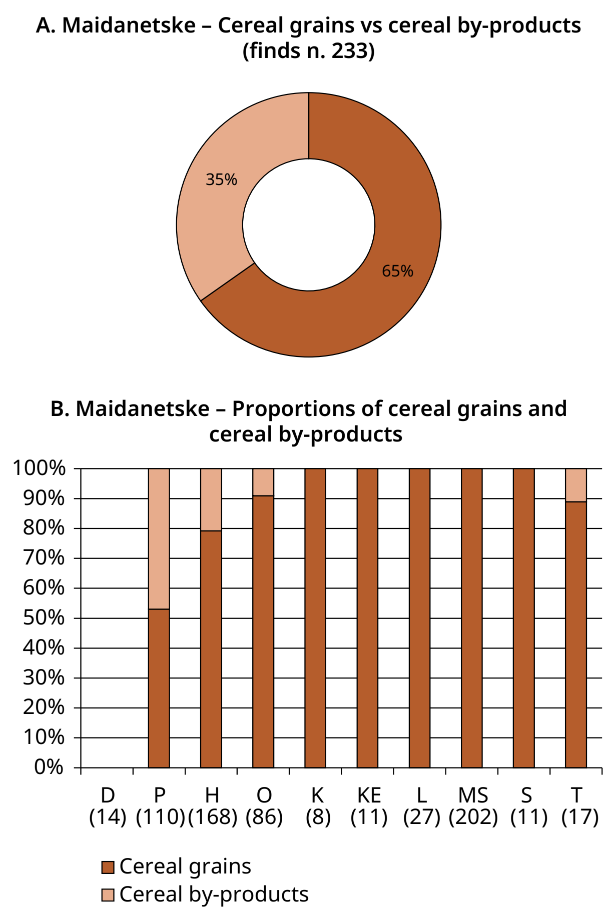
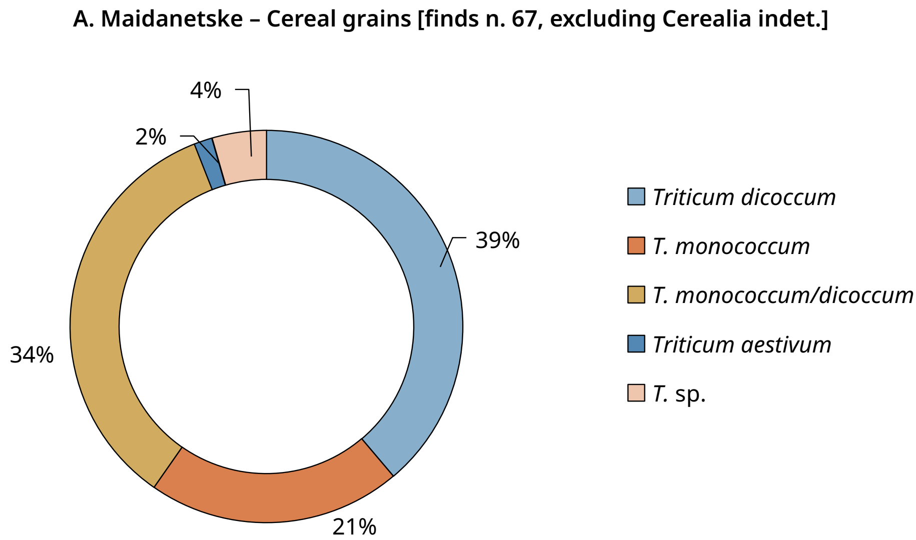


Figure 5. Proportions of cereal grains and cereal by-products in Maidanetske, including Cerealia indet. grains: (A) in general (233 finds); (B) in different archaeological features. Abbreviations indicate the categories of archaeological features: D = ditch fill; P = pit fill; H = houses; O = occupational layer around houses; K = kiln; KE = waste disposal at the end of kiln use; L = levelling layer below the mega-structure; MS = mega-structure; S = buried soil; T = topsoil. Numbers in brackets correspond to the number of samples per category.



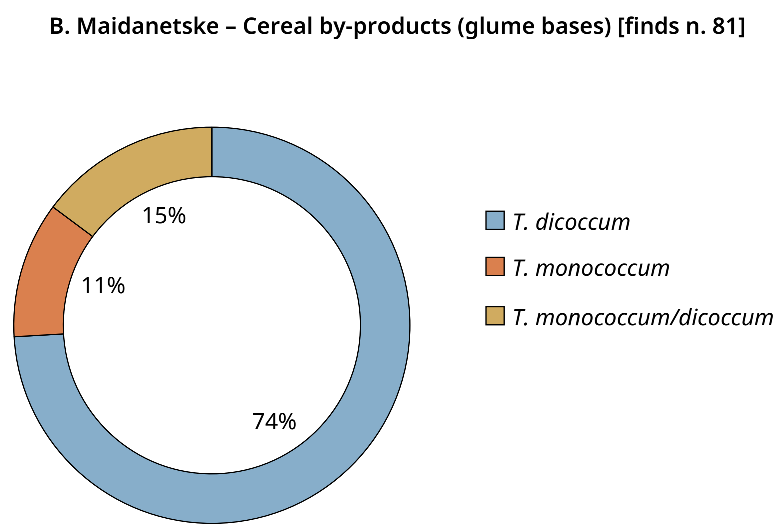


Figure 6. (A) Pie chart showing the relative proportions of cereal taxa, identified from the charred grains (excluding finds from topsoil). Cerealia indet. are excluded from the record. (B) Pie chart showing the relative proportions of cereal taxa identified through charred by-products derived from crop-processing (excluding finds from topsoil).

categories of plant remain have been attested, with a predominance of grains, inside pits (over 50% grains and over 40% by-products) and in houses and occupational layers outside houses (80–90% grains and 20–10% by-products). Cereal by-products are absent from other categories of features, such as the ditch, the buried soil, the kiln, the mega-structure and the levelling layer under the mega-structure. This distribution of the remains suggests a possible household level of cereal storage and final processing. The high quantity of pottery and vessels from house inventories (*e.g.* Müller *et al.* 2017; Shatilo 2021) seems to supports this interpretation.

Some cereals and by-products have been found in the higher levels sampled in the stratigraphy ('topsoil'), whereas in the buried soil below the archaeological features only a few grains are attested. In the case of topsoil, we cannot exclude the intrusion of modern material, besides possible upward movements due to bioturbation. In the case of the buried soil, bioturbation is likely responsible for movements of materials downwards, *e.g.* along *krotovinas*, channels dug by steppe rodents and visible across the archaeological stratigraphy starting from the steppe soil (Chernozem) overlaying the archaeological features (Kirleis and Dreibrodt 2016; Chapter 5, this work, Vol. I).

In Maidanetske the spectrum of cultivated cereal species includes emmer (*Triticum dicoccum*) and einkorn (*Triticum monococcum*; Fig. 6A and B). In both groups of remains, the most represented cereal is emmer followed by einkorn. A single grain of free-threshing wheat (*Triticum aestivum* s.l.) is attested in the in-situ stratigraphy from House 55 in Trench 91, and two more grains come from the topsoil. Based on this evidence from topsoil and on the occurrence of partly charred grains from this species, the attribution of free-threshing wheat to the Chalcolithic cereal spectrum in Maidanetske is not certain at present. Due to problematic preservation conditions of the charred remains, especially outside of pits, several *Triticum* caryopses could not be distinguished at the species level and many cereal caryopses that were fragmented have been attributed to the Cerealia indet. group (Figs. 7 and 8).

In the by-products derived from processing, there are glume bases of the hulled wheat species as discussed above (Fig. 6B).

Broomcorn millet (*Panicum miliaceum*), included in an earlier overview (Kirleis and Dal Corso 2016), has been excluded from the Chalcolithic cereal list at Maidanetske, because a radiocarbon date on one grain of millet shows that it was a medieval intrusion into the prehistoric stratigraphy (95.4% probability: 879–1013 cal CE; Dal Corso *et al.* 2019; for millet in Ukraine see Dal Corso *et al.* 2022). Two barley species, free-threshing barley (*Hordeum vulgare nudum*) and hulled barley (*Hordeum vulgare vulgare*) have been identified based on single grains plus several rachis fragments. However, barley is excluded from the record and not listed in Table 2 since radiocarbon dating gave modern dates and several barley grains were partly charred, thus suspicious for being modern intrusion. The complete list of radiocarbon dates on plant remains from Maidanetske is displayed in Table 3 and Figure 9. It includes also two finds from a concentration of *Pisum sativum* and *Triticum dicoccum* retrieved inside a hemispherical bowl found in 1980 during excavation in Maidanetske (Pashkevych and Videiko 2006, 51).

In the correspondence analysis in Figure 10 the records of cereal grains and cereal by-products per different categories of archaeological features are evaluated. Along the first axis, a gradient can be seen that separates the remains identified at a lower level (*Triticum* sp. grains, Cerealia indet. grains) from those with better taxonomic identification that cluster around pits and houses (see also Fig. 8). By-products of hulled wheats are closely related to pits.

Along with the cereals, two pulses species are present. Garden pea (*Pisum sativum*) is found in several contexts and in a small concentration of 20 seeds in Pit 26 in Trench 51 (Fig. 11), where House 44 is located. In the past *Pisum* had been found in Maidanetske as a concentration of more than 200 seeds in a vessel, together with emmer grains (Pashkevych and Videiko 2006). A further attested pulse species at Maidanetske is lentil (*Lens culinaris*), with just one find from Pit complex 27 in Trench 60.

Steppe vegetation

Charred, curled-up awn fragments of feather grass (*Stipa* sp.) regularly occur in the samples from Maidanetske (Fig. 12). Feather grass species are characteristic of steppe environments, where they tend to form dense communities (Fig. 13). They are very tiny and were retrieved using a very fine sieve mesh of 300 µm. Many of these fragments (1280 excluding 139 from topsoil; Tab. 2) were found in pits, houses and occupational layers. When looking at the concentration of feather grass awns per litre of sediment (Fig. 12), they constitute a common find everywhere other than in the ditch, the mega-structure and the levelling layer below it. They are particularly abundant in deposits that include discarded domestic waste, such as pit fillings and the layers covering the kiln. We can exclude that *Stipa* derives from modern contamination because a radiocarbon date on charred awn fragments from a profile confirmed that these finds are contemporaneous with the site occupation (3969–3794 2σ BCE; Tab. 3; Dal Corso *et al.* 2019).

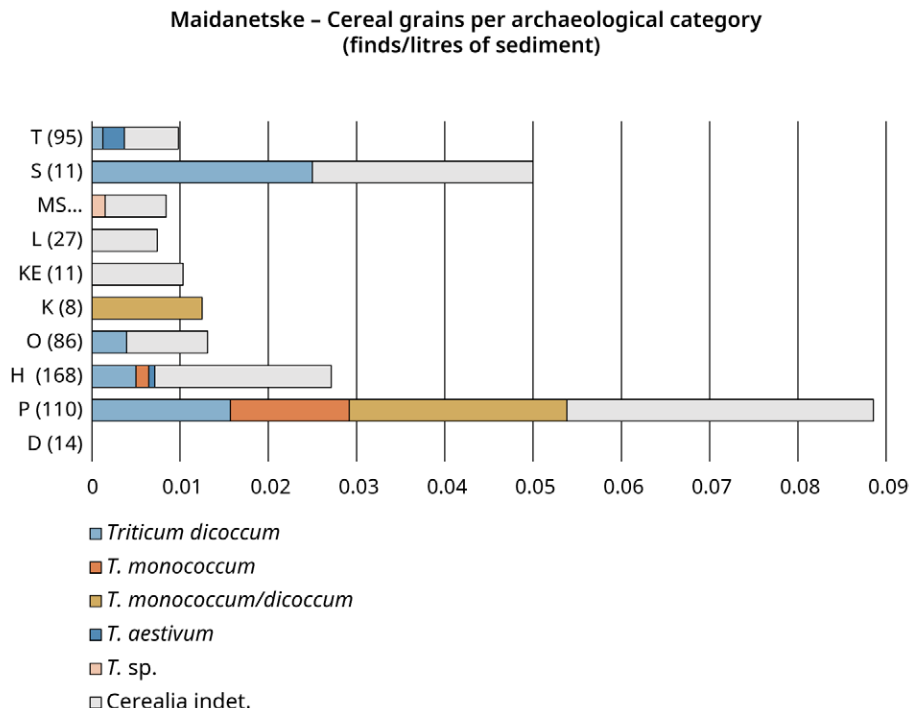


Figure 7. Histogram showing the concentration of cereal grains per litre of sediment analysed in the different categories of archaeological features. The number in brackets corresponds to the number of samples per category. Abbreviations indicate the categories of archaeological features: D = ditch fill; P = pit fill; H = houses; O = occupational layer around houses; K = kiln; KE = waste disposal at the end of kiln use; L = levelling layer below the mega-structure; MS = mega-structure; S = buried soil; T = topsoil.

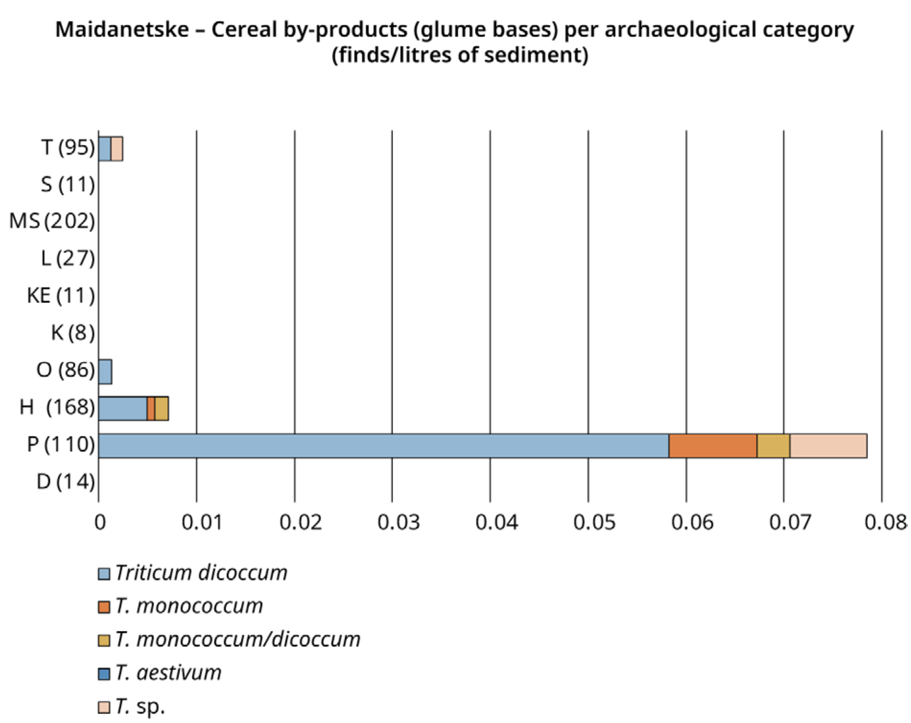


Figure 8. Histogram showing the concentration of cereal by-products per litre of sediment according to the categories of archaeological features. The number in brackets corresponds to the number of samples per category. Abbreviations indicate the categories of archaeological features: D = ditch fill; P = pit fill; H = houses; O = occupational layer around houses; K = kiln; KE = waste disposal at the end of kiln use; L = levelling layer below the mega-structure; MS = mega-structure; S = buried soil; T = topsoil.

Sample №	Material	Archaeological context	CO_2 / Graphit	pMC†	^{14}C date BP	^{14}C range BCE/CE	$\delta^{13}C$‡
KIA-56330	*Triticum dicoccum*, charred grain	Maidanetske Complex W, Square 015	1.8 mg C / 0.9 mg C	53.55 ± 0.20	5015 ± 30 BP	3946–3707 BCE, 94.1%	-20.3 ± 0.4‰
Poz-87518	*Triticum* sp., charred grain	Maidanetske 2014, Feature 80028 – Pit 29		0	5075 ± 35 BP	3961–3792 BCE, 95.4%	
KIA-55908	*Pisum sativum*, charred seed	Maidanetske 2013, Feature 51007	2.7 mg C / 0.9 mg C	53.52 ± 0.20	5020 ± 30 BP	3946–3709 BCE, 95.4%	-21.5 ± 0.1‰
KIA-56331	*Pisum sativum*, charred seed	Maidanetske Complex W, Square 015	0.3 mg C / 0.3 mg C	53.25 ± 0.46	5060 ± 70 BP	3984–3702 BCE, 92.7%	-26.3 ± 0.3‰
Poz-60192	*Fraxinus*, charcoal	Maidanetske 2013, Feature 60009 – Pit complex 27		0	5060 ± 35 BP	3958–3780 BCE, 95.4%	
Poz-87542	*Corylus avellana*, nutshell	Maidanetske 2014, Feature 101009 – House 64, burnt floor		0	5010 ± 35 BP	3942–3705 BCE, 95.4%	
KIA-55910	*Chenopodium album*, charred seeds	Maidanetske 2013, Feature 60009	0.6 mg C / 0.6 mg C	53.22 ± 0.20	5065 ± 35 BP	3956–3789 BCE, 95.4%	-24.2 ± 0.1‰
Poz-101976	*Stipa* (0.5 g awn fragments)	Maidanetske 2016, Feature 111029 – Pit 35 (111/3)		0	5090 ± 40 BP	3969–3794 BCE, 95.4%	
Poz-97625	*Panicum miliaceum*, charred grain	Maidanetske 2013, Feature 51001 – topsoil		0	1100 ± 35 BP	879–1013 cal CE, 95.4%	
Poz-87522	*Hordeum vulgare nudum*, charred grain	Maidanetske 2014, feature – Pit 92004, House 54, house rubble		123.86 ± 0.4	> modern	-	
KIA-55909	*Hordeum vulgare vulgare*, charred grain	Maidanetske 2014, Feature 92002 – topsoil	3.6 mg C / 0.9 mg C	124.86 ± 0.30	> modern	1980–1983 cal CE, 78.5%	-24.6 ± 0.2‰

Table 3. Radiocarbon dates on plant remains from Maidanetske, Ukraine. Most of the dates concern finds retrieved during excavations in 2013–2016. In addition, two dates concern a mass find of cereal grains and garden peas from a vessel content studied by G. Pashkevych (Pashkevych and Videiko 2006).

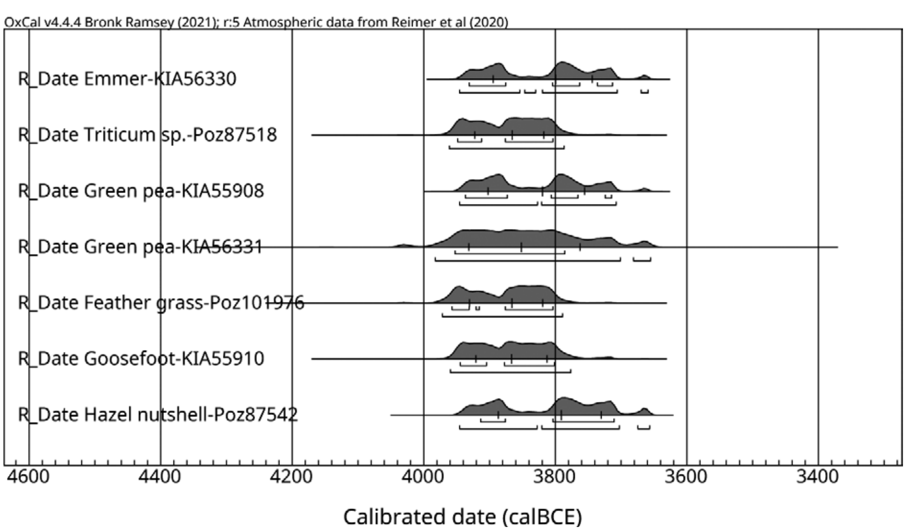


Figure 9. Multiplot of the radiocarbon dates based on plant materials available for Maidanetske (see Tab. 3). Modern dates have been excluded. The image has been generated by using Oxcal v. 4.4, with calibration curve Intcal20 (Bronk Ramsey 2009; Bronk Ramsey 2021; Reimer et al. 2020).

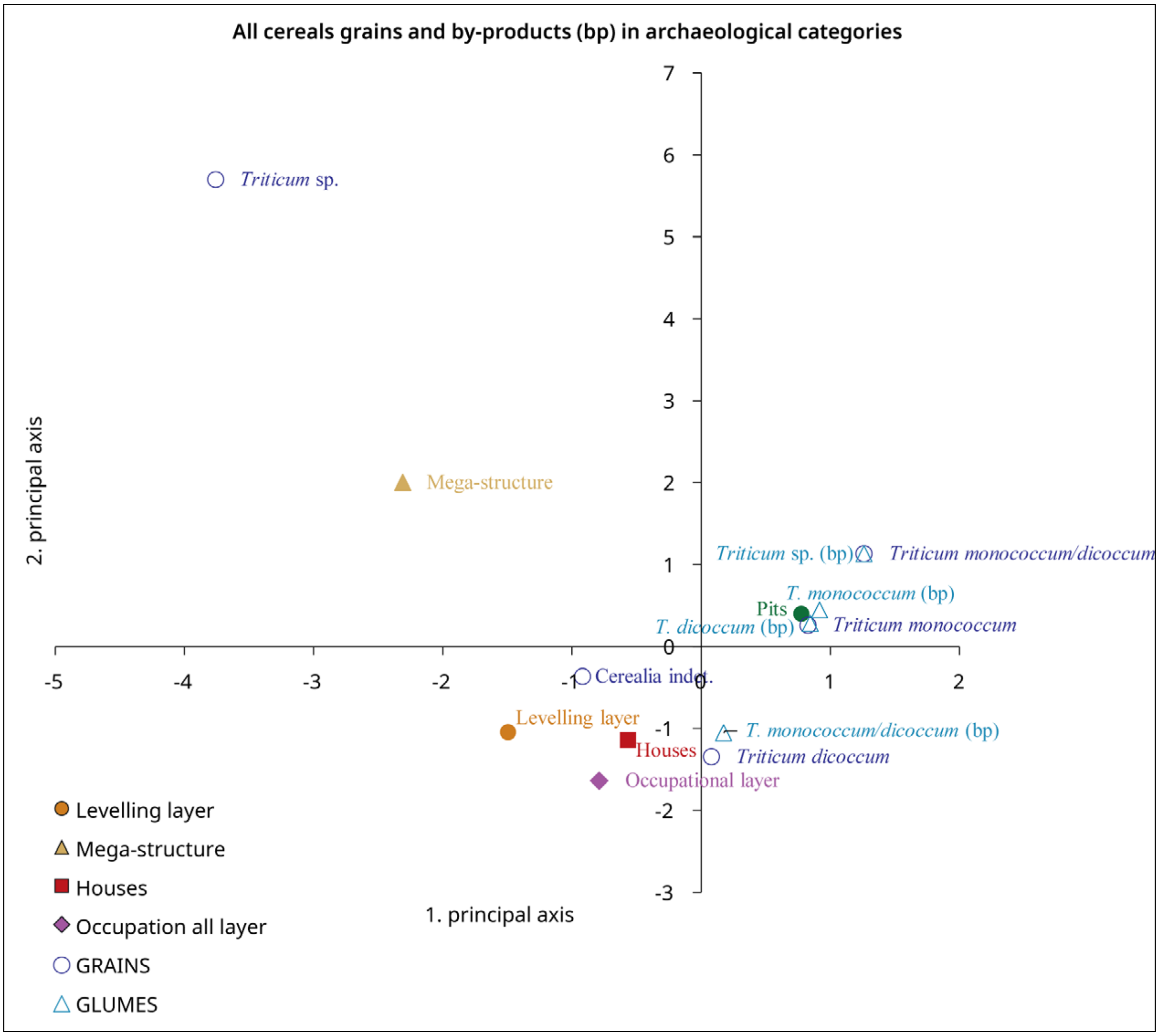


Figure 10. Correspondence analysis showing categories of archaeological features (excluding topsoil) and cereal remains. Axes 1 (73% explanation) and 2 (24% explanation).

Wild plants

The only gathered plants in the archaeological plant assemblage from Maidanetske are hazel, a light-demanding tree species, and, possibly, black henbane (*Hyoscyamus niger*), which grows in disturbed areas. This plant is a drug: the leaves can be toxic and can affect the nervous system, causing hallucinations. In addition, six arable weeds were identified byspecies/-type level. They indicate nutrient-rich soils: lady's bedstraw (*Galium aparine*), brome (*Bromus secalinus*-type), common knotweed (*Polygonum aviculare*), black nightshade (*Solanum nigrum*), many-seeded goosefoot (*Chenopodium polyspermum*) and, the most frequent and abundant, fat hen (*Chenopodium album*). Furthermore, there is evidence for the Panicoideae species green foxtail (*Setaria viridis*) and cockspur (*Echinochloa crus-galli*).

The plants of ruderal and segetal vegetation come almost exclusively from pit fillings (Fig. 12), and some can be connected to the cleaning of the cereal yields from weeds. Differently from *Stipa* awns, they do not constitute a sort of background noise: they rarely occur in the other archaeological contexts and are excluded especially from those without cereal by-products. It should be considered that these plants include edible parts (*e.g.* the leaves of fat hen) that might have been of interest to Chalcolithic people.

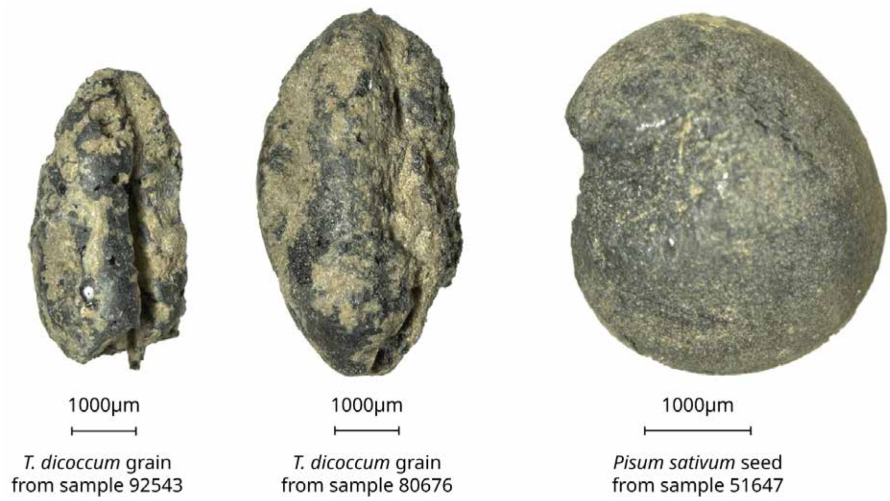


Figure 11. Emmer grains and green pea from different samples in Maidanetske (photos: T. Reiser, UFG Kiel, Keyence Digital Microscope VHX-3000).

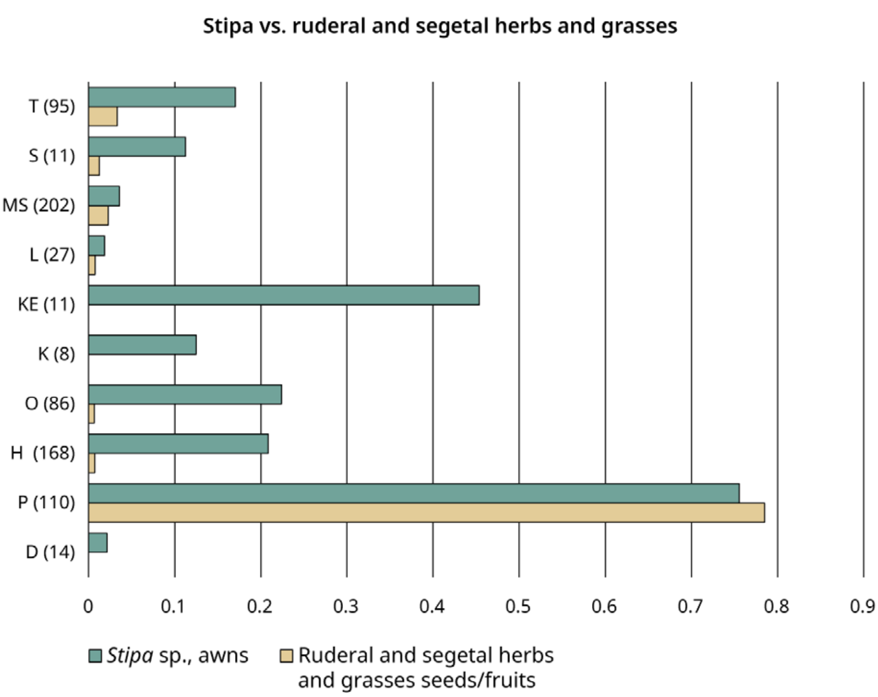


*Figure 12. Histogram showing the distribution of feather-grass awns (*Stipa *sp.), a grass typical of the steppe, and of seeds and fruits of segetal and ruderal herbs and other grasses as grouped in Table 1 according to categories of archaeological features. The histogram shows concentration values of carbonised finds per litre of sediment analysed. Abbreviations indicate the categories of archaeological features: D = ditch fill; P = pit fill; H = houses; O = occupational layer around houses; K = kiln; KE = waste disposal at the end of kiln use; L = levelling layer below the mega-structure; MS = mega-structure; S = buried soil; T = topsoil. Numbers in brackets indicate the number of samples.*

Discussion

Plant economy

In Maidanetske the crop spectrum includes emmer, einkorn, garden pea and lentil as the main cultivars. Such crops are known since the Neolithic in the second half of the 6th millennium BCE, in LBK sites in Ukraine (Motuzaitė Matuzevičiūtė and Telizhenko 2016). The rare grains of free-threshing wheat may be intrusive, as were shown to be those of millet and hulled barley after direct radiocarbon dating. For free-threshing barley, the attestation at Maidanetske is scarce and unsure, although it has been attested in other Trypillia sites (Pashkevych 2012; *e.g.* Nebelivka: Pashkevych 2020, 410). Apart for barley, in general, this record is in accordance with the expected crop spectrum of Trypillia sites (Gaydarska 2020; Kruts *et al.* 2008; Kruts *et al.* 2009; Pashkevych and Videiko 2006), although in Maidanetske there is no hint of bitter vetch (*Vicia ervilia*), which is known for instance in Nebelivka (Pashkevych 2020, 410) and from a mass find at Karbuna in Moldova, in an early Trypillia phase (Tripolye A; Yanushevich 1980).

In the correspondence analysis (Fig. 10), einkorn and emmer (grains and glumes) are usually clustered together. The processing of emmer and einkorn is likely to have occurred at the same time or in the same way/place, which is what can be further supported by the similar plant physiology of hulled wheats (Padulosi *et al.* 1996). For hulled wheats such as emmer and einkorn, the choice to store them as hulled spikelets is known to protect them from pathogens. Then, for human consumption, dehusking of spikelets is required and can be carried out locally in small portions prior to food preparation. Ethnographically, in areas with dry summer dehusking could also be carried out outside on the bulk of the harvest, while in areas with wet summers it was mostly carried out indoors, little by little (Hillman 1984). According to climatic conditions and to traditional uses, there are several methods known for dehusking, *e.g.* through pounding in a mortar, or in a hole in the ground, or milling with stones (Peña-Chocarro and Zapata 2003; Hillman 1984). Soaking in water prior to dehusking, and afterwards sun drying, or artificial drying/roasting in ovens, are also attested ethnographically (Peña-Chocarro and Zapata 2003 and references within). Finally, in areas with high rainfall, parching with fire/heat is a technique known ethnographically to break the ears if not fully ripe (Hillman 1984) or to remove the awns (Peña-Chocarro and Zapata 2003). After crop-processing of the hulled wheats, the derived glumes, glume bases and other parts of the inflorescence constitute an economically valuable good that in Maidanetske was collected and used, for instance, as plant temper in earthen architecture and artefacts (Pashkevych and Videiko 2006; Dal Corso *et al.* 2018; Chapter 8, this work, Vol. I). The leftovers from the processing procedure of barley, rachises and other parts of the ears are coarser than those from single hulled wheat spikelets but could also be valuable for plant temper and other purposes. The cereal by-products in general, and possibly also low-quality grains, may have served also as fodder for the pigs kept within the settlement (Makarewicz *et al.* 2022).

In the correspondence analysis (Fig. 10), and when looking at the cereal concentration, grains and by-products cluster with pits, houses and occupational layers, which suggests the repartition in domestic contexts of the final stage of crop-processing. In general, the by-products consist of the fine fraction derived from dehusking hulled spikelets that indicate leftovers from the final stages of crop-processing. Plants of the ruderal and segetal group have been also found only in archaeological features where cereal by-products are present, which suggest their link to the sorting of weeds out of the cereal yield. In contrast, the grains are charred leftovers of food preparation (Fuller *et al.* 2014). This picture can be compared with that of other sites where farmers were living (see *e.g.* Bogaard *et al.* 2017; Colledge and Conolly 2007; Filipović 2012; Fuller *et al.* 2014), with a household-based economy. In this case, we can hypothesise that structured routine activities were established, resulting in the discard of burnt remains in pits, little evidence of waste in the houses and adjacent areas, and even less in other archaeological features. However, it should be noted that preservation is poorer outside pits, where we encountered the highest concentration and largest variety of botanical remains. Phytoliths, which have different preservation requirements from macro-remains, confirm the fact that houses are quite clean while the remains of crop processing can be found in pits, in association to charred glume bases and rachises, and in the earthen architecture of buildings, indicating the daub temper (Dal Corso *et al.* 2018). We do not know much about the first stages of crop-processing, where collective activities such as harvest, threshing and winnowing/coarse sieving took place. In the correspondence analysis on the macrobotanical cereal remains (Fig. 9), the mega-structure stands apart from the rest of the statistically relevant features (pits, houses, occupational layers). It is possible that at the mega-structure different activities were taking place than in the other archaeological contexts. This assumption is to be further tested through application of phytolith analysis in the mega-structure.

To better understand agricultural practices, some samples from the crop record here discussed have been analysed for $\delta^{15}N$ and $\delta^{13}C$ stable isotope values. The detailed investigation and comparison with stable isotope data from other Trypillia sites, is published in Kirleis *et al.* (2024) and Schlütz *et al.* (2023). Results suggest that cultivation occurred in absence of water stress for the plants in a probable rain-fed agriculture in nutrient-rich soil. The application of manure derived from domesticated animals may be considered (Kirleis *et al.* 2024; Makarewicz *et al.* 2022) and for this practice the position of garden-like arable plots in the centre of the village (Schlütz *et al.* 2023), wide and empty from buildings, would have been an advantage, favouring the access to, and the movement of, resources (Kirleis *et al.* 2024).

Environment

Feather grass awns constitute a common find in Maidanetske archaeological features. *Stipa* sp. are characteristic of steppe environments, where they tend to form dense communities (Fig. 13). Their finds are particularly abundant in the pits and in the waste deposits covering the kiln. Feather grass inflorescences are dangerous for animals to eat because of their awns but the green plant before ripening may constitute a good fodder (Rivera Núñez *et al.* 2011). In any case, the availability of openings with steppe vegetation in the surrounding area of the site does not imply absence of woodland cover. The anthracological evidence may suggest stands of ash, elm and oak most possibly situated in the valley and northern slopes (Dal Corso *et al.* 2019). The pedological profiles from Maidanetske suggest an extension of the mixed oak deciduous woodland also into the Loess plateau, under which conditions a Cambisol formed (Kirleis and Dreibrodt 2016). The establishment of an open landscape with dominant steppe vegetation and formation of Chernozem soil would account for an outcome of intense Trypillia farming and population agglomeration of the landscape (Dreibrodt *et al.* 2022).

Conclusions

Traditionally, the Cucuteni-Trypillia archaeology has been focused on house structures. Throughout decades of research, the architectural remains have fascinated generations of archaeologists and resulted in the revelation of the impressive spatial arrangements of the proto-urban mega-sites (Müller *et al.* 2016; Gaydarska 2020;

Figure 13. (A) Stipa stands on the top of a sunny slope at the border between arable fields and gully woodland in the Hirsky Tikich river valley close to Talnoe (Cherkasy Oblast, Ukraine), September 2016. (B) Detail of intertwined, wind-blown Stipa fruits and awns (photos: M. Dal Corso).

Korvin-Piotrovsky *et al.* 2003; Nebbia 2017; Ohlrau 2020; Shatilo 2021). Even their social organisation and reason for collapse could be inferred from the architectural record (Hofmann *et al.* 2019). However, a shortcoming in Cucuteni-Trypillia archaeology is the lack of quantitative archaeobotanical data from soil samples to come up with evidence-based estimates on the character of subsistence economy (Pashkevych and Videiko 2006; Kirleis and Dal Corso 2016). The uneven distribution of botanical finds according to archaeological features that we were able to show for the Maidanetske mega-site may be one reason for this shortcoming. The potential of 'pit archaeology' for mega-site research was recently highlighted by Țerna (2021). The application of a pit-oriented excavation approach would add a solid foundation for the reconstruction of the Cucuteni-Trypillia subsistence economy.

The large majority of charred botanical remains retrieved at Maidanetske come from pits dug in the Loess substrate. For their connection with houses and the presence of other kinds of materials in the pits, the discard of waste into pits seems to depict rather routine activities (Fuller *et al.* 2014). There are several reasons why grains could have encountered fire and been accidentally carbonised, from a taste preference for roasted cereals to the need to dry them if wet (Peña-Chocarro and Zapata 2003). The traces of cereal grains and by-products from houses and occupational layers around them, together with the evidence of closed vessel shapes and even of very large *pithoi* from houses (Shatilo 2021) are likely to indicate their use to store small quantities of cereals in the house for food preparation. Nevertheless, houses are found to be quite clean in terms of macro- and micro-remains related to cereals (Dal Corso *et al.* 2018). There could be several reasons for this, including bad preservation, but also the fact that the cereal by-products derived from dehusking were kept and used for multiple economic purposes, most of those attested in Maidanetske being plant temper in earthen architecture and the potential intentional or random use as animal fodder. Our archaeobotanical investigations characterise Maidanetske as a settlement site where normal routine activities were carried out in a household-based subsistence economy. So far, evidence of communal storage facilities, or of activities related to cereal production in the mega-structure, are absent in Maidanetske although multiple fragments from grinding stones found there could account for collective activities (Hofmann *et al.* 2019). Information on land use and farming practices derived from the results of stable isotope analyses on charred grains, compared with those of the faunal remains, suggest that rain-fed agriculture in nutrient-rich soil with good hydrologic regime sustained Trypillia population at Maidanetske (Kirleis *et al.* 2024).

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References

Bogaard, A. and Jones, G., 2007. Neolithic farming in Britain and central Europe: contrast or continuity? *In*: A. Whittle and V. Cummings, eds. *Going over: the Mesolithic-Neolithic Transition in North-West Europe*. Proceedings of the British Academy. Oxford: Oxford University Press, 356–375. Available from: https://doi.org/10.5871/bacad/9780197264140.003.0019

Bogaard, A., Filipović, D., Fairbairn, A., Green, L., Stroud, E., Fuller, D. and Charles, M., 2017. Agricultural innovation and resilience in a long-lived early farming community: the 1,500-year sequence at Neolithic to early Chalcolithic Çatalhöyük, central Anatolia. *Anatolian Studies*, *67*, 1–28. Available from: https://doi.org/10.1017/S0066154617000072

Bronk Ramsey, C., 2009. Bayesian Analysis of Radiocarbon Dates. *Radiocarbon,* 51 (1), 337–360. Available from: https://doi.org/10.1017/S0033822200033865

Bronk Ramsey, C., 2021. *OxCal v.4.4* [Software]. Available from: https://c14.arch.ox.ac.uk/oxcal/OxCal.html

Burdo, N. and Videiko, M., 2016. Nebelivka: From Magnetic Prospection to New Features of Mega-Sites. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 95–116. Available from: https://doi.org/10.4324/9781315630731

Carciumaru, M., 1990. Étude paléobotanique pour les habitats Néolithiques et Énéolithiques de Roumanie. *Acta Interdisciplinaria Archaeologica,* 7, 61–73.

Chapman, J., Pashkevych, G. and Miller, D., 2020. Plant Remains. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 409–412. Available from: https://doi.org/10.1515/9783110664959-009

Colledge, S. and Conolly, J., eds., 2007. *The Origins and Spread of Domestic Plants in Southwest Asia and Europe*. New York: Routledge. Available from: https://doi.org/10.4324/9781315417615

Dal Corso, M., Out, W.A., Ohlrau, R., Hofmann, R., Dreibrodt, S., Videiko, M., Müller, J. and Kirleis, W., 2018. Where are the cereals? Contribution of phytolith analysis to the study of subsistence economy at the Trypillia site Maidanetske (ca. 3900-3650 BCE), central Ukraine. *Journal of Arid Environments*, 157, 137–148. Available from: https://doi.org/10.1016/j.jaridenv.2018.06.009

Dal Corso, M., Hamer, W., Hofmann, R., Ohlrau, R., Shatilo, L., Knitter, D., Dreibrodt, S., Saggau, P., Duttmann, R., Feeser, I., Knapp, H., Benecke, N., Videiko, M., Müller, J. and Kirleis, W., 2019. Modelling landscape transformation at the Chalcolithic Tripolye mega-site of Maidanetske (Ukraine): Wood demand and availability. *The Holocene,* 29 (10), 1622–1636. Available from: https://doi.org/10.1177/0959683619857229

Dal Corso, M., Pashkevych, G., Filipović, D., Liu, X., Motuzaite Matuzeviciute, G., Stobbe, A., Shatilo, L., Videiko, M. and Kirleis, W., 2022. Between Cereal Agriculture and Animal Husbandry: Millet in the Early Economy of the North Pontic Region. *Journal of World Prehistory*, 35 (3–4), 321–374. Available from: https://doi.org/10.1007/s10963-022-09171-1

Filipović, D., 2012. *An archaeobotanical investigation of plant use, crop husbandry and animal diet at early-mid Neolithic Çatalhöyük, Central Anatolia.* [PhD thesis. University of Oxford].

Fuller, D.Q., Stevens, C. and McClatchie, M., 2014. Routine Activities, Tertiary Refuse, and Labor Organization. Social Inferences from Everyday Archaeobotany. *In*: M. Madella, C. Lancelotti and M. Savard, eds. *Ancient Plants and People: Contemporary Trends in Archaeobotany*. Tucson: University of Arizona Press, 174–217.

Gaydarska, B., ed., 2020. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter. Available from: https://doi.org/10.1515/9783110664959

Golea, M., Stavrescu-Bedivan, M. and Lazăr, C., 2014. Macroresturile vegetale descoperite in situl arheologic Sultana-Malu Roşu, judeţul Călăraşi: studiu preliminar. *Studii de Preistorie*, 11, 163–172.

Hillman, G.C., 1984. Traditional husbandry and processing of archaic cereals in recent times: the operations, products and equipment which might feature in Sumerian texts. Part I: the glume wheats. *Bulletin on Sumerian Agriculture,* 1, 114–152.

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Hovsepyan, R., Buxò Capdevila, R., Popovici, D.-N., 2020. On the Chalcolithic plant economy of the Hârşova-Tell settlement (Romania): recent archaeobotanical results. *Cercetări Arheologice*, XXVII, 305–319. Available from: https://doi.org/10.46535/ca.27.13

Kirleis, W. and Dal Corso, M., 2016. Trypillian Subsistence Economy: Animal and Plant Exploitation. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 195–205. Available from: https://doi.org/10.4324/9781315630731

Kirleis, W. and Dreibrodt, S., 2016. The Natural Background: Forest, Forest Steppe or Steppe Environment. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 171–180. Available from: https://doi.org/10.4324/9781315630731

Kirleis, W., Klooß, S., Kroll, H. and Müller, J., 2012. Crop growing and gathering in the northern German Neolithic: a review supplemented by new results. *Vegetation History and Archaeobotany*, 21, 221–242. Available from: https://doi.org/10.1007/s00334-011-0328-9

Kirleis, W., Dal Corso, M., Pashkevych, G., Schlütz, F., Hofmann, R., Terna, A., Dreibrodt, S., Rud, V., Videiko, M.Y. and Müller, J., 2024. A complex subsistence regime revealed for Cucuteni–Trypillia sites in Chalcolithic eastern Europe based on new and old macrobotanical data. *Vegetation History and Archaeobotany*, 33, 75–90. Available from: https://doi.org/10.1007/s00334-023-00936-y

Köppen, W. and Geiger, R., 1939. *Handbuch der Klimatologie*, Vol. 3: *Regionale Klimakunde: Europa und Nordasien. Teil N: Klimakunde von Rußland in Europa und Asien. Hälfte 2: Tabellen*. Berlin: Bornträger.

Korvin-Piotrovsky *et al.* 2003: Корвін-Піотровський, О.Г., Круц, В.О. and Рижов, С.М., eds., 2003. *Трипільські поселення-гіганти. Матеріали міжнародної конференції / Tripolian settlements-giants. The international symposium materials*. Київ: Корвін Пресс.

Kruts *et al.* 2008: Круц, В.А., Корвин-Пиотровский, А.Г., Менотти, Ф., Рыжов, С.Н., Черновол, Д.К. and Чабанюк, В.В., eds., 2008. *Трипольское поселение-гигант Тальянки. Исследования 2008 г / Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2008*. Киев: Институт археологии НАН Украины.

Kruts *et al.* 2009: Круц, В.А., Корвин-Пиотровский, А.Г., Менотти, Ф., Рыжов, С.Н., Толочко, Д.В. and Чабанюк, В.В., eds., 2009. *Трипольское поселение-гигант Тальянки. Исследования 2009 г / Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2009*. Киев: Институт археологии НАН Украины.

Madsen, T., 2016. *CAPCA v.3.1.* [Software]. *Multivariate analyses in Excel using PCA, CA and MS*. Available from: https://www.archaeoinfo.dk/capca.htm [Accessed 15.04.2021].

Makarewicz, C.A., Hofmann, R., Videiko, M.Y. and Müller, J., 2022. Community negotiation and pasture partitioning at the Trypillia settlement of Maidanetske. *Antiquity*, 96 (388), 831–847. Available from: https://doi.org/10.15184/aqy.2022.32

Monah, F., 2007. The spread of cultivated plants in the region between the Carpathians and Dniester, 6th-4th millennia cal BC. *In*: S. Colledge and J. Conolly, eds. *The Origins and Spread of Domestic Plants in Southwest Asia and Europe*. New York: Routledge, 111–123. Available from: https://doi.org/10.4324/9781315417615

Monah, F. and Monah, D., 2002. Les céréales cultivées par les populations Néo et Enéolithiques de la Moldavie. *Civilisations*, 49 (1–2), 67–76. Available from: https://doi.org/10.4000/civilisations.1366

Motuzaitė Matuzevičiūtė, G., 2013. Neolithic Ukraine: A Review of Theoretical and Chronological Interpretations. *Archaeologia Baltica*, 20, 136–149. Available from: https://doi.org/10.15181/ab.v20i0.812

Motuzaitė Matuzevičiūtė, G. and Telizhenko, S., 2016. The first farmers of Ukraine: an Archaeobotanical Investigation and AMS Dating of Wheat Grains from the Ratniv-2 Site. *Archaeologia Lituana*, 17, 100–111. Available from: https://doi.org/10.15388/ArchLit.2016.17.10685

Müller, J. and Videiko, M., 2016. Maidanetske: New Facts of a Mega-Site *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 71–93. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Rassmann, K. and Videiko, M., eds., 2016. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site / Майданецьке 2013. Нові розкопки великого Трипільського поселення*. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Nebbia, M., 2017. *Early cities or large villages? Settlement dynamics in the Trypillia group*, *Ukraine*. [PhD thesis. Durham University]. Available from: http://etheses.dur.ac.uk/12109

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Padulosi, S., Hammer, K. and Heller, J., eds., 1996. Hulled Wheats. *Proceedings of the First International Workshop on Hulled Wheats, 21-22 July 1995, Castelvecchio Pascoli, Tuscany, Italy*. Promoting the conservation and use of underutilized and neglected crops 4. Rome: International Plant Genetic Resources Institute (IPGRI).

Pashkevych, G., 2012. Environment and economic activities of Neolithic and Bronze age populations of the Northern Pontic area. *Quaternary International*, 261, 176–182. Available from: https://doi.org/10.1016/j.quaint.2011.01.024

Pashkevych, G., 2020. The Mega-Structure (2012). *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 409–411. Available from: https://doi.org/10.1515/9783110664959-009

Pashkevych and Videiko 2006: Пашкевич, Г.О. and Відейко, М.Ю., 2006. *Рільництво племен трипільської культури*. Київ: Інститут археології НАН України.

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C., van der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A. and Talamo, S., 2020. The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon*, 62 (4), 725–757. Available from: https://doi.org/10.1017/RDC.2020.41

Peña-Chocarro, L. and Zapata, L., 2003. Post-harvest processing of hulled wheats. An ethnoarchaeological approach. *In*: P.C. Anderson, L.S. Cummings, T.K. Schippers and B. Simonel, eds. *Le traitement des récoltes: un regard sur la diversité du Néolithique au présent. Actes des rencontres, 17-19 octobre 2002.* XXIIIe rencontres internationales d'archéologie et d'histoire d'Antibes. Antibes: Éditions APDCA, 99–114.

Rivera Núñez, D., Matilla Séiquer, G., Obón, C. and Alcaraz Ariza, F., 2011. *Plants and humans in the Near East and the Caucasus. Ancient and Traditional Uses of Plants as Food and Medicine, a Diachronic Ethnobotanical Review*, Vol. 2: *The Plants: Angiosperms*. Murcia: Ediciones de la Unversidad de Murcia

Salavert, A., Messager, E., Motuzaite-Matuzeviciute, G., Lebreton, V., Bayle, G., Crépin, L., Puaud, S., Péan, S., Yamada, M. and Yanevich, A., 2015. First results of archaeobotanical analysis from Neolithic layers of Buran Kaya IV (Crimea, Ukraine). *Environmental Archaeology*, 20 (3), 274–282. Available from: https://doi.org/10.1179/1749631413Y.0000000016

Schiffer, M.B., 2010. *Behavioral Archaeology. Principles and Practice*. London: Routledge. Available from: https://doi.org/10.4324/9781315541242

Schlütz, F., Hofmann, R., Dal Corso, M., Pashkevych, G., Dreibrodt, S., Shatilo, M., Terna, A., Fuchs, K., Filipović, D., Flohr, P., Makarewicz, C., Ţerna, S.., Videiko, M., Rud, V., Müller, J. and Kirleis, W., 2023, Isotopes prove advanced, integral crop production, and stockbreeding strategies nourished Trypillia mega-populations, *Proceedings of the National Academy of Sciences of the United States of America*, 120 (52), e2312962120. Available from: https://doi.org/10.1073/pnas.2312962120

Shatilo, L., 2021. *Tripolye Typo-chronology: Mega and Smaller Sites in the Sinyukha River Basin.* Scales of Transformation in Prehistoric and Archaic Societies 12. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/m5457py

Shumova 1988: Шумова, В.А., 1988. Производство тарной посуды позднетрипольским населением междуречья Ю. Буга и Днепра. *In*: ИА АН СССР, *Древнее производство, ремесло и торговля по археологическим данным. Тэзисы докладов IV конференции молодых учёных ИА АН СССР*. Москва: ИА АН СССР, 29–30.

Țerna, S., 2021. How can we investigate the socio-economic structure of the Cucuteni-Tripolye mega-sites? Houses as Snapshots and Pits as Durable Narratives. *Archäologisches Korrespondenzblatt*, 51 (1), 37–60. Available from: https://doi.org/10.11588/ak.2021.1.86862

Yanushevich, Z.V., 1978. Prehistoric Food Plants in the South-West of the Soviet-Union. *Berichte der Deutschen Botanischen Gesellschaft*, 91 (1), 59–66. Available from: https://doi.org/10.1111/j.1438-8677.1978.tb03633.x

Yanushevich 1980: Янушевич, З.В., 1980. Земледелие в раннем Триполье (по данным палеобо таники). *In*: И.И. Артеменко, ed. *Первобытная археология – поиски и находки*. Киев: Издательство "Наукова думка", 225–234.

Yanushevich, Z.V., 1989. Agricultural evolution north of the Black Sea from the Neolithic to the Iron Age. *In*: D.R. Harris and G.C. Hillman, eds. *Foraging and farming: the evolution of plant exploitation.* London: Unwin and Hyman, 607–619.

8. X-Ray computer microtomography (XRay-µCT) as a fast non-invasive technique for compositional studies of burnt prehistorical materials: results and implications from burnt daub at Maidanetske, central Ukraine

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Abstract

In this paper we present results from an XRay-µCT study on burnt daub samples unearthed at the Trypillian mega settlement site of Maidanetske, central Ukraine. The volume and characteristics of pores of eight pieces of burnt daub were measured via XRay-µCT using the SkyScan1172 program and the raw data were evaluated using the NRecon program. The analysed daub pieces display porosities between 7.5 ± 1.9% and 22.3 ± 4.3%. Thorough visual inspection of the pictures resulted in estimations of organic remains imprints and non-organic cavities. The former consist of cereal grains, glumes, culm fragments and spikelet forks/rachis segments; the latter consist of voids, cracks, and inhomogeneities. The content of the organic remains was calculated by subtracting the cracks from the total porosity. The resulting contents of organic remains in the daub pieces totals between 0.6 ± 0.1% and 15.1 ± 6.0%. Archaeological daub classification, phytolith analysis and geochemical composition validated the XRay µCT results. Given the non-invasive character and the manageable effort of using this method, XRay µCT might be considered as a promising supplemental technique for the internal study of burnt artefacts.

Additional outcomes of this multidisciplinary daub study include information on daub processing technology and resource use as well as giving some ideas about social interaction within Trypillian communities. Chaff was preferentially used for outer walls of houses. Urine was probably added to the daub mass to mix it and make it malleable. This indicates a certain standardisation of daub production, which is

to be tested by further analysis. Since the harvest remains used as organic temper were present in large amounts annually, and storage pits filled with harvest remains are lacking so far in the extensive Trypillian archaeological record, this suggests that Trypillian house building was probably a well-planned communal activity which followed the annual cereal harvest.

Introduction

Burnt daub has been a research object of prehistorical archaeology for a long time. Research questions have concerned, for example, aspects of architecture, the provenance of building materials, the amount of working effort, the burning environment or geophysical mapping of single houses and complete settlements (*e.g.* Shaffer 1993; Stevanović 1997; Chapman 1999; Tringham 2005; Fries-Knoblach 2009; Lichter 2016; Pickartz *et al.* 2019; Chapter 4, this work, Vol. I).

Burnt daub is easily accessible for investigations as it is often present at prehistoric archaeological excavations in large amounts. Analysis of burnt daub pieces has so far been focussed on macroscopical classification, since compositional analysis after crushing the daub pieces or studying daub in thin sections is very time-consuming. In this paper we present a new approach which allows rapid insight into burnt daub internal composition using X-ray µCT. This pilot study was supplemented by traditional methods such as macroscopical daub classification, phytolith analysis and geochemical analysis (ped-xrf) to validate the results and to check the potential of the X-ray µCT method to deliver additional archaeobotanical data and ideas about plant resource management at a Chalcolithic Trypillian mega site in central Ukraine (Maidanetske).

Materials and methods

Study site

The burnt daub pieces analysed in this study were unearthed during archaeological excavations at Maidanetske, a Chalcolithic mega-site in central Ukraine. These early agglomerations of Chalcolithic people resulted in an incomparable amount of archaeological remains of buildings in earthen architecture, *i.e.* daub (Kruts 1989; Shmaglij and Videiko 2005; Menotti and Korvin-Piotrovskiy 2012; Chapman *et al.* 2014; Müller 2016; Müller *et al.* 2016b; Pickartz *et al.* 2019).

Large Trypillian settlements (so-called mega-sites) have been found especially in the Bug-Dnieper interfluve, *i.e.* the north Pontic steppe regions of central Ukraine (*e.g.* Kruts 2012; Wengrow 2015; Müller *et al.* 2016b; Gaydarska *et al.* 2019). Maidanetske (Cherkasy region, Ukraine), with an area of 200 ha, is one of the largest Trypillian mega-sites, having had up to 15,000 inhabitants and being occupied for ca. 200–350 years, with a peak in house occupation during the century between ca. 3800 and 3700 BCE (Müller *et al.* 2016a; Ohlrau 2020; Shatilo 2021). It is evident that reliable food supply is a relevant precondition for the existence of such mega-sites that are considered proto-urban, building upon an agrarian subsistence economy (*e.g.* Pashkevich and Videiko 2006; Harper 2011; Shukurov *et al.* 2015; Ohlrau *et al.* 2016).

The use of systematic extensive flotation programmes to acquire charred archaeobotanical material from archaeological stratigraphy containing cereal grains and chaff parts is a recent development and can help improve our knowledge of plant use in Trypillia (Kirleis and Dal Corso 2016; Dal Corso *et al.* 2019; Ţerna *et al.* 2019). In particular, excavations of deep pits next to house floors are highly beneficial and bring numerous finds to light. This suggests that pedogenetic processes produce a taphonomic bias, which may affect the preservation of charred organic remains in most of the settlement/house stratigraphy that lies less than a metre below the modern soil surface (Dreibrodt *et al.* 2022). Recent archaeobotanical and zooarchaeological studies highlight the relevance of cereal crops, as indicated by, *e.g.*, intensive use of cereal by-products and the herding of domestic animals (Dal Corso *et al.* 2018; Dal Corso *et al.* 2019; Kirleis and Dal Corso 2016).

Archaeobotanical research history on the Trypillia culture has studied plant imprints of cereal by-products and sometimes imprints of individual grains in ceramics and daub as a main source for reconstruction of the plant economy (Yanushevich 1975; Yanushevich 1978; Pashkevich and Videiko 2006 and references therein). Plant imprints in daub from Neolithic and Chalcolithic sites have been recently re-visited (*e.g.* An *et al.* 2018). The aim of this paper is to develop a rapid non-invasive procedure to quantify the amount and characterise the types of cereal by-products in the daub used for the construction of Trypillian houses.

Methods

Daub sampling and classification

At Maidanetske, similarly to other Trypillian settlements, daub from walls and other architectural parts has been preserved until present, since most of the houses were burnt and buried by the subsequent Chernozem formation (Dreibrodt *et al.* 2022). During the excavation of House 44 at Maidanetske, the locations, masses and types of daub were systematically documented with point coordinates and recorded in a grid of 1 × 1 m^2 cell sizes (Müller *et al.* 2017). Details of the advanced archaeological classification of the daub are given as supplementary information (Suppl. 1).

Eight daub samples from House 44 (Trench 51) were chosen that represent three material types (Fig. 1). The sample and unit number, location in the trench, macroscopic properties and sample code of the µCT laboratory are listed in Table 1.

The floor plan of the house follows a common template of houses of the Tomashovka local group: on top of a massive clay platform, the main floor of the house is located, with an anteroom in the northeast, a main room in the southwest, a podium on the southeastern longitudinal wall of the main room, a furnace in the northern corner of the main room and a central clay installation.

X-ray microtomography

Seven of the eight samples investigated were chaff-tempered daub fragments of Material Types 2 and 3 and were selected to acquire detailed information about the organic temper components, the daub porosity, and the spatial distribution of the components in the daub samples, using up to three individual ROI (region of interest) sections. As a control, one sample was chosen representing non-chaff-tempered daub (Material Type 1).

The selected daub samples are of various sizes and irregular in shape. Since the sample chamber of the X-ray microtomograph allows the processing of samples with a maximum diameter of 34 mm and a maximum height of 55 mm, rectangular bars with dimensions of (x, y) ~20 × 20 mm were cut out of the daub pieces. The top and bottom surfaces were left untreated in order to preserve unaffected the internal structure of the daub; this resulted in various heights (z) of the bars, ranging from ~25 mm to ~55 mm (see Fig. 2).

X-ray microtomography characterises internal structures two- and three-dimensionally. Because X-ray microtomography is a non-destructive technique,

Figure 1. Excavation plan of House 44 in Maidanetske with location of the eight investigated samples. Coordinates refer to the UTM coordinate system (zone 36N) and WGS 84 ellipsoid.

Find-ID	Feature-ID	Location	Daub category[1]	Material type[2]	µCT #[3]	Architectural context	Organic temper
51394	51003	I 13	1	3	E	Floor sub-layer	Plant-based temper
51366	51003	J 18	1	2	A	Exterior wall?	Plant-based temper
51416	51009	I 15	1	2	D	Clay installation	Plant-based temper
51413	51009	I 12	2	1	G	Floor screed	Non-plant-based temper
51392	51003	I 17	4	3	H	Clay installation	Plant-based temper
51390	51003	K 15	4	3	F	Podium	Plant-based temper
51402	51003	K 15	5	2	B	Podium	Plant-based temper
51379	51003	L 11	5	2	C	Exterior wall?	Plant-based temper

Table 1. Selected daub samples and related classifications.
[1] *classification after Müller* et al. *(2017);* [2] *see text for more details;* [3] *internal labelling by µCT laboratory.*

Figure 2 (above). Daub samples machined to ~20 × 20 mm rectangular bars.

it has a decisive advantage over wavelength dispersive X-ray fluorescence spectrometry and thin section petrography when investigating archaeological finds. Volume fractions of phases (inclusions) in the temper can be characterised and in addition 3D visible orientation of pores can be detected and classified. This allows, *e.g.*, conclusions to be made about the manufacturing procedure of the pottery (for more details see Menne *et al.* 2020). X-ray microtomographic devices consist of an X-ray source, a rotating sample holder and a detector. The X-rays penetrating through the sample are absorbed differenctly by the various phases present in the sample and are displayed space-resolved at the detector. The differences in X-ray absorption correspond to the densities of the present phases. When reconstructing the 2D and 3D images, grey values based on the degree of X-ray absorption are assigned to each pixel (2D bitmap) and voxel (grid in 3D space), respectively. Pores with the density of air are displayed in black or dark grey, while phases with high densities (*e.g.* clay, mineral and/or rock fragments used as matrix and temper, respectively, in ancient pottery) appear in light grey or even white (for more details regarding methodology, see Kahl *et al.* 2013 and references therein).

Sample-specific measurement routine and data processing

The X-ray microtomography scans in this study were carried out using the SkyScan 1172 system (SkyScan, Belgium) at the Institute for Geosciences, Kiel University, Germany. The following parameters were used: beam energy of 100 kV, beam current of 100 μA with an aluminium-copper filter, sample rotation (360°) with a step width of 0.5°, and medium resolution (detector resolution: 17.3 μm per pixel). Given the fragility of the daub samples, these were placed inside a frame of modelling clay and then mounted on the sample holder. The vertical maximum extension of a single scan corresponds to a height of 20 mm. The majority of the analysed daub samples are taller (Fig. 2). The sample holder was moved in a vertical direction and multiple scans were conducted (oversize scans) to scan the tall samples. After the data acquisition, the 2D and 3D images were reconstructed using the program NRecon (SkyScan). For each sample ~1000 stacked layered images were generated and correspondingly more for oversize scans (up to 3000 stacked layered images). Each layered image consists of isometric voxels (volumetric pixels) whose sizes depend on the detector resolution. Therefore, the stacked images give volumetric information. The SkyScan software tools CTAn and CTVol were used to decode the data into black and white images as well as to visualise and calculate the individual volumes of the various phases present, extracted from the binarised images. Hence, continuous image volume inspections were undertaken using computer-aided morphometry and quantitative image analysis. The reconstructed scans were apportioned to individual ROI sections, not only to keep the computing time manageable but also to allow direct comparison of the various daub samples.

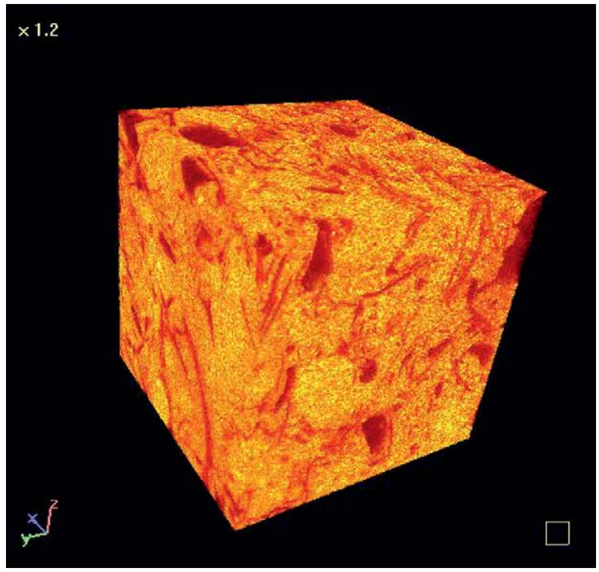


Figure 3. Representative virtually cut cube (µCT#: A). Please note: (i) x, y, z = 1 cm; (ii) the grey tone image is coloured for better visibility.

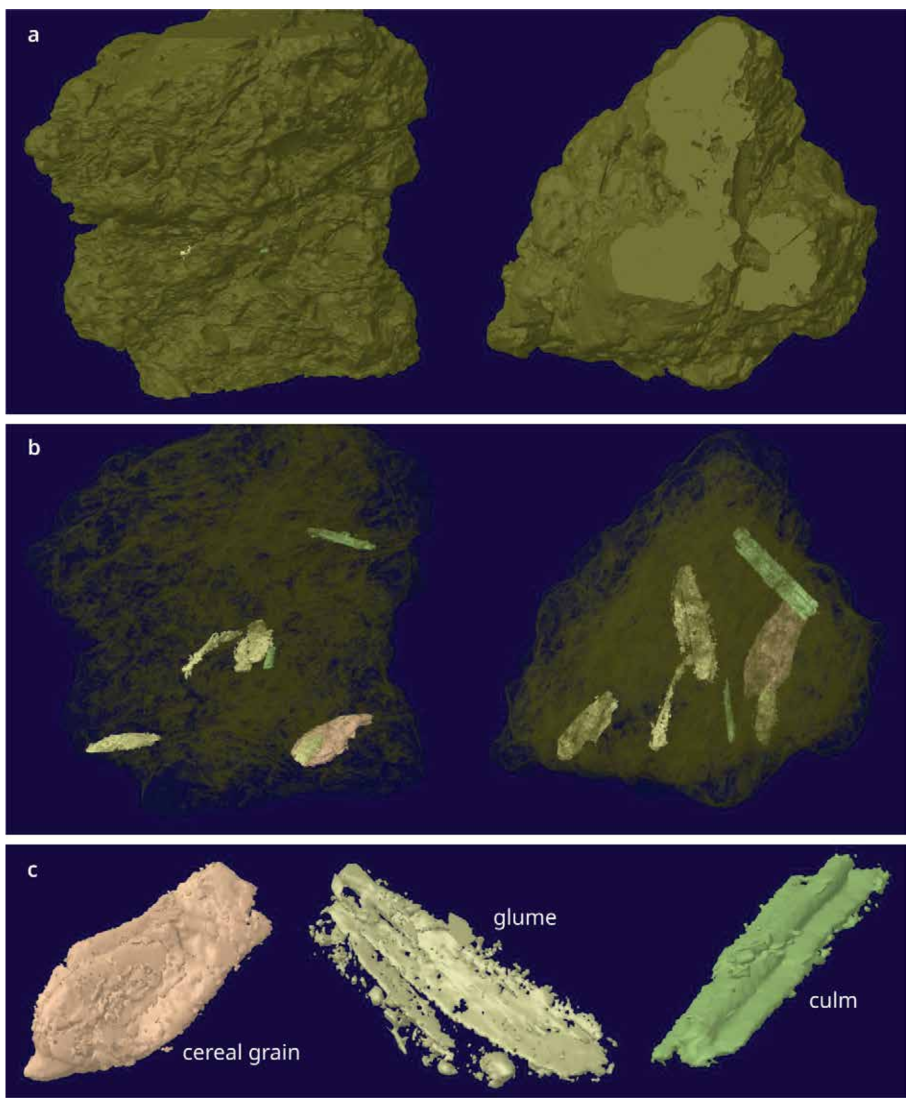


Figure 4. Correlation of pores of supposed organic origin in daub to mm-sized organic components: (a) 3D reconstruction of the outside surfaces of the daub as side view (left) and top view (right); (b) Unmasked pores using translucent matrix (left: side view; right: top view); (c) Distinct shapes of pores assigned to various organic components (mm-sized).

This was done using the CTVol software 're-slice' tool. Depending on the length of the daub samples, up to three cube-shaped areas (1 × 1 x 1 cm) were virtually extracted from the reconstructed 3D images. Figure 3 is a representative example of one of these cubes. As the cubes were cut virtually, there was no mechanical damage to the surfaces and edges.

The virtually cut cubes are mainly used to derive the portion of the used organic temper from the total fraction of porosity, based on a standardised volume (1 × 1 x 1 cm) to better compare the various daub samples. The method developed to determine organic temper proportions is described in detail below.

Assignment of pore shapes to specific organic components and determination of total volume of organic fraction

Organic components were used as temper in the daub, as attested by macroscopic observation of plant imprints and by phytolith analysis (Dal Corso *et al.* 2019). The organic components either decomposed over the years or were burnt to ash during the final burning of the houses, leaving behind impressions that are now seen as specifically shaped pores in the ancient daub samples. Figure 4 illustrates the various steps required to correlate pores of organic origin with the organic components after X-ray microtomography scans. First, a 3D image of the daub must be reconstructed (Fig. 4a). To unmask the pores, the matrix has to be displayed translucently (Fig. 4b). For better visualisation, some of the pores in Figure 4b are coloured. Finally, optical enlargement allows the pores to be assigned to various anatomical plant parts such as cereal grains, glumes, and culms (Fig. 4c).

The total pore volume consists not only of organic temper but also of cracks, vesicles and micropores formed during the manufacturing process of the daub and its use as building material. As a result, almost all objects (pores of varying origin) are interconnected and it is not possible to distinguish them automatically, other than by the volume of the micropores. In this study, micropores are defined as pores with volumes of less than 0.05 mm^3, as the majority of all assigned fragments of organic parts are larger than 0.05 mm^3. Fragments of organic parts are those organic components that are only preserved as several pieces and are no longer preserved as one piece in their original shape, as exemplified in Figure 4c. The SkyScan software CTAn allows automatic subtraction of pores with pre-defined volumes. All pores with volumes of less than 0.05 mm^3, *i.e.* all micropores, were subtracted from the total pore volume. To be able to subtract either the organic components or the cracks and vesicles from the total pore volume, it has proven useful to manually encircle cracks and vesicles rather than organic components, due to their complexities of shape. Thus, the proportions of organic temper in the studied daub samples (*i.e.* all pores of organic origin) were derived by subtracting the volumes of all cracks, vesicles and micropores from the total pore volume.

To verify not only the volume fractions calculated by the Skyscan software but also to ensure that the total pore volume is not significantly influenced by the manufacturing procedure of the daub, a quantitative test to verify the calculated volume fractions was performed. Menne *et al.* (2020) validated the calculated volume fractions. They conducted a quantitative test by placing ink filler balls with standardised diameters into a plastic container of known volume. This allows not only a precise calculation of the pore volumes or cavities as artificial porosities but also of the total ink filler ball volume. Figure 5 illustrates (a) the ink filler balls inside the plastic container and (b) the 3D view of the absorbed X-rays. All ink filler balls are made of glass, except one ball that is made of plastic and is easily recognisable in Figure 5b as a darker sphere, due to the lower density of plastic compared to glass. Menne *et al.* (2020) confirmed the software-based calculated pore volume by manually calculating the volumes.

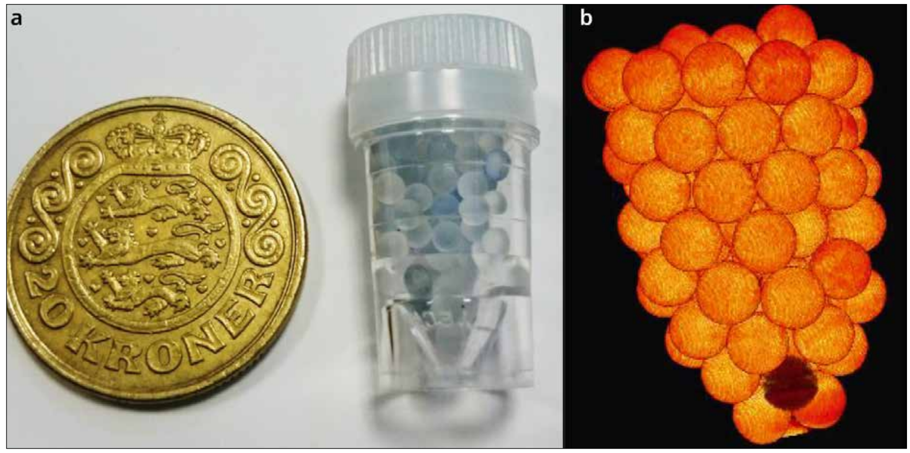


Figure 5. Validation of software-based volume fractions: (a) 97 ink filler balls (diameter: 2.5 mm) in the plastic container; (b) 3D view of the X-ray microtomography scan; Figure is modified after Menne et al. *(2020).*

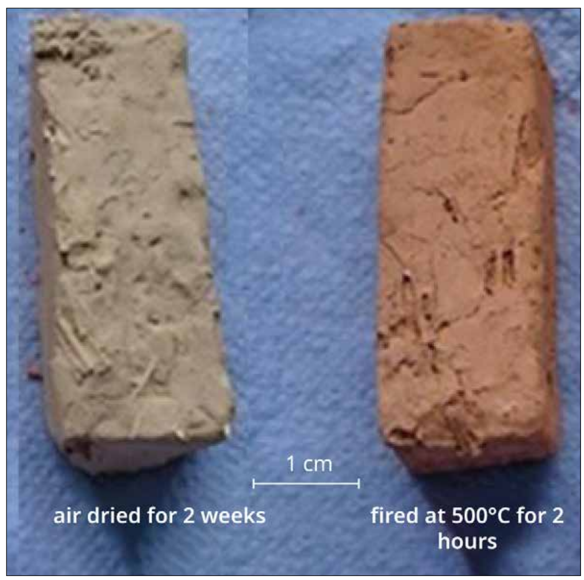


Figure 6. Daub bricks after air drying (left) and firing at 550°C (right).

To test if manufacturing procedures influence the total pore volume, experimental daub bricklets were produced by mixing loess, culms and glumes of einkorn (*Triticum monococcum*, a hulled wheat seen in the Trypillia period; Kirleis and Dal Corso 2016) with water, in proportions similar to those of the daub samples from Maidanetske. The volume ratios were 1400 ml (loess) : 250 ml (culm fragments) : 250 ml (glumes), corresponding to 20 g (loess) : 0.31 g (culm fragments) : 0.47 g (glumes). The solid mixture was worked with the aid of water to ensure a certain stiffness that would allow further handling. Finally, rectangular bricks with dimensions of ~1 × 1 x 4 cm were formed (Fig. 6). X-ray microtomography scans were carried out after air-drying the daub bricklets for 2 weeks at room temperature. The bricklets were then placed in a preheated (50°C) muffle furnace, fired under oxidised conditions (air) for 2 hours at 550°C and 800°C respectively, after which the X-ray microtomography scans were repeated.

To ensure proper recognition and classification of the organic components, culms, glumes and spikelets of einkorn were placed in a plastic container and X-ray microtomography scans were performed (Fig. 7). The culms to glumes ratio was identical to the final brick mixtures. The filled and more rounded objects in Figure 7c are whole cereal grains, the elongated objects are culm fragments and the more flat and linear appearing objects are glumes.

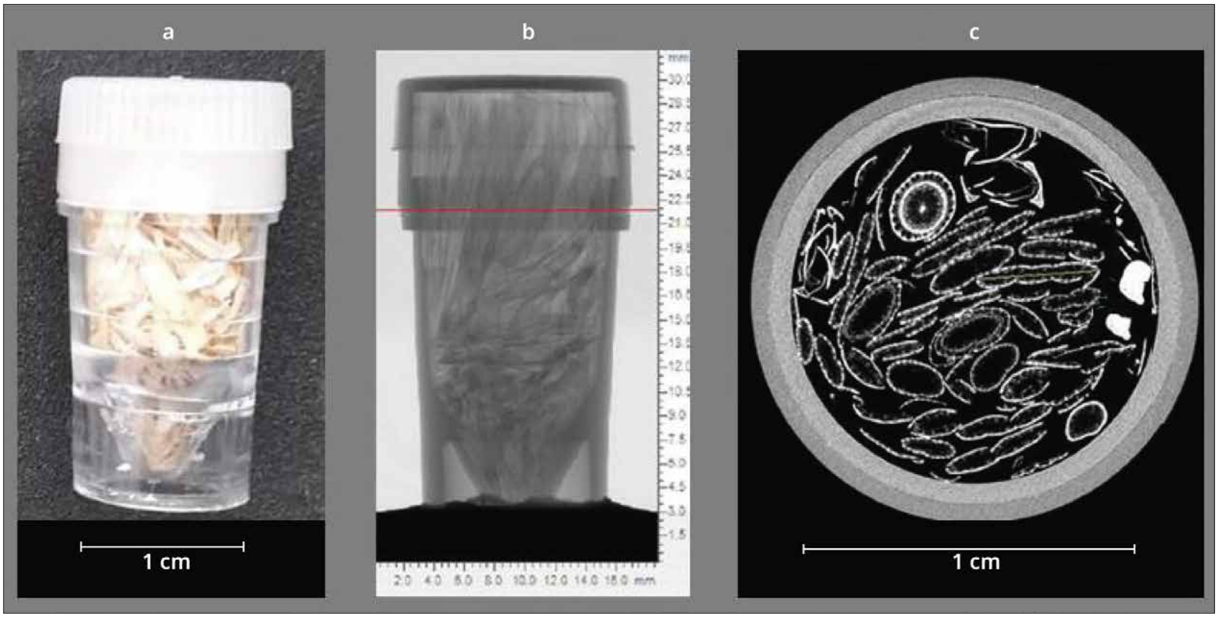


Figure 7. Analysis of raw material used in experimental daub bricks: (a) Culm-glume-spikelet mixture of einkorn in plastic container; (b) Microtomography scan; (c) 2D layer of the reconstructed 3D image. Whole cereal grains and fragments of culms and glumes are visible (see text for more details).

The known contours of the raw materials (Fig. 7c), allowed the recognition of components in the fired experimental daub bricklets as not yet carbonised organic matter. Figure 8 displays 2D layers of the reconstructed 3D images of an unfired daub bricklet (Fig. 8a, c) and the same daub bricklet fired at 550°C (Fig. 8b, d). Care was taken in displaying transverse sections at very similar vertical positions, for better comparison of the unfired and fired textures, *i.e.* Figures 8a and 8b as well as Figures 8c and 8d are 2D layers at similar vertical positions, respectively. However, Figures 8c and 8d are intentionally vertically off-set from Figures 8a and 8b. Two important observations can be made based on the optical appearance and morphometric analyses: (1) about 50% of the organic components remained unchanged, *i.e.* those components did not burn, instead the grains survived the firing of the bricklets at either 550°C or 800°C; (2) neither further cavities nor additional cracks formed from the firing of the daub bricklets in the experiment. This implies that the increase in total pore volume is closely correlated to the burning of the organic components.

Portable energy dispersive X-ray fluorescence (ped-xrf) measurements

Total elemental contents were measured on daub samples from Maidanetske by a ped-xrf analyser (NITON XL3t 900-series device, Thermo Scientific Niton Analyzers; see also Chapter 4, this work, Vol. I). 77 sub-samples from 32 daub pieces of two unearthed buildings were analysed (19 from House 44, including the samples analysed by X-Ray tomography; 13 from House 111). In adddition, 62 soil samples from Maidanetske and the surrounding landscape were analysed.

Sample preparation followed Lubos *et al.* (2016) and Dreibrodt *et al.* (2017). After drying the samples at 35°C for 2 weeks, they were gently disintegrated with mortar and pestle. The finer than 2 mm fractions were homogenised in an agate mill (<60 μm). Samples were transferred into plastic tubes which were then covered with a 4 μm film. Measurements were performed in a lead-mantled measurement chamber with He-flotation in the detector unit of the device. The measurement mode 'mining Cu/Zn' was applied. The following filter modes of the device were used: main filter 40 kV, 50 mA; high filter 50 kV, 40 mA; low filter 20 kV, 100 mA; light filter 6 kV, 100 mA. The total measurement time was 300 s (main filter, high filter, low filter: 60 s each, light filter: 120 s). If present in measurable amounts, the device measures the content of 35 main and trace elements and in addition calculates the amount of unmeasured residues ('bal'). Based on calibration with

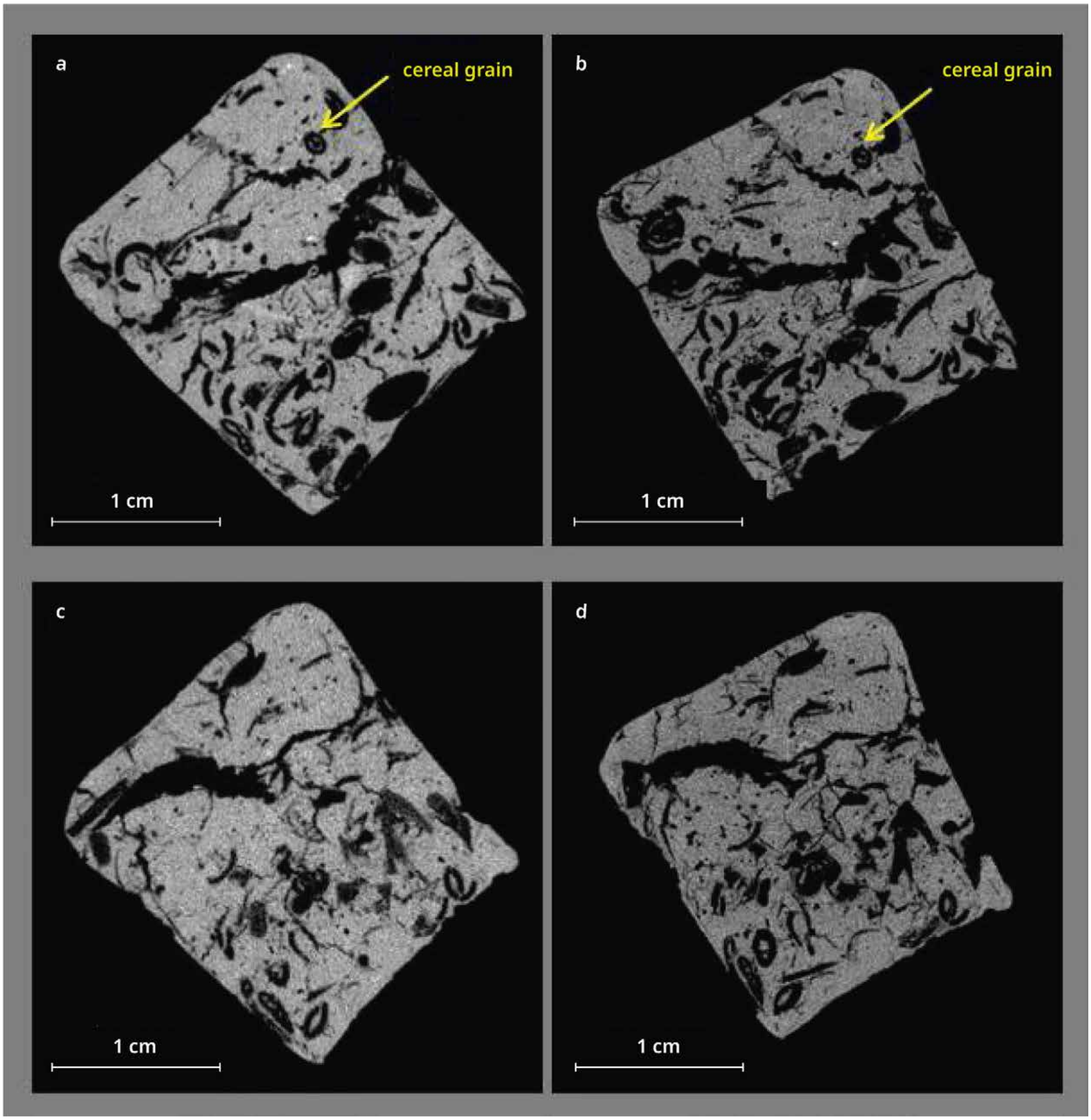


*Figure 8: 2D layers of the reconstructed 3D images before and after firing at 550°C: (a) and (c) unfired; (b) and (d) fired; transverse sections are at similar vertical positions: (a & b) and (c & d). Please note: some organic components (*e.g.* cereal grains) do not show a change in their microtomography signal after firing.*

internal standards, the NITON XL3t 900-series device also gives an estimation of measurement errors for each element. The only elements considered here were those with measured values with relative standard errors of ~15% or less. A certified standard sample (GBW07411) was measured regularly to check the reproducibility of the measurements (*e.g.* ageing of the X-ray source).

Phytolith analysis

From the eight daub pieces analysed by X-Ray tomography, 13 phytolith samples were taken (see Suppl. 2 for more details). Results from samples 51394 and 51402 were published in Dal Corso *et al.* (2018). In all cases, a portion of daub was subsampled from the middle of the piece, after being freshly opened and then disintegrated using mortar and pestle. 2.5–4 g of material was processed after Madella *et al.* (1998) using heavy liquid (sodium polytungstate/SPT) separation. Where possible, a minimum number of ca. 200 phytolith single cells (excluding unidentifiable phytoliths and multicellular aggregates) were counted at 400x magnifications under a light microscope and used as the base for percentage values. Samples poor in phytolith content resulted in lower counts; the counting was limited to ca. 100 oculars. For the identification and attribution to plant groups and/or parts see Dal Corso *et al.* (2018) and references therein. Phytolith morphotypes are named according to the International Code for Phytolith Nomenclature 2.0 (ICPT 2019). In the present study, only single phytolith cells are considered, although multicellular aggregates of phytoliths in anatomical positions (also called silica skeletons) have also been found (Dal Corso *et al.* 2018). The single cells record has been chosen because of easier comparability of relative proportions of morphotypes in the assemblage of each sample.

Results

X-ray microtomography of daub samples of House 44

Table 2 provides an overview of the qualitative amounts of the organic components (cereal grains, glumes, culm fragments, and spikelet fork/rachis segments), voids, cracks and inhomogeneities. Neither cereal grains nor significant amounts of glumes, culm fragments and spikelet fork/rachis segments were found in Sample 51413 (Material Type 1). This is in accordance with its classification as a non-chaff-tempered daub sample. Cereal grains were detected in half of the samples of Material Type 2 (51366, 51416, 51402, 51379) and in all studied samples of Material Type 3 (51394, 51392, 51390). Glumes are the dominant organic component in all samples of Types 2 and 3. No obvious sequence exists regarding the relative amounts of the other organic components, although most of the samples of both types contain slightly more spikelet fork/rachis segments compared to culm fragments. The same lack of grouping exists regarding the presence of voids, cracks and inhomogeneities. Table 3 summarises the quantitative morphometric information.

The distribution of organic components in all samples of Types 2 and 3 is heterogeneous, resulting in large variations of both porosities and organic components. The averages of most porosities and of absolute and relative organic contents, respectively, are identical within 1σ standard deviation in all the classes studied. The daub sample of Type 1 (non-chaff-tempered daub) has a very low porosity (7.5 ± 1.9%) and, thus, marginal organic components, which can be attributed to very few culm fragments (see Tab. 2). The total volume of organic components, now present as distinct shapes of pores and easily distinguishable from voids and cracks, is significant.

Total elemental contents of the studied daub pieces

The results of the ped-xrf measurements are shown in Supplement 3 and in Figure 9. The evaluation of the data shows that 15 elements (soil) and 13 elements (daub: Zr, Y, Sr, Zn, Fe, Mn, Ti, Ca, K, Al, P, Si, Mg), respectively, are measured with a relative error of <15% and could be considered appropriate for a statistical analysis.

A comparison of the mean values (box-plots) of indicative elemental ratios is given in Figure 9a. Considering the context of the study, a focus here is on biogenic silica. Geochemical analysis can provide data about biogenic silica in sediments (*e.g.* Kylander *et al.* 2011; Dreibrodt and Wiethold 2015) and within archaeological deposits (*e.g.* Lubos *et al.* 2013). While biogenic silica concentration can be measured in the eluate of alkaline solvents directly (*e.g.* Engström and Wright 1984; Lubos *et al.* 2013) the application of elemental ratios based on xrf-measurements has been

Sample #	µCT #[1]	Total volume[2]	Cereal grains[3]	Glumes[4]	Culm fragments[4]	Spikelet fork/rachis segments[4]	Voids[4]	Cracks[4]	Inhomoge-neities[4]
51394	E	9849	yes	+++	++	○	+	○	+
51366	A	8449	no	++	+	+	++	+	+
51416	D	10556	no	+++	++	○	○	++	-
51413	G	13683	no	-	+	○	○	○	++
51392	H	7569	yes	++++	○	++	+	+	○
51390	F	5588	yes	++++	○	+	++++	○	+
51402	B	12069	yes	++++	○	+	+	○	+
51379	C	6078	yes	+++	+	++	+	○	-

Table 2. Organic components in studied daub samples.
[1] internal labelling by µCT laboratory; [2] total volume of scanned sample in mm^3; [3] presence or absence of cereal grains in studied samples; [4] optical description of scanned sample (- : absent; ○ : barely recognisable and classification questionable; +/++/+++/++++ : organic components clearly identified with increasing relative amounts of different organic components in individual samples).

Sample #	µCT #[1]	Total porosity[2]	Total porosity [mm^3][3]	Porosity of ROI sections[4]	Organic content of ROI sections[5]	Relative organic content[6]	Avg. porosity[7]	Avg. organic content[8]	Avg. rel. org. content[9]	Avg. total organic volume [mm^3][10]
51394	E	15.8	1556	20.4 / 19.8 / 12.8	18.5 / 18.7 / 8.2	90.9 / 94.3 / 64.2	17.7 ±4.2	15.1 ±6.0	83.1 ±16.5	1293 ±257
51366	A	11.0	929	14.4 / 11.9 / 10.1	13.3 / 10.1 / 4.7	92.1 / 83.9 / 46.5	12.1 ±2.2	9.4 ±4.3	74.2 ±24.3	689 ±226
51416	D	17.5	1847	14.5 / 17.1 / 21.3	7.4 / 13.5 / 14.8	51.0 / 78.8 / 69.5	17.6 ±3.4	11.9 ±4.0	66.4 ±14.2	1226 ±262
51413	G	7.7	1054	8.8 / 8.3 / 5.3	0.6 / 0.5 / 0.7	6.4 / 5.7 / 13.0	7.5 ±1.9	0.6 ±0.1	8.4 ±4.0	88.5 ±42.2
51392	H	13.8	1045	13.8 / 18.6	12.8 / 17.2	92.4 / 92.5	16.2 ±3.4	15.0 ±3.1	92.5 ±0.1	967 ±1.05
51390	F	21.3	1190	17.3 / 25.3 / 24.2	9.0 / 15.3 / 10.8	52.0 / 60.4 / 44.8	22.3 ±4.3	11.7 ±3.2	52.4 ±7.8	624 ±92.8
51402	B	14.7	1774	17.1 / 15.9 / 12.5	13.3 / 14.5 / 9.1	77.6 / 91.3 / 73.4	15.2 ±2.4	12.3 ±2.8	80.8 ±9.4	1433 ±167
51379	C	15.0	912	15.7 / 15.9	14.2 / 13.9	90.1 / 87.3	15.8 ±0.1	14.1 ±0.2	88.7 ±2.0	809 ±18.2

Table 3. Quantitative morphometric information of studied daub samples.
[1] internal labelling by µCT laboratory; [2] porosity [%] of entire scanned sample; [3] porosity [mm^3] of entire scanned sample; [4] porosity [%] in up to 3 individual sections (ROI = region of interest); volume of ROI was standardised (1000 mm^3); [5] percentage of organic components related to porosity in individual ROI sections; [6] relative amount of organic components [%]; [7] average porosity of combined individual ROI sections with 1σ standard deviation [%]; [8] average amount of organic components of combined individual ROI sections with 1σ standard deviation [%]; [9] average relative amount of organic components with 1σ standard deviation [%]; [10] average total organic volume with 1σ standard deviation [mm^3].

established as a quick alternative, delivering additional multi-elemental datasets (Lubos *et al.* 2016; Dreibrodt *et al.* 2017). Silica (Si) is present in an amorphous form in plants (phytoliths) but also in minerals of the soil at the site. Thus, ratios of Si with other elements, limited to the minerals of a sample, could be considered to reflect the amount of excess (= biogenic) silica. Figure 9a gives a comparison of the mean values of Si:Ti, Si:Al, Si:Zr, and Si:K ratios in the soils of the site (considered to reflect the resource for daub production) and the daub pieces. T-tests of the mean values of the

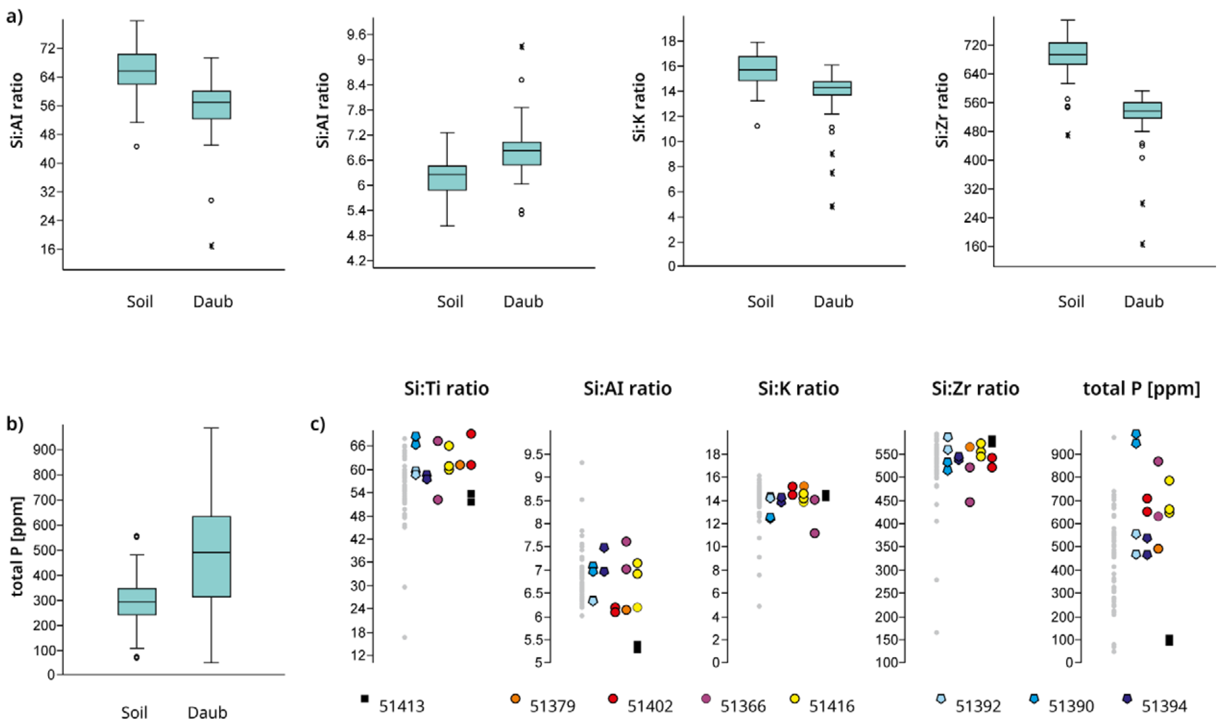


Figure 9. Geochemical properties of the daub from Maidanetske (n=77) compared to the local soils (n=62): (a) boxplots of elemental ratios considered to reflect the content of excess silica (biogenic silica); the differences in mean values are significant according to the t-tests; (b) total phosphorus content of daub and soil; (c) geochemical composition of the daub samples of House 44 and the building in Trench 111. Coloured symbols highlight the daub samples studied with μCT and phytolith techniques. Note that the symbols indicate the material types of the analysed daub: square = Type 1, circle = Type 2, pentagon = Type 3.

studied daub pieces and soils from the site show that the displayed differences are significant. Whereas there are enrichments of Si in the soils compared to the daub visible in Si:Ti, Si:Zr and Si:K ratios, the opposite is the case for Si:Al mean values.

Another difference is shown in the values of the total phosphorus contents (Fig. 9b). The mean values of the samples display a significantly higher P content in the daub samples compared to the soils at the site (significance approved by t-test).

Figure 9c shows all daub values for the aforementioned elemental values and the total phosphorus content for the studied daub pieces. The samples analysed by μCT and used in the phytolith analysis are marked with coloured symbols. It is obvious that the daub pieces selected for the study reflect a wide spectrum of daub present at the site, given their elemental composition.

Results of phytolith analyses

The phytolith record is rich and is composed of 15 different morphotypes (Fig. 10; Suppl. 2).

Single cell phytolith counts range from 205 and 420 per sample, with the exception of two samples with poor phytolith content (51413: 7 phytoliths; 51390b: 42 phytoliths). Those two samples are excluded from the following description of results. As expected from a previous study (Dal Corso *et al.* 2018), the phytolith record mostly refers to Poaceae. Grass short cell phytoliths produced in Poaceae are mostly represented by ubiquitous RONDELS (average 21.2%; maximum value 38.8% in Sample 51390a; minimum 5.4% in Sample 51402) and frequent TRAPEZOID/CRENATE phytoliths (average 2.6%; max. 11.2% in 51394; absent in 51416). These

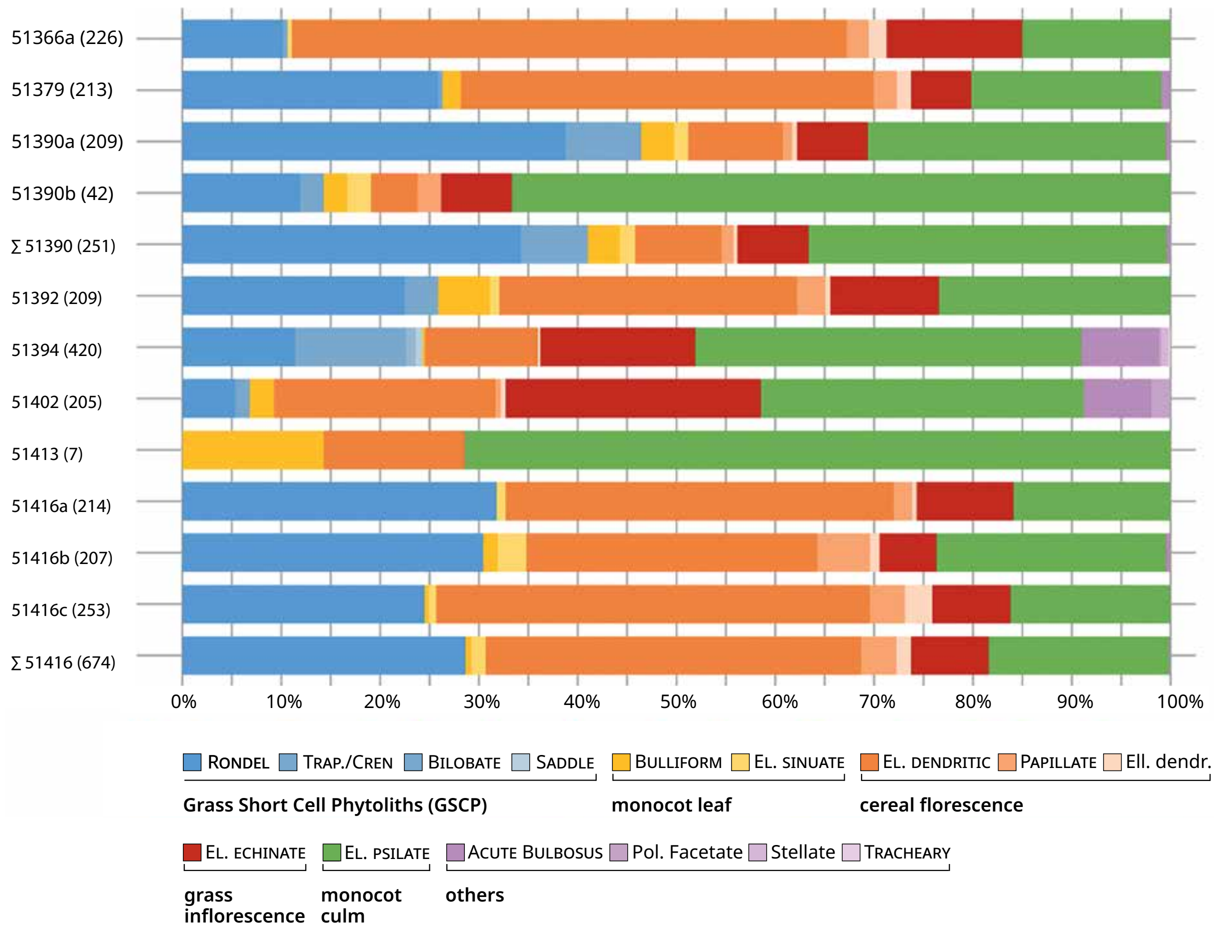


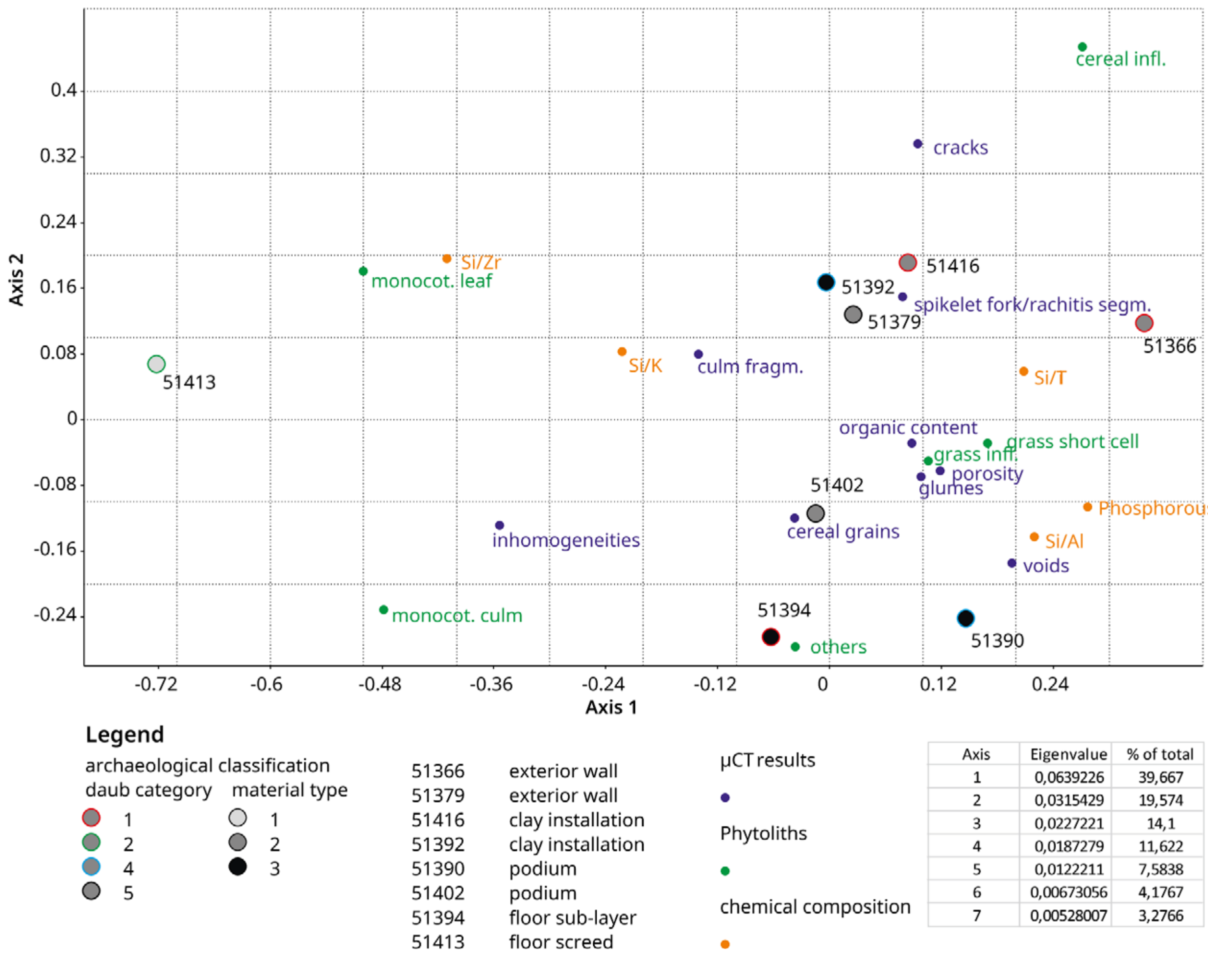
Figure 10. Summarised assemblages of phytolith single cells.

morphotypes are typical of pooid grasses and cereals (Ball *et al.* 1999). BULLIFORMS FLABELLATE from monocot leaves are rare (average 2.7%; max. 5.3% in 51392; absent in 51366a and 51416a). ELONGATE SINUATE from monocot leaves are also rare (average 1%; max 2.9% in 51416b). ELONGATE ENTIRE are ubiquitous and very frequent (average 31.3%; max. 39% in 51393; min. 15% in 51366a). They can be found in different plant groups and in different grass parts; they are especially abundantly produced in grass culms (Lancelotti and Madella 2012), *i.e.* they can originate from straw (Pető and Vrydaghs 2016). ELONGATE DENDRITIC are also ubiquitous and very abundant (average 26.9%; max. 56.2% in 51366a; min. 9.6% in 51390a). These phytoliths derive from light chaff parts (glumes, lemma, palea and awns), obtained from cereal ears (Ball *et al.* 2016; Pető and Vrydaghs 2016). Similarly, ELONGATE DENTATE phytoliths are commonly attributed to inflorescences and in minor part leaves of Poaceae too, although not only of domesticated cereals. They are common in this record (average 9.6%; max. 25.9% in 51402; min. 5.8% in 51416b).

Discussion

In this section, the µCT results of the daub pieces are compared with daub (phytoliths, chemical composition) and possible implementations of ancient human behaviour and socio-technological aspects are discussed.

The correspondence analysis of the whole dataset (Fig. 11) shows that the main results of XRay-µCT measurements (porosity, voids, organic content, cereal grains, glumes) plots in one cluster, with main compositional proxies for organic temper contents (grass phytoliths, phosphorus content, excess silica (Si:Al, Si:Ti)). On the



Axis	Eigenvalue	% of total
1	0,0639226	39,667
2	0,0315429	19,574
3	0,0227221	14,1
4	0,0187279	11,622
5	0,0122211	7,5838
6	0,00673056	4,1767
7	0,00528007	3,2766

Figure 11. Correspondence analysis of the daub samples. Numerical data on µCT data (porosity, organic content), phytolith assemblages and geochemical composition have been transformed to ordinally scaled data (classes).

other hand, other features such as cracks or inhomogeneities considered to result partly from the burning process plot outside this cluster. Thus, porosity and the deduced organic content measured by Xray-µCT correlate with the amount of organic temper added during the daub production, which backs up the validity of the XRay-µCT results. Some differences in the datasets might result from sampling volumes (*e.g.* cereal grains measured in XRay-µCT and cereal inflorescence in phytolith assemblages). Whereas the µCT and ped-xrf composition rely on a large part of the analysed daub samples, phytolith sampling was restricted to small amounts of the daub pieces. Some variability is visible within different phytolith sub-samples of the daub pieces (Suppl. 2). A comparison with the macroscopic archaeological daub classification, also integrating functional aspects of the daub, indicates that main categories (daub category 2, Material Type 1) are related to daub composition. The remainder of macroscopically differentiated daub types does not reflect well the daub's physical, microfossil and geochemical properties. The daub category classes (1, 4, 5) and material type classes (2, 3) show a large overlap in Figure 11 instead of forming distinct clusters. Looking at different architectonical components, exterior walls (51366, 51379), together with daub from interior components of clay installation (51416, 51392), plot in one group. Other house interior daub components such as podium (51390, 51402) and floor layers (51394) plot in a different group. Whether this indicates a kind of standardisation of source materials in daub production (as mainly indicated by phytolith analysis) or not is discussed in the following sections.

Socio-economic and technological insights from construction materials based on the phytoliths record

Phytoliths allow a quantifiable comparison of different plant parts that are otherwise not quantifiable (van der Veen 1999; Pető and Vrydaghs 2016). This brings the study of daub a step closer to an understanding of the use and management of by-products in prehistoric architecture. According to the phytolith record, three groups of samples can be distinguished that show good correspondence with the material type classification assigned by archaeologists. In the first category, Sample 51413, characterised by absence of plant temper visible macroscopically (Material Type 1), contains almost no phytoliths. The second group of phytolith samples includes samples 51366a, 51379, 51402, 51416a–c that are characterised by abundant indicators of chaff (ELONGATE DENDRITIC average 38.8%, ELONGATE DENTATE 11.5%) and that originate from daub pieces of Material Type 2, described as solid and with evident voids from organic plant temper. The third group of phytolith samples concerns 51390a–b, 51392, 51394, and presents evidence of an admixture of both chaff (ELONGATE DENDRITIC average 12.9%, ELONGATE DENTATE 9.6%) and straw (from culms, ELONGATE ENTIRE 39.1% *vs*. 20.4% of the average value in the previous group; from leaves, BULLIFORM FLABELLATE AND BLOCKY 2.8% *vs*. 1% and TRAPEZOID 6.2% *vs*. 0.4% in the previous group). This third group of samples corresponds to daub of Material Type 3, crumbly with visible porosity due to plant temper.

When considering the phytolith content in respect to architectural contexts, the two samples from external walls (51366a, 51379) show mostly chaff used as temper. In contrast, from the samples originating from podium and clay installation inside the house, in some cases the daub has mostly chaff (51402, 51416a–c) and in other cases an admixture of chaff and straw (51390a–b, 51392, 51394). According to this preliminary picture, it seems that chaff was preferred for building the most critical parts of the house architecture, such as external walls that are exposed to different weather conditions and that have to provide stability to the whole house construction. Interior clay installations that are less important for the house architecture as a whole could have been built at the time of house construction or at a later stage, depending on availability and function, either by using pure chaff as plant temper or an admixture of chaff and straw.

From a socio-economic perspective, emmer and einkorn, proven to be the main cereals in the macro-botanical record of Maidanetske (Dal Corso *et al.* 2019), are two species usually stored as spikelets and dehusked prior to cooking (Hillman 1984). If the chaff of such hulled wheat was such valuable construction material, it seems reasonable that it had to be collected and stored in a systematic way. Two options seem to be reasonable, either as piecemeal dehusking as part of routine household activities, or as a bulk, large-scale, collective scheduled action. Alternatively, house constructions could have been conducted as well-planned societal action immediately after the annual cereal harvest. The lack of pit records filled with harvest residues could be read as an indicator for the latter scenario; this would support the scenario of a longer duration of inhabitation of Trypillian mega-sites (Ohlrau *et al.* 2016; Müller *et al.* 2017; Hofmann *et al.* 2019).

Daub material and processing: insights from geochemical composition and porosity of the daub

Besides the indication that our selected daub pieces reflect the variety of a larger number of daub pieces at Maidanetske, additional clues might be offered by the geochemical composition of the analysed daub pieces and soil samples.

Assuming the use of the soils and loess deposits locally available for daub manufacturing, significant differences in the elemental ratios (Si:Ti, Si:Al, Si:Zr, Si:K; Fig. 9a) could be explained by an alteration of the daub samples during the burning process, a selective extraction of the building material or an alteration of the material during the processing of daub production. None of the compared elements is known to become lost in larger amounts during combustion processes. A selective extraction of material enriched in Ti, Zr or K also seems unlikely since the whole site is underlain by loess with a thickness of >2m. Processing that includes water saturation of the daub material renders the most probable process that could have resulted in the observed results. By watering and intensive mixing of the daub material before its application as plaster on the wooden walls, a separation of the mineral assemblage could have happened. During this process a part of the clay minerals may have been lost from the daub mixture by flotation. Clay might easily go into suspension when water is added to the mineral organic temper mixture. Aluminium, in comparison, is to a large extent bound to clay minerals and probably becomes lost through supernatant water suspension. Zirconium and titanium are mostly bound in heavy minerals with a comparable high density (>4 $g*cm^{-3}$) and may be assumed to be able to become enriched by flotation. Potassium could be considered to behave in a way that falls in between the above two cases, since considerable amounts could be present in clay minerals (mica/illite) but additional K might occur in feldspars. The order of enrichment observed in the daub compared with the soil samples (Zr++, Ti++, K+, Al-) thus probably reflects the loss of clay minerals due to the flotation process of the daub preparation.

The significantly higher phosphorous content of the analysed daub pieces compared to the soil samples probably reflects the addition of dung or urine during the processing of the daub (Fig. 9b). Since no sperulites have been detected in the phytolith assemblages, urine is the more probable source of phosphorus in this present case.

Comparing the xrf elemental composition of the daub with the porosity results, additional evidence emerges (Fig. 11). Although the number of measurements is small, the observed linear dependence of the Si:Ti ratio, the Si:Al ratio and the total phosphorus content to the porosity of the daub samples (as derived from µCT measurements) implies a close relationship between the porosity of the samples and organic admixtures included during the daub processing. This makes the µCT method that was applied a promising approach to quantify the amount of organic temper in the daub samples. Furthermore, of the three groups shown by phytoliths and material types, only the first group shows distinctly lower porosity in µCT scans compared to the other two groups, whose porosity results are quite homogeneous and similar (see Tab. 3).

The results from the material analysis of the daub pieces from Maidanetske suggest a standardised technology: during daub processing, similar amounts of plant material, sediment and a liquid (probably urine) were added. Plant temper has structural functions of providing more elasticity, thermic isolation and increased stability to wall structures, with even drying helping to prevent cracks from forming (Newton 2004; Bonnaire 2014). It is possible that different requirements account for the floor screed, which in this case did not require organic tempering in order to achieve smooth and even floor surfaces. This is also known for other samples of floor screeds in Maidanetske (see Müller *et al.* 2017 for more details). The use of urine as a liquid has been seen from ethno-archaeological work elsewhere. To test the extent of technological standardisation, a larger number of daub pieces needs to be analysed in future studies.

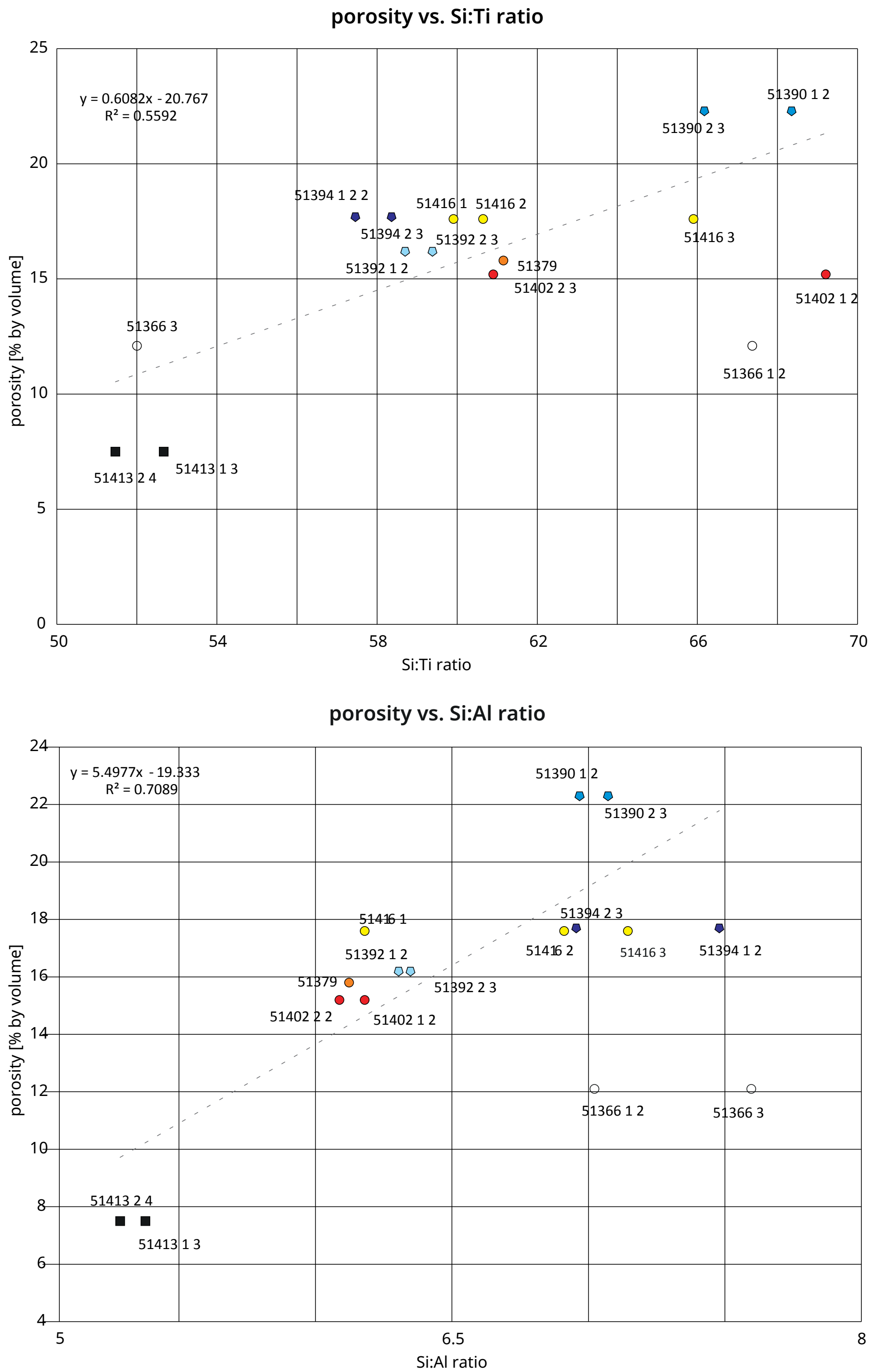


Figure 12. Linear regressions between Si:Ti and Si:Al ratios and total phosphorus content with the porosity values of the analysed daub samples. The symbol coding is identical to Fig. 9.

Possible connections between agricultural field size and use of harvest residue amounts in daub

Different models for the reconstruction of palaeo-economy, land-use and the carrying capacity for Trypillian sites have been developed (Bibikov 1965; Kruts 1989; Gaydarska 2003; Nikolova and Pashkevich 2003; Pashkevich and Videiko 2006; Harper 2012; Ohlrau *et al.* 2016; Dal Corso *et al.* 2019). All agree that resource availability was a given and that carrying capacity was never reached. As regards the soil resource, data from the investigated site do not indicate excessive depletion by soil erosion during Chalcolithic times (Dreibrodt *et al.* 2020).

In this section we relate the amount of harvest and the associated field sizes necessary to explain the amount of organic temper in the daub (Tab. 3) to calculations of field sizes necessary to supply the estimated population of the Chalcolithic mega-site with nutrition.

The average cereal remains content of the daub was first related to the daub mass included in a normal size one- and two-storey house (Pickartz *et al.* 2019) that is assumed to have been inhabited by five people (Ohlrau *et al.* 2016). By relating this amount of cereal remains to an assumed field size, 0.03 to 0.3 ha of agricultural fields would have been needed to account for the amount of organic temper of one house (Suppl. 4). This equals 0.0006 to 0.06 ha/capita. The construction of two-storied houses (Korvin-Piotroskiy and Menotti 2008; Johnston *et al.* 2018; Ohlrau 2020) would demand 0.36 to 0.6 ha/house, equal to 0.07 to 0.12 ha/capita.

In a second step, the calculation was related to the number of contemporaneous houses. The following calculations refer to the maximum phase of ca. 1,550 contemporaneous houses (time period 3800–3700 BCE) estimated by Ohlrau (2020) and Dal Corso *et al.* (2019) based on a detailed analysis of the available chronological data. A total of 3,100 houses were ascribed to the settlement period in question. A lifespan of ca. 50 years per house was assumed. Thus, an annual average of 62 houses must have been built to maintain the total number of 1,550 houses (total number of houses (3,100) divided by lifespan of houses (50 years)). Accordingly, a minimum size of 0.03 to 0.3 ha/house x 62 (if two-storied houses are considered: 0.06–0.6 × 62) of arable land area is required annually to obtain sufficient by-products for clay tempering needed for house construction. This is equivalent to 1.9 to 18.6 ha per year (one-storey house) or 3.7 to 37.2 ha per year (two-storey house).

Ohlrau *et al.* (2016, Tab. 3) consider a requirement of 0.3 ha/capita/year to achieve food security. Converted into estimates for the arable land necessary to feed the inhabitants of 1,550 houses with 5 inhabitants, this amounts to 2,325 ha of field size per year considering the whole period in consideration.

The size of agricultural fields to account for the amount of cereal remains used in house construction (1.9–37.2 ha per year) represents 0.1 to 1.6% of the area of agricultural fields necessary to meet the nutritional requirements of the contemporaneous mega-site population.

The major archaeological result of this pilot study relates to the resource management of a mega-site. In order to obtain the resources for the tempering of clay for house construction, no special cultivation processes were necessary. The chaff was available to the inhabitants of the large settlement as a by-product of cereal cultivation.

In addition to the evidence for prolonged occupation that can be inferred from radiocarbon dates (Müller *et al.* 2016a), the inventory of houses (Ohlrau 2020), and the absence of smaller settlements in the vicinity of Maidanetske, the results presented of the daub analysis provide additional arguments against the interpretation of large Trypillian settlements as temporary seasonal collection camps. Approximately 1.4 m^3 (one-storey houses) and 4.6 m^3 (two-storey houses) of crop residues would have had to be carried to the site to construct the houses at Maidanetske. This poses a certain logistical problem for the settlers, who are said to have gathered together from a surrounding region of unknown size.

Conclusions

A main aim of our study was to test the feasibility using XRay-μCT analysis to contribute to compositional analyses of burnt daub from the Chalcolithic mega-site settlement of Maidanetske, central Ukraine. Based on morphometric studies of the pores, not only can the amount of organic temper be quantified and distinguished from other kinds of porosity, but in addition, various components of the organic temper were classified successfully. The XRay-μCT results have been supported by comparison with results of archaeological classification, phytolith analysis and geochemical analysis. The development of standardised quantification and classification protocols for the XRay-μCT measurement in order to limit the amount of data processing and time and thus enable the analysis of larger numbers of burnt artefacts was a rewarding undertaking.

Detailed multidisciplinary analysis of burnt daub pieces from Maidanetske revealed in addition information on harvest residue use, daub processing and gave further hints to social interaction of Trypillian communities as regards plant use and construction of houses. The preference for using different plant compounds in different parts of the architecture (*e.g.* cereal inflorescence in house outer walls) and results from processing of the daub (*e.g.* geochemically indicated addition of urine to the daub mass) indicates a certain level of standardisation for house construction. The extent of this standardisation of house construction should be verified by further investigations. The selection of specific harvest residues (chaff) for the organic tempering of houses by Trypillian people indicates a well organised social interaction between the ancient farmers which probably took place after the annual cereal harvest was finished. A calculation of the total amount of harvest residues needed to construct the recorded number of houses in the mega-site of Maidanetske implies that this need was met by the yearly harvest of the fields supporting the inhabitants with nutrition.

The XRay-μCT method is a promising tool to make use of the high potential of the largely available daub archives of archaeological sites to reconstruct different aspects of crop use, archaeo-technology and ancient social interaction.

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Supplementary materials

The supplementary materials are freely available online under a CC BY 4.0 licence, in the Kiel University research data repository opendata@uni-kiel.de: https://doi.org/10.57892/100-55

Supplement 1: (text, tables, figure)
Classification scheme after Müller *et al.* (2017) and advanced classification with subdivisions in material characteristics and architectural features.
Supplement 2: (figure and table)
Sampling for phytoliths analyses and phytolith record from daub pieces.
Supplement 3: (table)
Geochemical composition (ped-xrf) of analysed daub and soil samples from Maidanetske.
Supplement 4: (table and text)
Background data for calculation of arable land size solely used to produce chaff for daub manufacturing.

References

An, T., Pashkevich, G. and Jones, M., 2019. Re-examining millet impressions in Usatovo clay materials from NW Black Sea region, Ukraine. *Archaeological and Anthropological Sciences*, 11, 3201–3211. Available from: https://doi.org/10.1007/s12520-018-0718-3

Ball, T.B., Gardner, J.S. and Anderson, N., 1999. Identifying inflorescence phytoliths from selected species of wheat (*Triticum monoccum*, *T. dicoccon*, *T. dicoccoides*, and *T. aestivum*) and barley (*Hordeum vulgare* and *H. spontaneum*) (Gramineae). *American Journal of Botany*, 86 (11), 1615–1623. Available from: https://doi.org/10.2307/2656798

Ball, T., Chandler-Ezell, K., Dickau, R., Duncan, N., Hart, T.C., Iriarte, J., Lentfer, C., Logan, A., Lu, H., Madella, M., Pearsall, D.M., Piperno, D.R., Rosen, A.M., Vrydaghs, L., Weisskopf, A. and Zhang, J., 2016. Phytoliths as a tool for investigations of agricultural origins and dispersals around the world. *Journal of Archaeological Science*, 68, 32–45. Available from: https://doi.org/10.1016/j.jas.2015.08.010

Bibikov 1965: Бибиков, С.Н., 1965. Хозяйственно-экономической комплекс развитого Триполья. *Советская археология*, 1965 (1), 48–62.

Bonnaire, E., 2014. Use of Crop-Processing By-Products for Tempering in Earthen Construction Techniques. *In*: A. Chevalier, E. Marinova and L. Peña-Chocarro, eds. *Plants and People. Choices and Diversity through Time*. EARTH 1. Oxford, Philadelphia: Oxbow Books, 282–286.

Chapmann, J., 1999. Deliberate house-burning in the prehistory of Central and Eastern Europe. *In: A. Gustafsson and H. Karlsson, eds. Glyfer och arkeologiska rum – en vänbok till Jarl Nordbladh. Gotarc Series A 3.* Göteborg: Göteborg University, Department of Archaeology, 113–126.

Chapman, J., Videiko, M.Y., Hale, D., Gaydarska, B., Burdo, N., Rassmann, K., Mischka, C., Müller, J., Korvin-Piotrovskiy, A. and Kruts, V., 2014. The Second Phase of the Trypillia Mega-Site Methodological Revolution: A New Research Agenda. *European Journal of Archaeology*, 17 (3), 369–406. Available from: https:doi.org/10.1179/1461957114Y.0000000062

Dal Corso, M., Out, W.A., Ohlrau, R., Hofmann, R., Dreibrodt, S., Videiko, M., Müller, J. and Kirleis, W., 2018. Where are the cereals? Contribution of phytolith analysis to the study of subsistence economy at the Trypillia site Maidanetske (ca. 3900-3650

BCE), central Ukraine. *Journal of Arid Environments*, 157, 137–148. Available from: https://doi.org/10.1016/j.jaridenv.2018.06.009

Dal Corso, M., Hamer, W., Hofmann, R., Ohlrau, R., Shatilo, L., Knitter, D., Dreibrodt, S., Saggau, P., Duttmann, R., Feeser, I., Knapp, H., Benecke, N., Videiko, M., Müller, J. and Kirleis, W., 2019. Modelling landscape transformation at the Chalcolithic Tripolye mega-site of Maidanetske (Ukraine): Wood demand and availability. *The Holocene*, 29 (10), 1622–1636. Available from: https://doi.org/10.1177/0959683619857229

Dreibrodt, S. and Wiethold, J., 2015. Lake Belau and its catchment (northern Germany): A key archive of environmental history in northern central Europe since the onset of agriculture. *The Holocene*, 25 (2), 296–322. Available from: https://doi.org/10.1177/0959683614558648

Dreibrodt, S., Furholt, M., Hofmann, R., Hinz, M. and Cheben, I., 2017. P-ed-XRF-geochemical signatures of a 7300 year old Linear Band Pottery house ditch fill at Vráble-Ve'lké Lehemby, Slovakia – House inhabitation and post-depositional processes. *Quaternary International*, 438, 131–143. Available from: https://doi.org/10.1016/j.quaint.2017.03.054

Dreibrodt, S., Hofmann, R., Sipos, G., Schwark, L., Videiko, M., Shatilo, L., Martini, S., Saggau, P., Bork, H.-R., Kirleis, W., Duttmann, R. and Müller, J., 2020. Holocene soil erosion in Eastern Europe-land use and/or climate controlled? The example of a catchment at the Giant Chalcolithic settlement at Maidanetske, central Ukraine. *Geomorphology*, 367, 107302. Available from: https://doi.org/10.1016/j.geomorph.2020.107302

Dreibrodt, S., Hofmann, R., Dal Corso, M., Bork, H.-R., Duttmann, R., Martini, S., Saggau, P., Schwark, L., Shatilo, L., Videiko, M., Nadeau, M.-J., Grootes, P.M., Kirleis, W. and Müller, J., 2022. Earthworms, Darwin and prehistoric agriculture-Chernozem genesis reconsidered. *Geoderma*, 409, 115607. Available from: https://doi.org/10.1016/j.geoderma.2021.115607

Engström, D.R. and Wright, H.E., 1984. Chemical stratigraphy of sediments as a record of environmental change. *In*: E.Y. Haworth and J.W.G. Lund, eds. *Lake Sediments and Environmental History. Studies in Palaeolimnology and Palaeoecology in Honour of Winifred Tutin*. Leicester: Leicester University Press, 11–67.

Fries-Knoblach, J., 2009. Hüttenlehm als Quelle zu Bauweise und Gestaltung eisenzeitlicher Gebäude. *In*: P. Trebsche, C. Eggl and I. Balzer, eds. *Architektur. Interpretation und Rekonstruktion. Beiträge zur Sitzung der AG Eisenzeit während des 6. Deutschen Archäologie-Kongresses in Mannheim 2008*. Langenweißbach: Beier & Beran, 31–53.

Gaydarska, B., 2003. Application of GIS in settlement archaeology: an integrated approach to prehistoric subsistence strategies. *In*: О.Г. Корвін-Піотровський, В.О. Круц and С.М. Рижов, eds. *Трипільські поселення-гіганти. Матеріали міжнародної конференції / Tripolian settlements-giants. The international symposium materials*. Київ: Корвін Пресс, 212–216.

Gaydarska, B., Nebbia, M. and Chapman, J., 2019. Trypillia Megasites in Context: Independent Urban Development in Chalcolithic Eastern Europe. *Cambridge Archaeological Journal*, 30 (1), 97–121. Available from: https://doi.org/10.1017/S0959774319000301

Harper, T.K., 2011. Visualizing Agricultural Production during the Eneolithic: A Case Study from the Tripol'ye Giant-settlement of Tal'yanki. *Chronika*, 1, 27–32 [and 62–63 for Fig. and Tabs.]. Available from: https://www.chronikajournal.com/resources/ChronikaOne%28online%29.pdf

Harper, T.K., 2012. *Sustaining Talianki: a Model of Eneolithic subsistence economics at a giant-settlement of the Western Tripolye Culture, Ukraine.* [Unpublished M.A.

thesis. Department of Anthropology, State University of New York at Buffalo]. Available from: https://doi.org/10.13140/RG.2.2.10409.44644

Hillman, G.C., 1984. Interpretation from archaeological plant remains: the application of ethnografic models from Turkey. *In*: W. van Zeist and W.A. Casparie, eds. *Plants and Ancient Man. Studies in palaeoethnobotany. Proceedings of the sixth symposium of the International Work Group for Palaeoethnobotany, Groningen 30 May-3 June 1983*. Symposium of the International Work-Group for Palaeoethnobotany 6. Rotterdam, Boston: A.A. Balkema, 1–42.

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

ICPT 2019: International Committee for Phytolith Taxonomy (Neumann, K., Strömberg, C.A.E., Ball, T., Albert, R.M., Vrydaghs, L. and Cummings, L.S.), 2019. International code for phytolith nomenclature (ICPN) 2.0. *Annals of Botany*, 124 (2), 189–199. Available from: https://doi.org/10.1093/aob/mcz064

Johnston, S., Diachenko, A., Gaydarska, B., Nebbia, M., Voke, P., Bondar, K., Litkevych, V. and Chapman, J., 2018. The experimental building, burning and excavation of a two-storey Trypillia house. *Past. The Newsletter of the Prehistoric Society*, 89, 13–15. Available from: https://www.prehistoricsociety.org/publications/past/89

Kahl, W.-A., Hinkes, R., Feeser, V. and Holzheid, A., 2013. Microfabric and anisotropy of elastic waves in sandstone – An observation using high-resolution X-ray microtomography. *Journal of Structural Geology*, 49, 35–49. Available from: https://doi.org/10.1016/j.jsg.2013.01.006

Kirleis, W. and Dal Corso, M., 2016. Trypillian Subsistence Economy: Animal and Plant Exploitation. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 195–205. Available from: https://doi.org/10.4324/9781315630731

Korvin-Piotroskiy and Menotti 2008: Корвин-Пиотровский, А. and Менотти, Ф., eds., 2008. *Трипольская культура в Украине. Поселение-гигант Тальянки.* Киев: Институт археологии НАН Украины.

Kruts 1989: Круц, В.А., 1989. К истории населения трипольской культуры в междуречье Южного Буга и Днепра. *In*: С.С. Березанская, ed. *Первобытная археология. Материалы и исследования*. Київ: Издательство “Наукова думка”, 117–132.

Kruts, V., 2012. Giant-settlements of Tripolye culture. *In*: F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture Giant-Settlements in Ukraine. Formation, Development and Decline*. Oxford: Oxbow Books, 70–78. Available from: https://doi.org/10.2307/j.ctvh1dvmn.8

Kylander, M.E., Ampel, L., Wohlfarth, B. and Veres, D., 2011. High-resolution X-ray fluorescence core scanning analysis of Les Echets (France) sedimentary sequence: new insights from chemical proxies. *Journal of Quaternary Science*, 26 (1), 109–117. Available from: https://doi.org/10.1002/jqs.1438

Lancelotti, C. and Madella, M., 2012. The ‘invisible’ product: developing markers for identifying dung in archaeological contexts. *Journal of Archaeological Science*, 39 (4), 953–963. Available from: https://doi.org/10.1016/j.jas.2011.11.007

Lichter, C., 2016. Burning Down the House – Fakt oder Fiktion? *In*: K. Bacvarov and R. Gleser, eds. *Southeast Europe and Anatolia in prehistory: Essays in Honor of Vassil Nikolov on his 65th anniversary*. Universitätsforschungen zur prähistorischen Archäologie 293. Bonn: Dr. Rudolf Habelt, 305–317.

Lubos, C., Dreibrodt, S. and Bahr, A., 2016. Analysing spatio-temporal patterns of archaeological soils and sediments by comparing pXRF and different ICP-OES extraction methods. *Journal of Archaeological Science: Reports*, 9, 44–53. Available from: https://doi.org/10.1016/j.jasrep.2016.06.037

Lubos, C.C.M., Dreibrodt, S., Robin, V., Nelle, O., Khamnueva, S., Richling, I., Bultmann, U. and Bork, H.-R., 2013. Settlement and environmental history of a multilayered settlement mound in Niederröblingen (Central Germany) – a multi-proxy approach. *Journal of Archaeological Science*, 40 (1), 79–98. Available from: https://doi.org/10.1016/j.jas.2012.07.022

Madella, M., Powers-Jones, A.H. and Jones, M.K., 1998. A Simple Method of Extraction of Opal Phytoliths from Sediments Using a Non-Toxic Heavy Liquid. *Journal of Archaeological Science*, 25 (8), 801–803. Available from: https://doi.org/10.1006/jasc.1997.0226

Menne, J., Holzheid, A. and Heilmann, C., 2020. Multi-scale Measurements of Neolithic ceramics—A Methodological Comparison of Portable Energy-Dispersive XRF, Wavelength-Dispersive XRF, and Microcomputer Tomography. *Minerals*, 10, 931. Available from: https://doi.org/10.3390/min10100931

Menotti, F. and Korvin-Piotrovskiy, A.G., eds., 2012. *The Tripolye Culture Giant-Settlements in Ukraine. Formation, Development and Decline*. Oxford: Oxbow Books. Available from: https://doi.org/10.2307/j.ctvh1dvmn

Müller, J., 2016. Demography and Social Agglomeration: Trypillia in a European Perspective. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 7–16. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Brandtstätter, L., Ohlrau, R. and Videiko, M., 2016a. Chronology and Demography: How Many People Lived in a Mega-Site? *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 133–170. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Rassmann, K. and Videiko, M., eds., 2016b. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site / Майданецьке 2013. Нові розкопки великого Трипільського поселення*. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Newton, C., 2004. Plant tempering of Predynastic pisé at Adaïma in Upper Egypt: building material and taphonomy. *Vegetation History and Archaeobotany*, 13, 55–64. Available from: https://doi.org/10.1007/s00334-003-0025-4

Nikolova and Pashkevich 2003: Николова, А.В. and Пашкевич, Г.А., 2003. К вопросу об уровне земледелии Трипольской культуры. *In*: О.Г. Корвın-Пıотровський, В.О. Круц and С.М. Рижов, eds. *Трипıльськı поселення-гıганти. Матерıали мıжнародної конференцıї / Tripolian settlements-giants. The international symposium materials*. Київ: Корвін Пресс, 89–95.

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Ohlrau, R., Dal Corso, M., Kirleis, W. and Müller, J., 2016. Living on the Edge? Carrying Capacities of Trypillian Settlements in the Buh-Dnipro Interfluve. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 207–220. Available from: https://doi.org/10.4324/9781315630731

Pashkevich and Videiko 2006: Пашкевич, Г.О. and Відейко, М.Ю., 2006. *Рільництво племен трипільської культури*. Київ: Інститут археології НАН України.

Pető, A. and Vrydaghs, L., 2016. Phytolith Analysis of Ceramic Thin-Sections. First Taphonomical Insights from Experiments with Vegetal Tempering. *In*: E. Sibbesson, B. Jervis and S. Coxon, eds. *Insight From Innovation: New Light on Archaeological Ceramics*. Southampton Monographs in Archaeology New Series 6. St. Andrews: The Highfield Press, 57–73.

Pickartz, N., Hofmann, R., Dreibrodt, S., Rassmann, K., Shatilo, L., Ohlrau, R., Wilken, D. and Rabbel, W., 2019. Deciphering archeological contexts from the magnetic map: Determination of daub distribution and mass of Chalcolithic house remains. *The Holocene*, 29 (10), 1637–1652. Available from: https://doi.org/10.1177/0959683619857238

Shaffer, G.D., 1993. *An Archaeomagnetic Study of a Wattle and Daub Building Collapse. Journal of Field Archaeology*, 20 (1), 59–75. Available from: https://doi.org/10.1179/009346993791974334

Shatilo, L., 2021. *Tripolye Typo-chronology: Mega and Smaller Sites in the Sinyukha River Basin.* Scales of Transformation in Prehistoric and Archaic Societies 12. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/m5457py

Shmaglij and Videiko 2005: Шмаглий, Н.М. and Видейко, Ю.М., 2005. *Майданецкое - трипольский протогород*. Киев: Институт археологии НАН Украины.

Shukurov, A., Sarson, G., Videiko, M., Henderson, K., Shiel, R., Dolukhanov, P. and Pashkevich, G., 2015. Productivity of Premodern Agriculture in the Cucuteni-Trypillia Area. *Human Biology*, 87 (3), 235–282. Available from: https://doi.org/10.13110/humanbiology.87.3.0235

Stevanović, M., 1997. The Age of Clay: The Social Dynamics of House Destruction. *Journal of Anthropological Archaeology*, 16 (4), 334–395. Available from: https://doi.org/10.1006/jaar.1997.0310

Țerna, S., Vornicu-Țerna, A., Hofmann, R., Dal Corso, M., Shatilo, L., Vasilache-Curoşu, M., Rud, V., Knapp, H., Kirleis, W., Rassmann, K. and Müller, J., 2019. Stolniceni – Excavation results from the 2017 campaign. *Journal of Neolithic Archaeology*, 21, 209–282. Available from: https://doi.org/10.12766/jna.2019.9

Tringham, R. 2005. *Weaving house life and death into places: a blueprint for a hypermedia narrative. In: D.W. Bailey, A.W.R. Whittle and V. Cummings, eds. (Un)settling the Neolithic.* Oxford: Oxbow Books, 98–111.

van der Veen, M., 1999. The economic value of chaff and straw in arid and temperate zones. *Vegetation History and Archaeobotany*, 8, 211–224. Available from: https://doi.org/10.1007/BF02342721

Wengrow, D., 2015. *Cities before the State in Early Eurasia*. Goody Lecture 2015. Halle/Saale: Max Planck Institute for Social Anthropology, Department 'Resilience and Transformation in Eurasia'. Available from: https://www.eth.mpg.de/4091237/2015_Goody_Lecture.pdf

Yanushevich, Z.V., 1975. Fossil Remains of Cultivated Plants in the South-West of the Soviet Union. *Folia Quaternaria*, 46, 23–30.

Yanushevich, Z.V., 1978. Prehistoric Food Plants in the South-West of the Soviet-Union. *Berichte der Deutschen Botanischen Gesellschaft*, 91 (1), 59–66. Available from: https://doi.org/10.1111/j.1438-8677.1978.tb03633.x

9. Archaeozoological and taphonomic examinations carried out on faunal remains from Ukrainian-German excavations at Maidanetske from 2013 to 2016

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Introduction

Besides growing cultivated plants and hunting wild animals, domestic animal husbandry also played a key role in Cucuteni-Trypillia settlements[1] (*e.g.* Benecke 1994; Kruts *et al.* 2001; Zhuravlov 2004; Zhuravlov 2008; Videiko and Burdo 2004; Orton *et al.* 2020; Kirleis and Dal Corso 2016). Ukrainian-German excavations carried out at Maidanetske in 2013, 2014 and again in 2016, brought to light large quantities of pottery and various assemblages of faunal remains in the form of bones, teeth, antlers and shells. Most of these finds were refuse produced by the settlement inhabitants using domestic and wild animals as a source of food and raw materials. The scientific examination of the finds has provided us with much insight into the economic activities that occurred at the site during its period of use from ca. 3950 to 3600 BCE.

In conjunction with earlier research, the study of the animal bone assemblages from Maidanetske has given us an opportunity to gain a better understanding of how animals were exploited at a Trypillia mega-site. On the one hand this applies to subsistence strategies in areas including animal husbandry and hunting. On the other hand, our analyses were also aimed at examining the variability of assemblages and at identifying potential functional disparities in how animals were used in different areas of the settlement. One question worth investigating was whether there were

1 This chapter was completed prior to the publication of the following, relevant article: Makarewicz, C.A., Hofmann, R., Videiko, M.Y. and Müller, J., 2022. Community negotiation and pasture partitioning at the Trypillia settlement of Maidanetske. *Antiquity*, 96 (388), 831–847. Available from: https://doi.org/10.15184/aqy.2022.32

detectible differences in the use of animals between certain types of feature, such as dwellings or mega-structures, or certain types of pit (cf. Orton *et al.* 2020, 401–407).

In view of the obvious specialisation in other areas such as pottery production (Ellis 1984; Korvin-Piotrovskiy *et al.* 2016), another topic of discussion was how far it was possible to identify different animal use practices within the settlement, *e.g.* within certain districts or households, which could then perhaps be linked to a particular social group. Besides taking into account the contexts and assemblages of finds, it was thus also necessary to examine the depositional and post-depositional processes that were at play when the faunal remains were disposed of and potentially damaged.

Besides the clearly overwhelming importance of animals for the subsistence of the inhabitants of Maidanetske and other Trypillia settlements, the possible use of domestic animals as draught animals is another question that has been discussed for some time now, prompted by finds of sledge models with cattle protomes, characteristic pathological changes found on the bones of working animals and the possible identification of neutered animals (Zhuravlov 2004; Shatilo 2017).

In addition to palaeobotanical and pedological features, the bones of wild animals identified in the faunal assemblages from Maidanetske also provided important clues with regard to reconstructing the natural environment both in the immediate vicinity and in the wider surroundings of the settlement.

Methods

Based on the results obtained from archaeomagnetic surveying, the excavations carried out at Maidanetske pursued a dual strategy which, on the one hand, aimed to excavate in detail certain selected contexts associated with different categories of features. On the other hand, various different areas of the settlement and concentric rings of houses were systematically sampled by means of mainly small-scale test trenches, with the aim of obtaining a representative sample from a Trypillia mega-site for carrying out chronological, typological and various other natural scientific examinations while keeping the effort and expenditure to an acceptable level.

The excavations followed natural 'layers', which were recorded as 'features'. As explained in greater detail elsewhere, we view features as units that can be distinguished based on material characteristics such as the type of soil substratum, its colour and the type, size and quantity of its admixtures (Hofmann *et al.* 2006, 64–67; Hofmann 2013, 52). Localisation of the finds was either by means of xyz coordinates (single finds, samples) or on the basis of a grid system (all) with a one metre column width. The finds were also assigned to features and spits, which generally allowed us to more closely identify and interpret the depositional conditions that existed within the larger contexts.

Analysis and interpretation of the features was based on Müller *et al.* (2017), Müller and Videiko (2016), Brandtstätter (2017) and Ohlrau (2020). Following a system, which was originally developed for Okolište, the features were grouped into three hierarchical levels, which allowed us to compare assemblages from certain areas of the settlement (layer formations), from certain categories of features (groups of layers such as houses, pits, ditch segments), or from parts of particular contexts ('*layers' e.g.* a part of a house or a fill of a pit).

Context dating was achieved by analysing and Bayesian modelling 93 radiocarbon dates from almost every context examined (Müller *et al.* 2017; Brandtstätter 2017; Ohlrau 2020). Modelling carried out by René Ohlrau (2020) enabled him to distinguish between four settlement phases which amounted to a total period of settlement of some 350 years between 3990 and 3640 BCE. The individual contexts were all assigned to one of the four phases. In some cases, however, there were slight chronological inaccuracies, which meant that the finds had to be aoristically

Finds density (kg/m³)	Fragmentation	Interpretation
Medium to high	Low	Primary refuse
Medium to high	Medium	Secondary refuse
Low	High	Tertiary refuse

Table 1. Framework for interpreting refuse contexts based on finds density and fragmentation.

assigned for the purpose of chronological analysis. From the point of view of absolute chronology, Phase 1 dated from between 3990 and 3935 calBCE, Phase 2 from between 3935 and 3800 calBCE, Phase 3 from between 3800 and 3700 calBCE and Phase 4 from between 3700 and 3640 calBCE. The highest settlement density was reached in Phase 3 when the settlement apparently consisted of 1700 houses.

The bulk of the soil was dry-sieved during the excavations.

In order to assess the informational value of the archaeological bone assemblages, one of the aims was to taphonomically reconstruct the depositional conditions and formation processes that existed at the site. Using Anglo-American terminology introduced into German-speaking research by Ulrike Sommer (1991), we attempted to differentiate between primary, secondary and tertiary refuse. This division is based on the concept that all artefacts that are left behind at an abandoned settlement, including ritually deposited artefacts, constitute 'refuse'. In that sense, both pottery left behind in its place of use, *i.e.* in a house that fell victim to a conflagration, and the remnants of a ritual feast that were left behind at their place of deposition, would be classified as *primary* refuse. *Secondary* and *tertiary* refuse, by contrast, would be refuse that was displaced or redeposited to varying degrees. An additional, separate category then is external refuse, which would have been brought into the site from 'outside'.

We do not share the opinion put forward by scholars like Bisserka Gaydarska, John Chapman and others who maintain that the majority of material remains that were disposed of and deposited at Trypillia (mega)sites did not constitute 'living assemblages' but were, rather, the result of deliberate and 'structured' depositional processes (*e.g.* Gaydarska and Chapman 2020, 292, 417). On the contrary: our analysis of finds distribution patterns has shown that ceramic household inventories, for instance, can indeed be interpreted as part of their functional context (Müller *et al.* 2017, 40–44; Ohlrau 2020, 100–102).

The taphonomic analysis of the faunal remains was based on the analysis of finds distribution patterns in various contexts, the archaeological interpretation of these contexts, the degree of fragmentation of the bone material and the composition of the bone assemblages. The *density of finds in relation to the material excavated* in different contexts and feature categories gives a general impression of where the bones were deposited. Taking into account the range of species present at the site, the average bone weight can be used as a proxy to determine the *degree of fragmentation* of the bones. Combining the density of finds with the degree of fragmentation potentially allows us to identify areas of primary and secondary refuse disposal (Tab. 1). The significance of the taphonomic analysis is further enhanced by a comparison between the results obtained from the analysis of the bones and the equivalent parameters obtained for the pottery vessels. It is possible that a particular context contained different kinds of secondary refuse or a mixture of primary and secondary refuse (thanatocoenosis).

The faunal remains from Maidanetske underwent a zoological primary analysis following universally accepted standards. The first step involved categorising the finds by skeletal element and animal species. Following the anatomical and taxonomic classification, each individual bone was recorded with regard to the following criteria: body half, degree of fragmentation, age, sex, anomalies and pathologies, evidence of blows, cuts, burning or chewing, traces of working and, finally, weight. Wherever possible, measurements were also taken. The individual measurements can be found in the Appendix 2. The zoological characterisation of

Trench-ID	N data sets	NISP	Weight (g)	Trench size (m²)	Earth volume (m³)*	Pits	Houses	Others
50	152	203	6624	38.5	46.17	179	-	4
51	46	78	794	199	177.35	21	15	42
52	7	9	182	48	26.86	9		
60	40	80	1201	40	42.83	72		8
70	1	1	10	4.6	-			
71	1	1	1	2.5	1.81			
72	1	1	1	2.4	3.53		1	
73	1	1	2	3.9	3.80		1	
74				5.2	2.22			
75				4.2	8.31			
76					3.02			
77	1	1	23	7.3	2.38		1	
79				3.9	0.9			
80	641	1743	5546	98.2	74.79	1667		61
91				9.3	6.56			
92	32	44	178	95.8	50.55		26	16
93	2	4	5	3.7	3.25		3	1
94	1	1	1	4.6	6.55		1	
95	1	3	100	4.3	2.15		3	
96	16	16	191	10.2	6.3		12	2
100				5.5	2.82			
101				6.6	3.93			
102		1		5.1	6.55		1	
110	54	54	2296	140	98.36			50
111	301	443	12846	342	170.65	271	91	80
total	1298	2679	29902	1084.8	751.64	2217	155	264

*Table 2. Maidanetske: frequency of animal bones and other zoological remains in excavation trenches. *In some cases, not all of the material excavated is included.*

the individual contexts involved assigning skeletal elements to meat value classes following the recommendations put forward by H.-P. Uerpmann (1972, 20). In this system, class A comprises bones that are rich in meat (vertebrae, scapula, humerus, pelvis, femur), class B contains elements that provide little meat (cranium, mandible, ribs, radius/ulna, tibia) and, finally, class C includes bones that are virtually devoid of meat (metacarpus, metatarsus, carpal bones, tarsal bones, phalanges). Information about the skeletons used for reference purposes was taken from Reichstein (1994).

Sample description and site formation processes

Sample size and distribution

A total of 2679 animal bones (NISP) weighing approximately 30 kg were retrieved from seventeen trenches at Maidanetske (Tab. 2). Due to significant differences in the size of the trenches, the sample was very unevenly spread between them. The

Figure 1. Maidanetske: Settlement plan with location of the Trenches 50–111 excavated between 2013 and 2016.

largest numbers of bones by far, with assemblages of more than 100 specimens each were retrieved from Trenches 50, 80 and 111, while the numerous test trenches generally yielded only a small number of bones. However, even some of the large trenches, which were opened up to fully examine houses destroyed by fire, only brought to light small assemblages of zoological finds counting far less than 100 (*e.g.* Trenches 51 and 92).

The excavation strategy pursued at Maidanetske was largely based on the magnetic survey plan and followed a two-pronged approach: on the one hand, various categories of features such as houses, pits, a so-called mega-structure, a ditch *etc.* were fully excavated and in great detail in order to obtain as much functional information as possible with regard to these features (Fig. 1). On the other hand, numerous test trenches were examined in an effort to gain an understanding of the chronological development and functional differentiation of households.

As a consequence, the material constitutes a differentiated random sample, the archaeological potential of which must first be established by means of a critical appraisal of the formation processes that resulted in the bone assemblages presented in this paper. Before analysing the distribution of bones among the different categories of features across the entire site, we will first describe the larger assemblages in terms of their archaeological context and composition. We will then discuss to what extent the depositional conditions can be reconstructed and whether post-depositional damage can be identified with respect to the assemblages.

Contextualisation of animal bones in individual areas of the excavation

Pit 25 in Trench 50

One pit in Trench 50 was fully excavated. It can be viewed as belonging to House 12 (Complex 'И'), which was previously unearthed by our Ukrainian colleagues. Oval to rectangular in shape, the pit was probably dug for the purpose of extracting loam initially, and then showed a complex biography consisting of a total of four phases of infilling (Müller *et al.* 2017, 51–56). After a fire had been lit in the bottom of the pit, the first fill was deposited probably as part of a regular disposal of waste (ARCH 1a). A large majority of the assemblage, which comprised 181 bones and bone fragments in total, came from the next two fills, ARCH 1b and ARCH 2a, which also had the lowest degree of fragmentation (Tab. 3). As part of a ritual act, two cattle skulls were deposited in layer ARCH 1b along with numerous other bones and fragments of ceramic vessels (mainly bowls; Figs. 2 and 3). As a consequence, this was the layer with the greatest number and density of bone finds. Perhaps as part of the same event, elements of a house destroyed by fire were deposited in the overlying fill, ARCH 2a, together with a significant quantity of bones. By contrast, the density of both burnt clay and bones decreased considerably in the overlying, fourth fill, ARCH 2b.

House 44 and Pit 26 in Trenches 51 and 52

An average-sized Trypillia house destroyed by fire and Pit 26 associated with the dwelling were fully excavated in Trench 51 (Müller and Videiko 2016; Müller *et al.* 2017). In terms of its construction, it was typical of the Tomashovka Group of the Trypillia Culture, with a solid, raised platform; spread over various levels it contained numerous ceramic finds and querns as well as a number of animal bones. The artefacts clustered, in particular, around the top surface of the platform, where several zones of activity were identified on the basis of different interior furnishings and finds distribution patterns.

Pit 26 was located at the rear of the house. Originally dug for the purpose of extracting building materials, it was then used to dispose of refuse during the lifetime of the house. Another pit, Pit 38, cut through a layer of burnt loam associated with the house in the middle of its south-eastern side. It probably dated from the post-Trypillia period after the house was destroyed by fire.

A total of 87 bones were retrieved from Trenches 51 and 52, most of which were found in Pits 26 and 38, in House 44 and in the layer of Chernozem soil above it. The density of bones was quite low and the degree of fragmentation relatively high in all contexts examined (Tab. 4).

Figure 2. Situation in the lower area of the pit found in Trench 50 with deposits of bones, two cattle skulls and large fragments of ceramic vessels (photo: UFG Kiel).

Figure 3. Cattle skulls deposited next to each other in a pit found in Trench 50 after restoration (photo: M. Videiko).

Pit complex 27 in Trench 60

A roughly rectangular pit, which stood out on the survey plan by virtue of its high degree of magnetisation, was examined in Trench 60. Because the anomaly was so distinct, the initial assumption was that this might have been a potter's kiln.

Layer formation	Layer group	Layer	Volume (m³)	Bones, NISP	Bones, weight (g)	Bones, kg/m³	Fragmentation (g)
Mai 50/1	Buried soil	Buried humus	9	3	17	0.0019	6
Mai 50/2	Pit 25	Fill 1 + 2 (ARCH 1a, 1b)	3.07	110	3905	1.27	44
		Fill 3 (ARCH 2a)	3.58	50	1724	0.48	46
		Fill 4 (ARCH 2b)	3.62	17	223	0.06	14
Mai 50/3	50 – topsoil	Topsoil (Chernozem)	26.9	1	6	0.0002	6

Table 3. Maidanetske: feature grouping in Trench 50 with information on distribution and fragmentation of the bone sample.

Layer formation	Layer group	Layer	Volume (m³)	Bones, NISP	Bones, weight (g)	Bones, kg/m²	Fragmentation (g)
Mai 51–52/2	House 44	Illicit excavation	5.8	2	48	0.008	24
	House 44	Undifferentiated	19.2	19	115	0.006	14
	Open space	Undifferentiated	20.55	5	18	0.0009	7
	Pit 26	Pit fill	5	9	182	0.04	25
Mai 51–52/3	Pit 38	Pit fill	0.3	15	245	0.8	30
	51 – topsoil	Chernozem	84.15	35	353	0.004	13
		Transitional layer	47.35	2	15	0.0003	8
	52 – topsoil	Undifferentiated	18.25	87			

Table 4. Maidanetske: feature grouping in Trenches 51 and 52 and distribution and fragmentation of the bone sample.

Layer formation	Layer group	Layer	Volume (m³)	Bones, NISP	Bones, weight (g)	Bones, kg/m²	Fragmentation (g)
Mai 60/1	Buried soil	Buried humus (GEO 1)	10.4				
Mai 60/2	Open space around Pit 27	Undifferentiated (GEO 2)	10.7	4	13	0.001	3
Mai 60/2	Pit complex 27	Fill 1–4 (ARCH 1–4)	6.5	72	1175	0.18	16
		Fill 1 (ARCH 1)		2	10		5
		Fill 2 (ARCH 2)		68	1149		17
		Fill 3 (ARCH 3)		1	7		7
		Fill 4 (ARCH 4)		1	9		9
Mai 60/3	Topsoil	Topsoil (GEO 3)	15,.25	4	13	0.0008	3

Table 5. Maidanetske: feature grouping in Trench 60 and the distribution and fragmentation of the bone sample.

However, it quickly became clear that the actual cause of the anomaly was that the pit fill was largely composed of clay from a house, which had been destroyed by fire. The pit was probably originally dug for the purpose of extracting material for the construction of the house in the neighbouring plot (ARCH 1) and subsequently filled with burnt rubble. At least three substantial re-cuts (ARCH 2–4) were later carried out.

A random sample of 80 bones (NISP), most of which were associated with the second pit fill ARCH 2, were retrieved from Trench 60. The uneven distribution of the bones suggests that they were not contained in the burnt rubble of the house but were probably disposed of in the context of subsequent re-cutting of the pit (Tab. 5).

Potter's workshop in Trench 80

A potter's kiln and its associated features were examined in Trench 80. The kiln itself bore evidence of two phases of alteration (Korvin-Piotrovskiy *et al.* 2016; Ohlrau 2020, 71–85). Three refuse pits, some of which contained substantial quantities of wasters, can be associated with the kiln, one for each of its three phases of use. During the first two phases the pits were located south of the kiln. Due to a change in where the kiln was charged from in its third phase of use, the refuse pit associated with this third phase was located to the east of it. After the kiln had become defunct, the area was potentially used for the disposal of external refuse.

A total of 1728 highly fragmented bones and bone fragments (NISP) weighing approximately 4.5 kg were retrieved from Trench 80 (Tab. 6). Of these, 95% came from Pits 28 and 29 and dated from the first and second phases of use of the potter's kiln. Smaller assemblages were found in the archaeological layer surrounding the kiln, in Pit 30 and in deposits from the period after the kiln had fallen into disuse. The average weight of the bone fragments from most contexts was strikingly low, which points to a very high degree of fragmentation.

House 59 in Trench 92

Located in the zone within the circular corridor, House 59, which had been destroyed by fire, was fully excavated in Trench 92 (Müller and Videiko 2016; Ohlrau 2020, 87–105). Like House 44, this house, in terms of its construction, was another classic building of the local Tomashovka Group with a raised platform. A small section of neighbouring House 60, which had also burnt down, came to light on the edge of the trench.

At 42 fragments (NISP), the bone assemblage recovered from Trench 92 was rather small. Most of the bones were found in the area of the house, and very few came from the open space around it (Tab. 7).

Ditch segments and settlement layer in Trench 110

Trench 110 was excavated, on the one hand, to examine a section of the ditch surrounding the settlement and, on the other, to clarify the chronological relationship between the ditch and the houses located beyond it. As well as a 12 m long segment of the ditch, the south-western corner of neighbouring House 67 to the north-east was also uncovered. The offshoots of a pit associated with the house were also unearthed on the eastern edge of the excavation.

The excavation showed that the ditch was not continuous but that it consisted of several short segments and the structure can thus be interpreted as a causewayed enclosure dating from the founding period of the settlement (Ohlrau 2020, 106–114). Two such segments with a gap of approximately 3 m in between were

Layer formation	Layer group	Layer	Volume (m³)	Bones, NISP	Bones, weight (g)	Bones, kg/m²	Fragmentation (g)
84 542	Kiln Phase 1	Undifferentiated	0.387	1	84	0.2	84
	Pit 28	Undifferentiated	2.9	189	542	0.2	6
175	Occupation layer	Undifferentiated	5.6	30	175	0.03	7
1	Kiln Phase 2	Channel infill centre	0.066				
		Channel infill east	0.066				
		Channel infill west	0.066	1	1	0.015	1
		Undifferentiated	0.01				
		White plaster (repair)	0.005	1	14	2.8	9
	Pit 29	Undifferentiated	8	1453	4146	0.5	3
Mai 80/4	Kiln Phase 3	Undifferentiated	0.78				
	Pit 30	Infills 1 and 2	1.75	25	227	0.1	13
Mai 80/5	Kiln end of use	Channel infill centre	0.035				
		Channel infill north	0.018				
		Channel infill south	0.07				
		Clear out zone	0.385	11	14	0.035	1
		Scatter zone	0.65	10	51	0.08	5
Mai 80/6	80 – topsoil	Topsoil 1 (Chernozem)	36				
		Topsoil 2 transition	18	7	41	0.002	7

Table 6. Maidanetske: feature grouping in Trench 80 and the distribution and fragmentation of the bone sample.

Layer formation	Layer group	Layer	Volume (m³)	Bones, number	Bones, weight	Bones, kg/m²	Fragmentation (g)
Mai 92/1	House 60	Soil above/among collapsed feature	0.4	2	1	0.0025	0.5
Mai 92/1	House 59	Undifferentiated	8.25	24	121	0.015	5
Mai 92/1	Occupation layer	Undifferentiated	15	14	20	0.001	1.5
Mai 92/2	92 – topsoil	Transition	5.4	2	13	0.0025	7

Table 7. Maidanetske: feature grouping in Trench 92 and the distribution and fragmentation of the bone sample.

found within the trench examined. The bones recovered from the western segment were associated with a significant number of vessel fragments (13 kg), many of which were found lying with their mouths pointing downwards, contrary to their natural point of balance. Based on the clearly non-defensive quality of the ditch system and the possible deposition of ceramic vessels, bones and a zoomorphic figurine, René Ohlrau (2020, 282) suggested that the assemblage may have been placed in the ditch in the context of ritual acts.

Using modelled radiocarbon dates, Ohlrau (2020, 212–214) was able to show that the ditch segments were not left open for the entire lifetime of the settlement but that they were refilled around 3700 BCE at the latest. House 67, located north of the ditch, was built after the segment had been infilled and during the final settlement

Layer formation	Layer group	Layer	Volume (m^3)	Bones, NISP	Bones, weight	Bones, kg/m^2	Fragmentation (g)
Mai 110/2	Eastern ditch segment	Fill	2.2	9	252	0.1	28
	Occupation layer	Above eastern ditch segment	2.4				
	Western ditch segment	Fill	1.5	25	1635	1.1	66
		Stone setting (quern)	0.125				
Mai 110/2–3	Occupation layer	Central daub concentration	1				
		Central area	10.5	12	160	0.015	13
		South-eastern area	0.8	1	83	0.1	83
		Around House 67	0.35				
		Western area	0.8				
Mai 110/3	House 67	Collapse	1				
		Floor	0.06				
		Ground floor	1.25				
		Above burnt daub	0.75				
Mai 110/4	Topsoil	Chernozem	41.55				
		Transitional layer	34	3	118	0.003	39

Table 8. Maidanetske: feature grouping in Trench 110 and the distribution and fragmentation of the bone sample.

phase at Maidanetske. Accordingly, the pit associated with the house cut through the fills of the eastern ditch segment (Ohlrau 2020, 109).

A total of 50 bones and bone fragments were retrieved from Trench 110 (Tab. 8). Most (n=34) came from the two ditch segments and the central section of the archaeological layer (n=12). The bones from all contexts were of medium to high average weight and therefore had a relatively low degree of fragmentation. This at least does not exclude the possibility of a *deposition* in the context of ritual practices.

Mega-structure 3 in Trench 111

Trench 111 was excavated to examine a so-called mega-structure. We believe that this special category of structure, clearly visible in the public areas of Trypillia settlements, were assembly houses that were not inhabited permanently, but used as places for various communal activities and decision-making processes (Hofmann *et al.* 2019; Chapter 2, this work, Vol. 1). Mega-structure 3, which was examined here, was divided into two parts, an open internal courtyard and a roofed section containing a hearth. A broad range of activities would have taken place within this architectural setting.

Features from an earlier phase of settlement were discovered beneath the burnt daub from the floor of the mega-structure. They included several pits which had originally been located at the rear of a row of houses which were still partially visible in the magnetic survey plan. This row of houses belonged to a settlement phase which predated the construction of the circular corridor at Maidanetske. The stratum from which the pits were dug was overlain by a layer which contained large quantities of finds and had probably formed during the preparation of the ground for the construction of the mega-structure when earlier settlement remains were levelled.

Layer formation	Layer group	Layer	Volume (m³)	Bones, NISP	Bones, weight	Bones, kg/m²	Fragmentation (g)
Mai 111/2	Pit 33 (111/1)	Fill	1.35	3	119	0.09	40
	Pit 34 (111/2)	Fill	3.8	237	9069	2.4	67
	Pit 35 (111/3)	Fill	2.4	31	339	0.15	13
	Pit 36 (111/4)	Fill	0.25				
	Levelled layer	n/a	20.8	80	2319	0.1	30
Mai 111/3	Mega-structure 3	Floor	1.3				
		Hearth	0.5	2	36	0.07	18
		Above wall debris	8	50	381	0.05	9
		Wall debris	11.5	39	582	0.05	17
Mai 111/4	Topsoil	Chernozem	120.75				

Table 9. Maidanetske: feature grouping in Trench 111 and the distribution and fragmentation of the bone sample.

Trench 111 yielded 442 bones and bone fragments (NISP) weighing just under 13 kg in total. The majority (80%) were retrieved from the pits and the levelled layer beneath the floor of the mega-structure (Tab. 9). Pit 34 stood out from the rest as it contained a large number of bones with a low degree of fragmentation.

The density of bone finds associated with the mega-structure itself was comparatively low, with a slight concentration observed in the northern, roofed section of the building. This distribution pattern was interpreted as potentially representing the remnants of ritual feasting prior to the abandonment of the building.

Small-scale bone assemblages from test trenches

The numerous test trenches excavated at Maidanetske generally yielded very small assemblages of animal bones (Tab. 10). In most cases, they were found in either the rubble of houses that had been destroyed by fire, the open spaces around them or in the adjacent geo-strata (Chernozem, buried soils). The largest of these assemblages comprised 14 bones and bone fragments and was recovered from Trench 96, where parts of two neighbouring houses and the open area between them were examined.

Intra-site distribution and fragmentation of bones

While different categories of features can be distinguished in all the trenches, the data quality must be critically assessed in each individual case. This applies, in particular, to the test trenches, since the naturally irregular distribution of finds can lead to over- or underrepresentation in such small-scale areas. Larger trenches generally yield considerably more reliable information on the density and fragmentation of finds.

The quantity of bone finds recovered from the individual trenches and contexts varied significantly. Overall, more than three quarters (>80%) of all finds were retrieved from pit fills, while far fewer finds came to light in other types of feature (Tab. 11). At just under 6%, houses destroyed by fire were in third position, while the open spaces around these houses ranked eighth.

These discrepancies also apply to the density and degree of fragmentation of bones when viewing the individual contexts (Fig. 4). At ca. 0.1 to 1 kg of bone material per cubic metre of excavated soil, the contexts that yielded the most finds were the pits and ditches, or the majority thereof. Some of the other pits, the houses destroyed by fire, one of the mega-structures, the open spaces around the potter's kiln and one

Layer formation	Layer group	Layer	Volume (m^3)	Bones, NISP	Bones, weight	Bones, kg/m^3	Fragmentation (g)
Mai 70/1	70 – geological trench	Undifferentiated		1	10		10
Mai 71/1	71 – buried soil	Buried humus		1	1		1
Mai 72/3	72 – topsoil	Layer above house	0.31	1	1	0.0032	1
Mai 73/2	73 – House 48	Wall debris	0.24	1	2	0.0083	2
Mai 77/2	77 – House 52	Wall debris	1	1	23	0.0230	23
Mai 93/1	93 – House 57	Undifferentiated	1.4	3	1	0.0007	0.3
Mai 93/1	93 – occupation layer	Alley between houses	0.2	1	4	0.0200	4
Mai 94/102/2	94/102 – House 59	Undifferentiated	0.6	1	1	0.0017	1
Mai 95/2	95 – House 60	Undifferentiated	0.6	3	100	0.1667	33
Mai 96/1	96 – House 61	Undifferentiated	1.9	10	67	0.0353	7
Mai 96/1	96 – House 62	Undifferentiated	0.65	2	10	0.0154	5
Mai 96/1	96 – occupation layer	Alley between houses	0.9	2	15	0.0167	8

Table 10. Maidanetske: archaeological contexts, distribution and fragmentation of the animal bones from the test trenches.

Feature category	Bones				Pottery	
	NISP	Weight (g)	NISP (%)	Fragment (g)	Weight (kg)	Percentage (%)
Pit fill	2190	21664	81.7	10	131	29.6
Layer (unspecified)	118	2736	4.4	23	48	10.9
Burnt down house	158	1335	5.9	8	150	33.9
Topsoil	57	547	2.1	10	24	5.3
Ditch fill	34	1887	1.3	56	0.01	0.0
Layer (around pottery kiln)	30	175	1.1	6	20	4.6
Pottery kiln (deposited after abandonment)	21	65	0.8	3	18	4.1
Layer (around a house)	18	240	0.7	13	9	2.1
Burnt down house (destroyed by pottery scavengers)	11	277	0.4	25	6	1.4
Natural soil	4	38	0.1	10	0.1	0.0
Pottery kiln construction	2	98	0.07	49	7	1.6
Pottery kiln, unspecified	1	1	0.04	1	5	1.2
Context unclassified	35	839	1.31	24	23	5.3
Total	**2679**	**29902**	**100**	**238**	**441.8**	**100**

Table 11. Maidanetske, 2013–2016: frequency of bone and ceramic finds in different categories of features.

of the ditches yielded moderate quantities of finds, *i.e.* between 0.005 and 0.1 kg per cubic metre. A low density of finds of <0.005 kg/m³ was recorded in the open areas around the fully excavated houses in Trenches 51 and 92, in the area around the pit found in Trench 60 and in Chernozem surface deposits.

Differences between the feature categories with regard to average sherd weight were considerably more graduate and less pronounced than the differences in finds density. A low degree of fragmentation and a high average fragment weight of 50–90 g were recorded in two pits uncovered in Trench 111, the western ditch segment in Trench 110, the earliest phase of the potter's kiln in Trench 80 and in

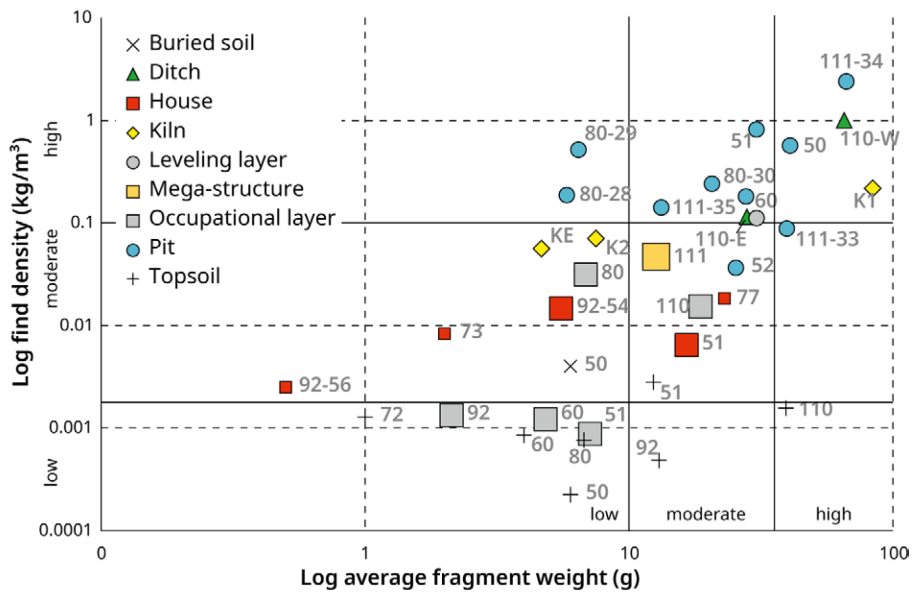

Figure 4. Maidanetske: Scatter plot of finds densities and average fragment weights of bone in layer groups. The labels are comprised of trench numbers and, where applicable, house numbers, pit numbers or phases within these sections.

the arable soil in Trench 110. The majority of pits, the eastern segment of the ditch in Trench 110, the houses in Trenches 51 and 77, Mega-structure 3 (Trench 111) and the open spaces in Trench 110 all yielded finds with a moderate degree of fragmentation and an average fragment weight of between 10 and 50 g. A high degree of fragmentation and a low average bone fragment weight of below 10 g were recorded for Pits 28 and 29, the later phases of the potter's kiln in Trench 80, most open spaces, certain houses and most arable soils.

Preliminary discussion of site formation processes

In view of the perishability of the bone material, one might ask to what extent the distribution patterns described reflect the actual waste and disposal strategies and to what extent they were, in fact, the result of different preservation conditions in different areas. In order to explore this question, the overall finds quantities were taken into account and the bone finds distribution patterns were compared to those of the pottery. In our opinion, pottery is a category of find that is far less likely to deteriorate upon deposition in the ground while representing a similar functional sphere as bones. The fact that pottery has a better chance of survival applies in particular to the Trypillia pottery from Maidanetske, which was of very high quality and fired at high temperatures.

In contrast to the animal bones, whose distribution was mainly focused on pits, pottery was spread quite evenly between pits and houses destroyed by fire (Tab. 11). Pottery retrieved from various 'layers' (*e.g.* the levelled layer) and from Chernozem layers overlying houses destroyed by fire followed in third to fifth position. Given their potentially unpleasant odour, the absence of bone finds from houses is not surprising, since dwellings were probably kept clean. The low numbers of finds in the open spaces around the houses, however, was striking, since these areas often constituted focal points for the disposal of waste, not just in the Neolithic settlements of south-eastern Europe but also at many central European sites (e. g. Müller-Scheeßel *et al.* 2010; Hofmann 2013, 229–262; Doppler 2013, 81–83; Brozio 2016, 92–95). Because of this and also the fact that they were close to the surface, the open spaces around the houses are among the areas where bone finds would most likely have decayed.

However, when the distribution patterns of pottery, which is less likely to decay, are used as a corrective, there are quite distinct differences in some cases between Maidanetske and other sites. While at the Late Neolithic settlement of Okolište in

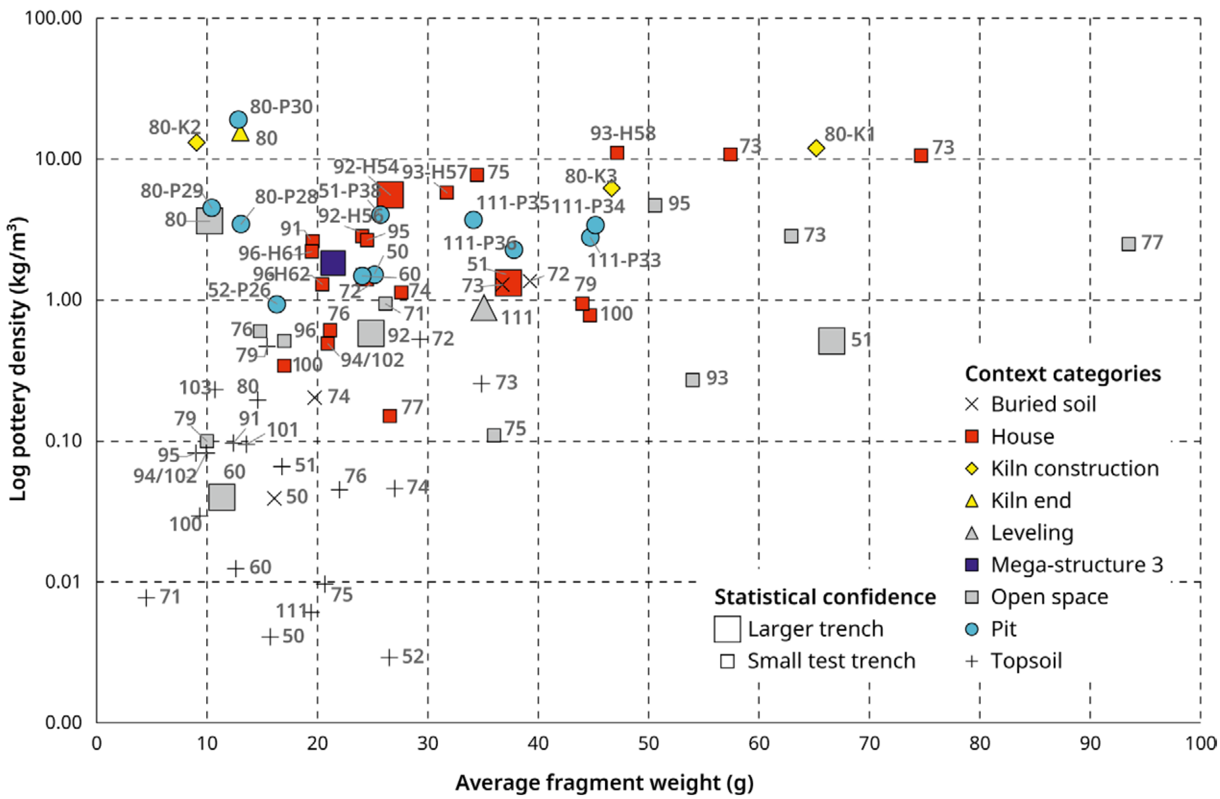

Figure 5. Maidanetske: Scatter plot of finds densities and average fragment weights of pottery in layer groups. The labels are comprised of trench numbers and, where applicable, of house numbers, pit numbers or phases within these sections.

central Bosnia, for instance, 50% of the pottery came from secondary refuse areas in the open spaces around the houses (Hofmann 2013, 229–262), the percentage at Maidanetske was clearly far lower. In contrast, the density of pottery finds at Maidanetske was almost always higher within the houses and pits than in the areas surrounding them (Fig. 5). These differences appear to be based, among other things, on the fact that the primary contexts within the houses at Maidanetske contained considerably higher percentages of pottery (ca. 30%) than at Okolište (15%).

The distribution patterns of both the bones and the pottery at Maidanetske show that the pits, which were associated with either houses or workshops (*e.g.* the potter's workshop), were obviously used for the regular disposal of refuse. In our opinion, the distribution patterns outlined for the pottery clearly refute the notion that accumulations of bones in pits and their under-representation in other contexts were the result of selective post-depositional processes of decay. In this sense, the refuse disposal strategy at Maidanetske appears to have been rather more specialised than it was at the tells of south-eastern Europe.

Apart from the general observations made on the distribution, one example of a deposit of two cattle skulls and a number of ceramic vessels, together with a low degree of fragmentation suggests that some contexts were the result of ritual depositions. As a consequence, bone assemblages in pits can be interpreted either as primary refuse (depositions) or as secondary refuse (secular domestic refuse), depending on the degree of fragmentation and finds density. This obviously does not exclude the possibility that some pits had more complex biographies, which might also have included deposits of tertiary refuse.

The emphasis on pits for the disposal of refuse is matched by the fact that the *open spaces* around the houses were obviously not used for dumping refuse on a regular basis, but that this only happened occasionally. As a consequence, the finds recovered from these areas were very low in number while their degree of fragmentation was high. Exceptions to this rule were open spaces associated with the potter's kiln and segments of the causewayed enclosure, which yielded far more bone finds also with moderate to high fragmentation. The levelled layer beneath Mega-structure 3 in Trench 111 appears to have been another exception in that it was characterised by a high density of finds with a moderate degree of fragmentation.

Bone remains within the *houses* and in *Mega-structure 3* exhibited a moderate finds density and a low to moderate degree of fragmentation. Since we can probably assume that the houses were kept clean, these were either primary assemblages deposited at the time the buildings were abandoned or they were secondary, external refuse. The relatively high degree of fragmentation appears to point to the latter.

Some of the less numerous context categories exhibited rather differentiated depositional processes, as exemplified by two ditch segments found in Trench 110. While in the western segment a low degree of fragmentation and a high density of ceramic and bone finds as well as vessels found lying on their mouths clearly suggest primary deposition as part of a ritual, the finds from the eastern segment were moderate in number and fragmentation, which would instead point to secondary deposition as part of a normal disposal of refuse.

The bone assemblages associated with the multi-phased potter's kiln in Trench 80 are more difficult to interpret. The bones were found either incorporated in the construction of the kiln or as part of refuse deposited in the fills of the channels in the kiln's substruction.

The formation processes that resulted in the finds assemblages recovered from the topsoil, most of which came from the lower part of the Chernozem layer directly above the features, are also difficult to assess. Depositional (anthropogenic) processes probably played a minor role in their formation. Instead, the pottery fragments or bones lying on top of burnt rubble or old occupation layers would initially have been buried and incorporated into the newly formed Chernozem by earthworms and later transported back up towards the surface by frost heaving and ploughing (Dreibrodt *et al.* 2022; Chapman *et al.* 2016, 125).

When the taphonomic interpretations discussed are applied to the entire bone assemblage from Maidanetske, it becomes clear that the vast majority of bone finds that have survived were secondary refuse of domestic origin (Tab. 12). However, the bone assemblage is strongly dominated by bone refuse associated with activities at the pottery kilns in Trench 80, which constitutes almost 65% of the NISP. Secondary domestic waste from other contexts, in contrast, only accounted for about 12% of all the bones recovered at Maidanetske.

After the secondary refuse mentioned, primary refuse deposited during the performance of ritual acts is the second-largest category of bone finds. If Trench 80 is excluded, this category even accounts for almost half of all bones found

Refuse category	All trenches		Without Trench 80	
	NISP	Percentage (%)	NISP	Percentage (%)
Primary, ritually deposited or secondary domestic refuse	72	2.7	72	7.9
Primary, ritually deposited refuse	424	16.1	422	46.5
Secondary domestic refuse	187	7.1	186	20.5
Secondary domestic refuse (external)	130	4.9	109	12.0
Secondary domestic refuse (kiln-type)	1697	64.4	-	-
Tertiary domestic refuse	17	0.6	17	1.9
Tertiary refuse embedded in the buried soils	3	0.1	3	0.3
Tertiary refuse embedded in the Chernozem and partly redeposited by frost heaving	105	4.0	98	10.8
Total	**2635**	**100**	**907**	**100**

Table 12. Frequency of waste categories according to the taphonomic interpretation of the bone assemblages from Maidanetske recovered between 2013 and 2016.

at Maidanetske, with secondary domestic refuse making up only ca. 30–40% of the finds. The site is therefore characterised by an over-representation of bone refuse whose provenance was possibly associated with the performance of ritual practices.

The relatively limited amounts of animal bones retrieved from areas of domestic refuse disposal and the potentially rather large quantity of finds associated with the performance of ritual acts give rise to numerous questions, which we will now attempt to answer, at least in part on the basis of the bones themselves. One of these questions is to what extent the assemblages from the various contexts of primary and secondary refuse disposal differ from each other.

Zoological characterisation of the bone assemblage

General characterisation of the finds assemblage

The majority of animal remains retrieved during the excavations carried out at Maidanetske were identified as butchering and food waste accumulated by the inhabitants of the settlement. This was suggested mainly by the type of fragmentation of the animal bones and the presence of characteristic evidence of blows and cuts. The finds were well preserved overall; the bones were light brown in colour and the majority had a solid consistency. Some finds (n=73) bore traces of varying degrees of burning. A total of 93% of the bone material, could be identified in terms of species or genus. The majority of identified species belonged to domestic animals known to have existed in the middle to late Trypillia period along with certain species of wild mammals and molluscs (Tab. 13). In some cases, it was not possible beyond doubt to differentiate between domestic cattle and aurochs or between domestic pigs and wild boar. Similarly, it was not clear whether three equine bones were from domesticated or wild animals. The overview in Table 13 lists these finds separately. Just under half of the bones (n=1300) could not be taxonomically identified. Most of these were small to minute fragments of mammal bones with an average weight of just under two grams.

The domestic animals represented in the material examined included cattle, sheep, goats, pigs and dogs. A total of 510 finds were identified as cattle bones (Tab. 13). At 73% the relatively high proportion of cattle bones by weight suggests that beef was an important source of food. However, there were considerable discrepancies between the larger assemblages, which represented different periods, in respect of the percentages of cattle bones (see below), the majority of which were highly fragmented. Some bore evidence of blows and cuts. As one would expect, the bones richest in meat had the highest degree of fragmentation, while the metapodials, ribs and vertebrae were better preserved and the large tarsal bones and phalanges had survived largely intact. The representation of skeletal elements generally corresponded to what one might expect. The only exception was Trench 80, where the elements of the trunk (vertebrae, ribs) predominated. Age determinations were carried out on the cattle jaw bones and on elements of the postcranial skeleton. The results showed that the bones had mainly come from subadult and adult animals. Sex determination was possible on five bones. Two were female and three were male. The measurements taken of the cattle bones and teeth attested to a considerable diversity in size. Most cattle probably stood between 1.2 m and 1.4 m high at the withers. None of the cattle bones bore any evidence of wear and tear, for instance from being used as working animals.

Small ruminants such as sheep and goats were represented by 533 finds in total (Tab. 13). The species could be identified in 44 of these, 42 of which were deemed to be sheep bones, while only two were identified as goat. This suggests

Species	NISP	Weight	NISP (%)	Weight (%)
Domestic				
Cattle	510	21945	19.0	73.4
Sheep/goat	489	1767	18.3	5.9
Sheep	42	463	1.6	1.5
Goat	2	27	0.1	0.1
Pig	244	1821	9.1	6.1
Dog	16	68	0.6	0.2
Domestic/wild				
Cattle/aurochs	3	353	0.1	1.2
Pig/wild boar	34	603	1.3	2.0
Domestic/wild horse	3	256	0.1	0.9
Wild				
Red deer	4	43	0.1	0.1
Red deer, antler	6	368	0.2	1.2
Roe deer	1	4	0.04	0.01
Elk	1	4	0.04	0.01
Wild boar	1	72	0.04	0.2
Spalax	3	4	0.1	0.01
Hamster	3	3	0.1	0.01
Red squirrel	2	2	0.1	0.01
Hedgehog	1	1	0.04	0.003
Hare	1	1	0.04	0.003
European ground squirrel	1	1	0.04	0.003
Molluscs				
Helix	8		0.3	
Unio	4		0.1	
Undetermined*	1300	2096	48.5	7.0
Total	**2679**	**29902**	100.0	100.0

*Table 13. Maidanetske: Species identification of the animal bone assemblage by number and weight. *Includes bones determined as 'small', 'medium' and 'large' mammals as well as 'cattle/deer/horse'.*

a clear predominance of sheep among ovicaprids. Significant differences in the proportions of sheep/goats were found among the domestic animals (see below). The representation of skeletal elements showed no abnormalities, at least in the larger assemblages, and all parts or elements of the skeleton were represented in roughly equal quantities. Age determination pointed to the presence of animals of varying ages. According to the teeth found in the two large pit assemblages from Trench 80, there were four young animals and eight older ones (older than 2 years). One cornual process and one pelvis of a sheep represented a male and a female animal respectively. A small number of measurements of sheep bones pointed to medium sized animals (see Appendix 2).

A total of 244 finds were identified as domestic pig bones (Tab. 13). In a further 34 porcine remains it was unclear whether they were from domestic pigs or wild boar. Most domestic pig bones were from assemblages associated with the earlier Periods 1 and 2 (see below). No unusual observations were made in terms of the skeletal element representation. According to age determination, the bones mainly represented juvenile and subadult pigs. Of the jaw bone fragments whose sex could be determined, three were from male animals and two from females. The measurements attested to animals that reached a height of 0.8 to 0.9 m at the withers.

Dogs were represented by 16 bones from the cranium, trunk and extremities. All bones were from adult animals. No evidence of butchering or cutting was found. The question of whether the meat or pelts of dogs were used must therefore remain unanswered. The osteometric data pointed to medium-sized to large dogs.

The zoological finds from Maidanetske also included a number of wild mammal bones (Tab. 13). Four species of big game were represented; they were red deer, elk, roe deer and wild boar. Compared to farm animals, the number of wild animal bones amounted to less than one percent, which suggests that game only made up a small proportion of the meat consumed. Other species hunted probably included hare and squirrel, both of which were represented by isolated bone finds. Remains of other species (hamster, hedgehog, spalax and European ground squirrel) were probably natural admixtures in the archaeological layer.

Zoological characterisation of individual contexts

Animal bones from Pit 25 in Trench 50

The two fills, ARCH 1b and ARCH 2a, yielded mainly cattle bones (n=118), with small numbers of sheep/goat (n=5), pig (n=3), dog (n=4) and hare (n=1) bones. Compared to the normal representation of skeletal elements, bones from meatless parts of the body (class C elements) were over-represented among the cattle bones (Fig. 6). Most were unfragmented, which was also shown by a relatively high average weight of 52 g per cattle bone. The fill therefore probably consisted mainly of butchering waste which was of no further use.

Animal bones from House 44 and Pit 26 in Trenches 51 and 52

A small assemblage of animal remains were recovered from Trenches 51 and 52; besides numerous unidentified bone fragments (n=61), it contained bones from many different species: sheep/goat (n=18), cattle (n=10), pig (n=5), wild or domestic horse (n=1), red deer (n=2), aurochs or domestic cattle (n=1), hamster (n=2) and edible snail (n=2). The representation of skeletal elements of farm animals showed no anomalies

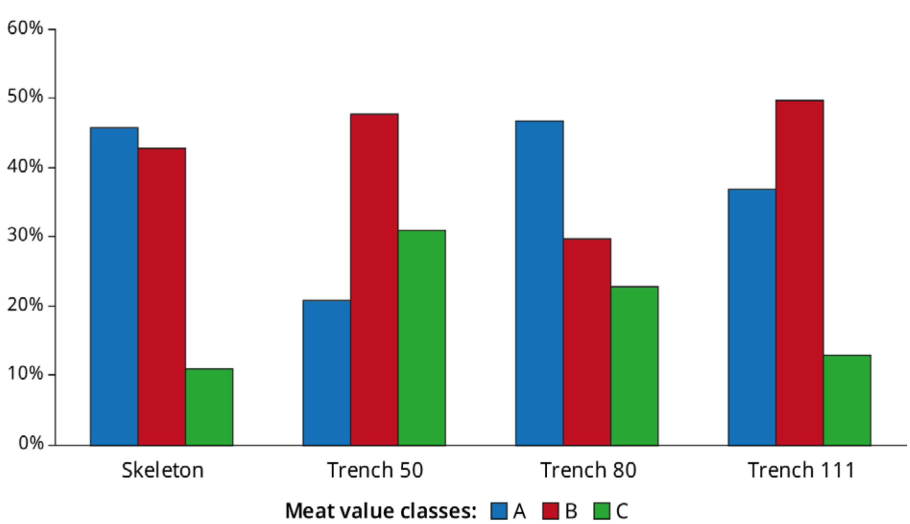

Figure 6. Relative proportions of elements from each class in the overall weight of a bovine skeleton and among the cattle bone assemblages from three trenches (Trench 111 does not include the mega-structure).

with all parts of the body being present. The average weight per cattle bone was 18 g. Overall, the assemblage appears to have consisted of typical butchering and food waste.

Animal bones from House 59 in Trench 92

A small assemblage of animal remains were recovered from House 59 and the open areas around it. The finds were comprised of four sheep/goat bones (carpal bone, tibia, metatarsal bone, rib), three pig bones (pelvis, two lumbar vertebrae), one cattle bone (rib) and three shells of edible snails. The assemblage also contained 28 fragments of unspecified mammals. The average bone weight was 4 g. The assemblage probably consisted mainly of food waste.

Animal bones from Pit complex 27 in Trench 60

The assemblage of 72 animal remains from Trench 60 were identified as cattle (n=24), sheep/goats (n=2) and pigs (n=2), with more than half being undeterminable (n=44). The cattle bones were all from elements assigned to meat value classes A (n=14) and B (n=10). At 41 g, the average weight per bone was relatively high. The deposit therefore consisted largely of high-quality food waste.

Animal bones from the potter’s workshop in Trench 80

Trench 80 yielded the largest assemblage of animal bones recovered during the excavations presented here. The identifiable bones belonged to the following animal species: sheep/goat (n=490), pig (n=211), cattle (n=62), dog (n=8), red deer (n=2), elk (n=1), squirrel (n=1), hamster (n=1), edible snail (n=1) and river mussel (n=3). With regard to the cattle bones, the representation of skeletal elements largely corresponded to what one would expect to find (Fig. 6). The same was also true for sheep/goat and pig bones. The sheep/goat bones represented the following meat value classes (percentages in brackets refer to a recent skeleton): class A 37% (46%), class B 58% (44%), class C 5% (10%). In the pig bones the proportions were as follows (percentages in brackets refer to a recent skeleton): class A 37% (39%), class B 51% (53%), class C 12% (7%). We can assume that the finds constituted typical butchering and food refuse and that the meat was processed on site or in the immediate vicinity. This was also confirmed by the relatively low average weight of 22 g per cattle bone.

Animal bones from the ditch segments in Trench 110

Trench 110 yielded a small assemblage of animal bones, 21 of which were identified as cattle and 10 as pig bones. At 79 g, the average weight per cattle bone was very high. Most fragments could be assigned to meat value classes A (n=11) or B (n=8). This and a low degree of fragmentation pointed to a special kind of deposition. The small number of pig bones, however, did not exhibit any unusual features.

Animal use and consumption patterns in Mega-structure 3 in Trench 111

A small bone assemblage recovered from the mega-structure in Trench 111 contained remains of the following species: cattle (n=27), pig (n=7), sheep/goat (n=5), aurochs or domestic cattle (n=1) and roe deer (n=1). The cattle bones weighed an average of 23 g per bone and were distributed evenly among the meat value classes. They and the other animal bones appeared to form a typical assemblage of butchering and food waste.

Animal remains from the area of Mega-structure 3 prior to its construction (Trench 111)

The assemblage from Trench 111 was mainly composed of the remains of cattle (n=210). The other bones were identified as belonging to the following species: pig (n=6), sheep/goat (n=5), dog (n=1), aurochs or domestic cattle (n=1), red deer (n=6), wild boar (n=1), edible snail (n=1) and river mussel (n=1). The average weight of the cattle bones was 14 g. The percentage distribution across the three meat value classes largely followed the normal anatomical patterns (Fig. 6). The finds therefore provide a record of the local exploitation of animals as a source of food.

Distribution within the site

The distribution of animal species within the settlement was not uniform, with some areas predominantly yielding cattle bones and others mainly sheep/goat and pig remains (Figs. 7 and 8). One context contained only cattle and pig bones, but this was a relatively small sample. While contexts that mainly contained cattle bones were spread throughout the entire settlement (in the north and south and in different rings of houses), those that yielded predominantly sheep/goat and pig bones were limited to the potter's workshop in Trench 80 and a nearby house in Trench 92. The eastern ditch segment in Trench 110 yielded cattle and pig bones only.

The three equine bones were retrieved from Trenches 51, 110 and 111 and were thus distributed throughout the entire settlement. A similar observation can be made for the dog remains, which were found in Pits 25, 28 and 29 (Trenches 50 and 80), in House 61 in Trench 96 and in the levelled layer beneath Mega-structure 3 in Trench 111.

Wild animal bones were found in clusters. Apart from possibly recent admixtures of hamster, hedgehog, spalax and European ground squirrel, this was the case, for instance, in Pit 29 in Trench 80, which yielded three bones of squirrel, elk and red deer, the levelled layer and settlement pits beneath Mega-structure 3 in Trench 111, which contained a total of 7 remains of red deer and wild boar (including antler fragments) and in Mega-structure 3 itself with one deer bone. Bones of other wild animals included a single bone of a hare in Pit 25 (Trench 50), two bones of a squirrel in the open space in Trench 110 and evidence of a red deer in the Chernozem in Trench 51.

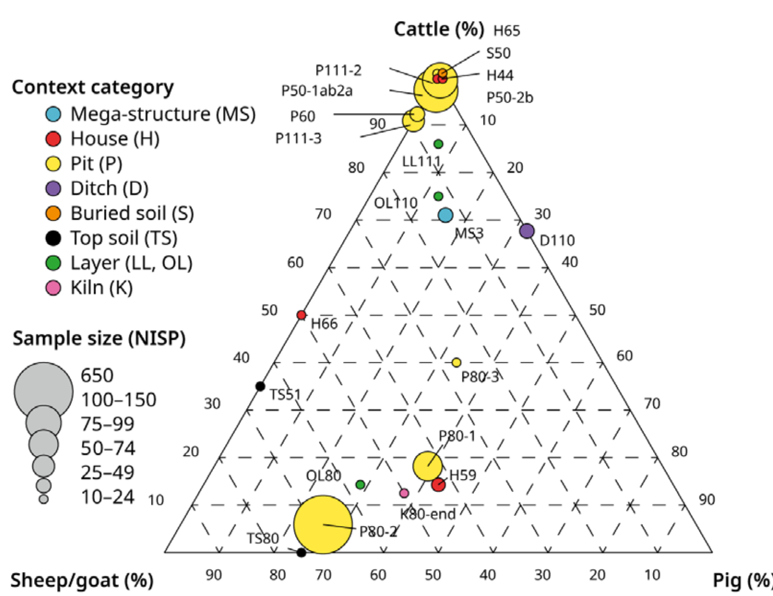

Figure 7. Maidanetske: Ternary plot with proportions of the main domestic animal species in various feature categories. Assemblages of less than 10 finds (NISP) are not shown here.

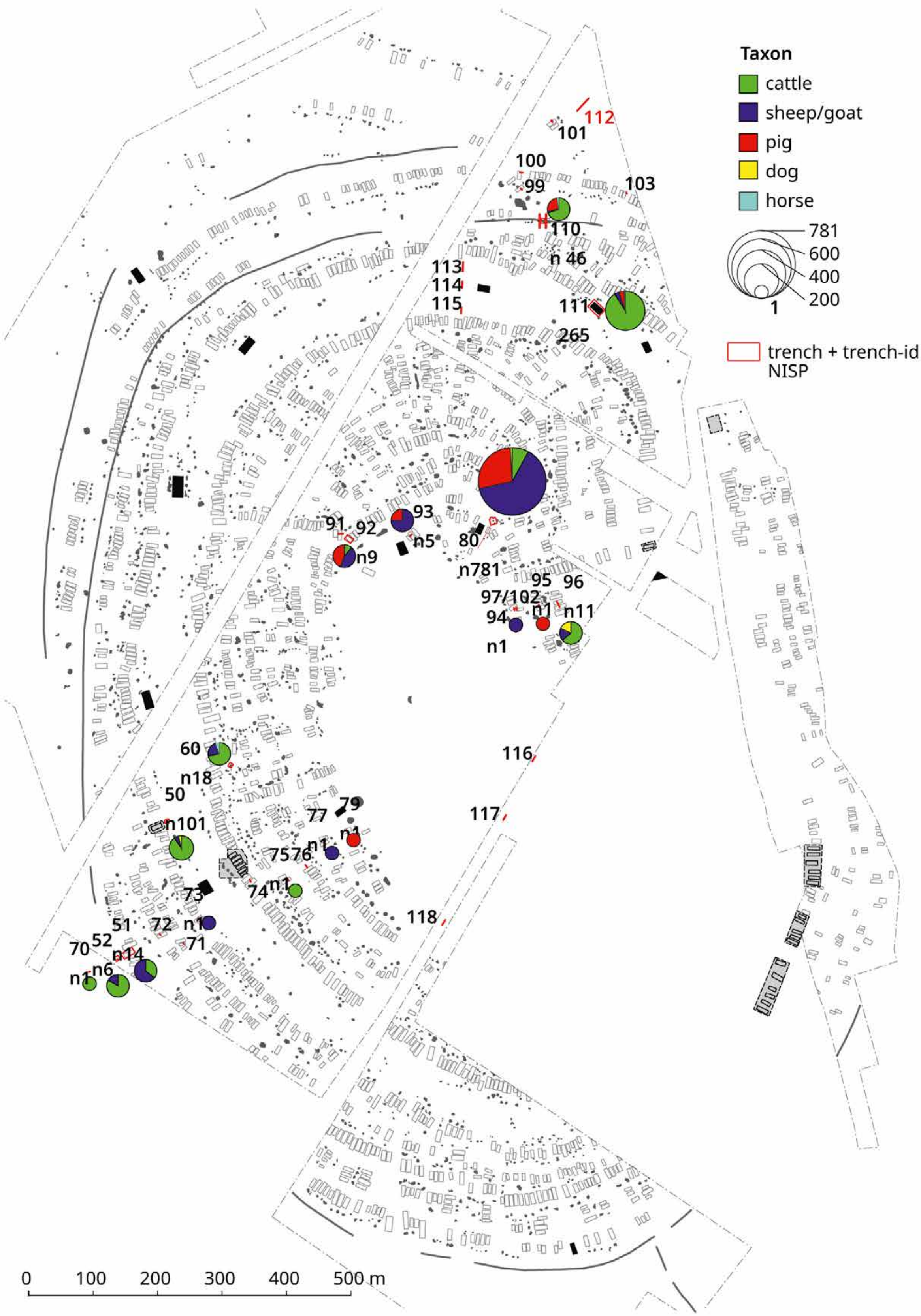

Figure 8. Maidanetske: Spatial distribution of the bones of domestic animals and possible domestic animals (NISP) recovered during the excavations carried out between 2013 and 2016.

Changes over time

Animal species

The random sample of zoological material from Maidanetske was very unevenly distributed between the four settlement phases. No more than approximately 30% of the finds were firmly attributed to a particular phase; the chronological information for the remaining 70% was blurred in that they exhibited links to at least two of the phases (Tab. 14). While the problem was solved statistically by evenly (aoristically) distributing the finds between the phases in question, it should be borne in mind when studying the data that hardly any of the bones could be firmly attributed to Phases 1 or 4. Meaningful comparisons can therefore only be made between an earlier and a later phase.

Table 15 shows the distribution of bones between the four Chalcolithic settlement phases.

Analysis of the bone sample shows radical changes in the range of domestic animals between Phases 1 and 2 and Phases 3 and 4. While sheep, goats and pigs were predominant in Phases 1 and 2, more than 80% of the bones were cattle bones from Phase 3 onwards (Fig. 9). Phase 4 did not yield a sufficient number of finds to allow an assessment to be made.

The dominance of sheep/goat and pig bones in the earlier Phases 1 and 2 was mainly based on assemblages from the northern and central areas of the settlement (Trenches 80 and 92), some of which were relatively rich in finds (Tab. 16). It is therefore possible that Figure 9 does not reflect a chronological development but rather a spatial pattern. On the other hand, other early assemblages, for instance the material from the ditch segments in Trench 110, did not really correspond to the later assemblages from Phase 3. Although cattle remains were clearly more abundant in Trench 110 (65% and 68%) than in Trench 80, pig bones were represented in similar proportions (35% and 32%). Most of the larger assemblages from Phase 3 had far higher proportions of cattle bones (90% or more) and thus far fewer bones from other domestic animals.

Wild animal species, on the other hand, did not exhibit any chronological trends, which may be due in part to the extremely small samples from Phases 1, 2 and 4

Phase	NISP
Phase 0	9
Phase 1	0
Phase 2	74
Phase 3	718
Phase 4	1
Phases 1–2	1673
Phases 1–3	37
Phases 1–4	3
Phases 2–3	98
Phases 2–4	16
Post-Chalcolithic	15
Unspecified	35
Total	2679

Table 14. Maidanetske: Distribution of the zoological samples over the settlement phases. Phase 0 = transitional stratum between the natural soil and the first archaeological layer.

Species	Phase 1	Phase 2	Phase 3	Phase 4	Post-Chalcolithic	Total
Domestic						
Cattle	35.2	74.3	392.8	7.7		510
Sheep/goat	224.2	230.7	33.2	1.0		489
Sheep	19.5	19.8	2.3	0.3		42
Goat			2.0			2
Pig	103.9	119.1	19.6	1.4		244
Dog	4.3	5.3	6.3	0.3		16
Domestic/wild						
Cattle/aurochs			3.0			3
Wild boar/pig	2.0	3.5	21.5	1.0	6.0	34
Horse		0.3	2.3	0.3		3
Wild						
Red deer	0.8	0.8	8.3	0.3		10
Roe deer			1.0			1
Elk	0.5	0.5				1
Wild boar			1.0			1
Spalax	1.0	1.5	0.5			3
Hamster	0.5	0.2	2.0			3
Squirrel	0.5	0.8	0.3	0.3		2
Hedgehog	0.3	0.3	0.25	0.25		1
Hare			1.0			1
European ground squirrel			1.0			1
Undetermined	466.1	526.6	293.1	5.3	9.0	1300
Molluscs						
Unio	1.5	1.5	1.0			4
Helix	0.5	3.5	4.0			8
Total	860.6	989	796	18	15	

Table 15. Maidanetske: Aoristic distribution of species between the four Chalcolithic settlement phases and post-Chalcolithic contexts. Values are rounded to one decimal place.

(Tab. 17). The available data did not allow us to draw any conclusions with regard to changes in the landscape.

Proportion of wild animals

The proportion of wild animal bones was difficult to interpret due to the limited sample size. While the proportion of wild animal bones in Phases 1 and 2 was around 1%, it appeared to have increased to almost 4% in Phase 3 (Tab. 17). Phase 4 could not be evaluated because of a dearth of finds.

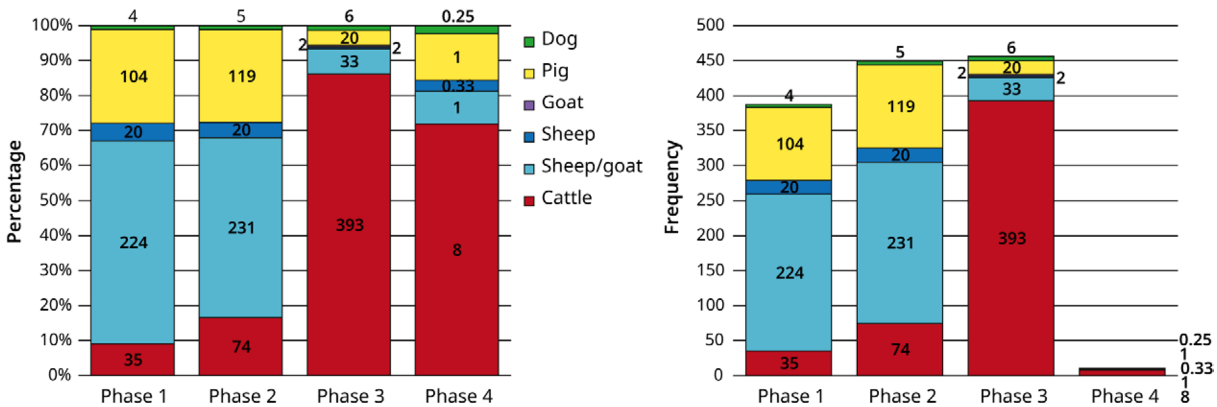

Figure 9. Maidanetske: Relative frequency of animal species in contexts dating from Phases 1–4.

Phase	Layer group	Cattle	Sheep/ goat	Pig	Dog	Total	Cattle (%)	Sheep/ goat (%)	Pig (%)	Dog (%)
1–2	80 – Pit 28	14	33	30	3	**80**	18	41	38	4
1–2	80 – Pit 29	38	440	168	5	**651**	6	68	26	1
1–2	80 – Pit 30	6	4	5		**15**	40	27	33	
2	110 – western ditch segment	15		8		**23**	65		35	
2	110 – eastern ditch segment	21		10		**31**	68		32	
2	92 – House 59 + outside area	1	4	3		**8**	13	50	38	
3	111 – levelled layer	48	4	4	1	57	84	7	7	2
3	111 – Mega-structure 3	27	5	7		39	69	13	18	
3	111 – Pit 34 (111/2)	153		1		154	99		1	
3	111 – Pit 35 (111/3)	10	1			11	91	9		
3	50 – Pit 25	118	2	1	4	125	94	2	1	3

Table 16. Maidanetske: frequency of domestic animal species by contexts (layer groups) with relatively large bone assemblages from Phases 1–2 and 3.

Phase	Domestic	Domestic/wild	Wild	Undetermined	Molluscs	Total	Domestic (%)	Wild (%)
Phase 1	387	2	4	466	3	391	99.1	0.9
Phase 2	449	4	4	527	6	454	99.0	1.0
Phase 3	456	27	15	293	5	472	96.7	3.3
Phase 4	11	1	1	5		12	92.8	7.2
Post-Chalcolithic		6		9				

Table 17. Maidanetske: Proportion of domestic and wild animals in Phases 1–4.

Discussion

The spatial and chronological distributions

Due in part to the limited size of the assemblages and in part to the challenging distribution patterns of partial samples, it is currently not possible to ascertain beyond doubt whether the spatial variations of cattle-predominated or sheep/goat/pig-predominated assemblages observed within the settlement reflect changes in the exploitation of animals over time or whether they mirror socioeconomic differences that might have existed between the individual households. The only large assemblage, which consisted mainly of sheep/goat and pig bones, came from the area of a potter's workshop and was also the only considerably-sized bone assemblage from the early phases of the settlement (Trench 80). The fact that the frequency of cattle bones increased over the pit's three phases of use while the frequency of sheep/goat and pig remains decreased, could be tentatively interpreted as an indication of a chronological relevance to the differences described.

On the other hand, some assemblages from the early phases, *i.e.* the ditch segments in Trench 110, predominantly yielded cattle bones, perhaps suggesting that the high proportion of sheep/goat remains associated with the potter's workshop in Trench 80 mirrored social differences in dietary habits.

The same is also suggested by a comparison between the Maidanetske bone assemblages with those from other Trypillia sites. It shows that animal bone assemblages were dominated by cattle remains from the very early phase of the Trypillia period (Fig. 10). The differentiation between assemblages with a strong emphasis on cattle bones and those with increased proportions of sheep/goat bones cannot be observed prior to the Trypillia B2 and C1 phases. While cattle dominated in the catchment area of the Syniukha River until at least the end of Trypillia C1, the proportions of sheep/goats increased, particularly in some of the Moldovan settlements.

For our interpretation of the assemblages from Maidanetske this means that the distinct differences between the earlier and later contexts were caused by the sample analysed and that they probably do not reflect an actual change in the system of animal husbandry. Rather than representing chronological differences, they probably reflect functional variations within the settlement.

Reconstruction of subsistence and economy

The animal bones from Maidanetske constitute the remains of butchering and food waste that typically accumulated at settlement sites. The majority of the finds came from farm animals, mainly from cattle, sheep and pigs. The question of whether horses were used as domestic animals at the site could not be answered. If the small number of equine bones found did all represent domestic animals, this would be very early evidence of the exploitation of horses (cf. Levine 1990; Levine 2005; Fages *et al.* 2019).

The age determinations of cattle (Tabs. 18 and 19) show that most animals were at an advanced age when they were butchered, which is the optimum time in terms of using the meat as a source of food. Cattle may also have been kept as a source of dairy, although intensive dairy production can probably be excluded as a possibility. If this had been the case, the material would have included higher numbers of calves. No evidence was found for the use of cattle as draught animals. Sheep and goats were also mainly kept for their meat, though aspects of a secondary use (milk, wool) may also have played a role. Limited sample sizes did not allow us to make any confirmed statements in this respect. The age determinations of pig bones attest to their use as a source of meat and fat.

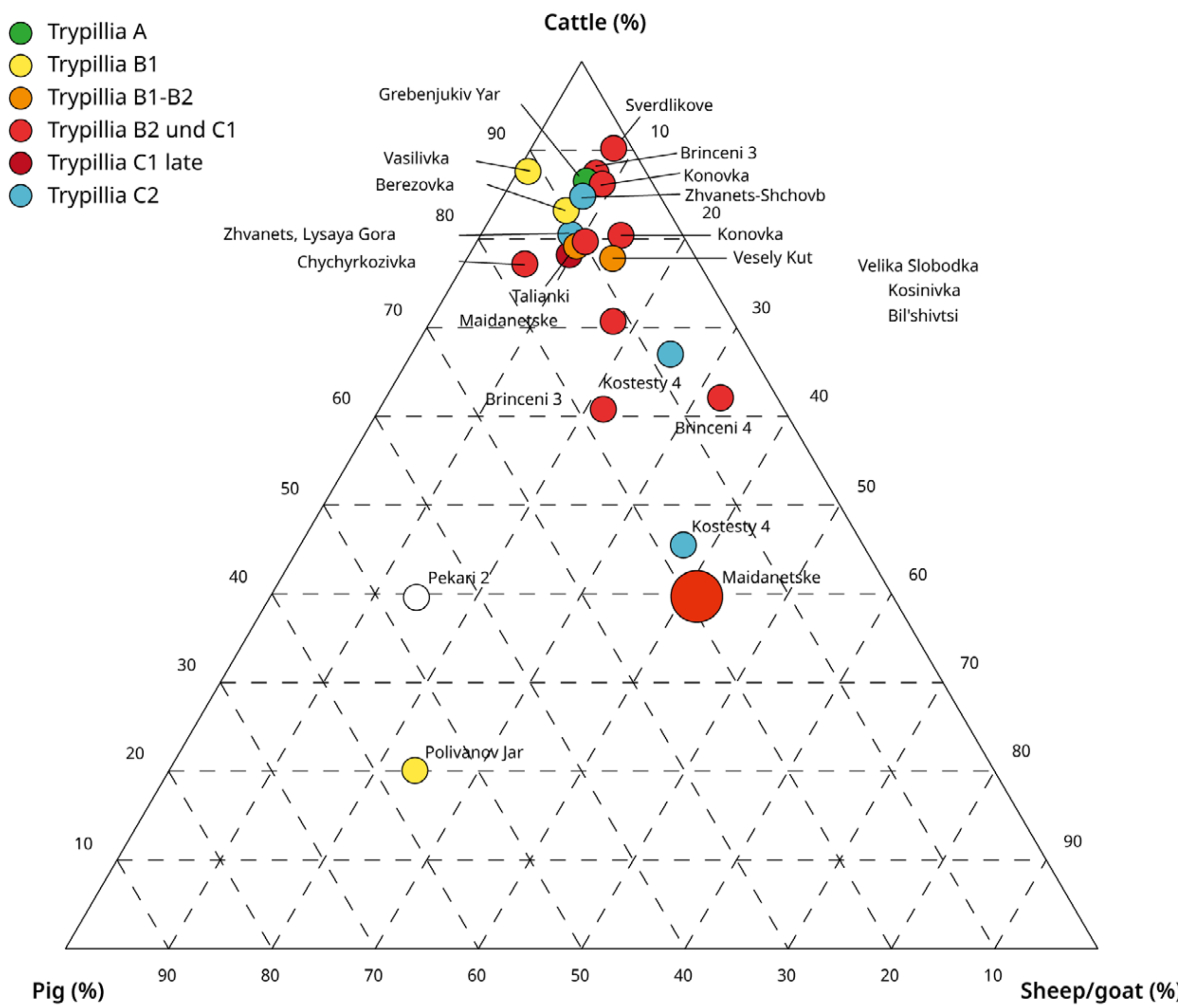

Figure 10. Ternary plot with percentages of the three main domestic animal species in Trypillia settlements, by periods.

Hunting does not appear to have been an urgent requirement for the inhabitants of Maidanetske to maintain a supply of meat and raw materials. The low proportion of wild animals at less than 1% points, rather, to occasional or perhaps seasonal hunting. The main species hunted were red deer, roe deer, elk and wild boar.

It is difficult to interpret the spatial and chronological differences in animal husbandry strategies, particularly the ratio between the keeping of cattle or sheep, as they were based on just a small number of large, diagnostically conclusive assemblages. They may also represent functional variation within the settlement. The three main domestic animal species were distributed quite unevenly across the entire settlement, with some assemblages predominantly containing cattle remains, while others consisted mainly of sheep bones. Some assemblages from both categories were associated with higher proportions of pig remains of up to 40%, while this appeared to be a chronological pattern with an emphasis on early contexts dating from Phases 1 and 2.

In as far as the contents of an animal bone assemblage can indeed help us make assessments with regard to the composition of a household's herd, a focus on cattle husbandry appears to have been the norm, while sheep, pigs, and even more so, goats appear to have been of less importance.

A complex of features which yielded predominantly sheep bones was directly associated with a potter's workshop from Phases 1 and 2 and therefore represented either 1) a special pattern of meat consumption linked to pottery production or 2)

Status	Cattle		Pig		Sheep/Goat	
M1 in wear	7–14 months	–	6–10 months	3	5–8 months	8
M2 in wear	19–24 months	1	12–16 months	5	12–17 months	4
M3 and P erupting	25–34 months	–	16–24 months	–	18–24 months	1
Permanent dentition:						
M3 without wear	>3 years	2	>2 years	5	>2 years	–
M3 slightly worn		6		–		6
Sum		9		13		19

Table 18. Age determination by dentition (maxilla and mandible).

Age of fusion	Cattle		Sheep/Goat		Pig	
Epiphysis	**unfused**	**fused**	**unfused**	**fused**	**unfused**	**fused**
<24 months						
Scapula-Coracoid	1	3	1	4	–	2
Humerus, distal	1	6	–	8	2	–
Radius, proximal	–	11	–	3	2	1
Phalanx 1, proximal	–	13	–	1	9	–
Phalanx 2, proximal	1	7	–	1	6	2
ca. 20–36 months						
Tibia, distal	2	9	1	6	1	1
Calcaneus (Tuber)	1	2	2	3	4	–
Metapodium, distal	3	7	6	2	13	–
ca. 36–48 months						
Humerus, proximal	2	–	–	1	–	–
Radius, distal	4	4	1	4	2	–
Ulna, proximal	–	1	2	–	–	–
Femur, proximal	3	–	7	–	1	–
Femur, distal	2	5	2	2	1	1
Tibia, proximal	3	1	5	2	3	–
>48 months						
Vertebra (Corpus)	16	15	23	6	23	–

Table 19. Age determination by epiphyseal fusion.

domestic refuse of a group of people specialised in the keeping of sheep. Because the bones were directly associated with wasters from the potter's workshop (Ohlrau 2020) and had probably accumulated directly at the butchering site, it is an obvious conclusion to make that this group were the potters themselves.

It is difficult at this point in time to ascertain whether the atypical sheep-centred animal husbandry strategy combined with pottery production probably carried out by specialist craftsmen observed not only at Maidanetske but also at other Trypillia sites, was a coincidental pattern (Korvin-Piotrovskiy *et al.* 2016; Ohlrau 2020). Although statistical projections of the pottery numbers recovered will be required to ascertain the extent and nature of the pottery production and whether it was a full-time or part-time occupation, we must take into account the possibility that potters set themselves apart from the majority of households in terms of their subsistence strategies. Whether this reflects the lower socioeconomic status of potters, as observed in various other societies (Rice 1987), or whether there were other reasons, must remain unanswered for now.

Reconstruction of depositional processes

Based on zoological examinations and taphonomic analyses and taking into account various archaeological interpretations, differentiated depositional conditions were reconstructed for the bone assemblages from Maidanetske (cf. Tab. 12). Analysis of the distribution of finds has shown that bones were mainly disposed of in pits and that they were only occasionally discarded in other contexts such as open spaces between houses.

Areas of secondary domestic refuse disposal characterised by moderate to high finds densities, moderate degrees of fragmentation and a normal distribution of meat value classes, were identified in the settlement remains beneath the mega-structure, in Houses 44 and 59 and associated pits and in pits that belonged to a potter's workshop. While these features yielded the majority of animal bones recovered from Maidanetske (ca. 65% NISP), a large proportion came from a relatively large assemblage associated with the potter's workshop.

In contrast to this secondary domestic refuse, possible *primary deposits* characterised by moderate to high finds densities, a low degree of fragmentation and an *ab*normal distribution of meat value classes, were discovered in various pits and ditch segments. At 16% (or 45% if Trench 80 is excluded), these assemblages contained a considerable amount of the bones recovered. However, they did not follow a uniform pattern, in that elements with little meat predominated in some contexts (pit in Trench 50) while meat-rich parts were more abundant in others (pit in Trench 60, ditch segments). It is clear overall, that a considerable proportion of the meat was apparently incorporated into an economy of ritual or consumed within this context.

Reconstruction of the environment

The wild animal species and their specific habitat requirements allowed us to draw certain conclusions with regard to the vegetation in the area at the time. The remains of red deer, elk and wild boar pointed to wooded and swampy areas nearby. Roe deer and hare represented forest edges and open terrain. If the equine bones came from wild horses, this would constitute irrefutable evidence of a steppe landscape.

Conclusion

The animal bone analyses yielded extremely important insight into both the economic organisation and the ritual significance of animals and animal processing at Maidanetske. They also helped to clarify various taphonomical issues.

Comparing the density and fragmentation of the pottery and the animal bones, in particular, made it possible to distinguish between primary and secondary refuse deposits. The pits contained fills from both the disposal of primary waste and from secondary disposals from 'events' that can be reconstructed. The extremely limited quantities of highly fragmented animal bones on the floors of houses and the almost complete absence of animal remains in the open areas around the houses attested to a very well-organised refuse economy. In contrast to tells in south-eastern Europe, close attention was paid to the disposal of animal and other refuse at Maidanetske, culminating in the composting of waste in pits.

Like other Trypillia settlements, the animal husbandry strategy at Maidanetske was mainly centred on cattle. Comparisons with other settlements showed that the higher proportions of sheep/goats identified for the earlier phase by purely quantitative means reflected the available sources rather than the historical reality. The main features from Phase 1 were a specialised assemblage associated with a potter's workshop as well as ritual deposits found in ditch segments (see below). Overall, we can assume that the dominance of cattle over sheep/goats and pigs also existed at Maidanetske during all phases of its occupation. There are some indications that there was a slight increase in sheep/goat remains in the later phase at Maidanetske, as seen also at other contemporaneous settlements. Hunting played hardly any role overall, though it was marginally more important towards the end of the occupation, which might point to certain problems the community was experiencing at that time. However, due to the limited number of bones in general, little can be said about the basic uses of animal products. What can be said without doubt is that butchering was very important; meat production was the main reason for keeping domestic animals, however, with a slight trend towards dairy production for sheep/goats.

The differences observed in the exploitation of livestock within the settlement were extremely important. The dominance of sheep/goats and the increased values for pigs in the house near the potter's kiln attest to the unique role played by the property and its apparent specialisation. The presumed household would have been more autonomous than the other households thanks to its pig husbandry and with its sheep/goat predominance would have pursued a different animal husbandry strategy to other households in the settlement (or it perhaps received the meat from other households in lieu of payment for its ceramic products).

Primary deposits, for instance in the pit in Trench 50, which contained what might have been the remnants of feasting in the context of the disposal of the burnt remains of a house, the re-cuts of the pit in Trench 60 with deposits of animal remains and the remnants of the consumption of meat around the hearth in the roofed area of the mega-structure all attest to acts where the use of animals was clearly non-secular. This was in contrast to the everyday consumption of animal products, whose remnants were deposited in the pits as part of the 'usual' refuse economy of individual households and of the settlement as a whole. Another unusual feature was that, unlike the open spaces around the houses, which were generally free of animal remains, the opposite was in fact true of the area around the potter's kiln, the ditches of the causewayed enclosure and the levelled layer beneath the mega-structure. The acts that led to this scenario must remain unknown for the time being.

It has been possible overall to link the exploitation of animals at Maidanetske to animal husbandry in general, to specialised animal husbandry in a particular household which was also associated with specialised pottery production, and to ritualised processes, be they celebrations, re-cuttings or acts performed within the mega-structure. It is the first time such detailed analyses have been carried out with respect to a Trypillia mega-site. A new methodological approach was chosen to compare the fragmentation and density of objects of different categories (pottery, animal bones). As opposed to hypothetical speculation (Nebelivka), it was possible in this way to distinguish between primary and secondary refuse and to differentiate between the refuse economy of working households and the ritual activities of the inhabitants of a mega-site.

Supplementary materials

The supplementary materials are freely available online under a CC BY 4.0 licence, in the Kiel University research data repository opendata@uni-kiel.de: https://doi.org/10.57892/100-55

Supplement 1. Information about the contexts, animal species and skeletal elements
Supplement 2. Measurements from animal bones
Supplement 3. Age and sex determinations with associated finds and features
Supplement 4. Finds assemblages from the different contexts

References

Benecke, N., 1994. *Archäozoologische Studien zur Entwicklung der Haustierhaltung in Mitteleuropa und Südskandinavien von den Anfängen bis zum ausgehenden Mittelalter*. Berlin: Akademie Verlag.

Brandtstätter, L., 2017. *Tripolje-Keramik aus Maidanteske (Ukraine): Auswertung der Grabungskampagne 2013*. [Unpublished Master thesis. Institute of Prehistoric and Protohistoric Archaeology, Kiel University, Germany].

Brozio, J.P., 2016. *Megalithanlagen und Siedlungsmuster im trichterbecherzeitlichen Ostholstein*. Frühe Monumentalität und soziale Differenzierung 9. Bonn: Dr. Rudolf Habelt. Available from: https://www.monument.ufg.uni-kiel.de/schwerpunktprogramm/publikationen/fmsd-9-megalithanlagen-und-siedlungsmuster-im-trichterbecherzeitlichen-ostholstein/index.html

Chapman, J., Gaydarska, B. and Hale, D., 2016. Nebelivka: Assembly Houses, Ditches, and Social Structure. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE*. Themes in Contemporary Archaeology 2. London, New York: Routledge, 117–131. Available from: https://doi.org/10.4324/9781315630731

Doppler, T., 2013. *Archäozoologie als Zugang zur Sozialgeschichte in der Feuchtbodenarchäologie. Forschungsperspektiven am Fallbeispiel der neolithischen Seeufersiedlung Arbon Bleiche 3 (Schweiz)*. [Unpublished PhD thesis. Basel University].

Dreibrodt, S., Hofmann, R., Dal Corso, M., Bork, H.-R., Duttmann, R., Martini, S., Saggau, P., Schwark, L., Shatilo, L., Videiko, M., Nadeau, M.-J., Grootes, P.M., Kirleis, W. and Müller, J., 2022. Earthworms, Darwin and prehistoric agriculture-Chernozem genesis reconsidered. *Geoderma*, 409, 115607. Available from: https://doi.org/10.1016/j.geoderma.2021.115607

Ellis, L., 1984. *The Cucuteni-Tripolye Culture*. Oxford: BAR Publishing.

Fages, A., Hanghøj, K., Khan, N., Gaunitz, C., Seguin-Orlando, A., Leonardi, M., McCrory Constantz, C., Gamba, C., Al-Rasheid, K.A.S., Albizuri, S., Alfarhan, A.H., Allentoft, M., Alquraishi, S., Anthony, D., Baimukhanov, N., Barrett, J.H., Bayarsaikhan, J., Benecke, N., Bernáldez-Sánchez, E., Berrocal-Rangel, L., Biglari, F., Boessenkool, S., Boldgiv, B., Brem, G., Brown, D., Burger, J., Crubézy, E., Daugnora, L., Davoudi, H., de Barros Damgaard, P., de los Ángeles de Chorro y de Villa-Ceballos, M., Deschler-Erb, S., Detry, C., Dill, N., do Mar Oom, M., Dohr, A., Ellingvåg, S., Erdenebaatar, D., Fathi, H., Felkel, S., Fernández-Rodríguez, C., García-Viñas, E., Germonpré, M., Granado, J.D., Hallsson, J.H., Hemmer, H., Hofreiter, M., Kasparov, A., Khasanov, M., Khazaeli, R., Kosintsev, P., Kristiansen, K., Kubatbek, T., Kuderna, L., Kuznetsov, P., Laleh, H., Leonard, J.A., Lhuillier, J., Liesau von Lettow-Vorbeck, C., Logvin, A., Lõugas, L., Ludwig, A., Luis, C., Arruda, A.M., Marques-Bonet, T., Matoso Silva, R., Merz, V., Mijiddorj, E., Miller, B.K., Monchalov, O., Mohaseb, F.A., Morales, A., Nieto-Espinet, A., Nistelberger, H., Onar, V., Pálsdóttir, A.H., Pitulko, V., Pitskhelauri, K., Pruvost, M., Rajic Sikanjic, P., Rapan Papeša, A., Roslyakova, N., Sardari, A., Sauer, E., Schafberg, R., Scheu, A., Schibler, J., Schlumbaum, A., Serrand, N., Serres-Armero, A., Shapiro, B., Sheikhi Seno, S., Shevnina, I., Shidrang, S., Southon, J., Star, B., Sykes, N., Taheri, K., Taylor, W., Teegen, W.-R., Trbojević Vukičević, T., Trixl, S., Tumen, D., Undrakhbold, S., Usmanova, E., Vahdati, A., Valenzuela-Lamas, S., Viegas, C., Wallner, B., Weinstock, J., Zaibert, V., Clavel, B., Lepetz, S., Mashkour, M., Helgason, A., Stefánsson, K., Barrey, E., Willerslev, E., Outram, A.K., Librado, P. and Orlando, L., 2019. Tracking Five Millennia of Horse Management with Extensive Ancient Genome Time Series. *Cell*, 177 (6), 1419–1435. Available from: https://doi.org/10.1016/j.cell.2019.03.049

Gaydarska, B. and Chapman, J., 2020. Discussion. *In*: B. Gaydarska, ed. *Early urbanism in Europe. The Trypillia megasites of the Ukrainian forest-steppe*. Warsaw, Berlin: De Gruyter, 415–507. Available from: https://doi.org/10.1515/9783110664959-010

Hofmann, R., 2013. *Okolište 2 - Spätneolithische Keramik und Siedlungsentwicklung in Zentralbosnien, Neolithikum und Chalkolithikum in Zentralbosnien.* Universitätsforschungen zur prähistorischen Archäologie 243 (Neolithikum und Chalkolithikum in Zentralbosnien 2). Bonn: Dr. Rudolf Habelt.

Hofmann, R., Kujundžić-Vejzagić, Z., Müller, J., Müller-Scheeßel, N. and Rassmann, K., 2006. Prospektionen und Ausgrabungen in Okolište (Bosnien-Herzegowina): Siedlungsarchäologische Studien zum zentralbosnischen Spätneolithikum (5300-4500 v. Chr.). *Bericht der Römisch-Germanischen Kommission,* 87, 41–212.

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Kirleis, W. and Dal Corso, M., 2016. Trypillian Subsistence Economy: Animal and Plant Exploitation. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 195–205. Available from: https://doi.org/10.4324/9781315630731

Korvin-Piotrovskiy, A., Hofmann, R., Rassmann, K., Videiko, M.Y. and Brandtstätter, L., 2016. Pottery Kilns in Trypillian Settlements. Tracing the Division of Labour and the Social Organization of Copper Age Communities. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 221–252. Available from: https://doi.org/10.4324/9781315630731

Kruts *et al.* 2001: Круц, В.А., Корвин-Пиотровский, А.Г. and Рыжов, С.Н., 2001. Трипольское поселение-гигант Тальянки. Исследования *2001 г* / *Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2001*. Киев: Институт археологии НАН Украины.

Levine, M.A., 1990. Dereivka and the problem of horse domestication. *Antiquity*, 64 (245), 727–740. Available from: https://doi.org/10.1017/S0003598X00078832

Levine, M.A., 2005. Domestication and early history of the horse. *In*: D.S. Mills and S.M. McDonnell, eds. *The Domestic Horse: The Origins, Development, and Management of its Behaviour*. Cambridge: Cambridge University Press.

Müller, J. and Videiko, M., 2016. Maidanetske: New Facts of a Mega-Site *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 71–93. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site* / Майданецьке *2013.* Нові розкопки великого Трипільського поселення. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Müller-Scheeßel, N., Hofmann, R., Müller, J. and Rassmann, K., 2010. Müllmanagement in einem spätneolithischen Tell Zentralbosniens. *TÜVA Mitteilungen*, 11, 67–79.

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Orton, D., Nottingham, J., Rainsford-Betts, G., Hosking, K. and Millard, A., 2020. Animal Bones. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 388–409. Available from: https://doi.org/10.1515/9783110664959-009

Reichstein, H., 1994. *Die Säugetiere und Vögel aus der frühgeschichtlichen Wurt Elisenhof*. Studien zur Küstenarchäologie Schleswig-Holsteins. Serie A, Elisenhof 6. Frankfurt am Main: Peter Lang.

Rice, P.M., 1987. *Pottery Analysis. A Sourcebook*. Chicago, London: The University of Chicago Press.

Shatilo, L., 2017. Ornaments and Signs on the Sledge Models from Talianki (Excavation 2012) – Art Decor or a source of information? *In*: C.-E. Ursu, A. Poruciuc and C.-M. Lazarovici, eds. *Symbols and Signs as a Communication System. Papers presented at the international symposium "From Symbols to Signs. Signs, Symbols, Rituals in sanctuaries" Suceava, Romania, 9-11 September 2016. In memory of Gheorge Dumitroaia*. Ethnoreligion Series III. Suceava: Editura Karl A. Romstorfer, 177–185.

Sommer, U., 1991. Zur Entstehung archäologischer Fundvergesellschaftungen: Versuch einer archäologischen Taphonomie. *In:* Mattheusser, E., author. *Die geographische Ausrichtung bandkeramischer Häuser*. Studien zur Siedlungsarchäologie 1 (Universitätsforschungen zur prähistorischen Archäologie 6). Bonn: Dr. Rudolf Habelt, 51–193.

Uerpmann, H.-P., 1972. Tierknochenfunde und Wirtschaftsarchäologie. Eine kritische Studie der Methoden der Osteo-Archäologie. *Archäologische Informationen*, 1, 9–27. Available from: https://doi.org/10.11588/ai.1972.0.35311

Videiko and Burdo 2004: Відейко, М.Ю. and Бурдо, Н.Б., 2004. Животноводство трипольской културы в ериод 5400-2750 гг. до. н.э. *In*: A. Kosko and M. Szmyt, eds. *Nomadyzm a pastoralizm w miedzyrzeczu Wisly i Dniepru (neolit, enolit, epoka brazu) / Nomadism and pastoralism between the Vistula and Dnieper rivers (Neolithic, Eneolithic, Bronze)*. Poznan: Wydawnictwo Poznanskie, 67–93.

Zhuravlov 2004: Журавльов, О.П., 2004. Тваринництво та мисливство у Трипільских племен на території України. *In*: М.Ю. Відейко and Н.Б. Бурдо, eds. Енциклопедія Трипільської Цивілізації, Vol. 1. Київ: Укрполіграфмедіа, 151–198. Available from: https://archive.org/details/trypillia

Zhuravlov 2008: Журавльов, О.П., 2008. Тваринництво та мисливство у трипільських племен на території України. Київ: Інститут археології НАН України.

10. The contribution of Chalcolithic terrestrial snail shells from Maidanetske to environmental reconstruction

Frank Schlütz, Marta Dal Corso, Wiebke Kirleis

Introduction

Various snail species live in distinct ecological niches. Assemblages of ancient snail shells from archaeological samples can thus be used as palaeo-ecological proxies that provide value information on former local environments. As snail individuals are short-living and very limited in range of motion, their finds inform on the contemporary ecological conditions in the direct vicinity of snail shell-bearing archaeological features (Ivanova *et al.* 2020). From the two excavation campaigns at the Chalcolithic mega-site Maidanetske carried out in 2013 and 2016, an assemblage of a total of 369 fossil terrestrial snail shells was analysed. The assemblage is dominated by species living today in open, mainly dry habitats supplemented by a few specimens of species from humid open and woodland environments. Overall, the snail record shows that between the houses and house rings of the Maidanetske settlement open sunny conditions prevailed, but that probably some shaded places potentially covered by small groups of trees or shrubbery existed. This is in line with the allocation of the Chalcolithic settlement in a patchy forest-steppe environment and the development of an anthropogenic agricultural steppe during the site occupation.

Material and methods

A total of 20 samples with small terrestrial snail shells from 12 features in three trenches excavated in 2013 and 2016 at the Chalcolithic mega-site Maidanetske were analysed. Overall 369 individual fossil snail shells could be assigned to a total of 18 taxa, within which 12 species were identified (Tab. 1). Species names and identification follow Kerney *et al.* (1983), Sysoev and Schileyko (2009) and Welter-Schultes (2009). The numbers given are minimum individual numbers. Sub-adult and incomplete shells were assigned to appropriate species within the same sample, specimens without well preserved counterparts were allocated to genus or family level. The earth dwelling species *Cecilioides acicula* was represented throughout by milky translucent shells partly containing remains of the snail bodies, not listed here due to their (sub-)recent age. Data are presented as absolute counts and percentages. Furthermore, a correspondence analysis was carried out to evaluate the interdependencies between archaeological context and snail habitat (Fig. 2) by use of the Excel add-in CAPCA, version 3.1 (Madsen 2016).

Results

All species identified still occur today in central Ukraine in the region around the Maidanetske region. The majority of the species has a Holarctic or European distribution (Tab. 1). *Chondrula tridens* shows a more southern areal which reaches into the steppes of the Pontic region. The Maidanetske snail species can be assigned to five different ecological groups representing a gradient from dry, open habitats to humid woodlands (Tab. 2).

The most dominant species in the Maidanetske snail shell record (Tab. 3) are *Vallonia pulchella* (40%) and *Vallonia excentrica* (19%), two closely related species of open grassy habitats on calcareous soils. In general, both species frequently occur together. In this record the more common *V. pulchella* tends to occur more often in moist environments such as meadows and swamps. On the other hand, *V. excentrica* and the third most common species *Truncatellina costulata* (15%) indicate dry sites with a sparse ground vegetation layer. In summary, the species indicating open, mainly dry habitats account for more than 80% of the finds (Tab. 3: Ecological groups B4 and B5). *Cochlicopa* cf. *lubricella* with single occurrences also lives in dry sites but also in woodland (C6). The two species *Carychium tridentatum* and *Succinea oblonga* contribute by 5% to the assemblage and indicate moist environments

Species	Modern regional occurrence	Ecological group
Acanthinula aculeata	western Palaeoarctis	A1
Carychium tridentatum	Europe	C8
Chondrula tridens	Middle, East and South Europe	B4
Cochlicopa (cf.) *lubricella*	Holarctis	C6
Platyla polita	Europe, alpine	A1
Pupilla muscorum	Holarctis	B5
Succinea oblonga	Europe and Western Asia	C8
Truncatellina costulata	northern Middle and East Europe	B4
Vallonia costata	Holarctis	B5
Vallonia excentrica	Holarctis	B5
Vallonia pulchella	Holarctis	B5
Vertigo pygmaea	Holarctis	B5

Table 1. Terrestrial snail species from Maidanetske and regional occurrence. Ecological groups following Ložek (1971) and Horáčková et al. *(2015).*

ECOLOGICAL GROUPING	HABITAT
B4	dry, open habitat
B5	open habitat
C6	dry, open habitat/woodland
C8	humid, open habitat/woodland
A1	woodland

Table 2. Ecological grouping and respective habitats for terrestrial snail species following Ložek (1971) and Horáčková et al. *(2015).*

SPECIES	SUMME	%	ECOLOGICAL GROUPING	HABITAT
Truncatellina costulata	55	14.9	B4	dry, open habitat
Chondrula tridens	6	1.6	B4	dry, open habitat
Vallonia pulchella	149	40.4	B5	open habitat
Vallonia excentrica	70	19.0	B5	open habitat
Vallonia costata	18	4.9	B5	open habitat
Pupilla (cf.) *muscorum*	3	0.8	B5	open habitat
Vertigo pygmaea	1	0.3	B5	open habitat
Cochlicopa cf. *lubricella*	2	0.5	C6	dry, open habitat/woodland
Carychium tridentatum	16	4.3	C8	humid, open habitat/woodland
Succinea oblonga	1	0.3	C8	humid, open habitat/woodland
Acanthinula aculeata	7	1.9	A1	Woodland
Platyla polita	3	0.8	A1	Woodland
Clausiliidae	7	1.9	-	Indifferent
Zonitidae	6	1.6	-	Indifferent
Cochlicopa sp.	4	1.1	-	Indifferent
Pupilla sp.	2	0.5	-	Indifferent
Truncatellina sp.	2	0.5	-	Indifferent
Columella cf. *columella*	2	0.5	-	Indifferent
Apex indet.	11	3.0	-	Indifferent
Varia	4	1.1	-	Indifferent
SUM	**369**	100		

Table 3. The Maidanetske terrestrial snail species record sorted according to habitat and individual numbers and percentages. Ecological grouping and habitats following Ložek (1971) and Horáčková et al. *(2015).*

including woodland areas. Only *Acanthinula aculeata* and *Platyla polita*, making up less than 3%, clearly prefer woodland. In addition, Clausiliidae are predominant woodland species, but are only represented by apex fragments that are not species-specific. As Miller (2020, 120) states, '*Clausiliidae and Zonitidae are only suggestive of limited shrub-like habitats or isolated stands, and not necessarily woodland* per se'.

Discussion

The Maidanetske terrestrial snail shell record shows a clear indication for open habitats with a predominance of dry steppe environment (Fig. 1). Some species indicate the ecological niche of moist and shaded woodland. This reflects a patchiness typical for a forest steppe environment with open habitats and small groups of trees. This fits with the palaeo-pedological observation that the settlement occupation at Maidanetske coincided with the alteration of the forest Cambisol to steppe Chernozem. The woodland clearance and subsequent land-use activities by the settlers triggered the development of an open agricultural steppe environment (Kirleis and Dreibrodt 2016; Dreibrodt *et al.* 2022). Similar to the mollusc record from Maidanetske, the high representation of open steppe habitat indicators independent from archaeological context was observed in the neighboring Chalcolithic mega-site of Nebelivka. There *Vallonia excentrica* was encountered as the most important species with regular occurrence (Chapman *et al.* 2020, 214). Low species diversity at the Chalcolithic mega-site Nebelivka is interpreted as being linked with Chernozem formation on the site's promontory prior to the time of mega-site occupation (Miller 2020, 119). However, the Nebelivka record could equally be interpreted as showing the patchiness of a mosaic-like forest steppe environment

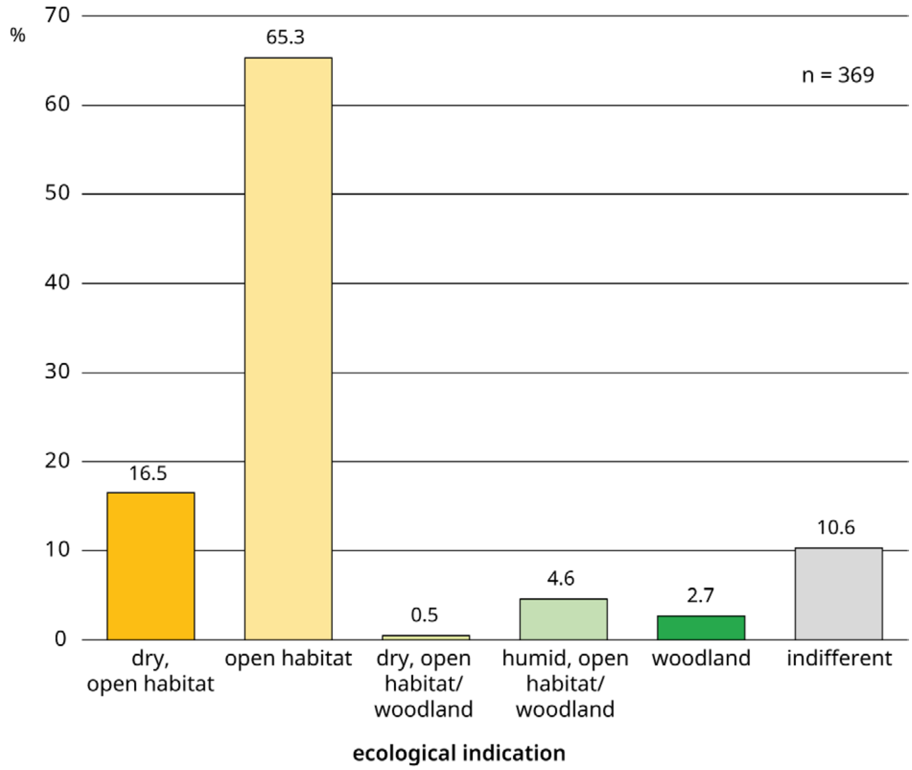

Figure 1. Allocation of the Maidanetske terrestrial snail shell record to ecological groups.

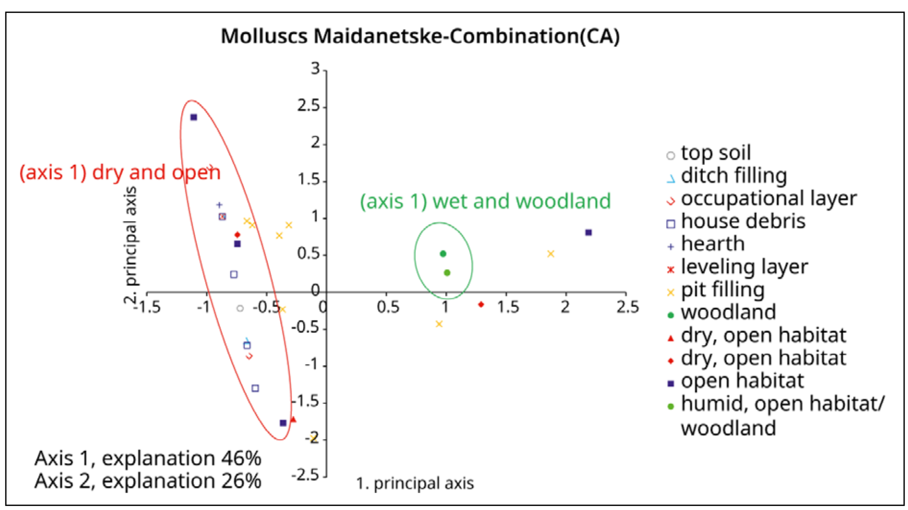

Figure 2. Correspondence analysis of the terrestrial snail shell record from Maidanetske showing interdependencies between archaeological context and snail habitat.

with calcareous soils as a common feature that could either be linked with typical forest soils (Cambisol) or steppe soils (Chernozem).

Proto-urban mega-sites like Nebelivka and Maidanetske are highly structured built environments with houses and pits organised in ring structures, and open spaces that are probably randomly timbered with single trees and shrubberies. To evaluate the dependencies between specific archaeological contexts and snail habitats, a correspondence analysis was carried out (Fig. 2). The eigenvector of the first axis with an explanation of 46% is best explained as a moisture gradient. Ecological groups indicative of dry and open habitats are grouped on the left-hand side of the diagram at eigenvalues between -1.0 and -0.5. There is an overlap with the archaeological feature of house debris. In contrast, the indication of pit fillings is less sharp, showing a wide ecological amplitude. They partially overlap with dry and open habitats, but also show a tendency towards snails from woodland environments.

Conclusions

The snail shell assemblage from Maidanetske reflects mainly dry, open habitats with sunlit open areas with a mostly sparse herbaceous and grass vegetation and, to a minor extent, shady and moist shrub or tree areas. A corresponding small-scale coexistence of these ecological niches shows the diversity of local habitats accessible for snails and human inhabitants within the settlement. On a regional scale, this picture fits nicely with the settlement being located in a patchy forest steppe environment or a heavily thinned forest.

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References

Chapman, J., Arroyo-Kalin, M., Kaikkonen, T. and Ivanova, S., 2020. The Barrow. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 212–214. Available from: https://doi.org/10.1515/9783110664959-008

Dreibrodt, S., Hofmann, R., Dal Corso, M., Bork, H.-R., Duttmann, R., Martini, S., Saggau, P., Schwark, L., Shatilo, L., Videiko, M., Nadeau, M.-J., Grootes, P.M., Kirleis, W. and Müller, J., 2022. Earthworms, Darwin and prehistoric agriculture-Chernozem genesis reconsidered, *Geoderma*, 409, 115607. Available from: https://doi.org/10.1016/j.geoderma.2021.115607

Horáčková, J., Ložek, V. and Juřičková, L., 2015. List of malacologically treated Holocene sites with brief review of palaeomalacological research in the Czech and Slovak Republics. *Quaternary International*, 357, 207–211. Available from: https://doi.org/10.1016/j.quaint.2014.03.007

Ivanova, M., Schlütz, F. and Benecke, N., 2020. Subterranean Silos at Vráble, Southwestern Slovakia: A Case Study of Geochemistry and Distribution of Finds in Fill Deposits. *Slovenská archeológia*, LXVIII (Suppl. 1), 257–271. Available from: https://doi.org/10.31577/slovarch.2020.suppl.1.21

Kerney, M.P., Cameron, R.A.D., Jungbluth, J.H. and Riley, G., 1983. *Die Landschnecken Nord- und Mitteleuropas. Ein Bestimmungsbuch für Biologen und Naturfreunde*. Hamburg: Parey.

Kirleis, W. and Dreibrodt, S., 2016. The Natural Background: Forest, Forest Steppe or Steppe Environment. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 171–180. Available from: https://doi.org/10.4324/9781315630731

Ložek, V., 1971. Zum Problem der Zahl der quartären Klimaschwankungen. *Quartär*, 22, 11–16.

Madsen, T., 2016. *CAPCA v.3.1.* [Software]. *Multivariate analyses in Excel using PCA, CA and MS*. Available from: https://www.archaeoinfo.dk/capca.htm [Accessed 15.04.2021].

Miller, D., 2020. The Molluscan Evidence. *In:* B. Gaydarska, ed. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter, 119–120. Available from: https://doi.org/10.1515/9783110664959-008

Sysoev, A.V. and Schileyko, A.A., 2009. *Land snails and slugs of Russia and adjacent countries*. Pensoft Series Faunistica 87. Sofia, Moscow: Pensoft Publishers.
Welter-Schultes, F.W., 2012. *European non-marine molluscs, a guide for species identification* / *Bestimmungsbuch* für *europäische Land- und Süsswassermollusken*. Göttingen: Planet Poster Editions.

11. Before Talianki: large Trypillian sites built before the largest mega-sites in the Sinyukha basin

Robert Hofmann, Liudmyla Shatilo

Introduction

In March 2017, archaeomagnetic surveys and test excavations were carried out at the three sites of Chizhivka, Veselyj Kut and Volodymyrivka, Ukraine, located in the Kirovograd and Cherkassy districts (Fig. 1). Based on the relative typo-chronology, these sites are older than the mega-sites of the Sinyukha River catchment such as Maidanetske, Talianki and Nebelivka, which have recently been re-evaluated due to a number of new studies (Hale *et al.* 2010; Hofmann *et al.* 2018; Kirleis and Dal Corso 2016; Kirleis and Dreibrodt 2016; Müller 2016; Müller *et al.* 2016b; Müller *et al.* 2017; Nebbia *et al.* 2018; Ohlrau 2020; Ohlrau *et al.* 2016; Ohlrau and Rud 2019; Rassmann *et al.* 2014; Rassmann *et al.* 2016). Accordingly, the idea of conducting fieldwork in Chizhivka, Veselyj Kut and Volodymyrivka was to study these sites in similar ways and understand how they differ from later mega-sites. In particular, we were interested: 1. in the layout and spatial organisation of these settlements; 2. the presence or absence of special buildings that were interpreted on other sites as 'mega-structures' and most likely used as public buildings (Hofmann *et al.* 2019a); 3. the presence or absence of ditches; 4. ceramic complex and indications for pottery production; and 5. of course, the absolute dating of these sites. Furthermore, one of the main objectives was to contribute to the better understanding of the formation process of Trypillia mega-sites, and in particular their ring-shaped settlement layouts. It should be emphasised that this was the first time that sites attributed to 'Eastern Trypillia' – Chizhivka and Veselyj Kut – were explored by magnetic survey.

In Trypillia studies, it is customary to divide sites of this cultural phenomenon into 'eastern' and 'western' (see *e.g.* Movsha 1984; Movsha 1985a; Movsha 1985b; Tsvek 1987; Tsvek 1989; Tsvek 2006; Tsvek 2012; Kruts 1989; Ryzhov 1999; Diachenko 2010; Diachenko 2012). Depending on the nature of the studies, these varieties of Trypillia, are labelled either a 'variant' or a 'culture', which from a modern perspective seems a little outdated. The main difference in material culture is the different ceramic complex, and above all the decoration of dishes – the dominance

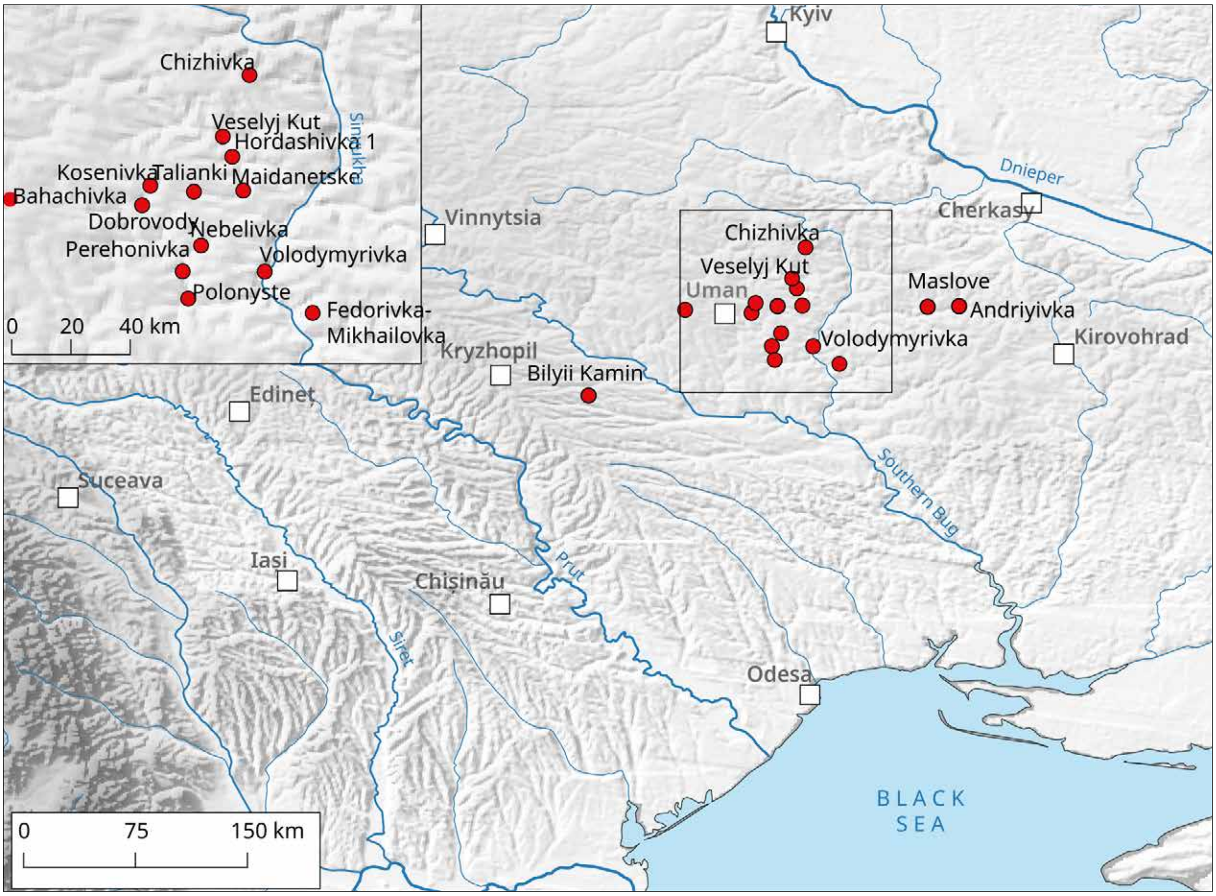


Figure 1. Location of the investigated settlements and other sites mentioned in the text.

deepened decor for the first 'variant' and painted for the second 'variant'. Other distinguishing features of the 'Eastern area' are the limited use of anthropomorphic and zoomorphic plastics, some differences in house constructions, and the presence of outbuildings. The structure of the 'eastern' Trypillia, as well as the 'western', is multi-component; the researchers distinguish four variants and many types of sites (see the background history for this: Shatilo 2021, 17–50). Chronologically, the sites of the 'Eastern Trypillia' in the Sinyukha catchment area are earlier than the 'Western'; the phase of their synchronous existence is assumed (Diachenko and Harper 2016; Ryzhov 2012a; Ryzhov 2012b; Shatilo 2021). With regard to all of the above, we were also interested in the difference in layout between these east-west Trypillia 'variants'.

Methods

Fieldwork strategy

Our fieldwork strategy included carrying out magnetic surveys of available areas at the selected sites over representative areas that were as large as possible. Digital elevation models were created from the elevation data generated during these surveys. In order to obtain archaeological samples for typo-chronological and radiometric dating, we excavated a test trench at each of the investigated sites. For this purpose, we selected pits according to the magnetic plans and excavated small trenches in them. In addition, we performed unsystematic surface collections of archaeological materials in Veselyj Kut and Volodymyrivka. It should be noted that the erosion of the selected sites is quite high; significant parts have been destroyed, primarily by agricultural work. In the settlement of Volodymyrivka, we also documented pits made by looters of antiquities.

Magnetic survey

For the geomagnetic surveys, the MAGNETO® MX V3 Survey System of the company SENSYS Sensorik & Systemtechnologie GmbH Bad Saarow (Germany) was used, which can be utilised in various configurations with up to 16 channels (sensors). During the fieldwork in Ukraine the device was installed on a wheeled cart pushed by two persons. At the time when the surveys where performed 8 sensors were installed with intervals of 0.5 m and a total width of 3.5 m. The magnetic device is coupled with the GPS-system (Leica, GNSS/GPS systems Viva GS 10) enabling continuous grid measurements (zig-zag) in a small amount of time.

No measurement points were available in all surveyed locations which could be used to locate the measurements precisely within the national and world coordinate system. Thus, in each case it was necessary to establish local measurement systems with the available Differential GPS System Leica, GNSS/GPS systems Viva GS 10. Using this method, our measurements can be located in the world coordinate system with a precision of several meters. In order to ensure the possibility of reconstructing the measurement system, fixed points were established and documented. The measurements themselves were performed in UTM coordinate system (zone 36N) and WGS 84 ellipsoid.

Data acquisition, primary data processing, interpolation and export were performed using the SENSYS software package MonMX (v. 4.0), DLMGPS (v. 4.01) and MAGNETO®-ARCH (V3). During export from DLMGPS the Automatic track offset correction was activated. For data export from MAGNETO ARCH we chose the format Surfer grid 7 which delivers raster maps which can be used in GIS-applications and enables the modification of thresholds and colour scale. The standard setting was used, which interpolates the measurement results to 0.2 m x 0.2 m raster cells.

For analysis of the magnetic maps the GIS application QGIS was used. The interpretation of the geomagnetic maps was performed in two different ways. On the one hand, anomalies which could be interpreted more or less definitely such as ditches, (rectangular) remains of burnt houses, or modern disturbances (*e.g.* from power poles) were interpreted and redrawn directly. On the other hand, an automatic classification of the features was performed in order to interpret anomalies of less obvious character too. Therefore, vector polygons were generated using the threshold value of 2 nT and the GRASS algorithm r.contour level based on the raster grid. For these vector objects different statistical values of average, mean and maximum flux density were calculated. To present the data we chose mean and maximum-nT values.

Excavation

For the excavations, we selected pits based on the magnetic plans. We are assuming that pit backfills potentially are the result of longer-term refuse disposal processes reflecting practically the entire biography of an associated house. Their vertical stratigraphy allows Bayesian modelling of ^{14}C dates. During the excavations, we applied a traditional methodology of Trypillia field investigations. Thus, the removal of earth was done in artificial layers (spits), each corresponding to circa 20 cm soil depth, on squares of 1 m^2. Then, after contouring the Copper Age features, excavation was carried out in 'natural' layers, following the specifics of the archaeological objects. After reaching sterile soil outside of the pit, this was left untouched and the pit contents (refill layers) were excavated positively with same 20-cm spits down to the bottom. For the horizontal plana and vertical profiles, digital photogrammetry was used. The exact position was measured for all of the single finds and samples. The finds from the excavations and surface collections remain in the State Historical and Cultural Reserve, 'Trypillia Culture', Lehedzyne, Ukraine. From each of our test cuts in the surveyed sites, we obtained a small number of samples for archaeobotanical studies, which were published elsewhere as part of a larger Trypillia dataset (Kirleis *et al.* 2024).

Veselyj Kut

Location

The site of Veselyj Kut is located in the vicinity of the village of the same name (Talne district, Cherkasy region), on the right bank of the River Gorny Tikich, on the promontory of the first floodplain terrace, which extends into a plateau (Fig. 1). The settlement has natural boundaries on the three sides – the waters of the Gorny Tikich on the north and east, and a natural ravine on the south. The terrain slopes gently upwards to the east in the area of the settlement.

Study history

Veselyj Kut is attributed to the earliest mega-sites (Tsvek 1980; Tsvek 1985; Tsvek 1999; Tsvek 2006; Ohlrau 2015); for a long time it was believed that its area reached 150 hectares. The settlement was discovered in 1970 by a history teacher M. D. Melnik from the village of Popuzhenka. In 1974-86 and in 1993 the site was explored by the expedition of the Institute of Archaeology headed by O. V. Tsvek. During this time, 24 'ploshadkas' were excavated completely and 32 were trenched (Tsvek 2006, 22; see Fig. 2). The materials obtained during these excavations is stored in the Institute of Archaeology of the National Academy of Sciences of Ukraine.

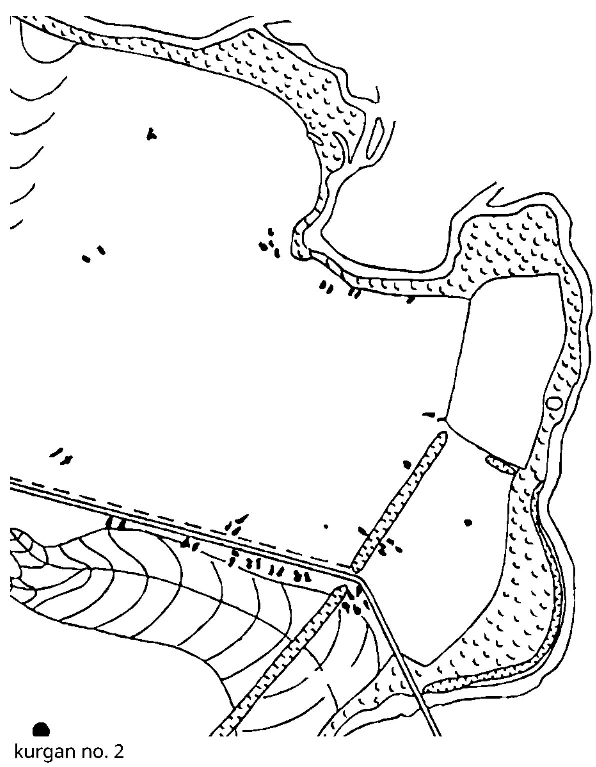


Figure 2. Veselyj Kut: Plan of the site (after Tsvek 2006, Fig. 10).

According to the head of the expedition, Elena Tsvek, at least 17 of the investigated houses are residential, one-story, ground-level, mostly two-roomed. For seven of the buildings, economic and production functions are being reconstructed (tannery, bone-cutting, stone-cutting workshops and outbuildings). In addition, for two buildings, an interpretation of pottery workshops is proposed (Tsvek 2006, 22–23).

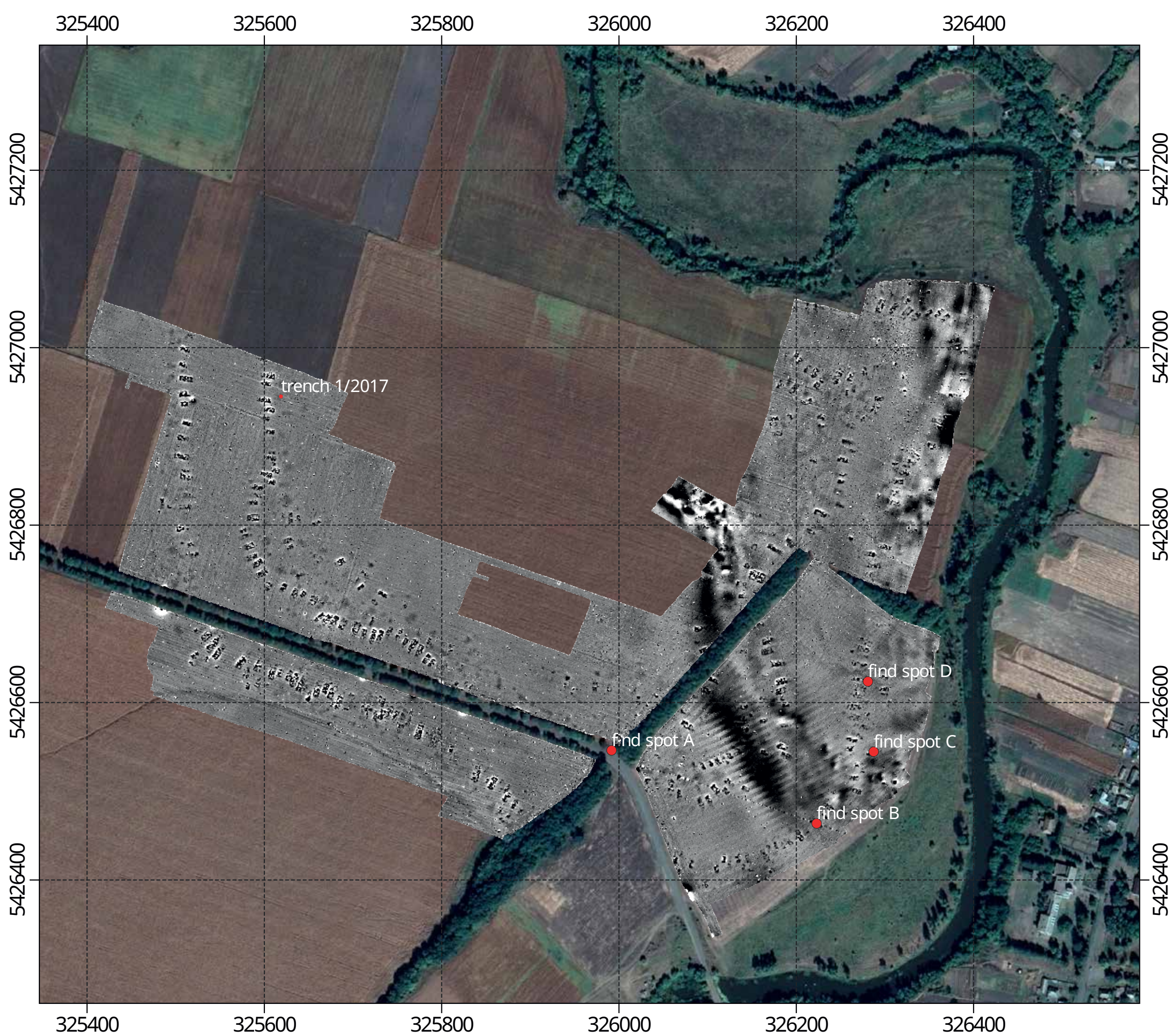
O. V. Tsvek placed the settlement within the Bug-Dnieper variant of the Eastern Trypillia Culture, stage B1–B2 and attributed it to the cognominal type of sites (type Veselyj Kut). According to the author, the sites of the same type are Botvinovka, Bugachevka, Deshky, Kharkivka, Kopiuvata (Tsvek 2006, 26).

Main results

Description of the settlement plan

During the fieldwork in Veselyj Kut, an area of 35 ha in the south and east of the site was surveyed archaeomagnetically, covering little more than half of the settlement area (Fig. 3). Based on the magnetic plan, we identified around 300 highly magnetic anomalies interpreted as the remains of burnt buildings, the majority of which exhibit a rectangular shape. Some of these anomalies show different degrees of

Figure 3. Veselyj_Kut: Magnetic map with location of Trench 1/2017 and surface find spots A–D. Coordinate reference system: WGS84/UTM36N.



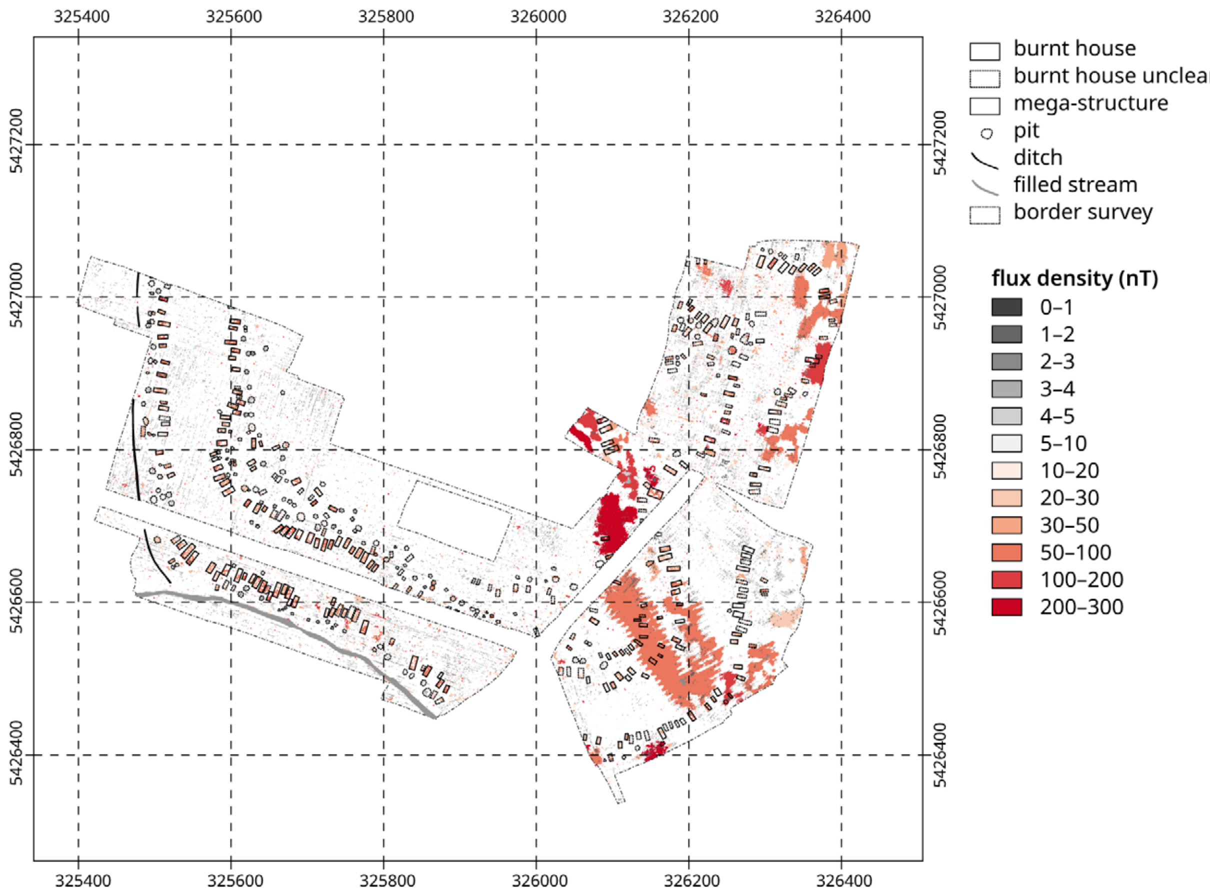


Figure 4. Veselyj Kut: Extension, maximum flux density and interpretation of archaeomagnetic anomalies based on a 1.5-nT isoline. Coordinate reference system: WGS84/UTM36N.

magnetisation and regularity (Fig. 4). Based on this, a classification was made into 171 securely delimitable and 127 less well delimitable buildings. Securely defined building remains have floor areas between 15 and 200 m², with a mean value of 64 and a median of 58 m². Less well-defined building remains are clearly smaller, with floor areas between 8 and 108 m², with a mean of 44 m² and a median of 39 m².

Besides buildings, numerous smaller oval or round anomalies exist in the magnetic plan next to the houses, the majority of which show lower magnetisations than houses and probably originate from pits. To the west of the surveyed area, a weak linear anomaly runs over a total length of 300 m, which we interpret as the remains of a backfilled ditch. To the south, this anomaly joins another linear anomaly, which runs in an east-west direction in a small valley. It is likely to represent an infilled creek. In the east of the surveyed area, there are several large-scale high-magnetic areas, some of which overlap just visible house anomalies. The latter anomalies are likely to represent structures of geological origin.

Given the location of the described anomalies in the magnetic plan and other houses in older excavation plans of O. Tsvek, the distribution of surface finds and the terrain in the area of the site, our survey covered the southern and eastern area of the settlement of Veselyj Kut (Fig. 5). The majority of the houses are arranged in two rows along a ca. 45–85 m wide unbuilt zone, which encircles the centre of the settlement in an irregular oval to the west, south and east. Individual houses and short rows of houses are placed behind the inner row of houses. In addition, pits are not located within the zone between the rows of houses, which is instead completely free of anomalies, but inside and outside of these house rows behind the narrow sides of the houses. To the west, this rear zone of houses is bordered

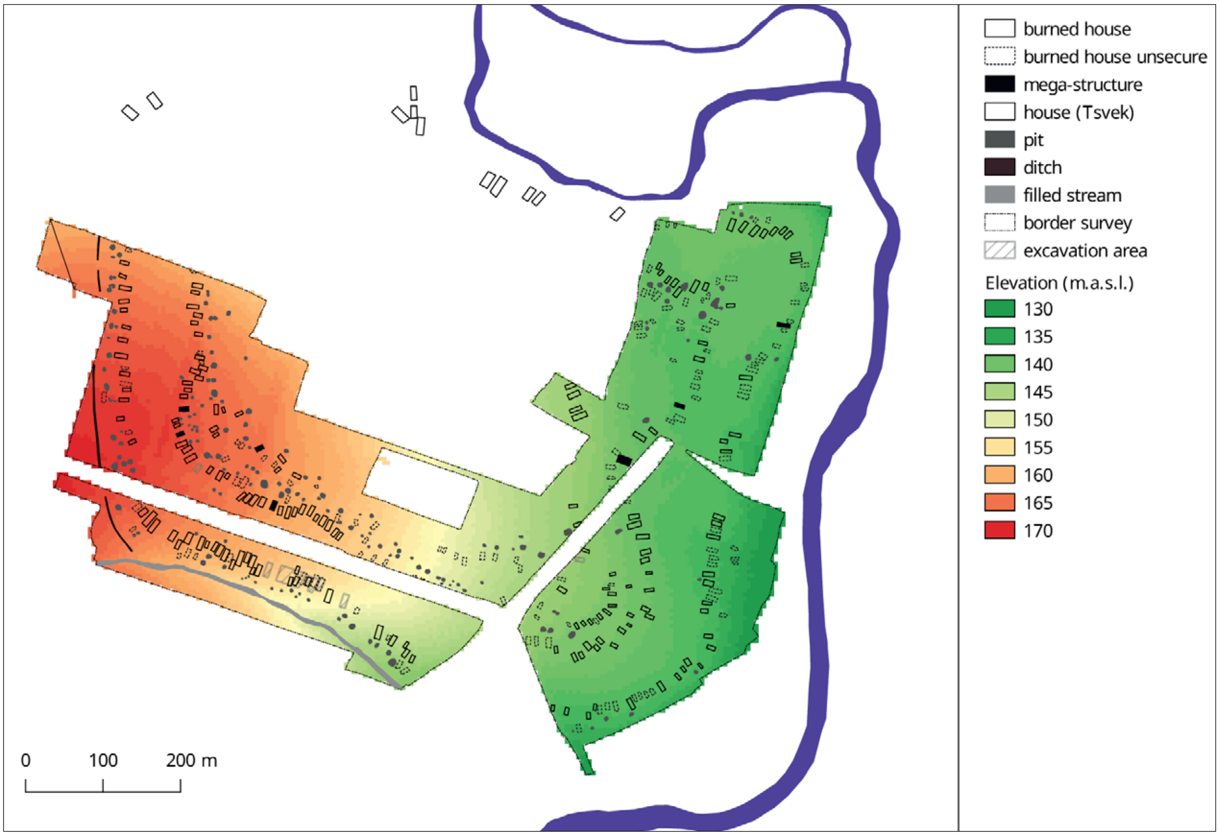


Figure 5. Veselyj Kut: Interpretation of the magnetic plan including digital elevation model of the surveyed area. Coordinate reference system: WGS84/UTM36N.

by the linear anomaly of the ditch, behind which the magnetic picture is free of archaeologically relevant anomalies.

The two main house rows show partly different courses. While the outer row tends to circumscribe a overall rectangular shape with slightly convex incurved sides and rounded corners, the inner row of houses shows stronger curvatures. As a result, the settlement layout has a cloverleaf-like shape. The difference between the inner and outer house rows is particularly evident on the east side of the settlement, where a triangular plaza was formed through the bending of the inner house row towards the centre of the settlement. In part, the course of the house rows seems to follow the natural terrain and could be due to the attempt to minimise elevation differences within the ring corridor. This is evident on the eastern side of the settlement, but is not the case for the western part.

Within the settlement plan, several buildings have been identified which, due to their position within the settlement and their architecture, could be considered as possible remnants of communal buildings (Hofmann *et al.* 2019a; see Fig. 6). This is particularly true in the case of an 18.5 × 11.0 m large building at the vertex of the curve of the inner house row on the east side of the settlement. In other cases, the interpretation as possible mega-structures is based on their signature in the magnetic plan which differs from residential buildings by highly magnetic linear anomalies appearing mainly along the walls.

Interpretation of the settlement plan

Based on the archaeomagnetic plan and the location of earlier archaeologically investigated houses, we can estimate the size of the settlement of Veselyj Kut to be 60 ha. Thus, the site was significantly smaller than assumed in earlier estimates.

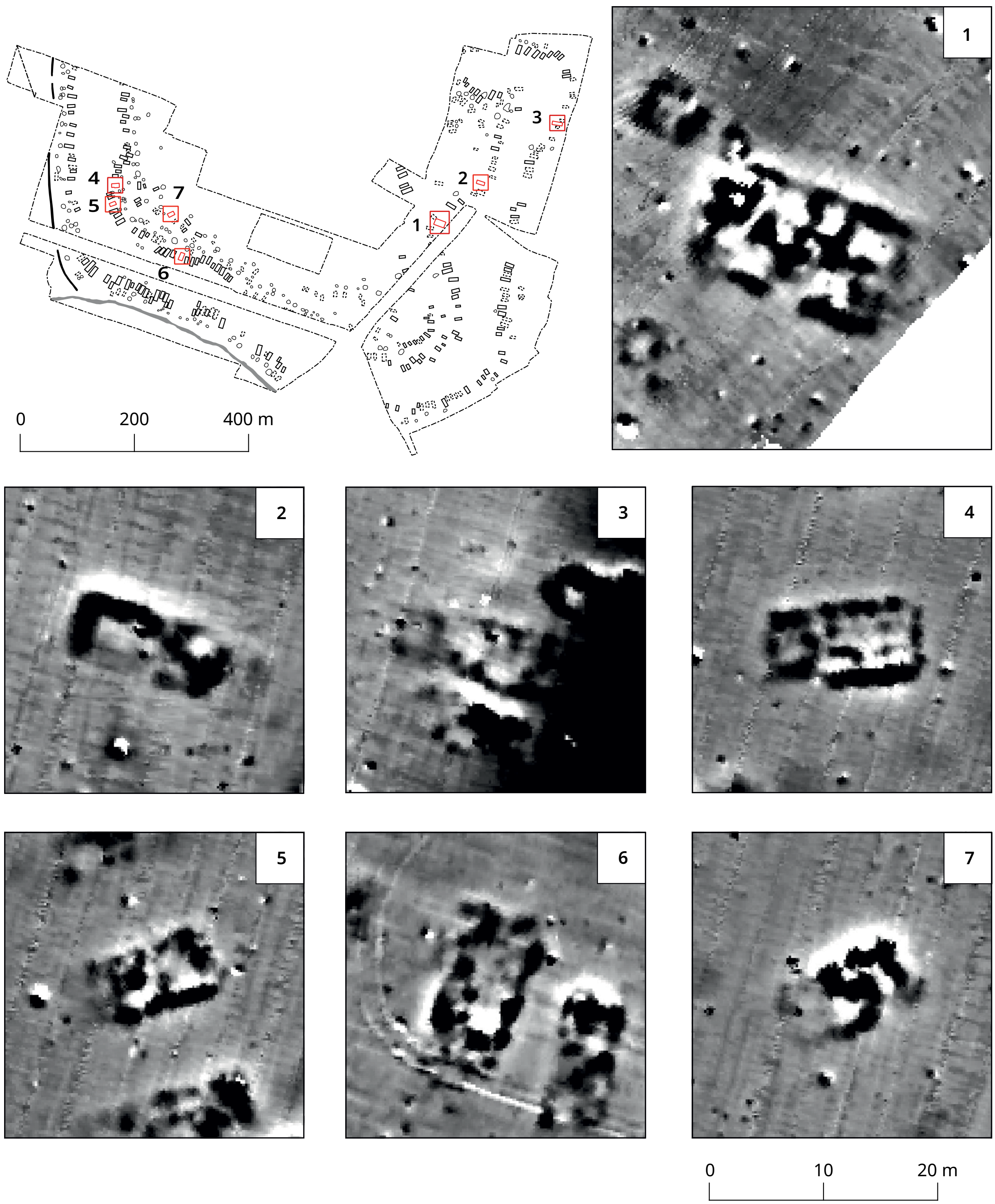


Figure 6. Veselyj Kut: Anomalies of buildings with potential public functions.

With regard to the layout of the settlement, it should be emphasised that in Veselyj Kut a concept was achieved in which a circumferential ring corridor was the central component of the settlement planning, which concentrically surrounded the unbuilt settlement centre (Fig. 5). However, in contrast to settlements such as Maidanetske and Talianki, perhaps a rectangular layout was intended. Apart from that, irregularities of the settlement layout were possibly motivated by alignment to the natural terrain.

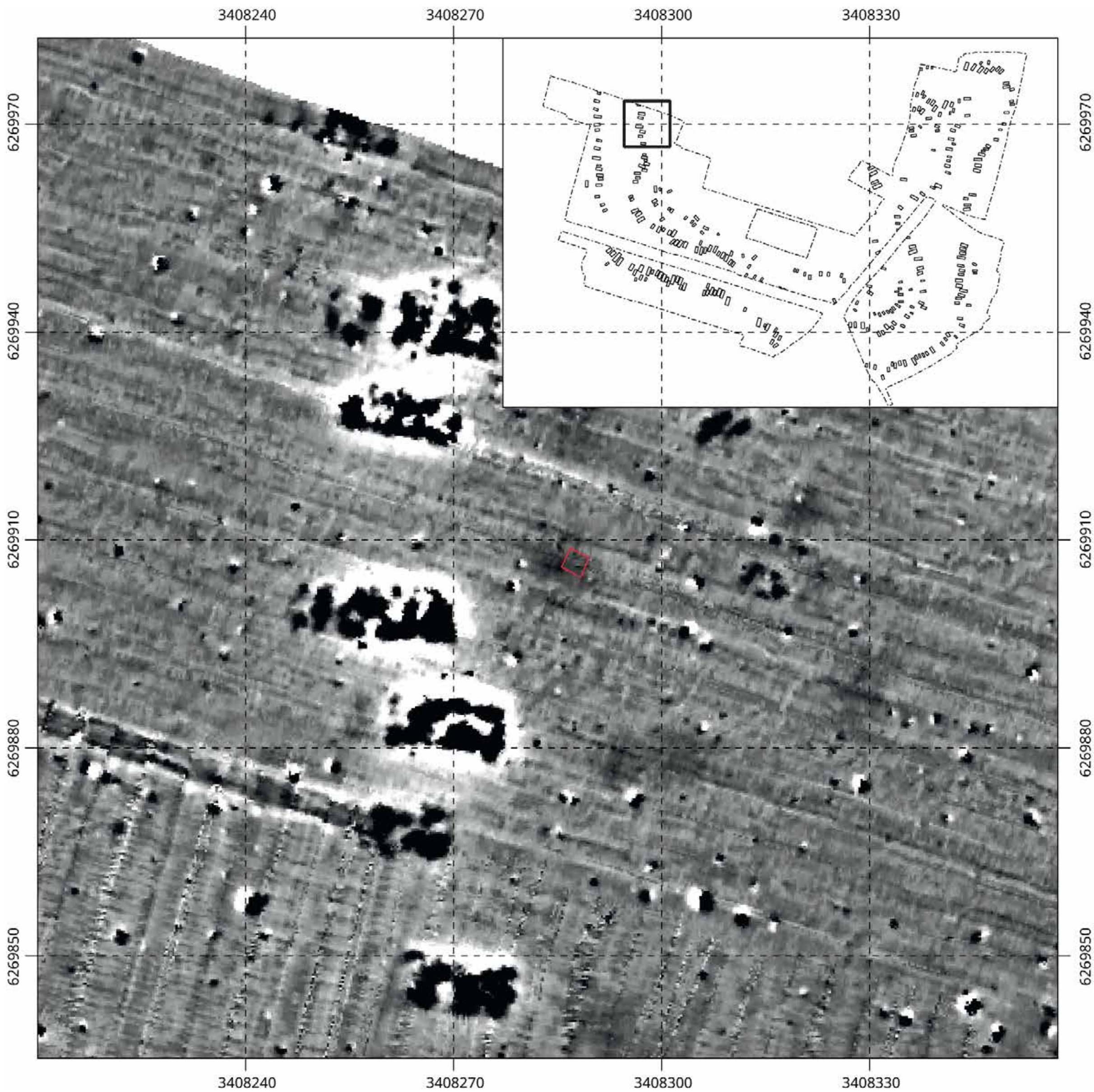


Figure 7. Veselyj Kut: Detail of the magnetic plan with location of Trench 1/2017 within the anomaly.

Measured along a central line, the ring corridor of Veselyj Kut was surveyed over a length of about 1750 m. This corresponds to 65% of the estimated total length of the ring corridor. Assuming a similar building density in the areas not surveyed, the settlement should have consisted of approximately 300 houses in total. However, as for other sites, these houses may not have all been in use at the same time, but should be distributed over the entire period of occupation (*e.g.* Shatilo 2021, 211–216).

Trench 1/2017

We established Trench 1/2017 in the rear area of the inner house row of the ring corridor, where a diffuse anomaly of about 4 × 3.5 m size is located, about 7 m northeast of a burnt house (Fig. 7). The trench, with an extension of 2 × 2 m, was placed at the presumed eastern boundary of the pit anomaly. The terrain surface in the area of the trench lay at a height of 161.77 m[1]. Beneath the 0.7 m thick Chernozem

1 Since the elevation values provided by the Leica GNSS system Viva GS 10 were systematically incorrect, they were corrected by a value of -30 m.

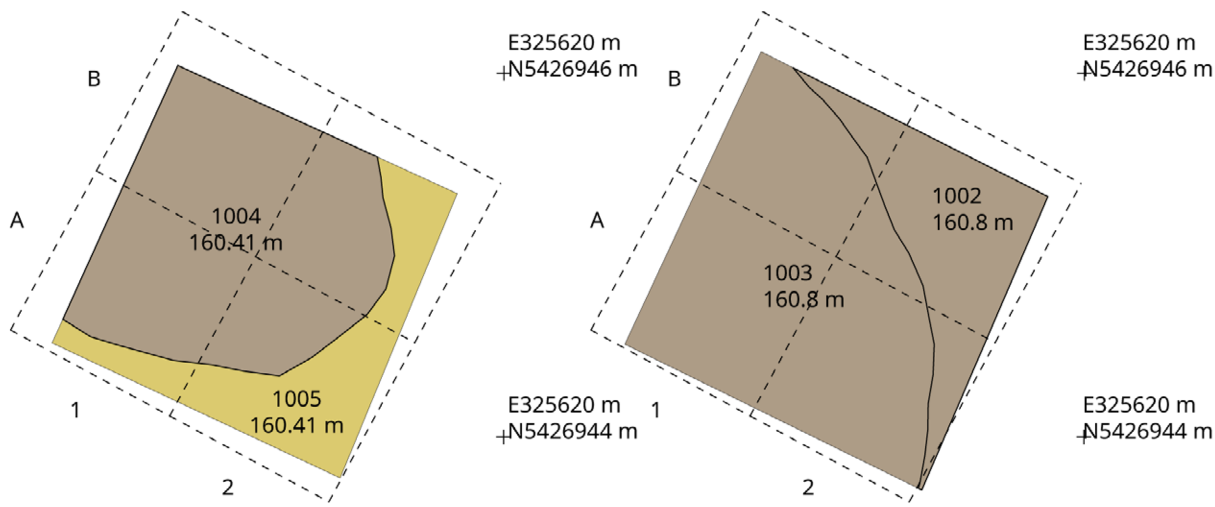


Figure 8. Veselyj Kut: North profile of Trench 1/2017

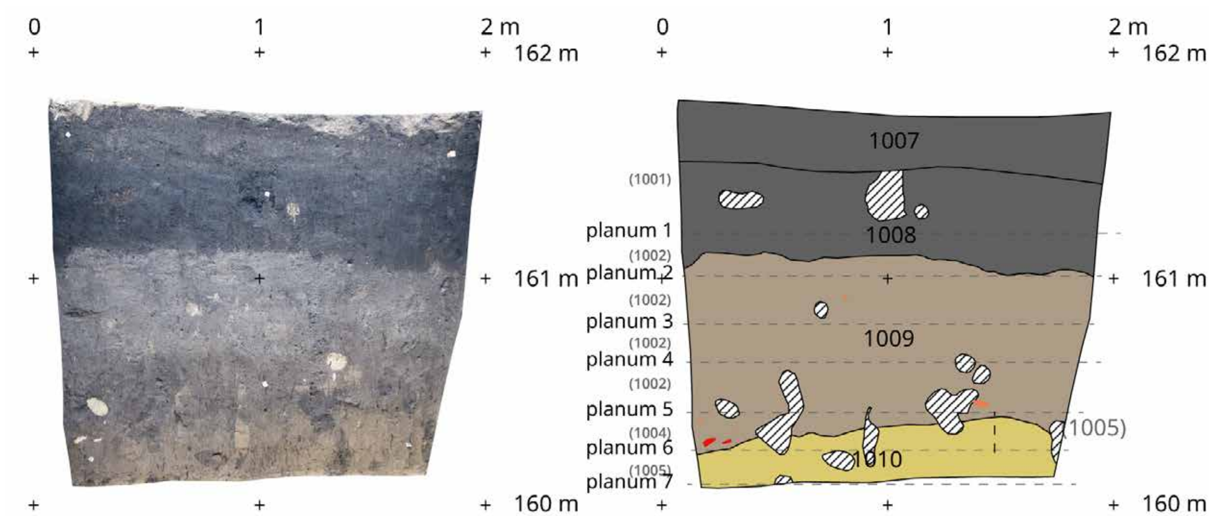


Figure 9. Veselyj Kut: Plana 3 and 5 of Trench 1/2017.

layer (Feature 1001, 1007, 1008), the relatively homogeneous upper filling of the pit was located (Features 1002, 1003, 1009; Fig. 8). Contrary to our expectations, we did not find the eastern limits of the pit within our trench. Only in Planum 5 at a level of 160.4 m did we reach the eastern wall of the pit (Features 1005 and 1010; Fig. 9). The lower backfill layer of the pit (Levels 5 and 6) contained a larger number of pottery and burnt daub fragments (lower part of Features 1002 and 1003 and Feature 1004). At a depth of 190.2 m, the bottom of the pit was reached, in the yellow loess loam (Features 1005 and 1010).

Finds from Trench 1/2017

The pottery assemblage from Trench 1/2017 in Veselyj Kut consisted of 64 pottery fragments weighing 0.96 kg, originating mainly from the 5th and 6th spits shortly above the pit bottom (Features 1002, 1003 and 1004).

From the technological point of view, we can distinguish medium fine and fine reduction-fired fabrics (n=51) and medium fine oxidation-fired wares (n=13). These fabrics are very different from the highly standardised light-fired fabrics that dominate the pottery spectrum of later mega-sites.

Fabrics fired in a reducing atmosphere show tempering with quartz sand, a colour spectrum from medium to black-grey and a homogeneous firing (homogeneous colour distribution). Some fragments are on their surface are secondarily discoloured orange, but retain a dark core. Apart from medium-fine wares with carefully smoothed surfaces (n=36), some high-quality sherds have polished surfaces (n=15). Fully oxidised fired sherds have smoothed light to medium orange surfaces and show macroscopically visible inclusions of quartz sand, grog or organic components.

From a morphological point of view, craters (n=2; Fig. 10: 5), crater-shaped (n=11; Fig. 10: 6), unspecified closed vessels (n=3) and conical and spherical bowls (n=1) can be identified. For the majority of the fragments (n=47), no morphological classification was possible.

Decorations or other surface designs occur in 38% (n=24) of the sherds which might be partly due to erosion of the sherd surfaces. Most frequent are 'deepened grooves' (n=29), which are usually arranged in parallel bundles forming different linear or curvo-linear motifs (Fig. 10: 4–7, 10, 11). In one case, possible remnants of incrustation were observed in such a groove. Frequently found also are rows of impressions on the outer or upper side of the rim of the vessel (n=12; Fig. 10: 5, 7) and stamp impressions as a single element or row (n=4; Fig: 10, 5). In one case the surface of the shoulder is decorated horizontal channelling (Fig. 10: 4). Engobe was detected on the interior and/or exterior of at least five sherds, however, it occurs on both oxidising and reducing fired pottery.

In addition to the collection of pottery, we found a fragment of an unidentified non-pottery ceramic object in Trench 1 (Find-ID 1018; Fig. 10: 12). The object was made of yellowish-white, smoothed and slightly weathered clay (without visible tempering) and had an orange engobe on the inside and outside. The object seems to depict a vertical element (post of a house model?) and has a small knob on the inside. Two quarry stones consisting of red fine-grained granite were also recovered from Trench 1.

Surface finds

During unsystematic surface collections, the surface find spots A–D were identified in the eastern part of the settlement, where burnt daub, pottery, ground stone artefacts and bones have been ploughed to the surface (Figs. 10 and 11; Tab. 1). Each of these find spots probably represents remnants of house inventories.

Only a very small collection of animal bones, mostly cattle, was recovered from Veselyj Kut (Table 2).

Scientific Dating

Eight ^{14}C dates were obtained on material from Veselyj Kut, three of which originated from Section 2017/1, and five dates from the surface hotspots A–D (see Suppl. 1 in Chapter 19, this work, Vol. II). An indeterminate bone from Feature 1002 and two charcoals (*fraxinus*) from Features 1003 and 1004 were dated from Trench 1/2017, all of which belong to the lower backfill layers of the pit. One date originates from each of the find concentrations A–C, and two dates from find concentration D, all obtained from cattle bones. Apart from the younger outlier Poz-97921, the samples fall into a longer flat section of the calibration curve between about 4200 and 4000 BCE.

After modelling of all Copper Age dates, the samples date with the highest probability to the period between 4070 and 4000 BCE (Shatilo 2021, 146–148). The pit in Section 1/2017 dates with the highest probability to the period between 4170 and 4040 BCE. A similar dating between 4170 and 4000/3990 was also found for find concentration B. Find concentration C falls with the highest probability between 4035–3970 and find concentration D between 4230/4225 or 4160 and 4050 BCE.

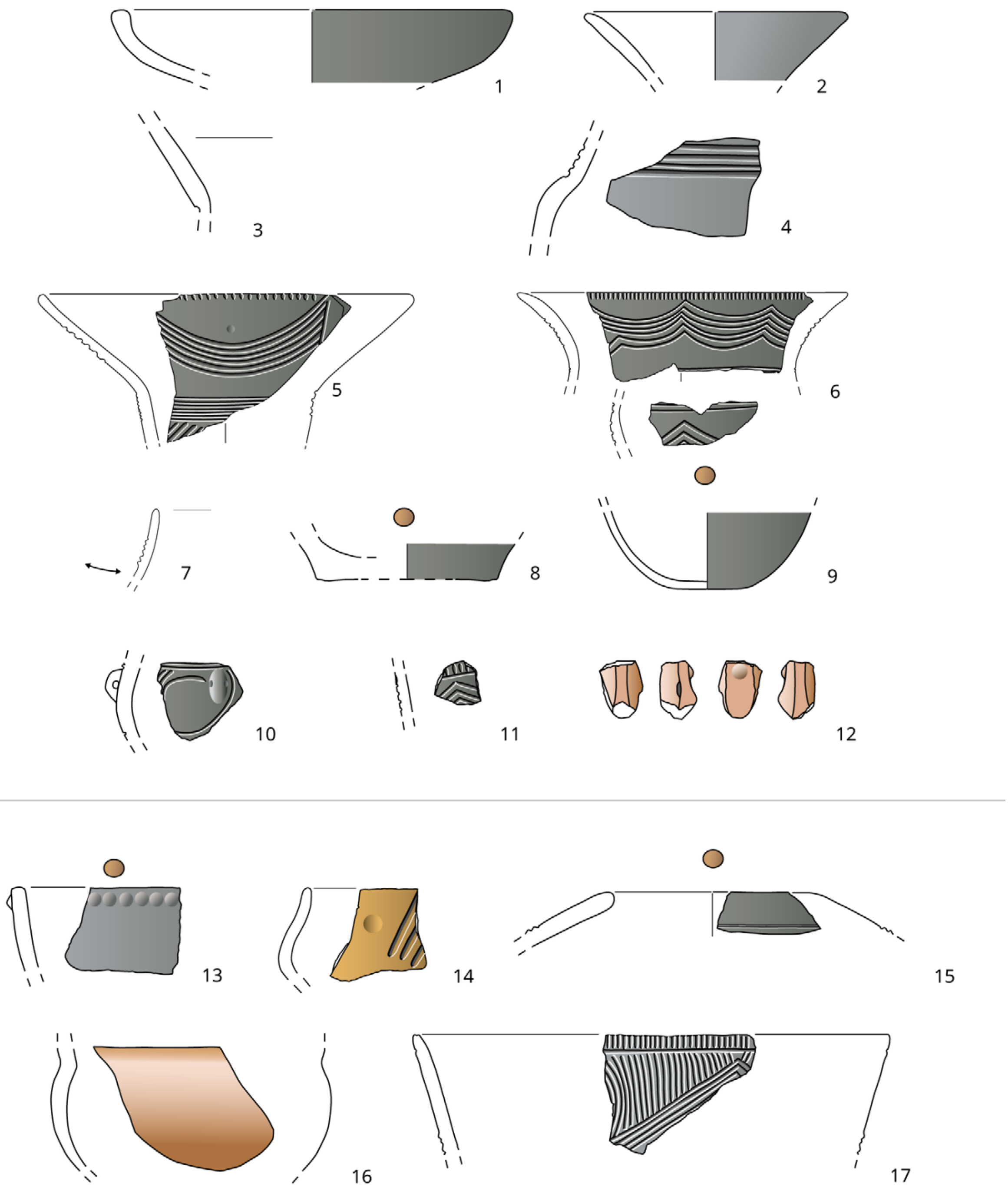


Figure 10. Veselyj Kut: Selection of ceramic finds from Trench 1/2017 (1–12) and find spot A (13–17): 1. Find-ID 1011; 2. Find-ID 1018; 3. Find-ID 1009; 4. Find-ID 1018; 5. Find-ID 1016; 6. Find-ID 1017; 7. Find-ID 1009; 8. Find-ID 1012; 9. Find-ID 1017; 10. Find-ID 1017; 11. Find-ID 1017; 12. Find-ID 1018; 13. Find-ID 2005; 14. Find-ID 2005; 15. Find-ID 2005; 16. Find-ID 2005; 17. Find-ID 2005. Scale 1:3 (3, 4 and 14) or 1:4 (1–2 and 5–13 and 15–17).

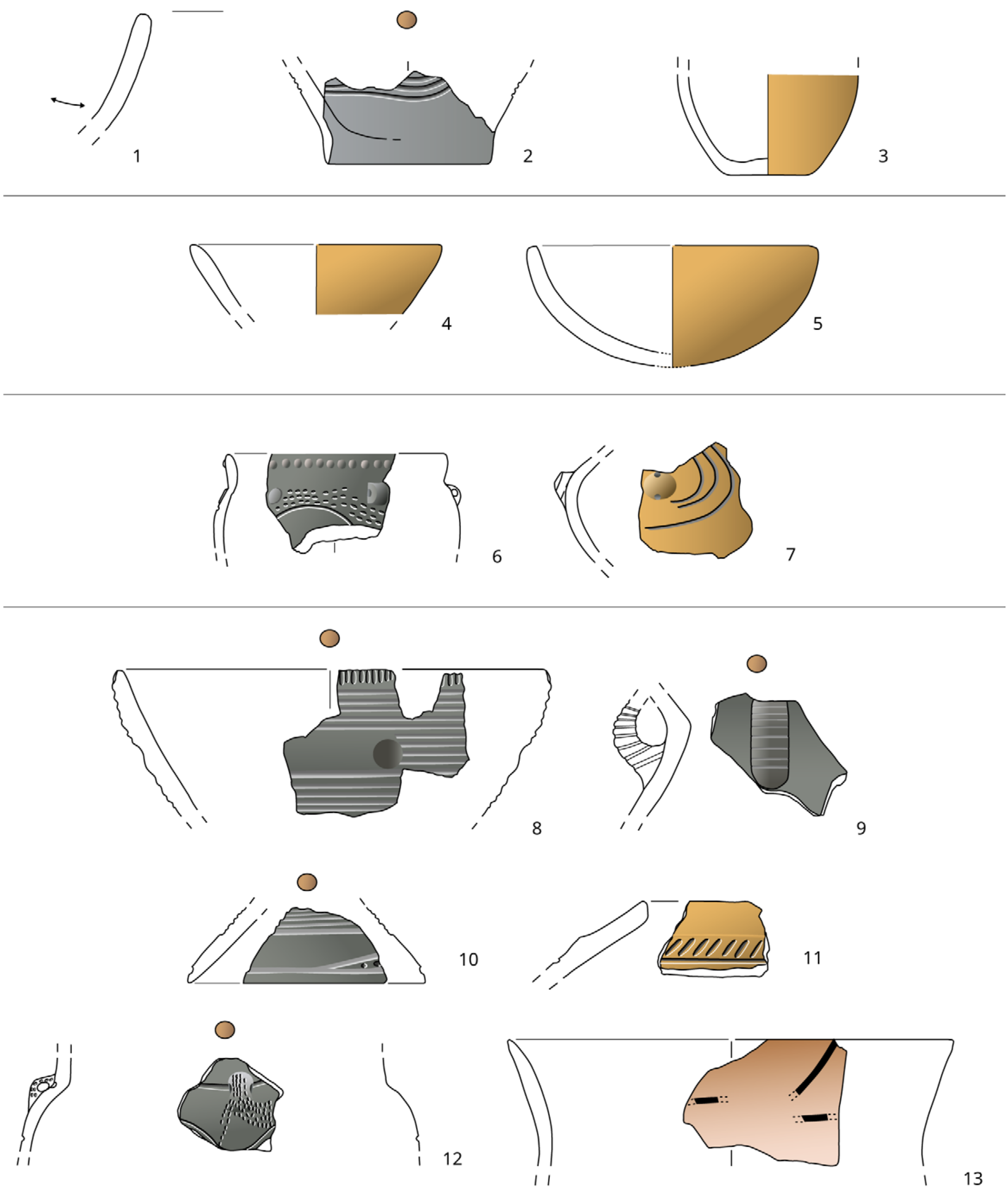


Figure 11. Veselyj Kut: Selection of ceramic finds from the find spots A–D: A. Find-ID 2005 (1–3); B. Find-ID 2004 (4–5); C. Find-ID 2002 (6–7); D. Find-ID 2003 (8–13). Scale 1:3 (1, 3, 4, 7, 11 and 13) or 1:4 (2, 5, 6, 8, 9, 10 and 12).

Table 1. Veselyj Kut: Frequency of technological fabric groups found in Trench 1/2017 and during unsystematic surface collections.

Fabric	Trench 1 number	Trench 1 weight (g)	Surface finds
01–04 table: undifferentiated	2	34	2
16 kitchen: organic/grog temper			1
Veselyj Kut: medium, reducing	36	544	102
Veselyj Kut: medium, reducing high quality	15	204	9
Veselyj Kut: medium, sand, oxidizing	11	174	54

Find-ID	Feature-ID	level	X	Y	NISP	weight (g)	taxon	element	14C
1007	1002	5	B	2	1	1	indet.	indet.	Poz-98225
2002	find spot C				1	9	bos	mandibula	Poz-97923
2003	find spot D				1	71	bos	humerus	Poz-97925
2003	find spot D				1	60	bos	talus	Poz-97926
2004	find spot B				1	8	bos	mandibula	Poz-97922
2005	find spot A				1	19	bos	tooth (M3)	Poz-97921

Table 2. Veselyj Kut: List of animal bones.

Chizhivka

Research history

The settlement was discovered by L. S. Leshchenko and in 1962 was examined by V. A. Stefanovich and by a teacher from the local school, O. F. Gorbanenko. In 1973–1974, the settlement was investigated by the expedition of the Institute of Archaeology of the Academy of Sciences USSR (IA AS USSR), headed by O. V. Tsvek. The materials are stored in the Uman Local History Museum and at the school in the village of Chizhivka (Tsvek 2006, 50).

Having analysed the material, O. V. Tsvek attributed Chizhivka to the late period of the Krasnostavky type or to the Onopriyivka type, which she dated to the second half of stage B1 or the beginning of B1–B2 (Tsvek 2006, 50, 65). In any case, the site relates to the Bug-Dnieper variant of the 'Eastern Trypillia Culture' (Tsvek 2006, 50).

Location

The site Chizhivka is located between the villages of Chizhivka and Tikhonovka (Zvenigorodka district, Cherkasy region), in the Sinozhad area, on the plateau formed by the bend of the nameless stream which defines the settlement from the east and north (Fig. 1). In the south of the settlement, there is a natural ravine.

Main results

Description of the settlement plan

During the fieldwork in Chizhivka, 12.7 ha were surveyed archaeomagnetically and most of the currently available settlement area was mapped (Fig. 12). Only a small area in the south unfortunately had to remain unsurveyed as the battery of the magnetic device was down and no further time was available. Not accessible is the northern part of the site, which is nowadays under forest. In the magnetic

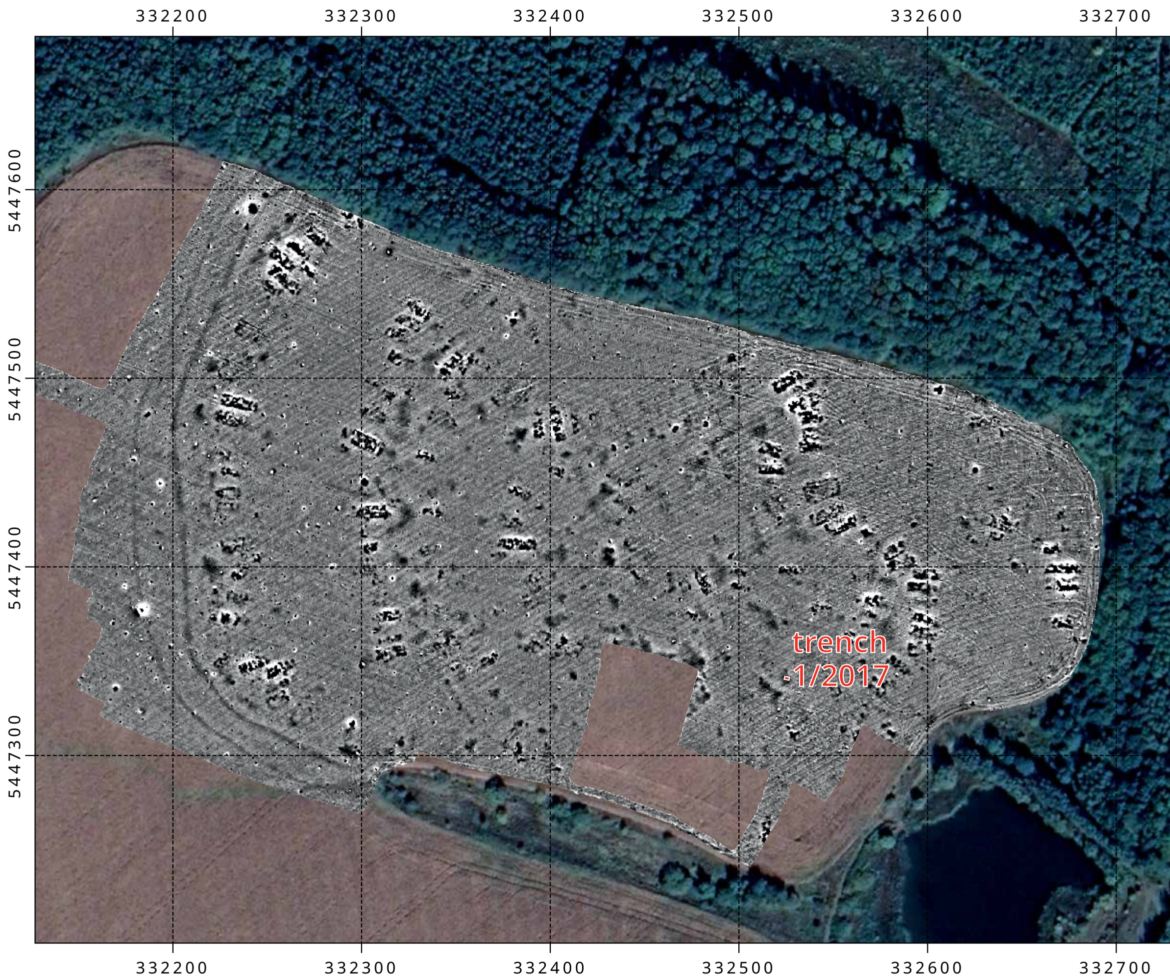


Figure 12. Chizhivka. Magnetic map with location of Trench 1/2017. Coordinate reference system: WGS84/ UTM36N.

plan of Chizhivka we can identify at least 137 tendentially rectangular anomalies of buildings, of which 61 were classified as securely delimitable house anomalies, 75 as less securely delimitable house anomalies and one as the remains of a communal building (Fig. 13). Securely definable anomalies have a median size of 60.48 m^2 and a mean of 66.49 m^2. Less definable anomalies of buildings have a median size of 57.1 m^2 and a mean of 63.55 m^2. The potential communal building shows a floor area of 175.4 m^2.

In the west, a semi-circular double ditch delimited the settlement area over a length of about 385 m, which seems to have widths of between 2.5 and 4 m. In addition, throughout the settlement between the anomalies of houses numerous smaller, oval or amorphous anomalies are visible, which in many cases show lower magnetisations. We interpret these as the remains of backfilled pits (Fig. 14).

The remains of dwellings forming longer and shorter rows are concentrically arranged around the centre of the settlement, where only single buildings or short rows of buildings are visible. The largest number of buildings is concentrated in the two outer rows of buildings, which run parallel to the ditch to the west and border a 50–80 m wide zone largely free of smaller anomalies. To the north and south, these ‘central’ rows swing concavely inwards and buildings appear less well preserved. In the east, the inner row of houses in particular shows good preservation, while the outer row nowadays lies partly under forest and beneath water level in a small pond.

The identification of a possible communal building is based on two of three elsewhere defined criteria (Hofmann *et al.* 2019a). By drawing in the inner row of houses towards the centre of the settlement, a small plaza of 80 x minimum 90 m

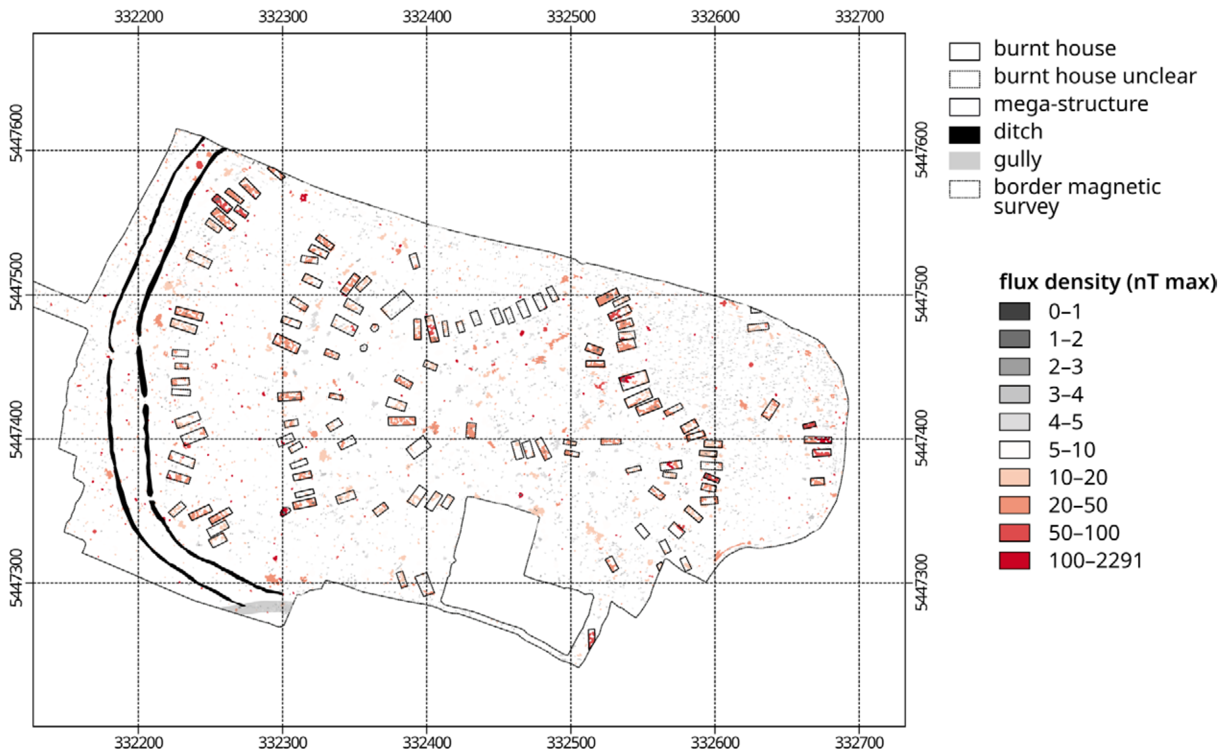


Figure 13. Chizhivka. Extension, maximum flux density and interpretation of archaeomagnetic anomalies based on a 2-nT isoline. Coordinate reference system: WGS84/UTM36N.

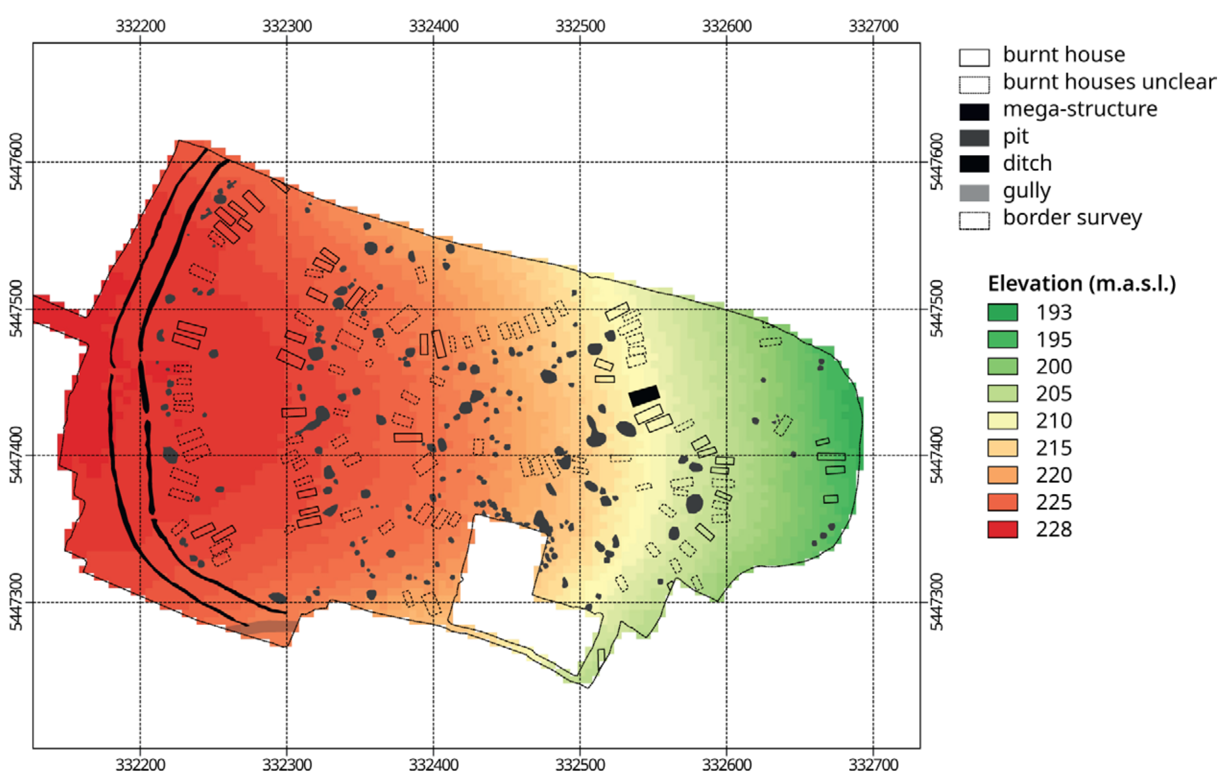


Figure 14. Chizhivka. Interpretation of the magnetic plan including digital elevation model of the surveyed area. Coordinate reference system: WGS84/UTM36N.

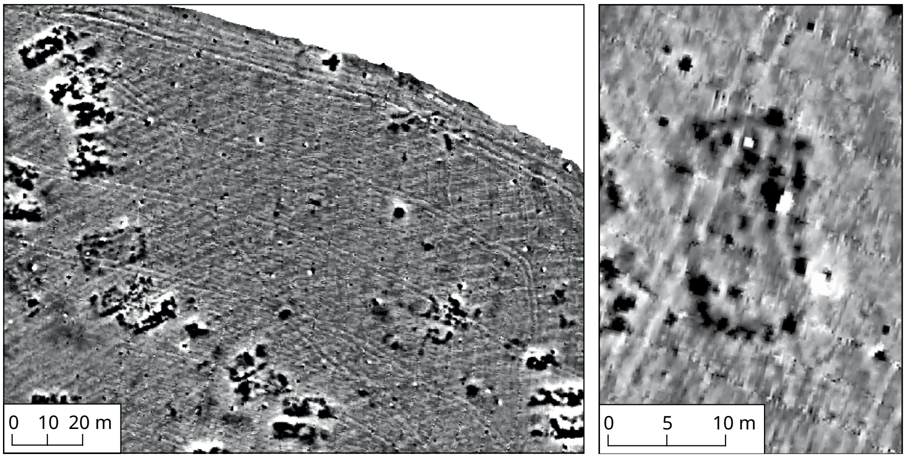


Figure 15. Chizhivka. Plaza-like widening of the ring corridor in the east of the settlement with central mega-structure.

was built on the eastern side of the settlement (Fig. 15). The building structure in question stands somewhat separated in the middle of the inner row of houses in a position where presumed communal buildings are also found in other settlements (*e.g.* Nebelivka, Veselyj Kut).

The building structure differs from presumed dwellings: 1) by a more compact length-to-width ratio and 2) the absence of larger deposits of burnt daub on the interior space. In analogy to other mega-structures, areas of higher magnetisation are restricted mainly to along the outer walls. According to excavation evidence at Maidanetske, this seems to indicate a building structure that was architecturally distinguished from dwellings at least partially by the absence of a roof.

Interpretation of the settlement plan

Although we only recorded about 12.7 ha of the settlement area during our survey, a reliable estimate of the settlement size is possible if we take the course of the adjacent small river as the northern and eastern limits. Accordingly, the settlement area amounted approximately to 20 ha. The measured area equates to about 62.5% of the total settlement surface. The entire settlement must have consisted of about 225 houses, which, however, were probably not simultaneously in use (*e.g.* Shatilo 2021, 211–216).

According to the results of our survey, we were dealing with a circular settlement layout with a similar curvature in the eastern part, as in Veselyj Kut. The central component and main traffic axis of this settlement was most likely the circumferential ring corridor. The crucial criterion for this interpretation is, among other things, the uneven spatial distribution of potential pits: while the zone between the outer two house rows – the probable ring corridor – is largely free of such features, numerous anomalies are concentrated in the centre of the settlement and in the space between the outer row of houses and the ditches. The distribution of anomalies also implies that in Chizhivka, unlike mega-sites such as Maidanetske or Talianki, no larger unbuilt area existed in the settlement centre.

In contrast to several mega-sites in the Sinyucka region but in accordance with many settlements in neighbouring regions, in Chizhivka we can identify only a single communal building in the magnetic plan, which – according to its position in the settlement plan – probably represented a high-level mega-structure for integrative activities at the level of the entire settlement.

Trench 1/2017

For Test Trench 1/2017, a relatively large amorphous anomaly was chosen in the southeastern central part of the settlement, which had an extension of 9.5 × 4.5 m (Fig. 16). The trench measured 2 × 1 m and was excavated into the central part of this anomaly. The terrain surface in the area of the trench lies at a level of 211.43 m. The absence of a Chernozem layer indicates advanced erosion. Under a homogeneous upper backfill (Features 1001–1007), a dense layer of larger burnt daub pieces mixed with pottery fragments (Feature 1009) was found above the pit bottom at a level of 210.33 m (Fig. 17, 18). Underneath, the pit bottom was reached at about 210.10 m in the natural yellow loess loam (Features 1010, 1008).

Find material

From Trench 1/2017 352 pottery fragments with a total weight of 2.6 kg were recovered. Within the stratigraphy of the pit, this pottery was concentrated in the 5th and 6th spits. The lowest fragmentation degree with an average sherd weight of >20 g was in the 4th and 6th spits, the highest with 3 g in the 5th spit. In terms of features, 1005,

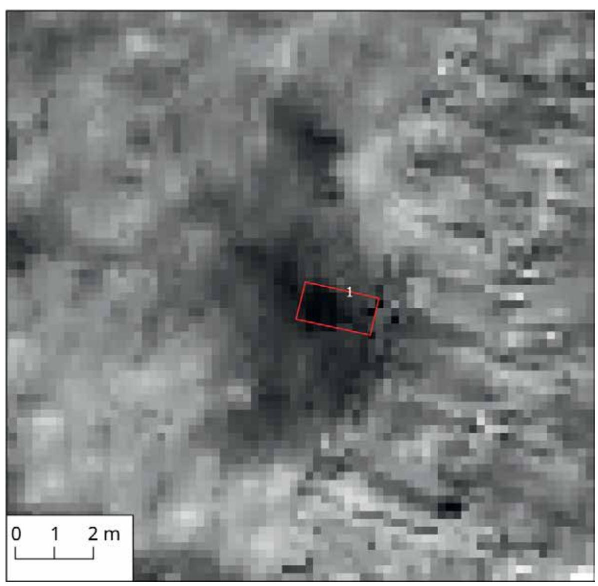


Figure 16. Chizhivka. Detail of the magnetic plan with location of Trench 1/2017 within the anomaly.

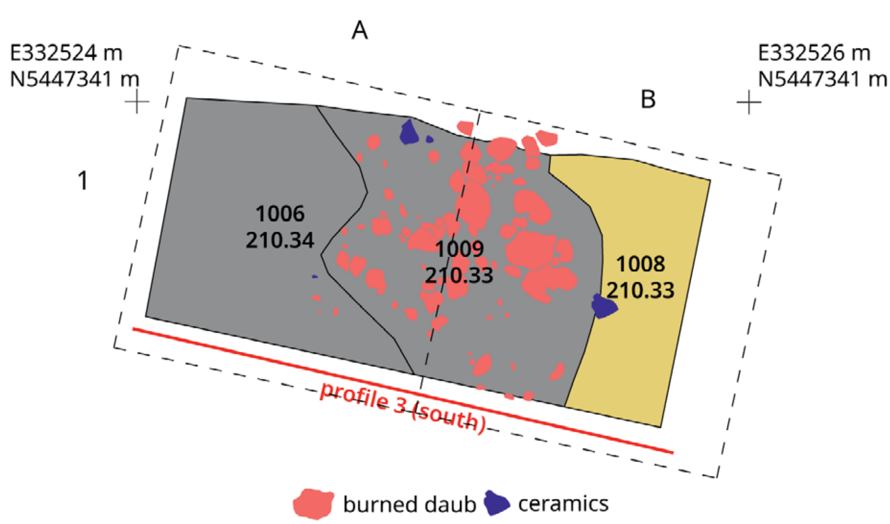


Figure 17. Chizhivka. Planum 5 of Trench 1/2017 with burnt daub on the bottom of the pit and location of Profile 3.

1006 and 1009 (≈20 g) had the lowest fragmentation and 1002, 1007 and 1010 had high fragmentation (2–10g).

From a technological point of view, three medium-fine wares and one coarse ware were distinguished based on temper and firing atmosphere (Tab. 3). According to weight, medium-fine wares dominate with 94%; according to the number of fragments, coarse 'kitchenware' are more common. A high proportion of the pottery (62% by weight and 19% by number) has a reducing firing atmosphere. Quartz sand and crushed limestone were identified as temper materials for coarse fabrics. In the case of medium-fine fabrics, tempering with sand and grog predominated.

Morphologically, open forms are represented in the find assemblage by spherical bowls (Fig. 19: 1), half-open forms by craters (Fig. 19: 8–11) and kitchen pots (Fig. 19: 16, 17). Closed forms are represented by peer-shaped vessels (Fig. 19: 6, 7), jugs (Fig. 19: 4–5), pots (Fig. 19: 12) and goblets/cups (Fig. 19: 13–15).

The pottery from Chizhivka shows a wide spectrum of mainly deepened decorations: impressions (Fig. 19: 9, 16, 17) and comb grooves (Fig. 19: 17) occur in association with coarse wares. Deepened grooves (Fig. 19: 3, 6, 7, 11), fluting (Fig. 19: 5, 10, 13, 15), stamps (Fig. 19: 10) and plastic applications (Fig. 19: 12, 14) are associated with medium-fine fabrics. In some pieces, possible remnants of incrustations are preserved in connection with deepened grooves (*e.g.* Fig. 19: 6, 11). In addition, there are isolated pieces with engobe but without painting.

Only two animal bones were recovered from the excavations at Chizhivka, both of which were from cattle (Tab. 4).

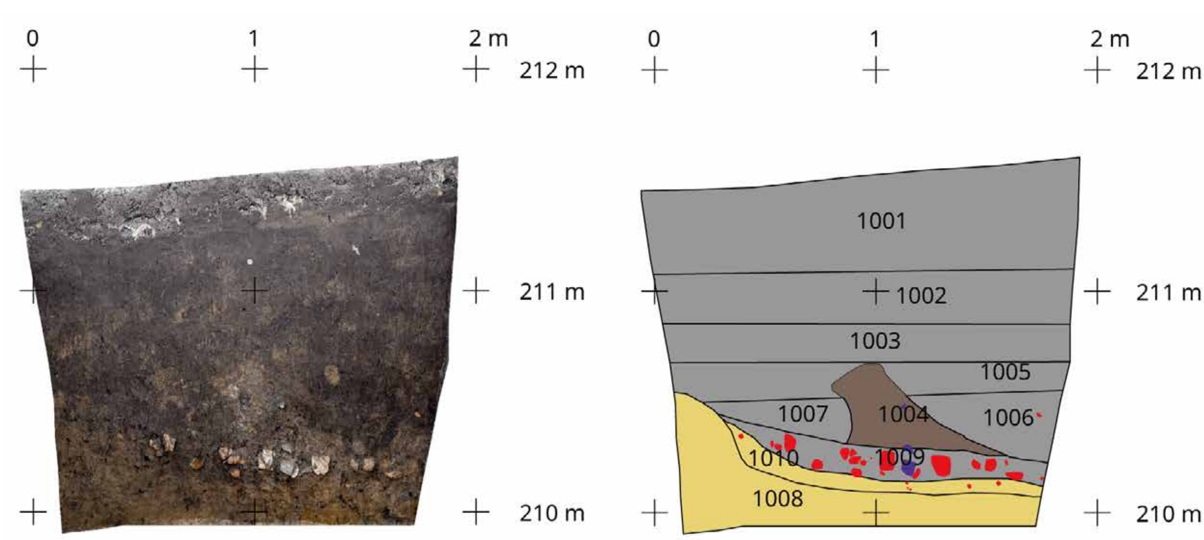


Figure 18 (above). Chizhivka. Profile 3 of Trench 1/2017.

Fabric	number	weight (g)	number (%)	weight (%)
coarse, orange, tempered	224	134	63.5	5.2
medium fine, reduction-fired, high quality	28	736	7.9	28.4
medium fine, sand, oxidation-fired	60	860	17.0	33.2
medium fine, sand, reduction-fired	40	862	11.3	33.2
?	1	2	0.3	0.1

Table 3. Chizhivka. Frequency of technological fabric groups found in Trench 1/2017.

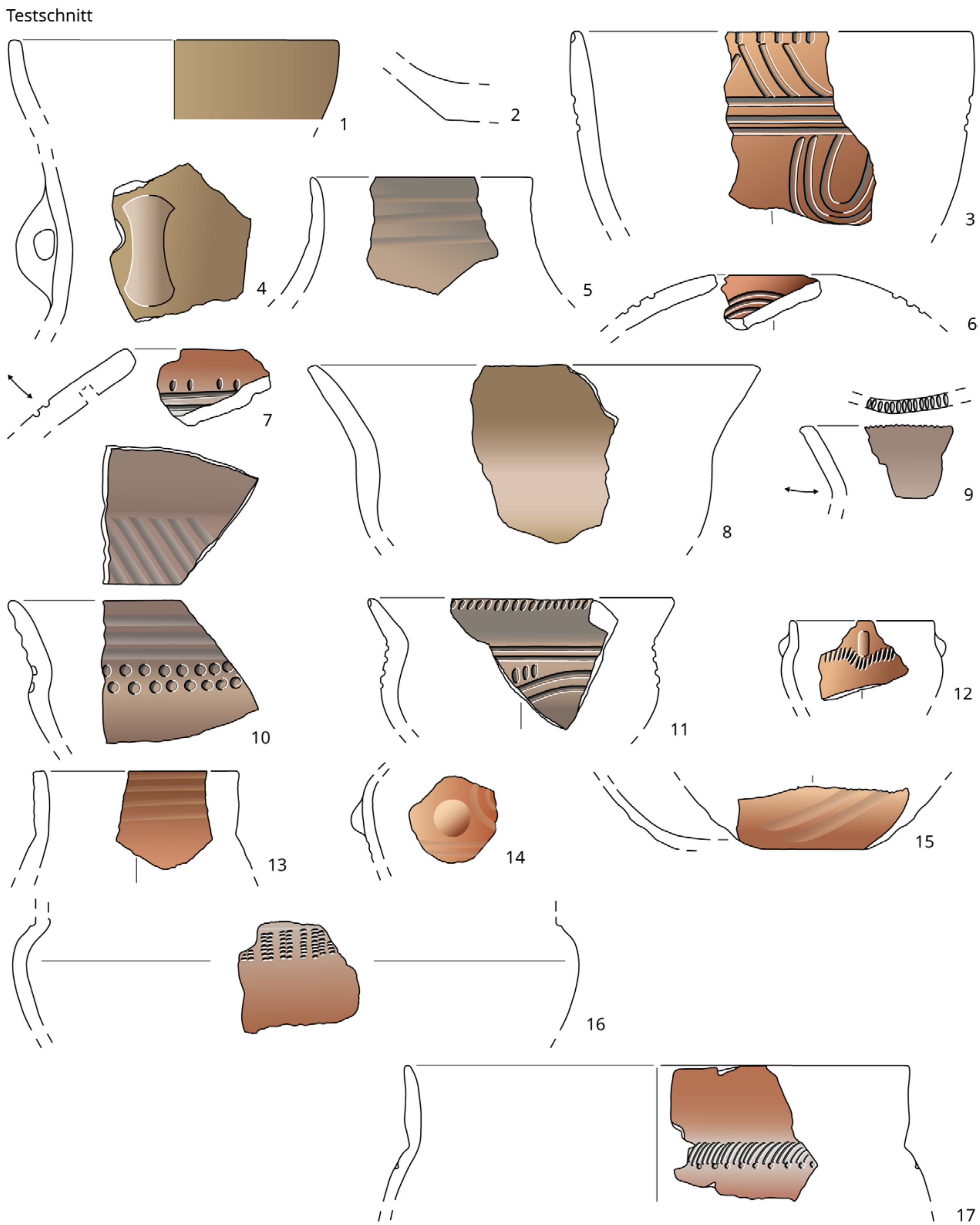


Figure 19. Chizhivka. Selection of ceramic finds from Trench 1/2017: 1. Find-ID 1008; 2. Find-ID 1010; 3. Find-ID 1016; 4. Find-ID 1008; 5. Find-ID 1020; 6. Find-ID 1017; 7. Find-ID 1025; 8. Find-ID 1008; 9. Find-ID 1010; 10. Find-ID 1012; 11. Find-ID 1015; 12. Find-ID 1032; 13. Find-ID 1028; 14. Find-ID 1011; 15. Find-ID 1011; 16. Find-ID 1011; 17. Find-ID 1024. Scale 1:3.

Find-ID	Feature-ID	Level	X	Y	NISP	weight (g)	taxon	element	14C/ remarks
1006	1005	4	A	1	1	11	bos	tooth (M1s), left	
1023	1009	6	A	1	1	27	bos	mandibula, left	Poz-98224/ age 5–8

Table 4. Chizhivka. List of animal bones.

Scientific dating

Three ^{14}C dates were obtained from Chizhivka from the lower section of the pit backfill in Trench 1/2017 (Chapter 19, this work, Vol. II, Suppl. 1). Two of the samples were obtained from cereal grains from botanical samples and one sample from a cattle bone. Two samples date from the Trypillia time period and one – Poz-98166 – yielded a dating of 2278-2136 BCE (1-sigma), which according to the chronology refers to the Transitional Period of the Bronze Age. No material belonging to the Bronze Age was found in the trench. The two samples, which were dated to the Trypillia time period, came from the same level of the pit – the sixth one (Feature 1009). Both dates were placed in one model, which dates the highest probability of the filling of the pit within the period from 4050 to 3990 BCE (Shatilo 2021, 148–149).

Volodymyrivka

Location

The site of Volodymyrivka is located to the south of the village of the same name, partly under its houses and gardens (Novoarkhangelsk district, Kirovograd region; Fig. 1). Topographically, the settlement is located on the plateau of the high right bank of the River Sinyukha. The site is confined by the river and a dried-up creek (which could have been an ancient channel of the Sinyukha) to the east, to the north by the stream Bondarivka (Passek 1941, 212). The settlement area is about 85 hectares.

Research history

The settlement of Volodymyrivka was discovered by M. K. Yakimovich, an employee of the Uman Regional Museum, in 1925. From 1927 to 1928, it was excavated by the Uman Local History Museum. In subsequent years, it was further investigated by B. P. Bezvenglinsky, S. S. Magura and V. E. Kozlovskaya (Yakubenko 2004, 104). In 1939-40 and 1946-47, the Trypillia expedition of the IA AS USSR and the Institute of History of Material Culture of the Academy of Sciences of the USSR, which was headed by T. S. Passek, worked there. The remains of 20 houses and other objects were excavated during the works (Passek and Bezvenglinsky 1939; Passek 1941; Passek 1947; Passek 1949). A large number of houses were excavated for rescue purposes, as during World War II, part of the settlement was cut through by an anti-tank moat (4.5 m wide and up to 2 m deep), which damaged a number of houses. As a result of the work of the expedition, a settlement plan was drawn (made by fixing the finds on the ploughed field and using the excavation data), which made it possible to identify around 150 dwellings (Passek 1949, 79; see Fig. 20).

From 1989 to 1990, research was carried out by the Trypillia archaeological expedition of the State Historical Museum of the Ukrainian SSR under the direction of O. O. Yakubenko (2004, 104). The materials are stored mainly in the National Museum of the History of Ukraine, the Hermitage and the State Historical Museum in Moscow.

Recently, surveys were undertaken on the site to test the method of establishing the edge of the built-up area (Nebbia 2017, 110-112). Walking from the middle of the

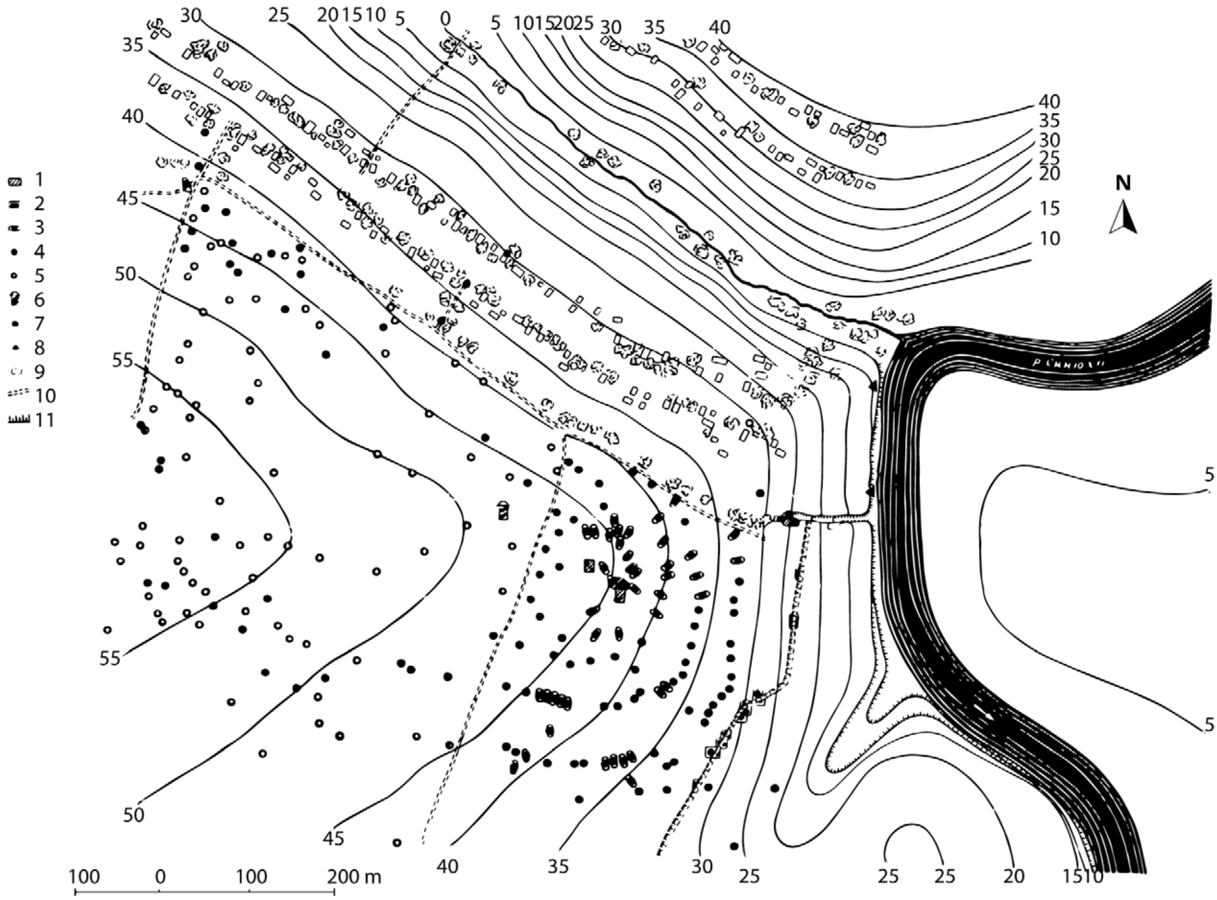


Figure 20. Volodymyrivka: Site plan (after Passek 1949, Fig. 36). 1. Dwellings excavated (1939–1940); 2. dwellings excavated (1946); 3. dwellings with determined orientation; 4. dwellings excavated (1940); 5. dwellings excavated (1947); 6. dwellings excavated (1947); 7. pit houses; 8. Late Paleolithic site; 9. building of the modern village Volodymyrivka; 10. roads; 11. river Sinyukha.

site towards the outside, using a 40 m spacing, the surveyors counted the number of pottery sherds.

T. S. Passek (1949, 79) attributed Volodymyrivka to stage B2. T. G. Movsha (1972, 7) singled out a separate regional group, named after this site. This group incorporated, in addition to Volodymyrivka, the sites of Fedorivka-Mikhailovka, Andriyivka, Polonyste, Hordashivka 1, Peregonivka, Maslove, and others. S. M. Ryzhov (2015, 162) attributed the site to the second phase (out of the three that he had singled out) of the group development (together with Andriyivka and, probably, Maslove).

Main results

Description of the settlement plan

In the east of the site of Volodymyrivka, an area of 26 ha was magnetically surveyed (Fig. 21). In the magnetic plan we identified at least 455 tendentially rectangular anomalies of dwellings, of which 303 were classified as securely delimitable anomalies, 79 as less securely delimitable anomalies and 73 as weekly burnt or eroded house anomalies (Fig. 22). Securely definable dwelling anomalies have a median size of 66.7 m² and a mean of 65.3 m². Less definable anomalies of dwellings have a median size of 54.5 m² and a mean size of 56.5 m². Less burnt or eroded dwelling anomalies show median sizes of 42.6 m² and mean sizes of 48.2 m².

In most cases, the anomalies of dwellings have an elongated rectangular shape and are often divided into two parts with a larger main part and a smaller anteroom.

Figure 21. Volodymyrivka: Magnetic map with location of Trench 1/2017. Coordinate reference system: WGS84/ UTM36N.

Highly magnetic sections in these house anomalies are mostly concentrated along the outer walls, while in the centre of the houses there seem to be areas free of burnt daub.

Similar to many other cases, anterooms are frequently characterised by a lesser intensity of anomalies, indicating a lighter construction of this house part (Fig. 23). The anteroom was usually located on the opposite short side to a clay extraction pit that belonged to the house. The location of the anteroom we can thus probably use to identify the front side of the house, while pits were located in the back area and potentially denote backyard situations.

In addition to the dwellings, at least 15 anomalies can be identified in the magnetic plan, which represent probably not dwellings but remains of buildings with

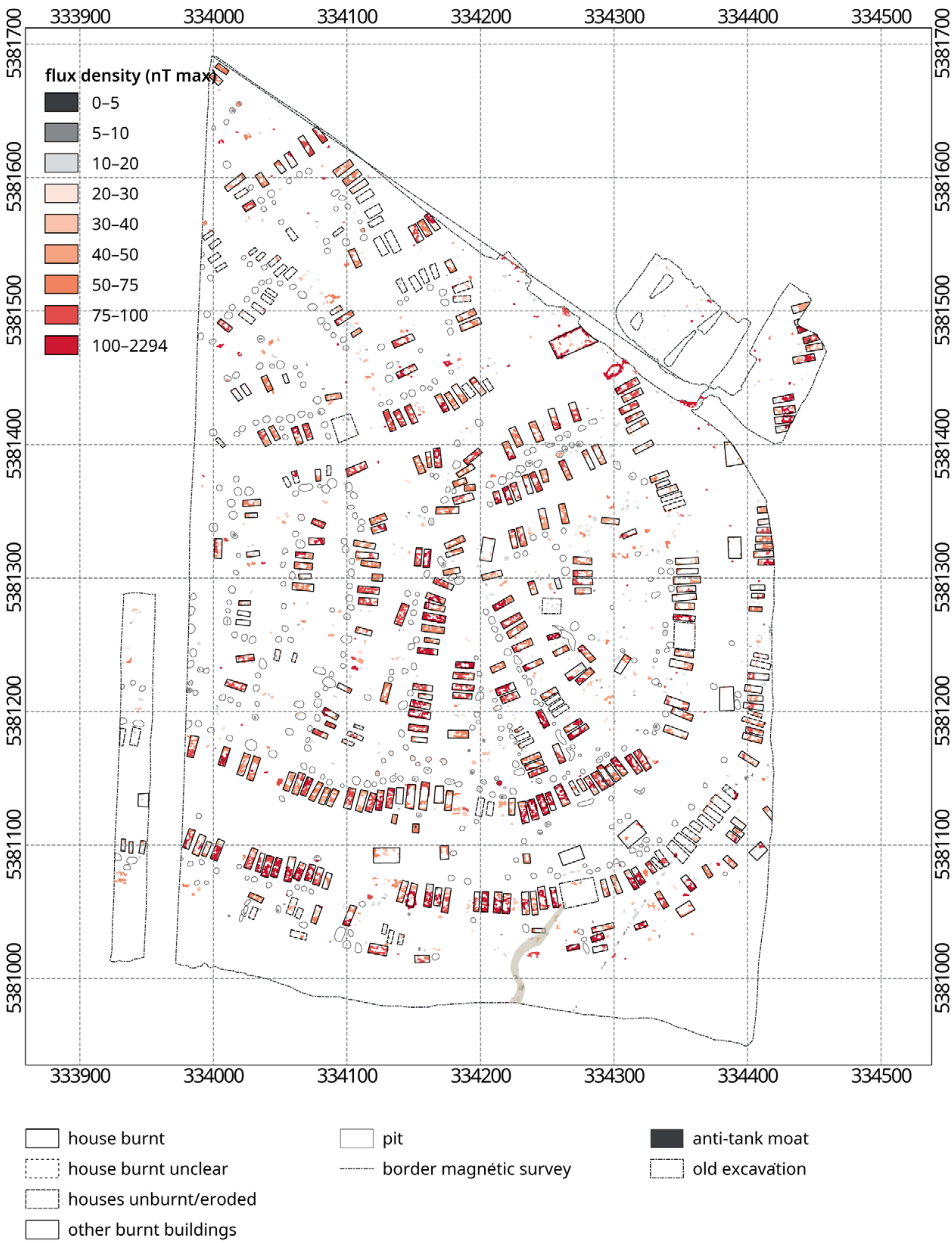


Figure 22. Volodymyrivka: Extension, maximum flux density and interpretation of archaeomagnetic anomalies based on a 5-nT isoline. Coordinate reference system: WGS84/UTM36N.

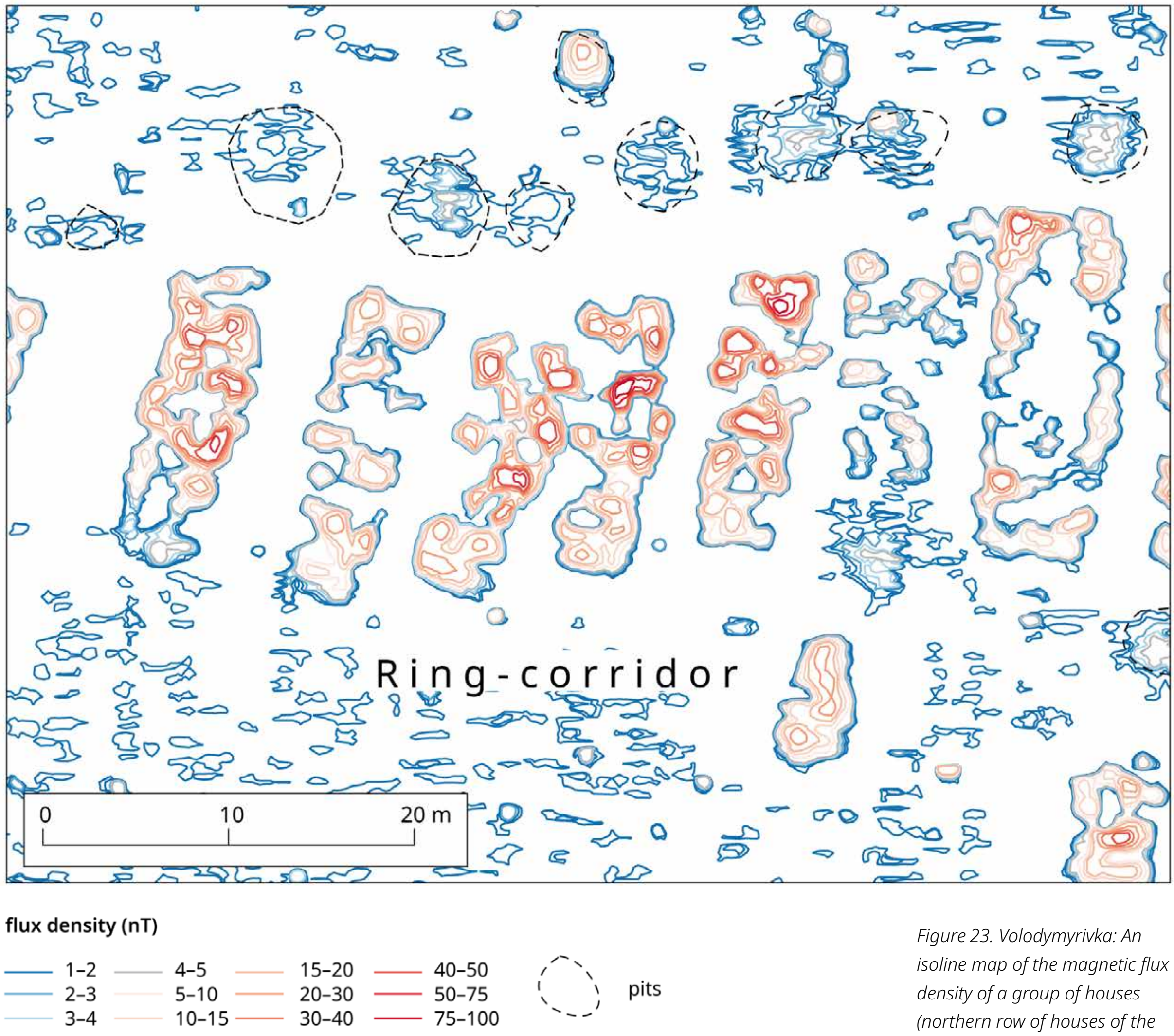


Figure 23. Volodymyrivka: An isoline map of the magnetic flux density of a group of houses (northern row of houses of the ring corridor in the south of the prospected area) shows a weaker signal on the side of the house facing the ring corridor (interpretation: frontside with anteroom) and a stronger signal in the area behind it (interpretation: main room).

other functions (Fig. 24). Criteria for the identification of such buildings have been described elsewhere in more detail, as regards positioning within the settlement, size and architecture (Hofmann *et al.* 2019a). According to their position within the settlement, we can distinguish four categories of such 'special' structures in the case of Volodymyrivka: 1. A large building structure is positioned in the centre of an approximately 150 × 220 m large square in the northeast of the surveyed area; 2. Eleven building structures are located in highly visible positions within the circumferential ring corridor; 3. Two structures are located on the outer edge of the settlement in the southeast; and 4. Another structure is located on a small plaza situated in the centre of the settlement at the intersection of several radially running streets.

Such buildings with potential special functions are very diverse in size. Four smaller building structures show sizes between 25 and 64 m²; seven low-level mega-structures belong to a medium-sized category with areas between 150 and 225 m². One high-level mega-structure has an area of 434 m². With regard to their architecture, eleven so-called mega-structures can be identified, which were probably assembly houses with integrative functions. In addition, four very small rectangular building structures exist within the ring corridor and are characterised either by linear anomalies along the outer walls or by a laminar signature.

Apart from the described anomalies of buildings, there are at least 425 round, oval or amorphous anomalies in the Volodymyrivka magnetic plan, most of which

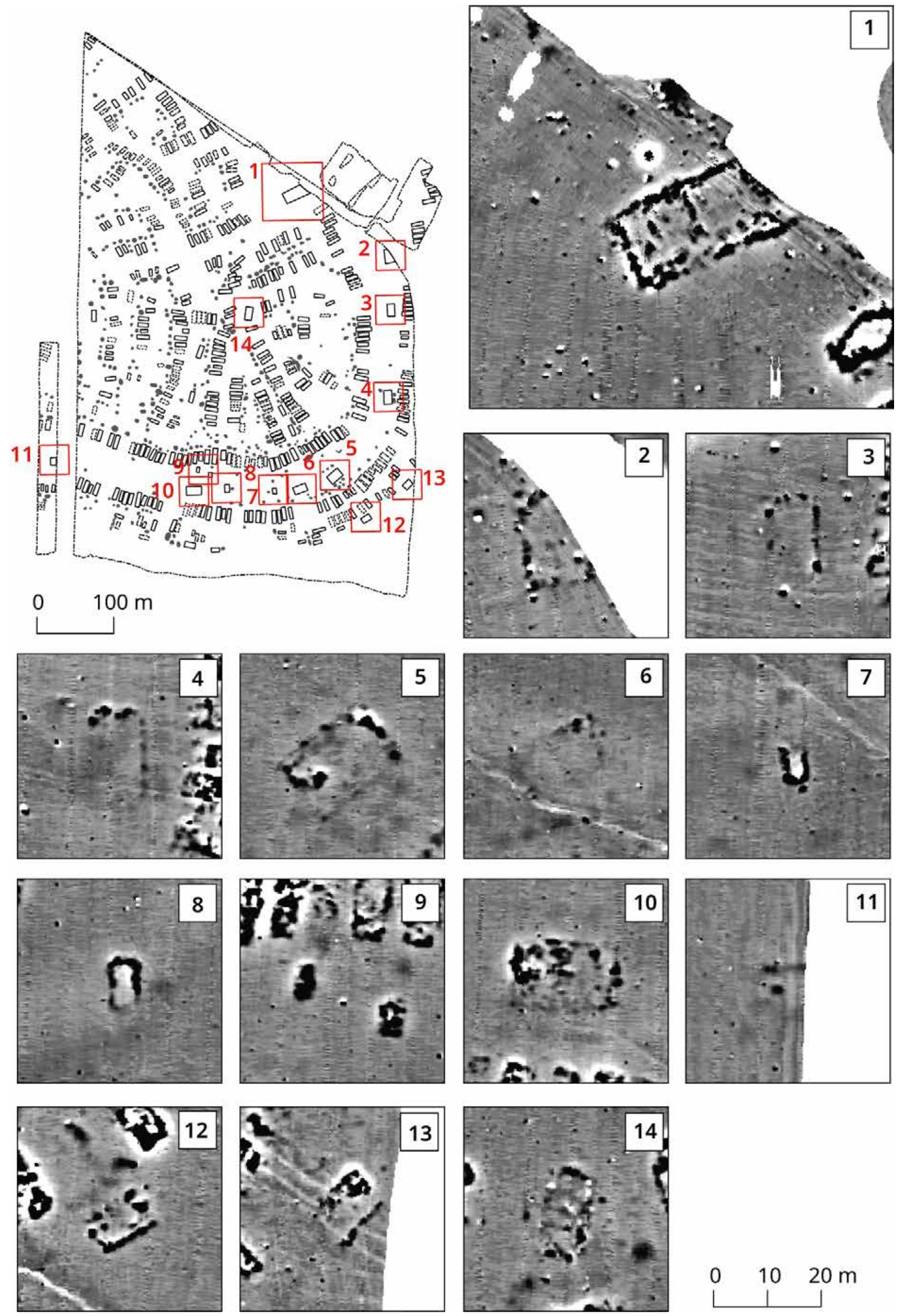


Figure 24. Volodymyrivka: Anomalies of buildings with potential public functions: (a) central mega-structure; (b–f) and (j–k) mega-structures within the ring corridor, (g–h) mega-structures at the outer edge of the settlement; (i) mega-structure in the centre of the settlement; (g–i) smaller buildings of unknown function within the ring corridor.

show low magnetic flux densities and probably represent pits. A small number of these anomalies show significantly higher maximum flux densities. As excavation findings from Maidanetske and other sites suggest, these anomalies could represent pottery kilns or pits backfilled with burnt daub.

The described elements of the Volodymyrivka settlement plan have been arranged in an oval settlement area, the size of which amounted at least to 85 ha according to Passek's plan. In the newly measured plan of the eastern part of the settlement, densely built house rows align an approximately 50 m wide ring corridor, which runs close to the outer boundary of the settlement area and within which there are only relatively few pits (Fig. 25). Between the outer row of houses of the ring corridor and the southern settlement boundary there are only shorter concentric

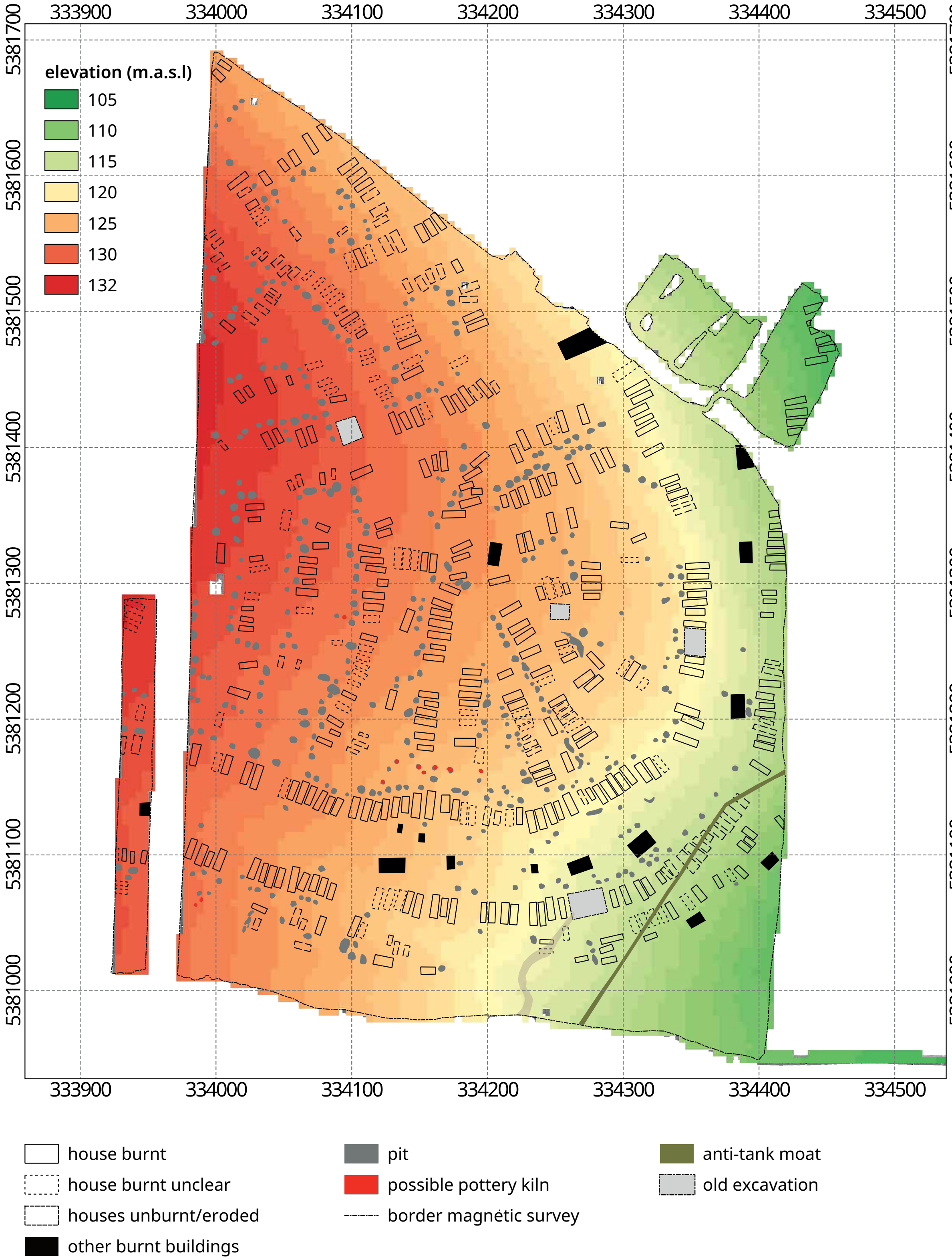


Figure 25. Volodymyrivka: Interpretation of the magnetic plan including digital elevation model of the surveyed area. Coordinate reference system: WGS84/UTM36N.

rows of dwellings and houses arranged in smaller radial groups. Numerous pits mark this area as a backyard area. The settlement did not have a ditch.

The central settlement zone, which is surrounded by the ring corridor, was densely overbuilt by radially running house rows and smaller concentric house groups. Within this zone, we can distinguish pit-free 'streets' from rear areas with numerous pits adjacent to the dwellings. On the intersection of the streets, small plazas existed. In the northeast of the settlement, the only partly surveyed main plaza of the settlement was situated with at least one central mega-structure.

The distribution of house sizes within the settlement is relatively even. A focussing of the largest size-class of dwellings along the ring corridor and the main plaza, as is proven in Maidanetske and interpreted there as suggesting a social topography, does not exist in Volodymyrivka. However, most of the smaller buildings are concentrated in the central settlement zone within the ring corridor.

Interpretation of the settlement plan

From the settlement plan of Tatjana Passek and aerial photos, there exist already good data on the size of the settlement in Volodymyrivka, which amounted to approximately 85 ha. The prospected area of 26 ha thus corresponds to 26% of the total settlement area. Assuming a uniform building density in the non-surveyed areas, the total number of houses should have been in the scale of 1700. In analogy to other settlements, we must also assume here that not all houses were inhabited at the same time (Shatilo 2021, 211–216).

Aerial photographs, older excavation plans and the plan of the new survey reveal a stocky oval layout for the settlement, in which a 40–50 m wide circumferential ring corridor ran close to the outer settlement boundary. As far as can be seen from the limited section of our survey, in Volodymyrivka, in contrast to other settlements, the zone enclosed by the ring corridor was also densely overbuilt. A larger unbuilt area, as regularly occurs in the largest mega-sites, is absent here. The zone outside the ring corridor is very small and consists only of a concentric row of houses and short radial groups of houses. In contrast to Veselyj Kut, Chizhivka and other settlements, a delimiting ditch is missing here.

Overall, the high density of public buildings in a central plaza in the north-east, distributed within the ring corridor, on the outer border of the settlement and in the inner zone in the centre of the settlement is remarkable. Similar to Maidanetske, these communal buildings were characterised by varying degrees of roofing.

Trench 1/2017

Test Trench 1/2017 was dug in the extreme southwest of the surveyed area (Fig. 21). A weakly visible anomaly, presumably a pit, in the rear area of the outer house row of the ring corridor, was selected as the object of investigation. The test trench had a size of 3 × 1 m and cut from the north into this anomaly (Fig. 26). We found that the trench was entirely located within the area of the pit backfill and that the northern boundary of the pit must run to the north of it. Due to limited time, the excavation was stopped at a depth of 1.20 m below the present terrain. The pit bottom had not yet been reached at this depth.

Four successive layers were identified in the profile of the investigated area (Fig. 27). Below the recent plough horizon (Feature-ID 1006, upper part of 1001) of 0.3 m in thickness, the Chernozem continued more compacted until a depth of 0.45–0.65 m (Feature-ID 1007, lower part of 1001). Underneath this there was a dark grey-brown humic layer (0.45/0.65 m–0.8 m/0.95 m; Feature-ID 1002, 1003 upper part, 1008) and a lighter grey brownish layer (0.8/0.95 m–1.2 m; Feature-ID 1004, 1003 lower part, 1009; Fig. 28). As in other settlements in the region, the Chernozem layer developed probably mainly after the settlement had been abandoned. It probably overlaid the backfill of the pit. The minimum depth of the pit was thus 0.55–0.75 m.

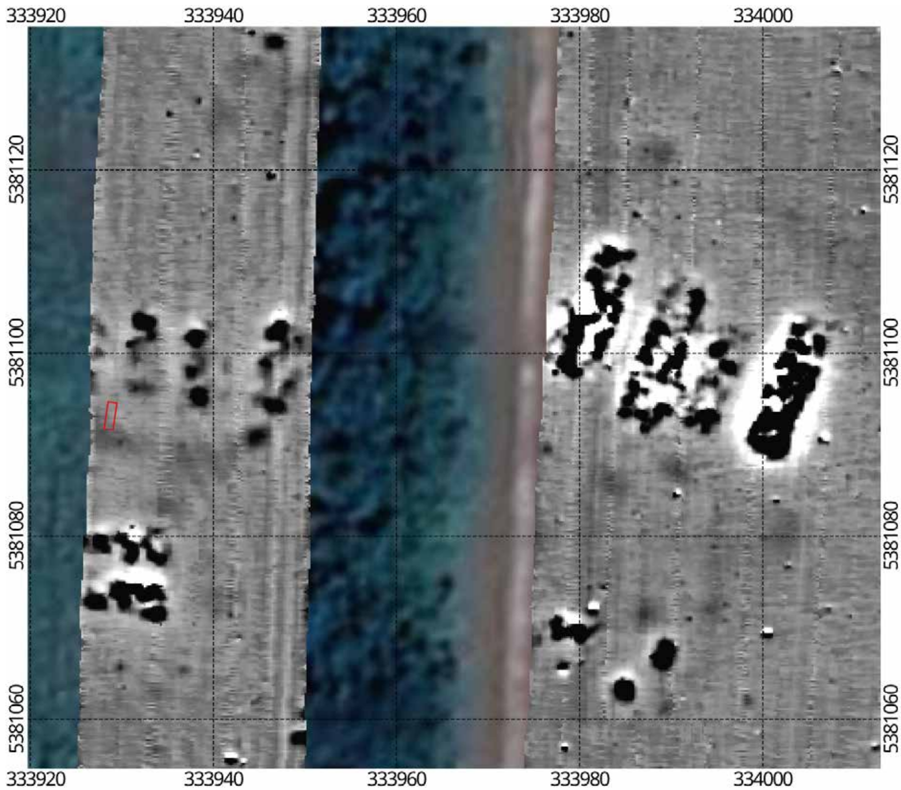


Figure 26. Volodymyrivka: Detail of the magnetic plan with location of Trench 1/2017 within the anomaly.

Finds from Trench 1/2017

The pottery assemblage from Trench 1/2017 consisted of 290 pottery fragments weighing 4.8 kg, originating mainly from the 3rd and 4th spits and the Features 1002, 1003 and 1004.

From the technological point of view, we can distinguish light-coloured, oxidising fired tableware from coarser so-called kitchenware. Depending on whether one takes number or weight as a calculation basis, tablewares comprise between 80–85% of the ceramic assemblage, while orange and grey-brown kitchenwares are significantly rarer with 15–20%.

Morphologically, the assemblage is characterised by a high proportion of closed vessels (76 fragments; 50%) and a lower proportion of bowls (32 fragments, 25%). The remaining 25% we can assign to goblets (22 fragments; 14%; Fig. 29: 2–3), pots (19 fragments; 12%), craters (2 fragments; 1%) and crater-shaped vessels (2 fragments; 1%). In addition, there is at least one fragment of a binocular vessel (Fig. 29: 12–13).

The majority of the surface designs on tableware are red engobe on the outside (n=272) and monochrome dark paintings (n=128) with linear and floral motifs (Fig. 29: 2–7, 11; Fig. 29: 1–3, 12). About a quarter of the engobed sherds (n=61) also show an engobe on the inside, which characterise them as fragments of bowls. Two sherds are decorated with deepened grooves that either run parallel around the top of the vessel (Fig. 29: 13) or delimit metope-like dark painted areas (Fig. 29: 12).

Kitchenware often shows comb stroke decorations that run vertically in the neck zone and horizontally on the body of the vessel (Fig. 30: 5, 7–11). In addition, there are plastic knobs, notches or perforations on the rim of the vessel and stamp impressions (Fig. 30: 4–8, 10).

Apart from pottery, an indeterminable grinding stone fragment (500 g) made of fine-grained red granite (Find-ID 1008) was recovered from Trench 1/2017.

From Trench 1/2017, a small collection of animal bones was recovered, which is dominated by cattle (Tab. 5).

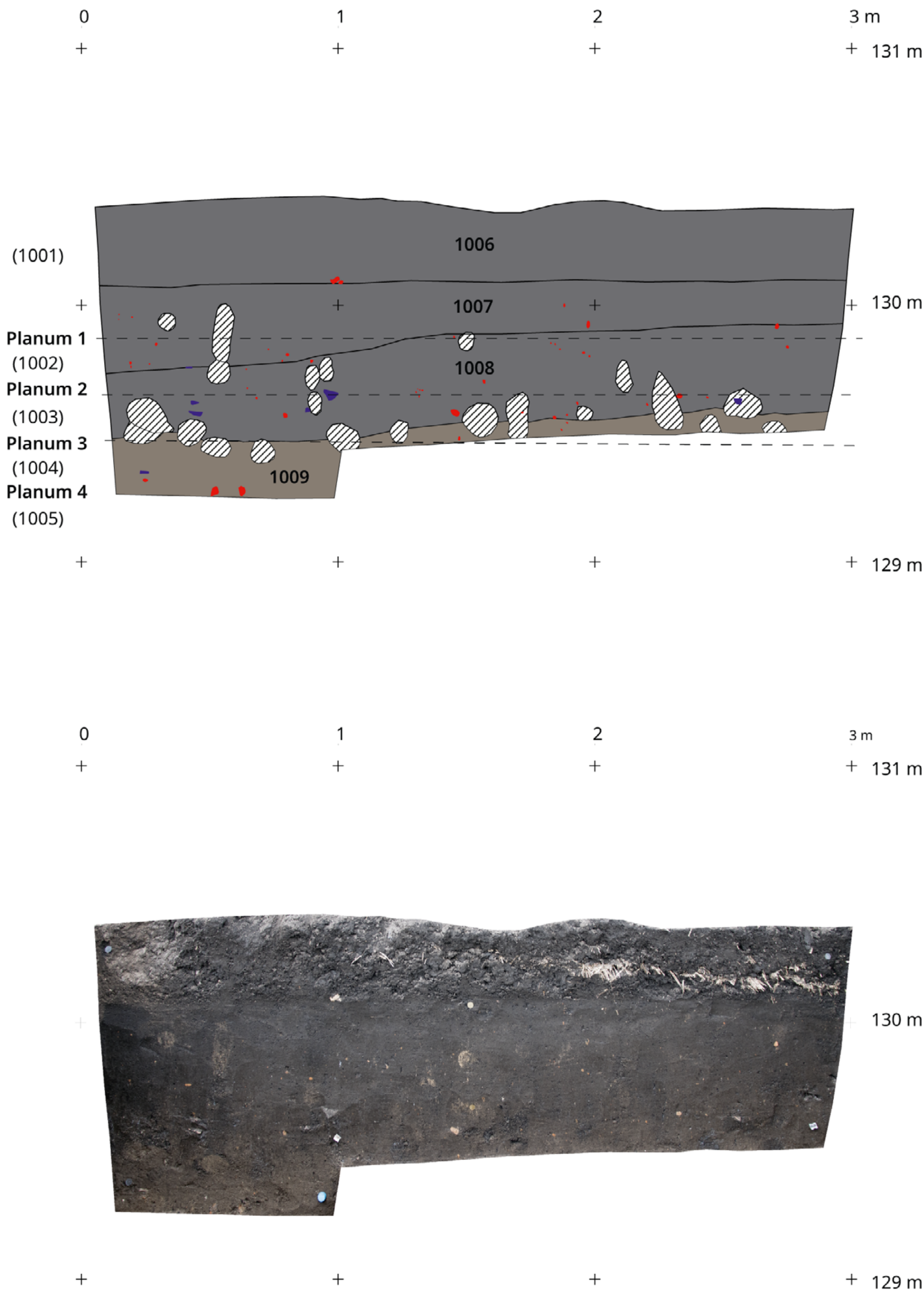


Figure 27. Volodymyrivka: Profile west of Trench 1/2017.

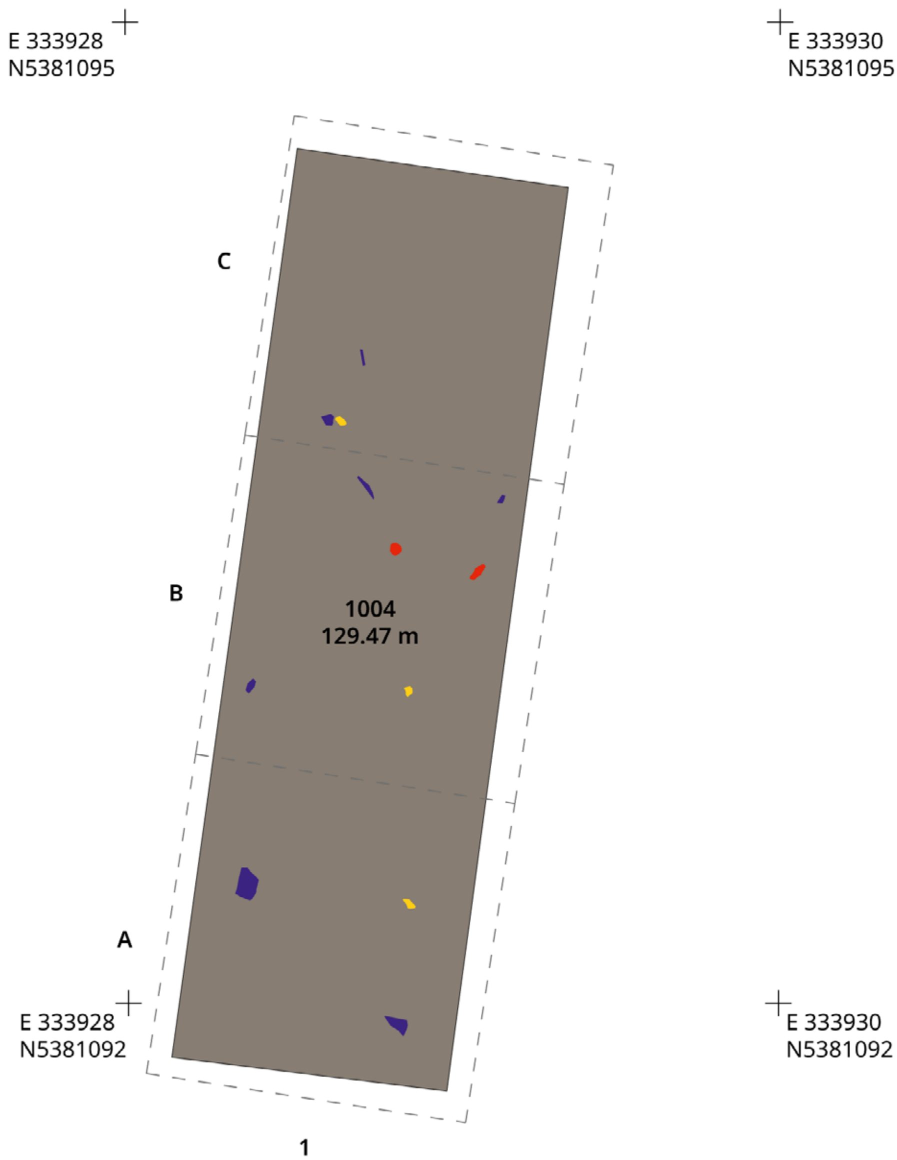


Figure 28. Volodymyrivka: Planum 3 of Trench 1/2017.

Surface finds

During unsystematic surface collections, a larger number of finds, some spectacular, were recovered during the fieldwork in Volodymyrivka. These were concentrated in the east of the settlements, where in the inner row of houses of the ring corridor a larger number of houses were apparently badly destroyed by modern agriculture. Apart from a small pottery assemblage (Fig. 30: 14–22), the find collection includes nine anthropomorphic and zoomorphic figurines (Fig. 31: 2–11), a spindle whorl (Fig. 31: 1) and a fragment of a loom weight. In addition, several groundstone artefacts and a collection of 121 flint artefacts, already previously published elsewhere, were recovered (Hofmann *et al.* 2019b).

The collection of figurines includes fragments of six smaller anthropomorphic figurines (Fig. 31: 2, 4–9), the upper part of a larger anthropomorphic figurine (Fig. 31: 11), the body and neck of a bird figurine (Fig. 31: 10) and the 'leg' of a bowl with a hole (Fig. 31: 3). The last artefact, by analogy with other similar objects, could represent a small bowl, potentially with zoomorphic elements – paired legs, tail and an animal head (?). Such artefacts are rather rare; besides Volodymyrivka they

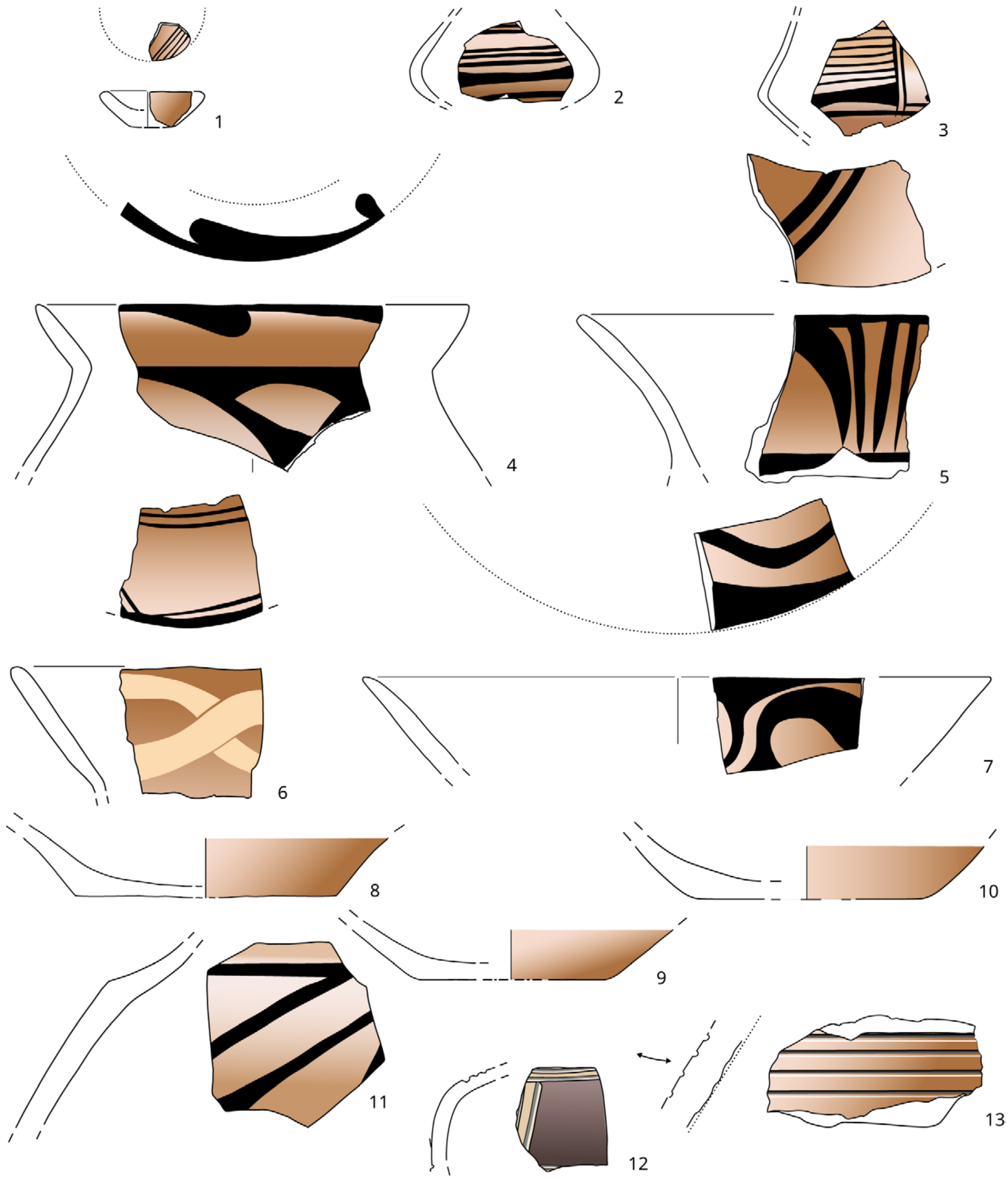


Figure 29. Volodymyrivka: Selection of ceramic finds from Trench 1/2017: 1. Find-ID 1002; 2. Find-ID 1078; 3. Find-ID 1078; 4. Find-ID 1009; 5. Find-ID 1010; 6. Find-ID 1024; 7. Find-ID 1078; 8. Find-ID 1035; 9. Find-ID 1078; 10. Find-ID 1047; 11. Find-ID 1030; 12. Find-ID 1030; 13. Find-ID 2001. Scale 1:3.

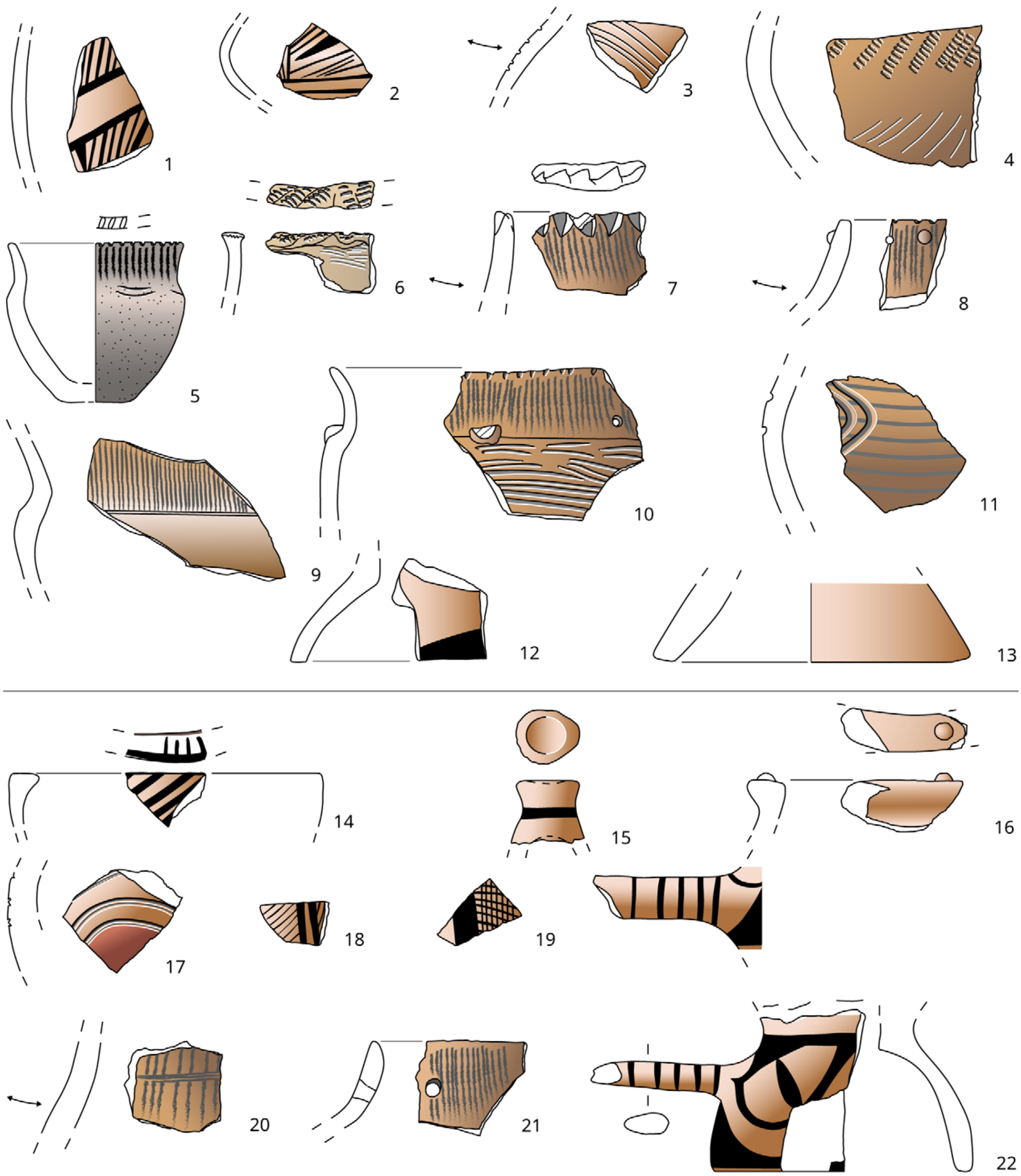


Figure 30. Volodymyrivka: Selection of ceramic finds from Trench 1/2017 (1–13) and the surface collection (14–22). 1. Find-ID 1030; 2. Find-ID 1037; 3. Find-ID 1078; 4. Find-ID 1057; 5. Find-ID 10130; 6. Find-ID 1026; 7. Find-ID 1054; 8. Find-ID 1056; 9. Find-ID1057; 10. Find-ID 1062; 11. Find-ID 1078; 12. Find-ID ?; ID 17; 13. Find-ID 1078; surface finds: 14.–22. Find-ID 2001. Scale 1:3.

find_id	feature_id	Level	X	Y	taxon	NISP	weight	element	^{14}C
1002	1002	2	A	1	*Bos*	1	7	atlas	
1002	1002	2	A	1	*Cervus elaphus*	1	12	tibia	
1003	1002	2	B	1	*Bos*	1	51	tibia	
1005	1002	2	B	1	*Bos*	1	65	patella left	Poz-98137
1006	1002		B	1	*Bos*	1	18	metatarsal	
1019	1003	3	C	1	*Sus scofra*	1	6	calcaneus	
1024	1004		A	1	*Bos*	1	30	rib	
1027	1002	3	B	1	*Bos*	1	71	talus right	
1032	1003	3	B	1	indet.	1	8		
1048	1003		A	1	indet.	1	25	talus	
1057	1003	3	A	1	indet.	1	4		
1060	1004	4	C	1	*Bos*	1	29	phalanx 1	Poz-98178
1065	1004	4	A	1	*Bos*	1	44	femur right	
1065	1004	4	A	1	*Bos*	1	27	metacarpus	
1078	1004	4	A	1	*Bos*	1	3	scapula	
1078	1004	4	A	1	*Unio*	1	1		
1100					*Bos*	1	33	phalanx 1 anterior	

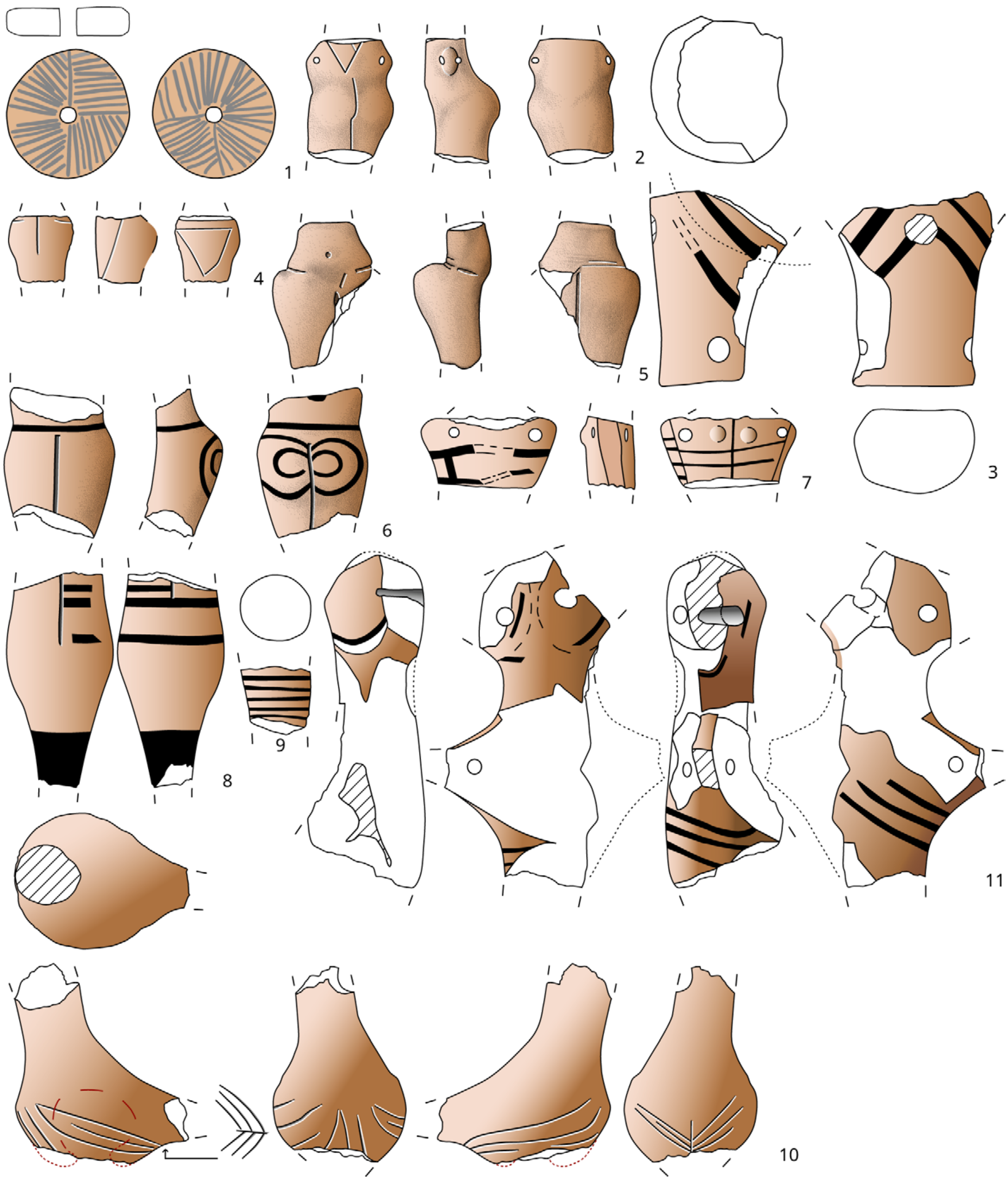
Table 5. Volodymyrivka: List of animal remains from Trench 1/2017.

have been found at sites such as Karolina, Nemirov and from sites of 'Uman district' (Fig. 32), where the information on the settlement context is lost (Gusev 1998, 23–24; Starkova 2018, 100; Yakubenko 2011b, 366, Fig. 6: 12). They date back to the B2 period (3950–3800 BCE). S. Gusev assumed that the perforation in the lower part of the paired legs was made for the axis on which small wheels could be located, although these two types of artefacts have not yet been found in the same complex. It should be noted that the hypothetical presence of wheels in these figurines is not reliable evidence for the existence of wheeled transport (*e.g.* Gusev 1998, 24).

All anthropomorphic statuettes are represented by fragments, five objects have painting, five shows details depicted with the help of deepened lines, one figurine shows the chest with small mouldings. Five artefacts are represented by the lower parts of the torso. Steatopygia of the figurines is not expressed. The sex of three figurines is not expressed. One figurine is defined as female, by the drawn triangle. One figurine has a for this time typical 'disc-shaped' head; the rounded eyes are shown as through holes (perforations). Realistic details, a belt, are shown only on one figurine. Perhaps the black painting on the lower part of one figurine, by analogy with other statuettes from Volodymyrivka and other sites, shows an image of footwear (see Yakubenko 2011a, 61–61, Figs. 41 and 72; Pogoševa 1985, Figs. 795, 830 and 834).

The figurine of the bird has been partially preserved but the head, tail and lower part have been broken off. Inside, the figurine is hollow, which allows us to reference it as a type of 'rattle'. In general, such figurines are found from time to time in Trypillia settlements of different periods and regions (see *e.g.* Bibikov 1953; Passek 1961; Chernysh 1982; Dumitrescu 1979; Markevich 1985; Popova 1996; Balabina 1998; Ovchinnikov 2014; Peresunchak and Burdo 2015; Ţerna and Heghea 2017; see Fig. 33). From Volodymyrivka, three more similar statuettes and two fragments attributed to ornithomorphic figurines are known (Yakubenko 1998). The figurine found in 2017 is decorated with deepened lines, which seems to show the wings.

The map of the sites where bird figurines were found (55 objects were taken into account) shows the chronological and partially territorial difference in the distribution



of different types of these objects. Items with a solid body are earlier and originate from sites from the Dniester to the Southern Bug (Trypillia A), on the Siret and Prut settlements (Trypillia B), reaching the Sinyukha basin a little later (Trypillia C, for example, the Sushkivka site). Hollow artefacts, so-called 'rattles', are chronologically younger, and occur after 4250 BCE, in the immediate western zones of the Trypillia (Dniester and Prut basins) and in the Sinyukha basin. At stages B2 and C1, they are also known on the Dnieper sites. At stage C2, neither type of figurine has been found. If the number of figurines of the first type decreases with time, then the number of the second type increases, and a significant number of the latter type were found

Figure 31. Volodymyrivka: Anthropomorphic figurines and other non-pottery ceramic objects obtained during surface collections. Find-ID 2001. Scale 1:2.

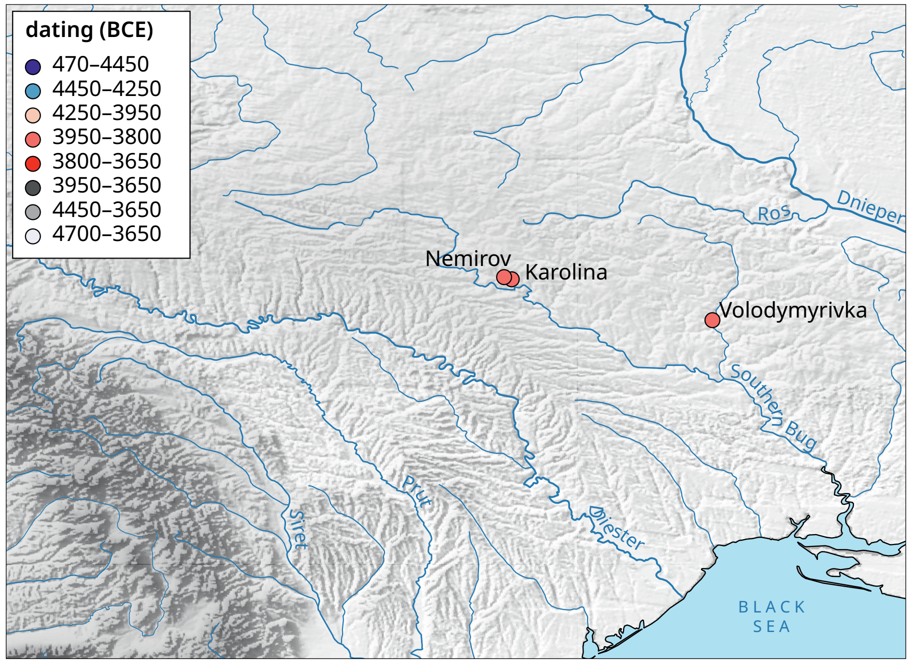


Figure 32. Distribution map of bowls with zoomorphic elements and perforated legs.

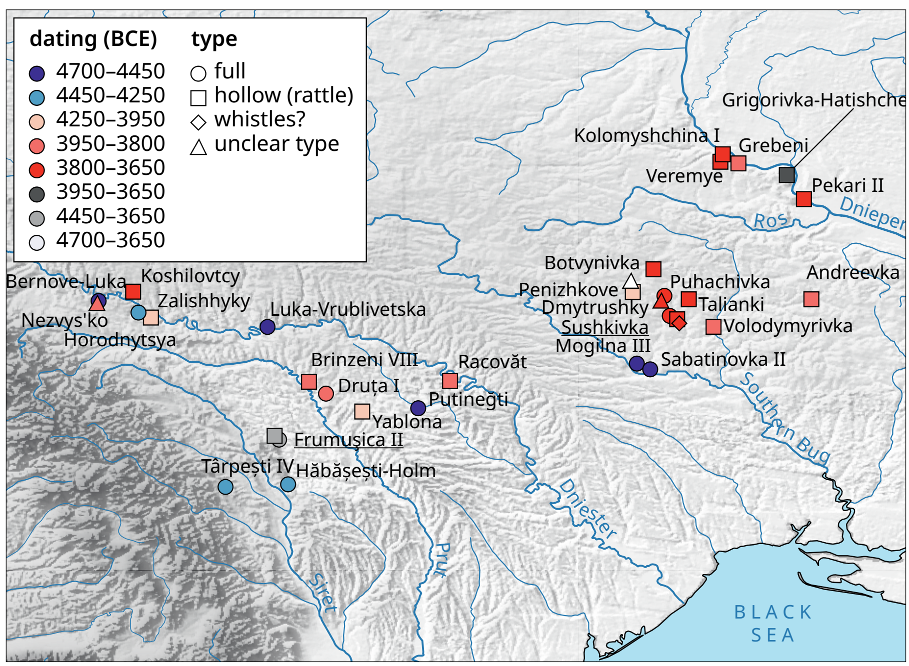


Figure 33. Distribution map of ornithomorphic figurines from Cucuteni-Trypillia settlements (find list in Appendix 2).

at the Trypillia sites of the Sinyukha basin and on the Dnieper. However, each new discovery of this rare category of material can lead to some adjustments being made.

These new anthropomorphic and ornithomorphic figurines complement a fairly large collection of such finds from Volodymyrivka, of which more than 140 (anthropomorphic) and 5 (bird-like) objects have been already published (Yakubenko 1998; Yakubenko 2011a).

All figurines found during field work in Volodymyrivka are made of light-coloured clay and most of them show remains of engobe, painting and partial incisions for the representation of clothing and other details. Arms, as far as they have survived, are represented by perforated stumps; the legs of the figurines are pointed.

The collection of flint artefacts comprises two categories: production waste and tools (Hofmann *et al.* 2019b). Cores, flakes, blades and other products represent production waste (56 items). Among the tools (65 lithics), there are retouched blades and flakes, end scrapers, notched pieces, perforators, chisels, sickle insets, arrowheads and other products with secondary processing. Most of the artefacts found in Volodymyrivka are made of local raw material, which is found in sufficient quantities along the banks of the Syniukha River, not far from the settlement, although the collection also contains items made of Volynia-like flint. From the nature of the finds, a full cycle of flint processing took place at the settlement: extraction, primary and secondary treatment of flint. This is evidenced by the presence of outcrops of raw material near the settlement and products made of it, which were found directly at the settlement; the presence in the collection of both production wastes and tools related directly to the process of flint knapping – stone hammers; the presence of retouched products and examples of their reutilisation or repair. We have also identified tools that were not previously found on the site: chisels.

Scientific dating

Two consistent ^{14}C dates (Poz-98137 and Poz-98178) were obtained from Volodymyrivka from two different backfilling layers of the pit which was partly excavated in Trench 1/2017 (see Chapter 19, this work, Vol. II, Suppl. 1). Both samples were cattle bones. According to two Bayesian models the filling of this pit can be dated with the highest probability at between 3920 or 3940 and 3800 BCE (Shatilo 2021, 145–146).

Discussion

The works carried out on the sites Chizhivka, Veselyj Kut and Volodymyrivka gave a number of important results regarding the early period of mega-sites and, in particular, regarding the development of ring-shaped layouts. The results have already been published partly elsewhere (Hofmann *et al.* 2019a; Shatilo 2021; Müller *et al.* 2022; Chapters 19 and 20, this work, Vol. II).

Chronology

The newly obtained radiometric data confirm established relative chronologies insofar as the three settlements date earlier or are contemporaneous with the largest mega-sites of the Sinyukha region. With the highest probability, Veselyj Kut was inhabited between 4070–4000 BCE, Chizhyvka between 4050–3990 BCE and Volodymyrivka between 3920–3800 BCE (Shatilo 2021). In view of the fact that only single contexts have been dated, the actual duration of the settlements may be longer. The dates show that East Trypillia settlements are earlier than West Trypillia settlements. In this respect, they do not seem to reflect different 'cultures' but primarily chronological differences.

Pottery styles

In the ceramic assemblages studied, we see the transition from predominately-dark fired pottery, decorated mainly by means of deepening techniques, to pottery fired under oxidising conditions and mainly decorated with painting (Shatilo 2021, 223). While in the two East-Trypillia sites of Veselyj Kut and Chizhivka both kinds of pottery were produced, in Volodymyrivka, oxidising fired painted pottery was already fully established. The described stylistic changes were associated with a marked standardisation of ceramic pastes and firing conditions, which might imply changes in production conditions.

Pottery kilns

In Trypillian mega-sites, numerous examples of evidence of a novel type of dual-chambered pottery kiln have been found in recent years (*e.g.* Korvin-Piotrovskiy *et al.* 2016; Ţerna *et al.* 2019; Rud *et al.* 2019b; Korvin-Piotrovskiy and Ovchinnikov 2020), which can also be identified in magnetic plans based on their specific signature (Kruts *et al.* 2011). The earliest secure evidence so far of this type of furnace dates from the period after 4000 BCE (Ţerna *et al.* 2019). While no corresponding anomalies are detectable in the magnetic plans of Veselyj Kut and Chizhivka, numerous corresponding anomalies appear in Volodymyrivka. Although the existence of such pottery kilns in Volodymyrivka still needs confirmation by excavations, the negative finding from Veselyj Kut and Chizhivka is remarkable insofar as here two pottery production workshops were discovered during earlier research (Tsvek 2006). In both cases, the associated one-chamber kilns were located inside houses. Our working hypothesis is therefore that the novel double-chamber kilns may have been invented in conjunction with the stylistic shift towards oxidising fired ceramics and paintings within Trypillian mega-sites. In association with the technological improvement of the kilns, their placement outside houses may have developed. Presumably, the changes in firing technology were associated with a higher degree of craft specialisation, which would explain the greater standardisation.

Settlement layouts

All three settlements represent a layout type that we call 'ring-shaped' based on its main component – a circumferential ring corridor (see Chapter 20, this work, Vol. II). The earliest evidence for this settlement type from the period between 4300 and 4200 BCE is currently known from the region west of the Southern Bug (Chapter 14, this work, Vol. II). However, we do not yet know what earlier settlement layouts of the Phase Trypillia B1 in the Sinyukha region looked like. Trypillia A sites from the period before 4450 BCE were still organised in linear arrangements and ring streets are not yet known.

Unlike the later round or oval settlements, the layouts of the East Trypillia settlements of Chizhivka and Veselyj Kut exhibit a very specific cloverleaf-like shape. So far, we know only one probable analogy for such a settlement layout from the Pieniążkowa (Bugachivka II) site plan (Fig. 34; Himner 1933, 49) which belongs to the same period, pottery style and region (Tsvek 2006, 20). In our opinion two possible reasons for such a layout should be considered. On the one hand, the settlement layout could represent a specific adaptation to the site topography with the aim of limiting the elevation differences within the ring corridor. In this case, the same curvature in the western part of Veselyj Kut, where the relief does not imply such a curve, is hard to understand. On the other hand, the settlement pattern could be a result of the fusion of formerly independent communities into larger mega-sites. This would match the sudden emergence of large aggregated settlements, practically without smaller predecessors and without preceding population growth (Shatilo 2021, 206–211). René Ohlrau was able to show that the formation of large mega-sites is not possible through natural population growth alone and that external population influx is inevitably required (Ohlrau 2020, 236–237).

The idea of the fusion of previously independent communities into mega-site populations might be supported, among other things, by the occurrence of low-level and high-level mega-structures at different positions within the settlements, which was observed in Volodymyrivka, Nebelivka and Maidanetske, for example (*e.g.* Ohlrau 2015; Müller *et al.* 2016a; Hofmann *et al.* 2019a). Behind these mega-structures stand a system of integrative institutions, which probably provided the

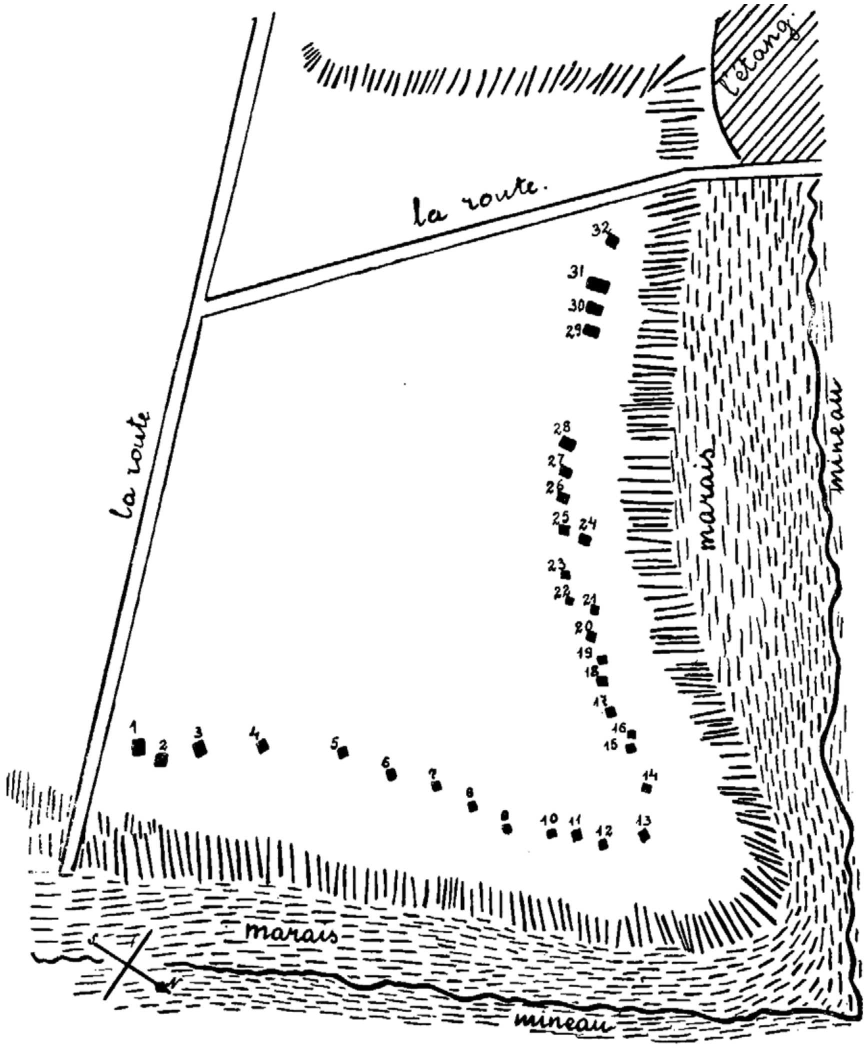


Figure 34. Settlement plan of Pieniazkowa (after Himner 1933, 49).

basis for a chain of sequential decision-making and was an integral characteristic of social organisation in the top group of mega-sites.

While this system was already fully established in Volodymyrivka, low-level mega-structures seem to be missing in Chizhivka and not very clearly pronounced in Veselyj Kut. In contrast, in both of the two latter sites, high-level mega-structures for the whole settlement could be clearly identified on a plaza-like widening of the ring corridor in the east of the settlements. In Veselyj Kut, we assume in addition the existence of five low-level mega-structures (see Hofmann *et al.* 2019a). The criteria for this classification were in four cases the possible differing architecture of the buildings from dwellings and in one case the exceptional size of a building. Unlike later examples from B2 period settlements, these mega-structures are located within clusters of houses on the ring street. Evidence for integrative buildings within house rows is presented by Stanislav Ţerna *et al.* (Chapter 16, this work, Vol. II) through comparisons of pit inventories in the settlement of Stolniceni 1. Consequently, the plaza-like widenings within the ring corridors of Chizhivka and Veselyj Kut could well be interpreted as focal points of integrative low-level decision-making processes.

One of the indirect arguments in favour of the fusion of previously independent communities into mega-sites is the recently proposed theory that major chronological differences are located within groups of buildings (Shatilo 2021, 125). If we follow this hypothesis, then at the initial stage of settlement of the site, houses were erected in its different parts, leaving free space for subsequent buildings, which in these sites may also potentially reflect settlement by groups of different origins.

Ditches

The two older settlements, Chizhivka and Veselyi Kut, are partly enclosed by double or single perimeter ditches at the settlement boundary, while the youngest of the three settlements Volodymyivka shows no bordering ditch in the magnetic plan. Recent investigations at Nebelivka and Maidanetske have provided evidence that ditches at Trypillian mega-sites may not represent proper fortifications, but must have had other functions (Ohlrau 2020, 114–116; Videiko and Chapman 2020). In the case of Nebelivka, the small dimensions of the ditches and the shorter and longer gaps clearly argue against a fortificatory character (Videiko and Chapman 2020). Also, the inner ditch of the Maidanetske settlement does not show a continuous course, but consists probably only of ditch segments that show different backfilling biographies (Ohlrau 2020, 212–214, 282). In both cases, therefore, they appear to be causewayed enclosures, which could have been used to separate the settlement area from the outside world (Harding *et al.* 2006) or as a planning element for the establishment of the ring corridor when the settlement was founded (Ohlrau 2020, 116; Gaydarska and Chapman 2020).

The fact that the ditch at the western settlement boundary of Veselyj Kut is only very faintly visible and seems to show larger gaps could indicate a shallow depth and discontinuities. The two ditches in Chizhivka are clearly more visible, but also seem to have minor interruptions from passages or similar features.

For the interpretation of the nature and causes of the presence and absence of ditches, it is worth taking a global look at the network of Cucuteni-Trypillia settlements. This shows that certainly not all Trypillian settlements had ditches (Fig. 35). We must take into account that ditches are only visible in high-resolution magnetic survey plans, whereas their discovery was previously considerably more difficult and determined by chance. The presence and absence of ditches can therefore only be taken as certain if high resolution magnetic plans or large-scale excavation plans are available.

In the Sinyukha region, perimeter ditches are regularly proven in settlements founded in the time between 4100 and 3900 BCE. In the majority of earlier and later foundations, however, ditches occur only very sporadically (*e.g.* Kosenivka). In the region between Southern Bug and Dniester evidence for settlements without ditches has been found already for the period between 4300 and 4000 BCE. For the period between ca. 3900 BCE and 3600 BCE, data are missing. Similar to the Sinyukha area, ditches are absent in late settlements from the 36th and 35th centuries BCE.

West of the Dniester, ditches generally seem to be much more widespread and occur frequently in settlements built in naturally protected locations on promontories. However, it is unclear whether this picture is due to a certain bias in the data, caused by the focus of research on promontory settlements. Similar to the situation east of the Dniester, there are also indications that settlements with ditches generally became rarer over time.

Overall, at the geographical macro-level, we cannot identify clear phases of more or less importance of ditches based on the presence and absence of ditches alone. However, elsewhere we have highlighted systematic spatio-temporal differences with regard to the dimension of ditches (Hofmann *et al.* Chapter 17, this work, Vol. II). While ditches from settlements from the period before and after aggregated settlements (Cucuteni A, Trypillia B1, Trypillia C2) tend to have greater depths and often occur in settlements in naturally protected locations, perimeter ditches from the phase of aggregated mega-sites tend to be of lesser dimensions.

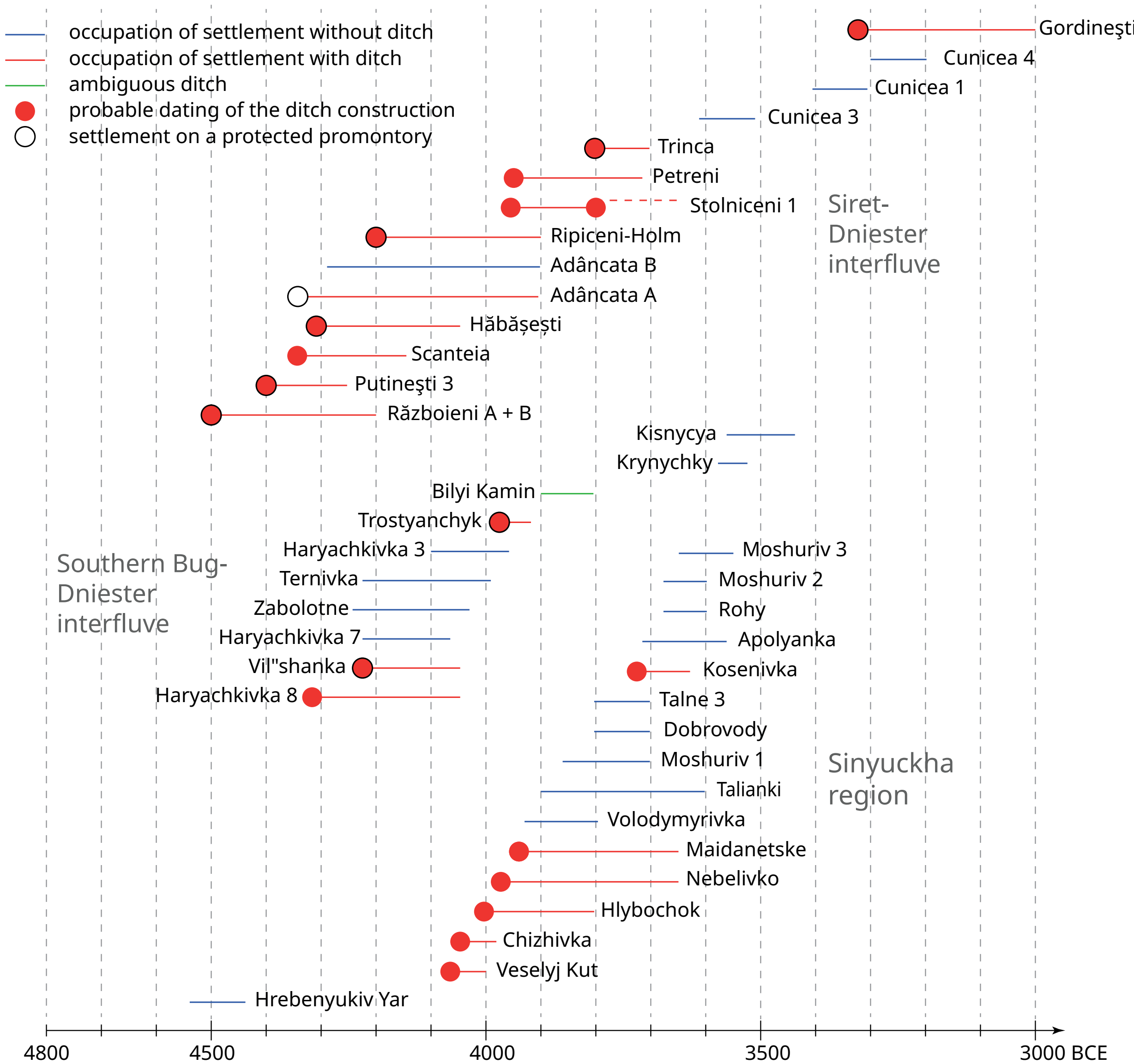


Figure 35. Occurrence of ditches in Trypillia settlements.

These differences and the causewayed character of the perimeter ditches of some mega-sites indicate that ditches probably had different functions in the settlements investigated. In cases where deep ditches occur in the context of additionally protected settlement sites, fortificatory intentions seem very plausible. In the case of shallow perimeter ditches, some of which have interruptions, other interpretations are more likely.

Demography

Our surveys provide important new data for estimating population sizes and trends (Tab. 6).

In a long-term perspective, there is a slight trend towards an increase in the floor areas of houses from a median of 59 m² in Veselyi Kut to 68 m² in Volodymyrivka, which continues in later settlements such as Maidanetske (72 m²) and Kosenivka (79 m²). This trend might indicate a slight increase in average household sizes.

Increasing settlement sizes and building densities also show a dramatic increase in population aggregation. In the three settlements investigated, the number of houses increases from a few hundred to several thousand and the building density from five to twenty houses per hectare settlement area. In a regional comparison of the Sinyukha River Basin, Volodymyrivka is the settlement with one of the highest building densities. In other mega-sites, this value is significantly lower (cf. Diachenko 2016; Ohlrau *et al.* 2016; Ohlrau 2022).

Similar to other studies, the main problem in interpreting this data is the quantification of houses that were occupied at the same time. Unfortunately, for the three settlements investigated, the ^{14}C dates obtained only punctually for single contexts are not sufficient to estimate the total durations of the investigated settlements. However, larger series of ^{14}C dates obtained from Bilyii Kamin (Rud *et al.* 2019a) Nebelivka (Millard 2020), Maidanetske (Ohlrau 2020) and Talianki (Shatilo 2021) have shown that for many settlements we have to assume significantly longer durations of individual settlements than previously estimated, in the scale of 150+ years (Shatilo 2021, 211–216). According to estimates based on this new data, the population size in Chizhivka most likely ranked in the mid three-digit range, in Veselyj Kut in the lower four-digit range and in Volodymyrivka in the mid four-digit range (Ohlrau 2022).

The work carried out on the three sites from the period before the largest mega-sites and of the Sinyukha River catchment yielded important results. With regard to their smaller size and lower building density, these settlements represent earlier stages of Trypillian population aggregation. We are able to show clearly that settlements from the time before 4000 BCE were already planned according to the ring-shaped settlement scheme that was typical for later settlements including mega-sites. Thanks to our new data on mega-structures, it is possible to trace better the evolution of the system of communal institutions, which formed the basis for the successful integration of large populations.

Additional research on chronologically even earlier settlements is needed to understand, firstly, whether the ring-shaped settlements of the Vinnitsa region are really the earliest settlements of this type of spatial organisation (see Chapter 14, this work, Vol. II) or whether this layout appears simultaneously in different regions and, secondly, whether the 'curved' ring-shaped layout of Veselyj Kut is the result of adaptation to the site topography or else reflects the process of unification of different communities in one settlement and, thirdly whether this type of layout is typical for all 'East Trypillia' sites or not. From the perspective of the surveys in Veselyj Kut, Chizhivka and Volodymyrivka, the differences between Eastern and Western Trypillia can be partly explained by their chronological position and verified based on the ceramic styles and production technology.

Table 6. Data from selected settlements of the Sinyukha River catchment area according to this study and Ohlrau (2022). The data on median house sizes were obtained from magnetic plans based on the outer boundary of the burnt daub packages, based on the premise that the houses were rectangular and excluding houses with unclear boundaries and remains of communal buildings.

site	total size (ha)	number of houses (extrapolated)	houses/ha	median house size (m²)
Veselyi Kut	60	300	5	58.8
Chizhivka	20	225	11	60.5
Volodymyrivka	85	1700	20	67.7
Nebelivka	238	1370	5.8	-
Maidanetske	170	2930	17.2	65.6
Dobrovody	189	1384	7.3	69.1
Talianki	320	2200	6.9	60.4

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References

Balabina 1998: Балабина, В.И., 1998. *Фигурки животных в пластике Кукутень-Триполья*. Москва: Российская Академия Наук, Институт Археологии.

Bibikov 1953: Бибиков, С.Н., 1953. *Раннетрипольское поселение Лука-Врублевецкая на Днестре: К истории ранних земледельческо-скотоводческих племен на юго-востоке Европы*. Материалы и исследования по археологии СССР (МИА) 38. Москва, Ленинград: Издательство Академии наук СССР.

Chernysh 1982: Черныш, Е.К., 1982. Энеолит Правобережной Украины и Молдавии. *In*: Р.М. Мунчаев, Е.К. Черныш, Н.Я. Мерперт and В.М. Массон, eds. *Энеолит СССР*. Москва: Наука, 165-320.

Diachenko 2010: Дяченко, О.В., 2010. До проблеми систематизації поселень західнотрипільської культури у межиріччі Південного Бугу та Дніпра. *Археологія і давня історія України*, 2, 17–22. Available from: http://dspace.nbuv.gov.ua/bitstream/handle/123456789/83712/05-Dyachenko.pdf?sequence=1

Diachenko, A., 2012. Settlement System of West Tripolye Culture in the Southern Bug and Dnieper Interfluve: Formation Problems. *In:* F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture giant-settlements in Ukraine: Formation, development and decline*. Oxford, Oakville: Oxbow Books, 116–138. Available from: https://doi.org/10.2307/j.ctvh1dvmn.10

Diachenko, A., 2016. Demography Reloaded. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 181–193. Available from: https://doi.org/10.4324/9781315630731

Diachenko, A. and Harper, T.K., 2016. The absolute chronology of Late Tripolye sites: a regional approach. *Sprawozdania Archeologiczne*, 68, 81–105. Available from: https://rcin.org.pl/dlibra/publication/80409

Dumitrescu, V., 1979. *Arta culturii Cucuteni*. Bucureşti: Editura Meridiane.

Gaydarska, B. and Chapman, J., 2020. Discussion. *In*: B. Gaydarska, ed. *Early urbanism in Europe. The Trypillia megasites of the Ukrainian forest-steppe*. Warsaw, Berlin: De Gruyter, 415–507. Available from: https://doi.org/10.1515/9783110664959-010

Gusev 1998: Гусев, С.А., 1998. К вопросу о транспортных средствах трипольской культуры / On the Issue of the Tripolye Culture Transportation Means. *Российская археология*, 1998 (1), 15–28. Available from: https://www.archaeolog.ru/media/books_sov_archaeology/1998_book01.pdf

Hale, D., Chapman, J., Swann, N., Videiko, M. and Villis, R., 2010. Early Urbanism in Europe? Geophysical Survey at Nebelivka, Ukraine. *Recent Work in Archaeological Geophysics, Abstracts*, 2010, 35–36.

Harding, A., Sievers, S. and Venclová, N., eds., 2006. *Enclosing the Past: Inside and Outside in Prehistory*. Sheffield Archaeological Monographs 15. Sheffield: J.R. Collis Publications.

Himner, M., 1933. Étude sur la civilisation prémycénienne dans le bassin de la Mer Noire, d'après des fouilles personnelles. *Światowit*, 14, 26–163.

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019a. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Hofmann *et al.* 2019b: Хофманн, Р., Шатіло, Л.О. and Пічкур, Є.В., 2019b. Нові розвідкина Трипільських поселеннях Буго-Дніпровського межиріччя: колекція крем'яних знахідок / New Explorations of the Trypillia Settlements of Bugh-Dnieper Interfluve: a collection of flint finds. *Vita Antiqua*, 11, 144–158. Available from: https://doi.org/10.37098/VA-2019-11-144-158

Hofmann, R., Shatilo, M., Ohlrau, R., Dal Corso, M., Dreibrodt, S., Videiko, M., Rassmann, K., Kirleis, W. and Müller, J., 2018. Tripolye – Strategy and Results of an ongoing Ukrainian-European Project. *Vita Antiqua*, 10, 146–154. Available from: https://doi.org/10.37098/2519-4542-2018-1-10-146-154

Kirleis, W. and Dal Corso, M., 2016. Trypillian Subsistence Economy: Animal and Plant Exploitation. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 195–205. Available from: https://doi.org/10.4324/9781315630731

Kirleis, W. and Dreibrodt, S., 2016. The Natural Background: Forest, Forest Steppe or Steppe Environment. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 171–180. Available from: https://doi.org/10.4324/9781315630731

Kirleis, W., Dal Corso, M., Pashkevych, G., Schlütz, F., Hofmann, R., Terna, A., Dreibrodt, S., Rud, V., Videiko, M.Y. and Müller, J., 2023. A complex subsistence regime revealed for Cucuteni–Trypillia sites in Chalcolithic eastern Europe based on new and old macrobotanical data. *Vegetation History and Archaeobotany*, 33 (2024), 75–90. Available from: https://doi.org/10.1007/s00334-023-00936-y

Korvin-Piotrovskiy and Ovchinnikov 2020: Корвин-Пиотровский, А.Г. and Овчинников, Э.В., 2020. Виробничі об'єкти комплексу «Сім'я гончара» на трипільському поселенні Тальянки. *Емінак*, 25 (1), 254–276.

Korvin-Piotrovskiy, A., Hofmann, R., Rassmann, K., Videiko, M.Y. and Brandtstätter, L., 2016. Pottery Kilns in Trypillian Settlements. Tracing the Division of Labour and the Social Organization of Copper Age Communities. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 221–252. Available from: https://doi.org/10.4324/9781315630731

Kruts 1989: Круц, В.А., 1989. К истории населения трипольской культуры в междуречье Южного Буга и Днепра. *In*: С.С. Березанская, ed. *Первобытная археология. Материалы и исследования*. Київ: Издательство «Наукова думка», 117–132.

Kruts, V.A., Korvin-Piotrovskiy, A.G., Rassmann, K. and Peters, D., 2011. Talianki: reloaded. Geomagnetic Prospection three decades after V.P. Dutkin's work. *In:* Круц, В.А., Корвин-Пиотровский, А.Г., Рыжов, С.Н., Черновол, Д.К. and Чабанюк, eds. *Трипольское поселение-гигант Тальянки. Исследования 2011 г / Talianki – Settlement-Giant of the Tripolian Culture. Investigations in 2011*. Киев: Институт археологии НАН Украины, 60–85.

Markevich 1985: Маркевич, В.И., 1985. *«Далекое — близкое»*. Кишинев: Тимпул.

Millard, A., 2020. The AMS Dates. *In*: B. Gaydarska, ed. *Early urbanism in Europe. The Trypillia megasites of the Ukrainian forest-steppe*. Warsaw, Berlin: De Gruyter, 246–256. Available from: https://doi.org/10.1515/9783110664959-008

Movsha 1972: Мовша, Т.Г., 1972. Перıодизацıя ı хронологıя середнього та пıзнього Трипıлля. *Археологiя*, 1972 (5), 3–24. Available from: http://www.vgosau.kiev.ua/a/Archaeology_1972_05.pdf

Movsha 1984: Мовша, Т.Г., 1984. Хронология Триполья-Кукутени и степные культуры эпохи раннего металла в ее системе. *In*: И.Ф. Ковалева, ed. *Проблемы археологии Поднепровья*. Днепропетровск: Днепропетровский государственный университет, 60–83.

Movsha 1985a: Мовша, Т.Г., 1985a. Средний этап трипольской культуры. *In*: С.С. Березанская, Ю.Г. Колосов, В.А. Круц, В.В. Отрощенко, Д.Я. Телегин and Н.Н. Чередниченко, eds. *Археология Украинской ССР*, Vol. 1: *Первобытная археология*. Киев: Издательство «Наукова думка», 206–223.

Movsha 1985b: Мовша, Т.Г., 1985b. Поздний этап трипольской культуры. *In*: С.С. Березанская, Ю.Г. Колосов, В.А. Круц, В.В. Отрощенко, Д.Я. Телегин and Н.Н. Чередниченко, eds. *Археология Украинской ССР*, Vol. 1: *Первобытная археология*. Киев: Издательство «Наукова думка», 223-263.

Müller, J., 2016. Demography and Social Agglomeration: Trypillia in a European Perspective. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 7–16. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Brandtstätter, L., Ohlrau, R. and Videiko, M., 2016a. Chronology and Demography: How Many People Lived in a Mega-Site? *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 133–170. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Rassmann, K. and Videiko, M., eds., 2016b. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge. Available from: https://doi.org/10.4324/9781315630731

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site / Майданецьке 2013. Нові розкопки великого Трипільського поселення*. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Müller, J., Hofmann, R. and Shatilo, M., 2022. Tripolye Mega-Sites: "Collective Computational Abilities" of Prehistoric Proto-Urban Societies? *Journal of Social Computing*, 3 (1), 75–90. Available from: https://doi.org/10.23919/JSC.2021.0034

Nebbia, M., 2017. *Early cities or large villages? Settlement dynamics in the Trypillia group, Ukraine*. [PhD thesis. Durham University]. Available from: http://etheses.dur.ac.uk/12109

Nebbia, M., Gaydarska, B., Millard, A. and Chapman, J., 2018. The making of chalcolithic assembly places: Trypillia megasites as materialized consensus among equal strangers? *World Archaeology*, 50 (1), 41–61. Available from: https://doi.org/10.1080/00438243.2018.1474133

Ohlrau, R., 2015. Trypillia Großsiedlungen: Geomagnetische Prospektion und architektursoziologische Perspektiven. *Journal of Neolithic Archaeology*, 17, 17–100. Available from: https://doi.org/10.12766/jna.2015.3

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Ohlrau, R., 2022. Trypillia Mega-Sites. Neither Urban nor Low-Density? *Journal of Urban Archaeology*, 5, 81–100. Available from: https://doi.org/10.1484/J.JUA.5.129844

Ohlrau, R. and Rud, V., 2019. Testing Trypillian site development via geomagnetic survey – New “mega-structures” and plans of smaller sites. *In*: D. Mischka, C. Mischka and C. Preoteasa, eds. *Beyond Excavation. Geophysics, Aerial Photography and the Use of Drones in Eastern and Southeastern European Archaeology. Proceedings of the International Colloquium, 5-8 December 2016, Piatra-Neamț, Romania*. Bibliotheca Memoriae Antiquitatis 40; Erlanger Studien zur Prähistorischen Archäologie 3. Piatra-Neamț: Editura “Constantin Matasă”, 87–113.

Ohlrau, R., Dal Corso, M., Kirleis, W. and Müller, J., 2016. Living on the Edge? Carrying Capacities of Trypillian Settlements in the Buh-Dnipro Interfluve. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 207–220. Available from: https://doi.org/10.4324/9781315630731

Ovchinnikov 2014: Овчинников, Е.В., 2014. *Трипільська культура Канівського Подніпров'я*. Київ: Видавець Олег Філюк.

Passek 1941: Пассек, Т.С., 1941. Трипольское поселение у Владимировки. *Вестник древней истории*, 1941 (1), 212–220.

Passek 1947: Пассек, Т.С., 1947. Трипольские поселение у Владимировки в свете новых исследований. *Кратких сообщений ИИМК*, 21, 65–72.

Passek 1949: Пассек, Т.С., 1949. *Периодизация трипольских поселений (III–II тыс. до н.э.)*. Материалы и исследования по археологии СССР (МИА) 10. Москва, Ленинград: Издательство Академии наук СССР.

Passek 1961: Пассек, Т.С., *Раннеземледельческие (трипольские) племена Поднестровья*. Материалы и исследования по археологии СССР (МИА) 84. Москва, Ленинград: Издательство Академии наук СССР.

Passek and Bezvenglinsky 1939: Пассек, Т.С. and Безвенглинский, Б.П., 1939. Новые открытия трипольской археологической экспедиции в 1939 г. *Вестник древней истории*, 1939 (4), 186–192.

Peresunchak and Burdo 2015: Пересунчак, О.С. and Бурдо, Н.Б., 2015. Колекція пластики із ранньотрипільського поселення Могильна III. *In*: О. Дяченко, Ф. Менотті, С. Рижов, К. Бунятян and С. Кадров, eds. *Культурний комплекс Кукутень-Трипілля та його сусіди. Збірка наукових праць пам'яті Володимира Круца.* Львів: Астролябія, 357–366.

Pogoševa, A.P., 1985. Die Statuetten der Tripolje-Kultur. *Beitrage zur allgemeinen und vergleichenden Archäologie*, 7, 95–242.

Popova 1996: Попова, Т.А., 1996. Некоторые группы глиняных изделий из трипольского поселения Раковец. *Археологія*, 1996 (3), 134–141. Available from: http://www.vgosau.kiev.ua/a/Archaeology_1996_03.pdf

Rassmann, K., Ohlrau, R., Hofmann, R., Mischka, C., Burdo, N., Videjko, M.Y. and Müller, J., 2014. High precision Tripolye settlement plans, demographic estimations and settlement organization. *Journal of Neolithic Archaeology*, 16, 96–134. Available from: https://doi.org/10.12766/jna.2014.3

Rassmann, K., Korvin-Piotrovskiy, A., Videiko, M. and Müller, J., 2016. The new Challenge for Site Plans and Geophysics: Revealing the Settlement Structure of Giant Settlements by Means of Geomagnetic Survey. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE*. Themes in Contemporary Archaeology 2. London, New York: Routledge, 29–54. Available from: https://doi.org/10.4324/9781315630731

Rud, V., Hofmann, R., Kosakivskyi, V., Zaitseva, O. and Müller, J., 2019a. Trypillia Megasites West of the River Southern Buh: Preliminary Results of Bilyi Kamin Site Investigation in 2018. *Journal of Neolithic Archaeology*, 21, 27–60. Available from: https://doi.org/10.12766/jna.2019.2

Rud, V., Zaitseva, O., Hofmann, R., Rauba-Bukowska, A. and Kosakivsky, V., 2019b. Unique Pottery Kiln Construction? The Interpretation of Massive Clay Objects from the Trostianchyk Site of the Trypillia Culture. *Sprawozdania archeologiczne*, 71, 11–39. Available from: https://doi.org/10.23858/sa71.2019.001

Ryzhov 1999: Рижов, С.М., 1999. *Керамiка Поселень Трипiльської Культури Буго-Днiпровського Межирiччя Як Iсторичне Джерело*. [Unpublished PhD thesis. Нацıональна Академıя Наук України].

Ryzhov, S.N., 2012a. Relative Chronology of the Giant-settlement Period BII–CI. *In:* F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture giant-settlements in Ukraine: Formation, development and decline*. Oxford, Oakville: Oxbow Books, 79–115. Available from: https://doi.org/10.2307/j.ctvh1dvmn.9

Ryzhov, S.N., 2012b. Tripolian Pottery of the Giant-settlements: Characteristics and Typology. *In:* F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture giant-settlements in Ukraine: Formation, development and decline*. Oxford, Oakville: Oxbow Books, 139–168. Available from: https://doi.org/10.2307/j.ctvh1dvmn.11

Ryzhov 2015: Рыжов, С., 2015. Владимирская локально-хронологическая група западнотрипольской культуры в Буго-Днепровском междуречье. *In*: О. Дяченко, Ф. Менотті, С. Рижов, К. Бунятян and С. Кадров, eds. *Культурний комплекс Кукутень-Трипiлля та його сусiди. Збiрка наукових праць пам'ятi Володимира Круца.* Львiв: Астролябiя, 153-166

Shatilo, L., 2021. *Tripolye Typo-chronology: Mega and Smaller Sites in the Sinyukha River Basin.* Scales of Transformation in Prehistoric and Archaic Societies 12. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/m5457py

Starkova 2018: Старкова, Е.Г., 2018. Материальный комплекс Немировского городища в энеолите (трипольская культура). *In*: Г.И. Смирнова, М.Ю. Вахтина, М.Т. Кашуба and Е.Г. Старкова, eds. *Городище Немиров на реке Южный Буг. По материалам раскопок в XX веке из коллекций Государственного Эрмитажа и Научного архива ИИМК РАН / Nemirov Hill Fort on South Bug River. According the excavation materials of the 20th century from collections of the State Hermitage Museum and documents kept in IHMC RAS*. Санкт-Петербург: Государственный Эрмитаж; Российская Академия Наукинститут Истории Материальной Культуры, 75–136. Available from: https://doi.org/10.31600/978-5-9909872-2-7

Ţerna, S. and Heghea, S., 2017. Middle and late Copper Age settlements from the Brînzeni microzone on the Prut river: older research in a modern background. *Sprawozdania archeologiczne*, 69, 297-325. Available from: https://doi.org/10.23858/sa69.2017.012

Ţerna, S., Rassmann, K., Vornicu-Ţerna, A. and Müller, J., 2019. The evolution of dual-chambered updraught kilns on the Cucuteni-Tripolye mega-sites in the 4th millennium BC: a view from Stolniceni. *Godišnjak*, 48, 41–58. Available from: https://doi.org/10.5644/Godisnjak.CBI.ANUBiH-48.116

Tsvek 1980: Цвек, Е.В., 1980. Трипольские поселения Буго-Днепровского междуречья (к вопросу о восточном ареале культуры Кукутени-Триполье). *In*: И.И. Артеменко, ed. *Первобытная археология – поиски и находки*. Киев: Издательство «Наукова думка», 163–185.

Tsvek 1985: Цвек, О.В., 1985. Особливостı формування схıдного регıону трипıльсько-кукутенської спıльностı. *Археологıя*, 1985 (51), 31–45. Available from: http://www.vgosau.kiev.ua/a/Archaeology_1985_51.pdf

Tsvek 1987: Цвек, Е.В., 1987. *Трипольская культура междуречья Южного Буга и Днепра (средний этап)*. Автореф. дис. канд. ист. наук., Киев, 17 с. [Summary of the unpublished PhD thesis. Академия Наук Украинской ССР].

Tsvek 1989: Цвек, Е.В., 1989. Буго-днепровский вариант восточнотрипольской культуры: К пробл. выделения культур и локал. вариантов Триполья. *In*: С.С. Березанская, ed. *Первобытная археология. Материалы и исследования*. Київ: Издательство «Наукова думка», 106-117.

Tsvek 1999: Цвек, О.В., 1999. Структура східнотрипільської культури / Structure of Eastern Tripolie Culture. *Археологія*, 1999 (3), 28–40. Available from: http://www.vgosau.kiev.ua/a/Archaeology_1999_03.pdf

Tsvek 2006: Цвек, О.В., 2006. *Поселення східнотрипільської культури (короткий нарис).* Київ: Інститут археології НАН України.

Tsvek 2012: Цвек, Е.В., 2012. Восточнотрипольская культура и некоторые аспекты структуры Кукутено-Трипольской мегаобщности. *In*: В.В. Отрощенко, ed. *Земледельцы и скотоводы Древней Европы. Проблемы, новые открытия, гипотезы.* Киев, Санкт-Петербург: Институт археологии НАН Украины, Институт истории материальной культуры, 225-245.

Videiko, M. and Chapman, J., 2020. Ditches. *In*: B. Gaydarska, ed. *Early urbanism in Europe. The Trypillia megasites of the Ukrainian forest-steppe*. Warsaw, Berlin: De Gruyter, 233–236. Available from: https://doi.org/10.1515/9783110664959-008

Yakubenko 1998: Якубенко, О.О., 1998. Трипільські статуетки птахів у збірці Національного музею історії України. *In*: Н.Г. Ковтанюк, ed. *До 100-річчя Національного музею історії України: Матеріали науково-практичної конференції, присвяченої Міжнародному дню музеїв (1997 р.).* Київ: ІІІ Лтд, 42–59.

Yakubenko 2004: Якубенко, О.О., 2004. Володимирівка. *In*: М.Ю. Відейко and Н.Б. Бурдо, eds. *Енциклопедія Трипільської Цивілізації*, Vol. 2. Київ: Укрполіграфмедіа, 104–105. Available from: https://archive.org/details/trypillia

Yakubenko 2011a: Якубенко, О.О., 2011a. Антропоморфна пластика трипільського поселення Володимирівка. *In*: Ю. Олійник, ed. *Тематичний збірник наукових праць (20 років Незалежності України)*. Київ: Національний музей історії України, Такі справи (2010), 56–80.

Yakubenko 2011b: Якубенко, О.О., 2011b. Зооморфна пластика та посуд з трипільського поселення Володимирівка з колекії музею. *In*: Ю. Олійник, ed. *Тематичний збірник наукових праць (20 років Незалежності України)*. Київ: Національний музей історії України, Фенікс (2011), 354–380.

Appendices

Abbreviations: FA = Firing atmosphere; C = Surface colour; T = Temper (kind, maximum size, intensity); S = Surface treatment.

Appendix 1: Description of non-ceramic finds in the illustrations.

figure	find-ID	inventory-ID	type	description
34: 1	2001	31	spindle whorl?	1, 18 g, FA: oxidised, C: yellowish-white, T: invisible, S: carefully smoothed with incisions.
34: 2	2001	24	anthropomorphic figurine, fragment	1, 24 g, FA: oxidising, C: whitish-yellow, S: carefully smoothed with remains of orange engobe, dark painting and incisions.
34: 3	2001	28	'toy wagon', fragment	1, 90 g, FA: oxidising, C: yellowish, T: sand, 0.5 mm, medium, S: carefully smoothed with an orange engobe and black painting. The partly preserved cavity above the leg shows a very rough surface treatment on the inside. It was consequently a closed object.
34: 4	2001	22	anthropomorphic figurine, fragment	1, 6 g, FA: oxidising, C: whitish, T: invisible, S: destroyed.
34: 5	2001	-	anthropomorphic figurine, fragment	1, 26 g, FA: oxidising, C: yellowish white, T: sand, 1 mm, medium, S: carefully smoothed.
34: 6	2001	25	figurine, fragment	1, 52 g, FA: oxidising, C: yellowish white, T: quartz sand, 0.5 mm, low; S: carefully smoothed with orange engobe, dark painting and incised lines.
34: 7	2001	26	anthropomorphic figurine, fragment	1, 32 g, FA: oxidising, C: whitish yellow, T: ?, S: carefully smoothed with orange engobe, red-brown painting.
34: 8	2001	21	anthropomorphic figurine, fragment	1, 14 g, FA: oxidising, C: whitish yellow, T: organic, 0.5 mm medium and limestone 0.5 mm medium, S: carefully smoothed with orange engobe, dark red painting.
34: 9	2001	23	figurine, fragment	1, 8 g, FA: oxidising, C: yellowish white, T: invisible, S: carefully smoothed, but slightly uneven with an orange engobe and dark red-brown painting.
34: 10	2001	27	bird figurine, fragment	1, 78 g, FA: oxidising, C: yellowish white, T: invisible, S: carefully smoothed, but slightly uneven with remains of an orange engobe. On the underside there is an opening with a diameter of approx. 13 mm, which leads to a hollow space inside the figurine.
34: 11	2001	27	figurine, fragment	2, 104 g, FA: oxidising, C: yellowish white, T: invisible, S: very carefully smoothed with an orange engobe and dark brown painting. The partly preserved cavity above the leg shows a very rough surface treatment on the inside. It was consequently a closed object. Cavity in the belly, presumably created by mounting the belly elevation on a base plate.

Appendix 2: Find-list of ornithomorphic figurines.

site	lat	long	bird	bird?	rattles	full	whist-les?	loc_group
Vladimiriovka	48,56430	30,75057	6	2	4			Vladimirivka
Sushkovka	48,65908	30,36010	3	1	1	1	1	Tomoshivka
Pugachivka	48,83760	30,31260	1			1		Tomoshivka
Andreevka	48,80352	31,62846	1		1			Vladimirivka
Botvinovka	48,95711	30,02281		1				
Dmitrushki	48,79550	30,28132		1				Tomoshivka
Veremye	50,04195	30,81173	1		1			
Kolomyshchina I	50,10024	30,82680	1		1			
Koshilovtcy	48,87505	25,57622	5		2			Koshilovetska
Brinzeni VIII	48,07160	27,14398	3	1	2			
Pekari II	49,70066	31,55033	1		1			Kaniv
Mogilna III	48,23324	30,06678	1			1		
Racovers	48,07871	28,40148	1		1			Racovets
Luka-Vrublivetska	48,56031	26,77426	1			1		
Bernove-Luka	48,79190	25,26868	2			2?		
Nezvisko	48,77343	25,25318	1					
Frumushika II	47,55527	26,87730	4		2	2		
Grigorivka-Hatishche	49,92140	31,40372	1		1			Kaniv
Sabatinovka II	48,18194	30,18598	2	1		1		
Putineshti	47,83508	28,11761	1			1		
Tyrpesht IV / Tirpesti	47,13333	26,40000	1			1		
Gorodnica	48,68852	25,62397	1			1		
Hebashesht / Habasesti-Holm	47,15637	26,95798	2			1		
Talianki	48,80677	30,52994	1		1			Tomashovka
Yablona	47,80592	27,61871	3	1	2			
Grebeni	50,01913	30,97238	2		2			Kolomyishchina
Drutcy 1	47,96530	27,29567	1			1		
Zalishchiki	48,64408	25,73504	2		2			
Penezhkovo	48,87169	30,03077	1	1	1			
Cucuteni								
Uman region'	no		5		3		1	?
Birlaesht-Strurza			1			1		
Glavan I			1		1			

dating	dating	source	remarks
B2	3950-3800	Yakubenko, 1998	
C1	3800-3650	Yakubenko, 1998	
C1	5´6	Yakubenko, 1998	
B2	3950-3800	Yakubenko, 1998	
?		Yakubenko, 1998	случайная находка
C1	5,6	Yakubenko, 1998	
C1	3800-3650	Yakubenko, 1998	
C1	3800-3650	Yakubenko, 1998	
C1-C2	3700-3550	Yakubenko, 1998, Chernish, 1982:297; Balabina 1998: 191	
B2, Cucuteni B1		Markevich 1985: 78, 159; Yakubenko, 1998; Balabina 1998: S. Terna, S. Heghea 2017. Middle and late Copper Age settlements from the Brlnzeni microzone on the Prut river: older research. in a modern background.	
C1	5,6	Ovchinnikov, 2014: 108-109, 353	
A2	4700-4450	Peresunchak, Burdo, 2015:363, 365	
B2, Cucuteni B1	3950-3800	Popova, 1996: 135-136; Balabina 1998:	
A2	4700-4450	Bibikov, 1953: 27-28; Balabina 1998:	there are figurines of birds of this type in Vincha, Lendel, Gumelnitsa, Aldeni-Stoykani (link to literature at Balabina St. 148)
A2	4700-4450	Chernish, 1982:3011, Passek, 1961: 48, 50, 52; Balabina 1998:	not clear, what type it represents: Passek wrote that they are 'vessels', 1 artifact (according to the photo) could not be really empty inside, the second was drawn by Balabina as a complete one... but then in the text Balabina wrote that 2 birds from this site are rattles
B2	3950-3800	mentioned in Yakubenko 1998	
Cucuteni A1-B3		Chernish, 1982:283; Dumitrescu 1979: 89	no stratigr.p Cucuteni A1? AB or B3 (last 2 from Balabina)
B2-C1	4.6	Ovchinnikov, 2014: 108-109, 353	
Precucuteni	4700-4450	Balabina 1998: 163, 147	
Precucuteni		Balabina 1998: 163, 147	
Cucuten A1A2		Balabina 1998: 147, 164	
Cucuten A1A2		Balabina 1998: 147-48	
Cucuteni A3A4		Balabina 1998: 147-48, 244	
C1, Cucuteni B2	3750-3650	Balabina 1998:	
Cucuten AB		Balabina 1998: 191, 199	
B2	3950-3800	Balabina 1998:	the only bird figurine that represents only the head
B1		Balabina 1998:	
B1-B2; Cucuten AB	4250-3950	Balabina 1998:	
Cucuten AB, B1-B2, phase 3	Balabina 1998:		
?		mentioned in Yakubenko 1998	
?		Yakubenko, 1998	
Cucuteni A		Balabina 1998: 147-48	
Cucuteni B2		Balabina 1998: 191	

12. What was the significance of small Trypillia settlements? Report on a test excavation in Moshuriv 1, Sinyukha river basin, Ukraine

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Introduction

Since the 1980s, enormous efforts have been made by Soviet, Ukrainian, Romanian and Moldavian archaeologists, recently with international participation, to clarify the phenomenon of Copper Age aggregated settlements with the labels Trypillia and Cucuteni (*e.g.* Menotti and Korvin-Piotrovskiy 2012; Videiko and Rassmann 2016; Müller *et al.* 2016; Müller *et al.* 2017; Gaydarska 2020). The largest known agglomeration of such so-called mega-sites is situated in the Sinyukha river basin in central Ukraine (*e.g.* Kruts 2012; Shatilo 2021). After many years of research programmes that were carried out in mega-sites such as Nebelivka, Maidanetske, and Talianki, smaller settlements and the reconstruction of regional settlement dynamics came more and more into focus in recent years (Ohlrau and Rud 2019; Ohlrau 2020; Hofmann and Shatilo 2022; Chapter 13, this work, Vol. I). The ambition of this research is to come up with a conclusive interpretation and categorisation of these unique settlements.

Since small settlements have tended to be neglected in research for a long time, it is an open question what role they played in relation to the mega-sites. Did they exist as dependent villages simultaneously representing the agricultural hinterland of early urban settlements? Did they represent those communities that later moved to one of those mega-sites? Or did they perhaps represent groups of people who did not want to integrate into mega-sites? To answer these and other questions, a better understanding of the chronology and economic basis of such settlements is required.

In spring 2016, for the first time high-resolution archaeomagnetic plans of small Trypillia settlements were obtained in the Sinyukha catchment by René Ohlrau and Vitalii Rud (2019), in the larger framework of the Ukrainian-German cooperation on Trypillia settlements addressed in this work. Comparable to mega-sites, these settlements reveal a concentric layout, partly with circumferential ring corridors, and a decentralised social organisation represented by communal buildings (Ohlrau and Rud 2019; Ohlrau 2020, 239–259; Hofmann *et al.* 2019).

The aforementioned survey included the archaeomagnetic prospection of the settlement of Mochuriv 1. Complementary to the magnetic survey, test excavations were carried out in September 2016, directly connected to the Trypillia expedition in Maidanetske. The main aim of this excavation was to obtain material for scientific dating and clarification of the temporal relationship to the adjacent mega-sites.

The settlement of Moshuriv 1

This settlement is located in the Tal'nivs'kyi Raion in Cherkas'ka Oblast, 11 km west of the modern town of Talne. The site is situated 185 m above sea level on a gently southward sloping hillside on the left bank of the Moshuriv stream, a right tributary of the Gorni Tikich. As the crow flies Moshuriv is situated 10 km north-northeast of the mega-site of Talianki and 15 km northwest of the mega-site of Maidanetske (Fig. 1).

The site was discovered in the 1960s and has been an object of interest for archaeologists for a long time. Under the direction of Vladimir Kruts, in 1981 systematic surface collections were carried out, the first plan was drawn up and Ploshchadka 1 was excavated (Kruts *et al.* 1982). Based on the pottery inventory, this house and settlement were identified as belonging to the Thomashovka local group (Ryzhov 1999). According to Sergej Ryzhov it shows characteristics of Stage III/1 of this local group and thus should be contemporaneous with mega-settlements like Maidanetske and Talianki (Ryzhov 1999; cf. Shatilo 2021, 133).

New research activities took place in 1996, when an archaeomagnetic survey of an area of 9 ha in the west of the site was carried out by V. P. Dudkin (2004, 357; cf. Koshelev 2004, 282 ff.). This survey included an area situated about 100 m west of the settlement Moshuriv 1, where surface finds of the distinctly later Trypillia CII-period Kochergintcy-Shulgovka group were found, which is defined as the third phase of the Kosenovka Group. Since the site Moshuriv 2 had been discovered in the meantime to the south of the village, this later site was given the name Moshuriv 3. Based on Dudkin's survey data, a burnt house was excavated here in the same year under the direction of S. M. Ryzhov (1996; Ryzhov and Weimer 1996; Ryzhov 2001–2002, 189–192; Ryzhov and Shumova 2021).

The high-resolution archaeomagnetic survey carried out in 2016 by Vitalii Rud and René Ohlrau made a crucial contribution to clarifying the situation (Ohlrau and Rud 2019; Ohlrau 2020). By surveying an area of 12.4 ha, it is now possible to spatially differentiate very precisely between the 7 ha Tomashovka settlement Moshuriv 1 in the east and the considerably smaller Kochergintcy-Shulgovka settlement Moshuriv 3 in the west (Fig. 2). In the former settlement, about 85 dwellings are arranged in two rows concentrically on both sides along a ring corridor, supplemented by several communal buildings, so-called mega-structures, numerous pits and possible pottery kilns. In the latter settlement, 6–7 houses are arranged in a cluster without any recognisable order.

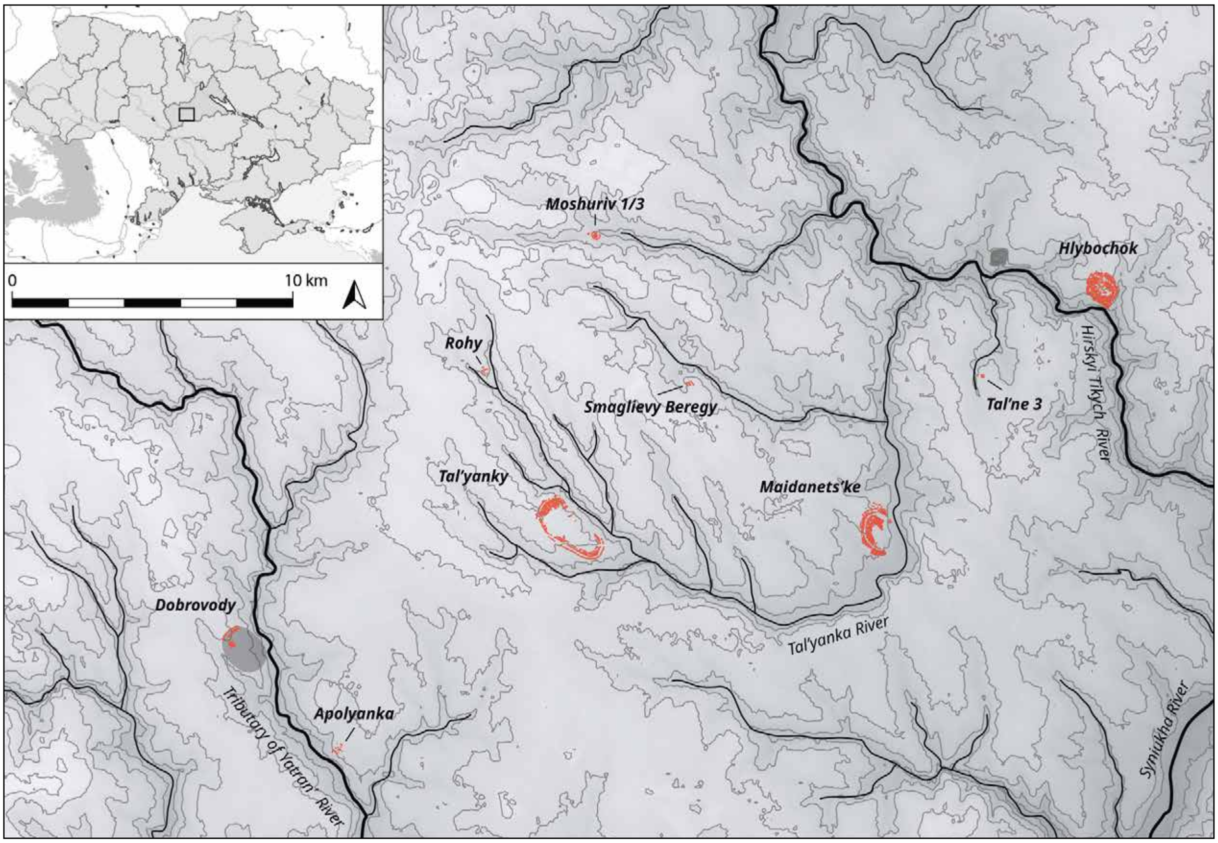

Figure 1. Concentration of Tripolye mega-sites and smaller settlements in the region northeast of the modern city of Uman (after Ohlrau 2020, 241, Fig. 148).

Figure 2. Interpretation of the magnetic plan of the settlements Moshuriv 1 and 3 with location of Trench 1/2016 (after Ohlrau and Rud 2019, Fig. 3).

Test excavation 2016

Excavation results

The new excavations in Moshuriv 3 took place in 2016 in the period from 22–27 September. A pit in the west of the settlement was chosen as the object of investigation, which probably belonged to a heavily eroded building in the outer row of houses in the ring corridor (Fig. 3). This pit appeared on the magnetic survey plan as an anomaly with a diameter of 5 m and a maximum flux density of 20 nT. The south-eastern quarter of this pit was excavated over an area of 3 × 3 m.

The pit was superimposed by a 0.4 m thick layer of dark brown-blackish Chernozem. In the underlying Planum 2, the upper edge of the pit was very faintly visible, but extremely blurred by animal burrows (Figs. 4 and 5). The pit proved to be a shallow depression, 0.3 m deep. Its dark brown-yellow spotted backfill (Feature 1002) did not show any visible differentiation. It contained a total of 0.16 kg of strongly fragmented burnt daub (average fragment weight 7 g). At the bottom of the pit, a thin, yellow, very calcareous layer (Feature 1005) was documented, which was most likely a product of weathering due to accumulated water. The pit was deepened into a medium brown layer (Feature 1003), which lay above the yellow loess (Feature 1004) and is interpreted as buried soil (see feature description in Appendix 1).

Finds

During the excavation in Moshuriv 1, finds of different categories were recovered, which were documented and described in detail in the database of the CRC 1266 subproject D1 (Hofmann *et al.* 2023).

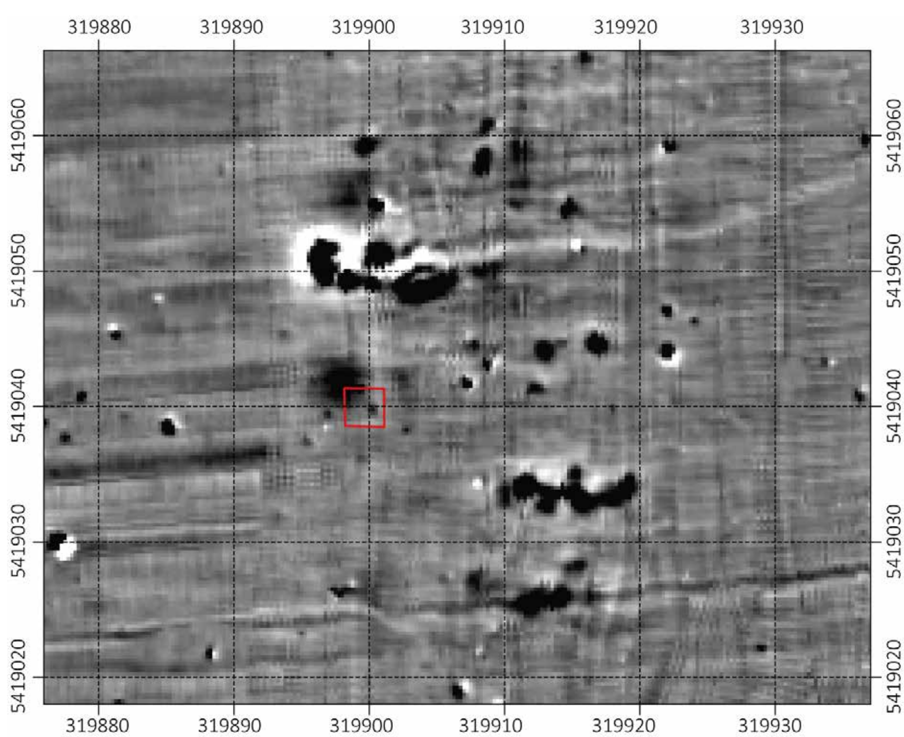

Figure 3. Detail of the magnetic plan of the settlement Moshuriv 1 (after Ohlrau and Rud 2019), with location of Trench 1/2016.

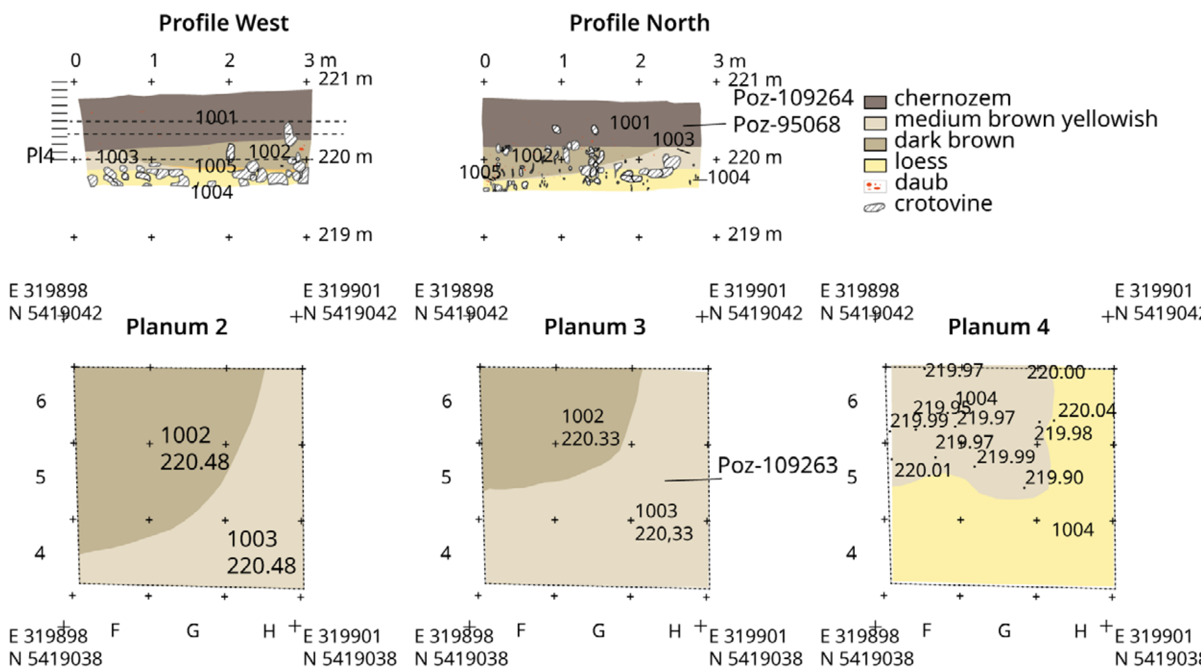

Figure 4 (above). Plana and profiles of Trench 1/2016 in Moshuriv 1.

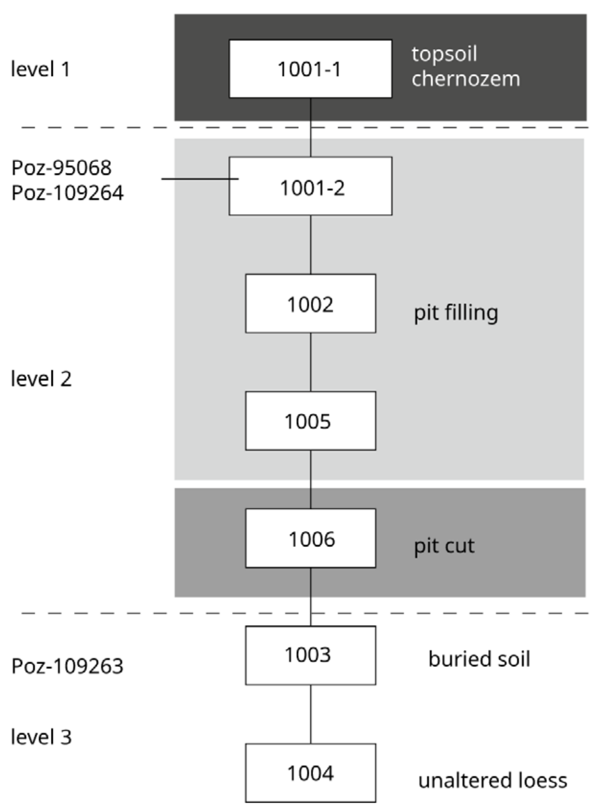

Figure 5. Harris matrix displaying the stratigraphic relationships and the location of the [14]C dates in Trench 1/2016 of Moshuriv 1.

Pottery

During our excavation, a total of about 1 kg of pottery of different categories was recovered. In technological terms, 85–95% of these ceramics represent different kinds of tableware and 5–15% so-called kitchenware, depending on whether one calculates by number or weight (Tab. 1).

The majority of the pottery showed a high to medium degree of fragmentation; only six fragments had low fragmentation (Tab. 2). The surface of the pottery was damaged in at least half of the cases. On 75 tableware fragments, no colour or engobe was preserved. At least six fragments showed a surface destroyed by soil corrosion. At least two other fragments showed traces of secondary firing, which in one case led to slagging.

From a morphological point of view, conical bowls with different rim shapes (Fig. 6: 1–4), goblets, one with a sharply carinated body, (Fig. 6: 6, 7) and a closed vessel also with a sharply carinated body (Fig. 6: 5) were identified from the tableware. From the kitchenware pottery, at least one pot with a steep rim zone (Fig. 6: 10) was identified.

On 31 fragments (294 g or 20–27%) decorations or surface designs were detected. In the case of tableware, remnants of red engobe were found on 23 fragments (161 g) and monochrome dark painting on 4 fragments (17 g). Due to the high degree of fragmentation, the paintings cannot be assigned to any painting schemes. The amount of fragments with engobe and paint is likely to have been significantly larger. Kitchenware pottery, in the case of one pot, was decorated with a row of finger impressions outside the rim, a vertical comb pattern on the rim zone, and a horizontal roughening on the belly (Fig. 6: 10).

Anthropomorphic clay figurine

Originating from the north profile is the middle part of an anthropomorphic figurine (14 g) with the buttocks and the upper part of the legs (Fig. 6: 11). The legs and female vulva are indicated by deepened grooves. The figurine is relatively roughly formed and exhibits a smoothed surface. The clay shows few voids from organic inclusions and some quartz grains. The figurine exhibits a primary medium grey colouration due to reducing firing, but is partially discoloured light orange on the side due to secondary oxidising firing.

Fabric	Number	Weight (g)
01 table: fine white	25	89
02 table: fine reddish	11	36
03 table: medium white	27	187
04 table: medium reddish	70	454
08 table: low secondary fired	12	47
11 table: secondary fired (slagged)	1	94
Sum tableware	**146**	**907**
05 kitchen: coarse, grey brown	5	48
06 kitchen: coarse, orange	3	82
Sum kitchenware	**8**	**130**
07 indefinite: reduced	1	40
Sum total	**155**	**1077**

Table 1. Moshuriv, Trench 1/2016: technological groups of pottery.

Fragmentation	Description	Number	Weight (g)	Average fragment weight (g)
High	<3 cm	116	458	3.9
Medium	3–7 cm	29	456	15.7
Low	>7 cm	6	126	21.0
Unknown	?	4	37	9.3

Table 2. Moshuriv 1, Trench 1/2016: pottery fragmentation.

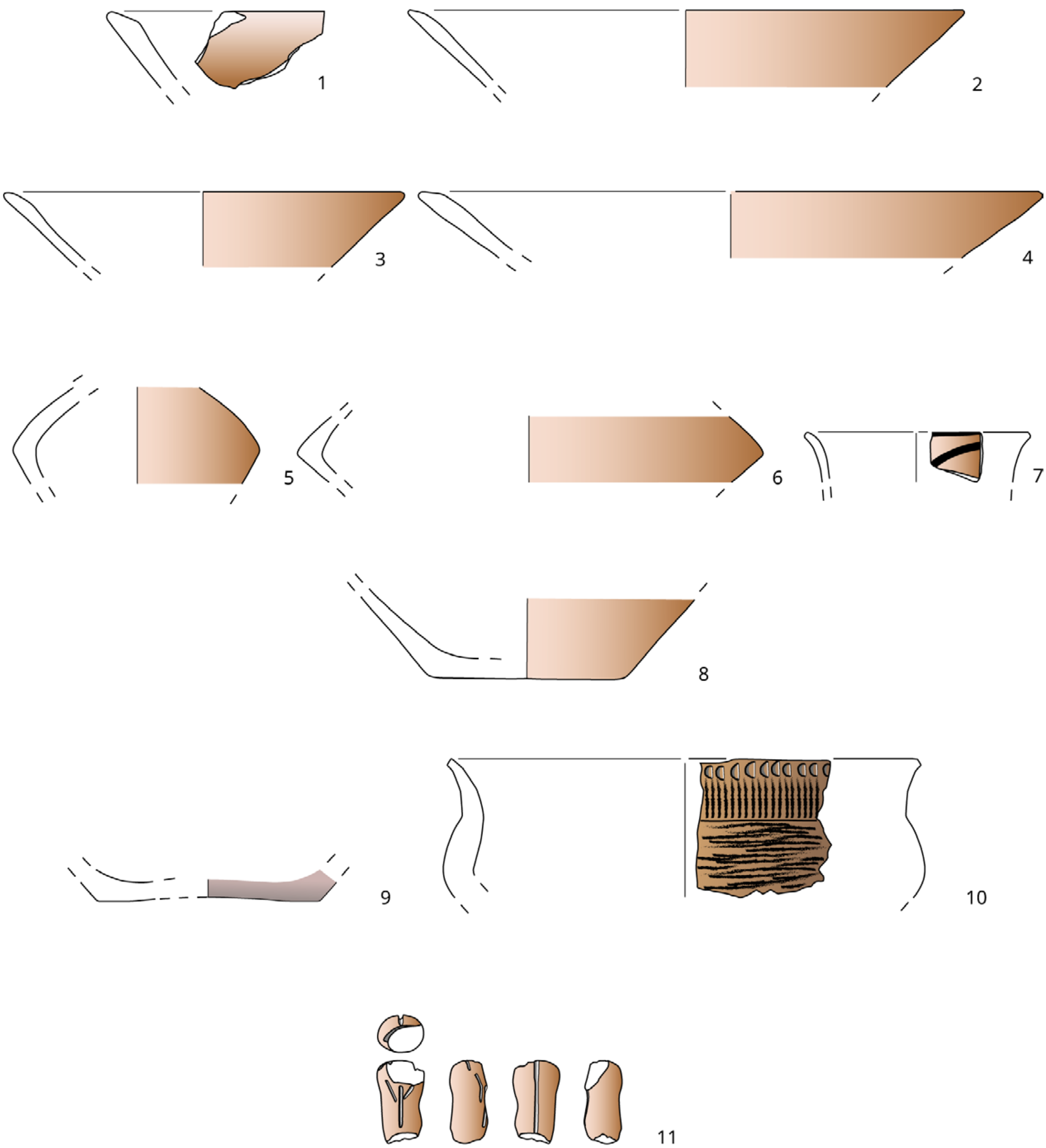

Figure 6. Selection of finds from ceramics in Section 1/2016 of Moshuriv 1: 1. Find-ID 1003, Ceramic-ID 15347; 2. Find-ID 1015, Ceramic-ID 15354; 3. Find-ID 1017, Ceramic-ID 15346; 4. Find-ID 1034, Ceramic-ID 15350; 5. Find-ID 1067, Ceramic-ID 15248; 6. Find-ID 1067, Ceramic-ID 15248; 7. Find-ID 1042, Ceramic-ID 15328; 8. Find-ID 1026, Ceramic-ID 15325; 9. Find-ID 1018, Ceramic-ID 15343; 10. Find-ID 1019, Ceramic-ID 15336; 11. Find-ID 1047, Other-Ceramic-ID 124. Scale 1:3.

Stone artefacts

The inventory of finds includes a small collection of stone artefacts (Tab. 3). The category of chipped stone is represented by two debris fragments – one of which belonged to a nucleus – recovered from the buried soil (Feature 1003) adjacent to the pit. Furthermore, the inventory includes one boulder and two rubble stones consisting of granite and quartz, all of which show no further modifications.

Bones

A small collection of bones included six items whose composition cannot be evaluated due to their small number (Tab. 4).

Find distribution

Within the backfill of the pit, finds of most of the categories were concentrated mainly in the upper layers of the 2nd level, while their frequency decreased in the lower part of the pit (3rd level; Fig. 7). The finds from Levels 4–6, which are located below the pit bottom, are probably material that has been displaced by bioturbation. The concentration of finds in the upper part of the pit indicates a backfilling process of at least two stages. The finds mainly originate from the younger phase of the pit backfill.

Table 3. Moshuriv 1, Trench 1/2016: stone artefacts.

Find-ID	Feature-ID	Level	Square x	Square y	Number	Weight (g)	Artefact category	Material description
1024	1003	3	F	4	1	38	debris (core fragment)	dark brown (Volynian?)
1025	1003	3	F	4	1	1	debris	light brown (regional?)
1009	1001	2	H	5	1	70	boulder	red coarse-grained granite
1010	1001	2	H	4	1	20	quarry stone (slightly rounded corners)	quartz
1022	1002	3	G	5	1	10	quarry stone	red coarse-grained granite

Table 4. Moshuriv 1, Trench 1/2016: animal bones.

Find-ID	Feature-ID	Level	Square	NISP	Weight (g)	Species	Element	14C Laboratory-ID
1004	1001	2	H6	1	15	cattle	Carpalia	Poz-109264
1014	1001	2	H4	1		Indet.	Tooth indet.	Poz-95068
1016	1001	2	G4	1	3	Large mammal	Indet.	
1027	1003	3	H4	2	4	Indet.	Indet.	
1028	1003	3	H5	1	2	sheep/goat	Phalanx 1 ant./post.	Poz-109263

^{14}C dating

From Trench 1/2016 in Moshuriv 1, a total of four samples were submitted for dating to the ^{14}C laboratory in Poznan, but only three of them were successfully dated (Suppl. 1 in Chapter 19, this work, Vol. II). All dates were obtained from bones. The two samples Poz-95068 and Poz-109264 were obtained from the find agglomeration in the upper part of the pit or associated with waste deposited above the pit backfill. Sample Poz-109263 derives from Cultural Layer 1003, interpreted as buried soil, adjacent to the pit. Thus, with some probability, datings can be assigned to two successive phases.

The samples were analysed with the online version of the Oxcal software v4.4 using the *boundary* function (Oxcal codes see below in Appendix 2). Model 1 assumes two successive phases, but results in a very low probability of A_{model}=30.1 and $A_{overall}$=47.4. With the highest probability the beginning of the activities in the area of the excavation would be either around 3900 or around 3780 BCE, the end around 3715 BCE (Tab. 5).

A higher probability of A_{model}=93.8 is achieved with the simplified model 2, in which all three datings are attributed to one phase. In this case, the settlement activities in the area of the investigated pit fall with the highest probability into the 200-year interval between 3840 and 3650 BCE (Tab. 6).

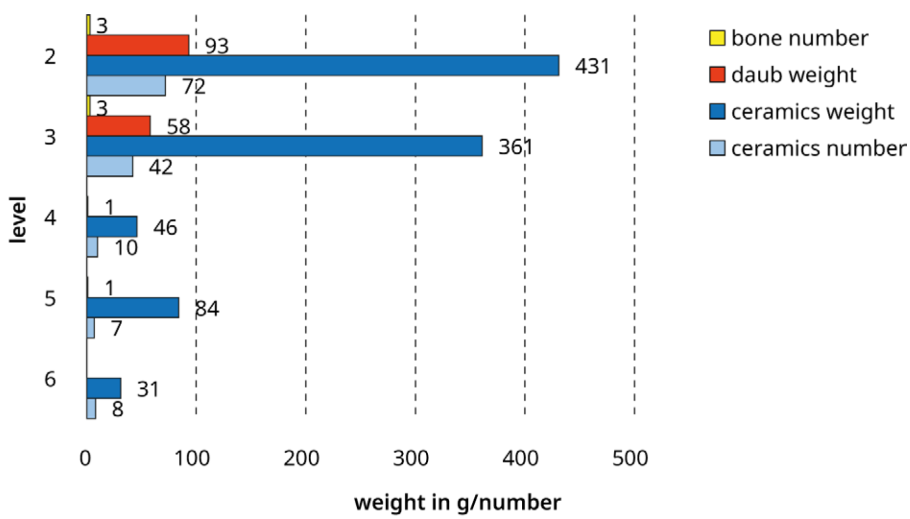

Figure 7. Quantitative vertical distribution of different find categories in Trench 1/2016 of Moshuriv 1.

Event	68.2%	95.4%	Highest
start activities	4000–3878 (42.6%) 3818–3733 (25.7%)	4233–3712	3900 or 3780
start waste disposal	3901–3831 (43.5%) 3769–3719 (24.8%)	3924–3711	3880 or 3740
end waste disposal	3772–3619	3800–3263	3715

Table 5. Moshuriv 1: modelled ^{14}C chronology BCE of Trench 1/2016 when assigning dates to two successive phases (model 1).

Event	68.2%	95.4%	Highest
start activities	4052–3798	4985–4934 (0.7%) 4554–3713 (94.7%)	3840
end activities	3754–3536 (67.7%) 3528–3524 (0.5%)	3785–3070	3650

Table 6. Moshuriv 1: modelled ^{14}C chronology BCE of Trench 1/2016 when assigning dates to one phase (model 2).

Discussion

A test excavation carried out in 2016 at Moshuriv 1 provided new source materials to reconsider the chronological position of this small settlement in relation to the adjacent mega-sites. This discussion is necessary, among other things, because the chronological models of the Trypillia mega-sites have also undergone important changes recently. Particularly worth highlighting is the evidence, based on a large series of ^{14}C datings, for significantly longer durations of these huge settlements of 200 years in Nebelivka (Millard 2020), of >300 years in Maidanetske (Ohlrau 2020) and of at least 150 years in Talianki (Shatilo 2021, 95–125), which is contrary to the earlier idea of significantly shorter occupations (Shatilo 2021, 215–216; Harper *et al.* 2021). On the reconstruction of regional settlement dynamics, this 'update' has significant implications insofar as in some cases we have to consider the coexistence of large settlements only 10–15 km from each other. For the agglomeration area of the largest mega-sites, this implies a significantly higher regional population density, more inter-communal interaction and probably also competition between settlements for resources in the intersecting areas of their catchments (cf. Ohlrau *et al.* 2016).

Small settlements are an important category insofar as they can be considered as a possible source of population for the large settlements. As René Ohlrau (2020, 236) was able to show, entire communities probably integrated themselves into these large settlements, where they also maintained their decision-making institutions. On the other hand, the question arises as to whether small settlements might have formed the rural hinterland of the large settlements of proto-urban character (*e.g.* Gaydarska *et al.* 2019).

Even if these questions cannot be answered by the evidence in Moshuriv 1 alone, a clear trend can be observed: regardless of which scenario we take as a basis for the evaluation of the ^{14}C dating. The settlement of Moshuriv 1 most likely falls into the phase between 3800 and 3700 BCE, in which the peak of population is also recorded in the mega-site Maidanetske. We can therefore rule out with some probability that a community lived in Moshuriv 1 that later moved to a mega-site.

In fact, the opposite scenario is more likely: as the study of the regional dynamics in the Sinyukha catchment area has shown, we see an increasing trend of a growing number of small settlements starting from 3950 BCE and intensifying from 3800 BCE onwards (Hofmann and Shatilo 2022). In that sense, in the case of Moshuriv 1, we could be dealing with a local community that has consciously made the decision not to live in one of the mega-sites and may even have moved out of such a mega-site. Therefore, we could understand the establishment of the settlement in the sense of a beginning of the disintegration of the large aggregated settlements.

The interpretation presented is also supported by the investigation of other small settlements in the vicinity of the mega-sites of the Sinyukha catchment area (Chapter 13, this work, Vol. I): the settlement Talne 3 also dates to a similar phase in the century after 3800 BCE. The settlements of Rohy and Moshuriv 2 date to the phase after 3700 BCE, which is characterised by the disintegration of the mega-sites.

It is questionable to what extent the aforementioned small settlements can be understood as the rural hinterland of the mega-sites. Although one may favour the denial of a direct dependence of these small settlements upon the mega-sites in view of the settlement dynamics outlined and the partly large distances, on the other hand the existence of numerous kinship relations with their population is likely. In the sense of network centrality, mega-sites may nevertheless have represented *de facto* central settlements temporarily. Therefore, statements made earlier must be partially corrected, according to which the existence of a rural hinterland of aggregated large settlements has been explicitly rejected.

Acknowledgements

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References

Dudkin 2004: Дуткин, В.П., 2004. Мошурів. *In*: М.Ю. Відейко and Н.Б. Бурдо, eds. Енциклопедія Трипільської Цивілізації, Vol. 2. Київ: Укрполіграфмедіа, 357. Available from: https://archive.org/details/trypillia

Gaydarska, B., ed., 2020. *Early Urbanism in Europe. The Trypillia Megasites of the Ukrainian Forest-Steppe*. Warsaw, Berlin: De Gruyter. Available from: https://doi.org/10.1515/9783110664959

Gaydarska, B., Nebbia, M. and Chapman, J., 2019. Trypillia Megasites in Context: Independent Urban Development in Chalcolithic Eastern Europe. *Cambridge Archaeological Journal*, 30 (1), 97–121. Available from: https://doi.org/10.1017/S0959774319000301

Harper, T.K., Diachenko, A., Rassamakin, Y.Y., Chernovol, D.K., Shumova, V.A., Nechitailo, P., Chabaniuk, V.V., Tsvek, E.V., Bilas, N.M., Pohoralskyi, Y.V., Eccles, L.R., Kennett, D.J. and Ryzhov, S.N., 2021. Combining relative chronology and AMS ^{14}C dating to contextualize ‘megasites’, serial migrations and diachronic expressions of material culture in the Western Tripolye culture, Ukraine. *Documenta Praehistorica*, 48, 276–296. Available from: https://doi.org/10.4312/dp.48.11

Hofmann, R. and Shatilo, L., 2022. Tripolye population aggregation and dispersal in light of regional settlement trajectories. *In*: M. Dębiec, J. Gorski, J. Müller, M. Nowak, A. Pelisiak, T. Saile and P. Włodarczak, eds. *From Farmers to Heroes? Archaeological Studies in Honor of Sławomir Kadrow*. Universitätsforschungen zur prähistorischen Archäologie 376. Bonn: Dr. Rudolf Habelt, 197–212.

Hofmann, R., Müller, J., Kirleis, W., Terna, S., Rud, V., Terna, A., Dal Corso, M. and Schlütz, F., 2023. Database of the Kiel CRC 1266 sub-project D1 ‘Population Agglomerations at Trypillia-Cucuteni Mega-sites’. [Dataset, status as of 06.10.2023] https://doi.org/10.57892/100-317

Hofmann, R., Müller, J., Shatilo, L., Videiko, M., Ohlrau, R., Rud, V., Burdo, N., Dal Corso, M., Dreibrodt, S. and Kirleis, W., 2019. Governing Tripolye: Integrative architecture in Tripolye settlements. *PLoS ONE*, 14 (9), e0222243. Available from: https://doi.org/10.1371/journal.pone.0222243

Koshelev 2004: Кошелев, И.Н., 2004. Памятники трипольской культуры (по данным магнитной разведки). Киев: Самиздат.

Kruts, V., 2012. Giant-settlements of Tripolye culture. *In*: F. Menotti and A.G. Korvin-Piotrovskiy, eds. *The Tripolye Culture Giant-Settlements in Ukraine. Formation, Development and Decline*. Oxford: Oxbow Books, 70–78. Available from: https://doi.org/10.2307/j.ctvh1dvmn.8

Kruts *et al.* 1982: Круц, В.А., Рыжов, С.Н. and Шумова, В.А., 1982. Отчет о работе Трипольской комплексной экспедиции в 1982 г. Київ: Науковий архів Інституту археології НАН України. [Unpublished excavation report in the archive of the Institute for Archaeology of the National Academy of Science of Ukraine (IA НАНУ), archive signature: ф. е. 1982/21a 1982].

Menotti, F. and Korvin-Piotrovskiy, A.G., eds., 2012. *The Tripolye Culture Giant-Settlements in Ukraine. Formation, Development and Decline*. Oxford: Oxbow Books. Available from: https://doi.org/10.2307/j.ctvh1dvmn

Millard, A., 2020. The AMS Dates. *In*: B. Gaydarska, ed. *Early urbanism in Europe. The Trypillia megasites of the Ukrainian forest-steppe*. Warsaw, Berlin: De Gruyter, 246–256. Available from: https://doi.org/10.1515/9783110664959-008

Müller, J., Hofmann, R., Kirleis, W., Dreibrodt, S., Ohlrau, R., Brandtstätter, L., Dal Corso, M., Out, W., Rassmann, K., Burdo, N. and Videiko, M., eds., 2017. *Maidanetske 2013. New excavations at a Trypillia mega-site* / Майданецьке *2013.* Нові розкопки великого Трипільського поселення. Studien zur Archäologie in Ostmitteleuropa 16. Bonn: Dr. Rudolf Habelt.

Müller, J., Rassmann, K. and Videiko, M., eds., 2016. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge. Available from: https://doi.org/10.4324/9781315630731

Ohlrau, R., 2020. *Maidanets'ke: Development and decline of a Trypillia mega-site in Central Ukraine*. Scales of Transformation in Prehistoric and Archaic Societies 7. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/h0912kt

Ohlrau, R. and Rud, V., 2019. Testing Trypillian site development via geomagnetic survey – New "mega-structures" and plans of smaller sites. *In*: D. Mischka, C. Mischka and C. Preoteasa, eds. *Beyond Excavation. Geophysics, Aerial Photography and the Use of Drones in Eastern and Southeastern European Archaeology. Proceedings of the International Colloquium, 5-8 December 2016, Piatra-Neamț, Romania*. Bibliotheca Memoriae Antiquitatis 40; Erlanger Studien zur Prähistorischen Archäologie 3. Piatra-Neamț: Editura "Constantin Matasă", 87–113.

Ohlrau, R., Dal Corso, M., Kirleis, W. and Müller, J., 2016. Living on the Edge? Carrying Capacities of Trypillian Settlements in the Buh-Dnipro Interfluve. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 207–220. Available from: https://doi.org/10.4324/9781315630731

Ryzhov 1996: Рижов, С.М., 1996. Дослідження пізньотрипільського поселення біля с. Мошурів на Черкащині. *In*: Толочко, П.П., ed. Охорона історико-культурної спадщини. Історія та сучасність: Тези доповідей конференції. Київ: ДКПП «ТИРАЖ», 108–110.

Ryzhov 1999: Рижов, С.М., 1999. Кераміка Поселень Трипільської Культури Буго-Дніпровського Межиріччя Як Історичне Джерело. [Unpublished PhD thesis. Національна Академія Наук України].

Ryzhov 2001-2002: Рижов, С.М., 2001–2002. Позднетрипольские памятники Буго-Днестровского междуречья. *Stratum Plus*, 2001–2002 (2), 187-196.

Ryzhov and Shumova 2021: Рижов, С.М. and Шумова, В.О., 2021. Результати археологічних досліджень біля с. Мошурів на Черкащині. Археологія, 2021 (2), 80–91. Available from: https://doi.org/10.15407/arheologia2021.02.080

Ryzhov and Weimer 1996: Рижов, С.М. and Ваймер, Б.У., 1996. Звіт про археологічні та геофізичні дослідження трипільського поселення біля с. Мошурів Тальнівського району Черкаської області за 1996 рік. Київ: Інститут археології НАН України.

Shatilo, L., 2021. *Tripolye Typo-chronology: Mega and Smaller Sites in the Sinyukha River Basin.* Scales of Transformation in Prehistoric and Archaic Societies 12. Leiden: Sidestone Press. Available from: https://doi.org/10.59641/m5457py

Videiko, M. and Rassmann, K., 2016. Research on Different Scales: 120 Years of Trypillian Large Sites Research. *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE.* Themes in Contemporary Archaeology 2. London, New York: Routledge, 17–28. Available from: https://doi.org/10.4324/9781315630731

Appendices

Appendix 1. Description of the features.

Feature-ID	Soil substrate, compactness, colour distribution, colour	Non-plastic admixtures	Stratigraphy	Interpretation
1001	Silt, humus, compact, homogeneous, dark brown blackish	Daub few <1 cm and lime (Lößkindl) moderate 1–10 cm	Younger than 1002	top layer
1002	Silt, humus, moderate compact, dark brown and ligh yellow dottet	Daub few <1 cm and 1–10 cm, lime (Lößkindl) 1–10 cm	Older than 1001, younger than 1005	Pit backfill with numerous animal burrows and loess gravels
1003	Silt, moderate compact, homogeneous medium brown yellowish	Daub few <1 cm and 1–10 cm, lime few <1cm	Older than 1006, younger than 1004	Buried surface soil. By human activities enriched with finds
1004	Silt, compact, homogeneous medium orange/ochre brownish	-	Older than 1003	Undisturbed subsoil
1005	Silt, moderate compact, medium yellow with medium brown greyish and light yellow dots	Daub few <1cm, lime moderate <1cm	Older than 1002, younger than 1006	'Transitional horizon' to the underlying bedrock with white lime precipitates and loess gravel at the bottom of the pit (weathering product).
1006			Older than 1005, younger than 1003	Cut of the pit

Appendix 2. Oxcal codes.

Model 1

```
Plot ("Moshuriv 1")
 {
 Sequence("buried soil")
 {
 Boundary("start buried soil");
 Phase("buried soil phase")
 {
 R_Date("Poz-109263",4970,35);
 };
 Boundary("start pit");
 Phase("pit")
 {
 R_Date("Poz-109264",4920,35);
 R_Date("Poz-95068",5100,40);
 };
 Boundary( "end pit");
 };
 };
```

Model 2

```
Plot("Moshuriv 1")
 {
 Sequence("buried soil")
 {
 Boundary("start buried soil");
 Phase("buried soil phase")
 {
 R_Date("Poz-109263",4970,35);
 R_Date("Poz-109264",4920,35);
 R_Date("Poz-95068",5100,40);
 };
 Boundary( "end find agglomeration");
 };
};
```

13. Trypillia mega-sites vicinity: the chronology of several small sites of the Southern Buh left bank region

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Abstract

In order to achieve radiometric dating and better typo-chronological contextualisation, test trenches were carried out in four small, previously archaeomagnetically prospected Trypillia settlements in the vicinity of some of the largest mega-sites in the catchment area of the southern Bug. The main aim of these investigations was to clarify the chronological relationship between these small settlements and the nearby-situated Trypillia mega-sites.

Introduction

While examining the large settlements (50–100 to 200–340 ha) of the Cucuteni-Trypillia cultural complex (CTCC) between the Southern Buh and Dnipro rivers in the 1980s–1990s, a number of settlements of 1–2 to 10 ha were discovered nearby. Among them were Talne 2, Talne 3, Moshuriv 2, Rohy *etc.* Surficial surveys and excavations showed that, based on ceramic complex comparisons, some of these belong to the Tomashivka local group and others to the Kosenivka group. The same can be said of the large settlements. At the Talne 2 settlement remains of seven dwellings were excavated and a partial plan of the settlement was made (Kruts and Videiko 1991, 31–32). The comparison of ceramic assemblages allowed the synchronisation of the Talne 2 and Talne 3 settlements with the Maidanetske mega-site (Shmagliy and Videiko 2001–2002, 124). These were important discoveries as they present data for the reconstruction of settlement systems and their economic functioning. However, complete plans of the settlements as well as their radiocarbon dating were absent.

In a cooperation between the Institute of Archaeology of the National Academy of Sciences of Ukraine, Kyiv (IA NASU) and two German institutes, the Romano-

Germanic Commission of the German Archaeological Institute in Frankfurt am Main and Kiel University, magnetic plans for the number of Trypillia culture settlements were made between 2011 and 2018 (Rassmann *et al.* 2014; Videiko *et al.* 2017; Rud *et al.* 2016; Rud *et al.* 2019). Archaeomagnetic plans for the Talne 3, Moshuriv 2 and Rohy settlements of 1.2 ha, 3.6 ha and 5.3 ha respectively were made in 2016 (Ohlrau and Rud 2019). It was established that the Apolianka settlement with an area of 19 ha (Rassmann *et al.* 2014, 126) must be considered a small settlement too. Previously it was considered a mega-site with a presumed area of 90–100 ha.

The next step was to gather the materials for radiocarbon dating of the four mentioned sites through test excavations of the objects revealed by magnetic prospection – the remains of buildings and pits. Thus, the complete data about site structure, pottery and radiocarbon dating of small settlements which surround Trypillia mega-sites, have been acquired for the first time beside of the settlements Moshuriv 1 (Chapter 12, this work, Vol. I). The investigations took place in 2019 in cooperation between the CRC 1266 'Scales of Transformation' sub-project D1 'Population agglomerations at Trypillia-Cucuteni mega-sites', the Borys Grinchenko Kyiv University and the IA NASU.

One of the key questions of large-small settlement system research is their synchronisation and absolute chronology based upon pottery complexes and radiocarbon dating, to which this article is dedicated.

Brief sites characteristics

The Apolianka settlement (48°43'52.9"N 30°25'41.4"E; see Chapter 12, Fig. 1, this work, Vol. I) is located on a slightly sloping edge of the plateau on the right bank of the Revukha River (Revukha → Yatran → Syniukha → Southern Buh). It was identified in the 1960s by V. Stefanovych and H. Khraban's fieldwalking. In the 1980s, this settlement was excavated for several seasons of expeditions led by T. Movsha. And at the same time one ground structure was excavated (Movsha and Kolsenikov 1982). Another structure of the same type was excavated by an expedition led by V. Chabanyuk in 2007.

The Moshuriv 2 settlement (48°51'04.7"N 30°35'30.5"E; see Chapter 12, Fig. 1, this work, Vol. I) is located on the plain of the promontory-shaped edge of the plateau and connected with the basin of the stream – the right tributary of Talianka River (Talianka → Hirskyi Tikych → Tikych → Syniukha → Southern Buh). V. Stefanovych discovered this site in 1958 (Stefanovych and Didenko 1968, 141).

The Rohy settlement (48°51'10.7"N 30°29'34.8"E; see Chapter 12, Fig. 1, this work, Vol. I) is located on a promontory between two streams – the Talianka River outflows. Probably, the site was discovered by the Trypillia expedition of IA NASU (Ryzhov 2001–2002).

The Talne 3 settlement (48°51'23.5"N 30°44'02.6"E; see Chapter 12, Fig. 1, this work, Vol. I) is located on the high right bank of the stream which flows into Hirskyi Tikych River (Hirskyi Tikych → Tikych → Syniukha → Southern Buh), opposite the glasshouses where the synchronic Talne 2 settlement was located. The Talne 2 settlement was investigated in 1990 by V. Kruts and M. Videiko (1991, 31–32). In the same year, the settlement Talne 3 was discovered and found to be related to the Tomashivka local-chronological group (Videiko 1991, 11–12, Fig. 1).

Excavated features

Apolianka

Part of the south-west sector of a round pit was excavated by Test Trench 1 of 3 by 1 m size (Fig. 1A). The diameter of the magnetic anomaly is 5.3 m. At 5.5 m to the south west from the object is a rectangular anomaly 16.5 × 6.4 m in size, most likely of a burnt house. The objects are located in the north-east part of settlement's inner circle.

The cultural layer of the pit was covered by a layer of Chernozem 20 cm thick (Fig. 1C). The filling of the pit begins at 189.7 m asl and continues to 187.6 m asl. This means that the depth of the pit was at least 2.0 m. On the radial profile the pit has a stepped wall. The pit was dug in the layer of sandy loess (1005) which is found at 188.4 m asl (Fig. 1B and C).

All layers of the pit except 1008 are filled with different percentages of fragmented materials which include pieces of bones, ceramics, burnt clay and tools. In Layer 1003 in addition to these artefacts, osteological materials with signs of calcination were found, while in Layer 1004 there were tiny separate pieces of charcoal. Stratigraphically middle contexts (1004, 1006, 1007) contained anthropomorphic and zoomorphic figurines. The soil of Layers 1004, 1006 contained ash. Layer 1009 is a continuous stratum of ash. Context 1007 consisted of numerous horizontal lines of clay only 3–4 cm thick, which probably reflect the backfilling of the pit as a result of natural erosion processes.

Moshuriv 2

In Test Trench 1 (2 × 1.5 m) an area at the longitudinal edge of a rectangular anomaly of a building was investigated (Fig. 2A). The size of this building is 11.0 × 5.3 m. The edge is the north-west long side of the building. The long axis of the building is located in line north-east – south-west. The test trench had the same orientation. Part of the anomaly (no more than 0.8 m) is within its borders, the rest is a territory outside the building.

The excavation confirmed the magnetic data (Fig. 2B). The edge of the wood-clay building (1004) was examined. It is covered by a layer of dark-grey and yellowish soil (1003) 7–14 cm thick. Above it is the Chernozem layer, 28–39 cm thick (Fig. 2C). A layer of grey-yellow soil (1006) lies below the building and above yellow-grey loam (1005). The artefacts on the ancient surface outside the building are in soil (1002) which is analogical to Context 1003. Below that is a layer of grey-yellow soil (1007) similar to 1006.

The top of remains of the building (1004) are reached at 205.14–204.92 m asl. They are represented by the cluster of daub which is located in a line up to 60 cm wide alongside the south-east wall of the test trench. There are two types of daub. Fragments of the first type are made of clay with large organic admixtures. Some fragments have a flat surface. The fragments of the second type have flat surfaces and are made of clay with admixture of sand. The pieces are 4–5 cm thick. They are scattered all around the building remains. The daub of both types is well-burnt; fragments are light-brown in colour. Stratigraphically the daub of the second type is located above the daub of the first type. Some fragments of Type 1 cover part of the ceramics fragments which are located in east corner of the trench. The construction remains of the building were left *in situ*.

Finds outside the building (1002) are located at 204.99–204.89 m asl. They include fragments of bones, ceramics including one partially collapsed vessel, as well as anthropomorphic figurines.

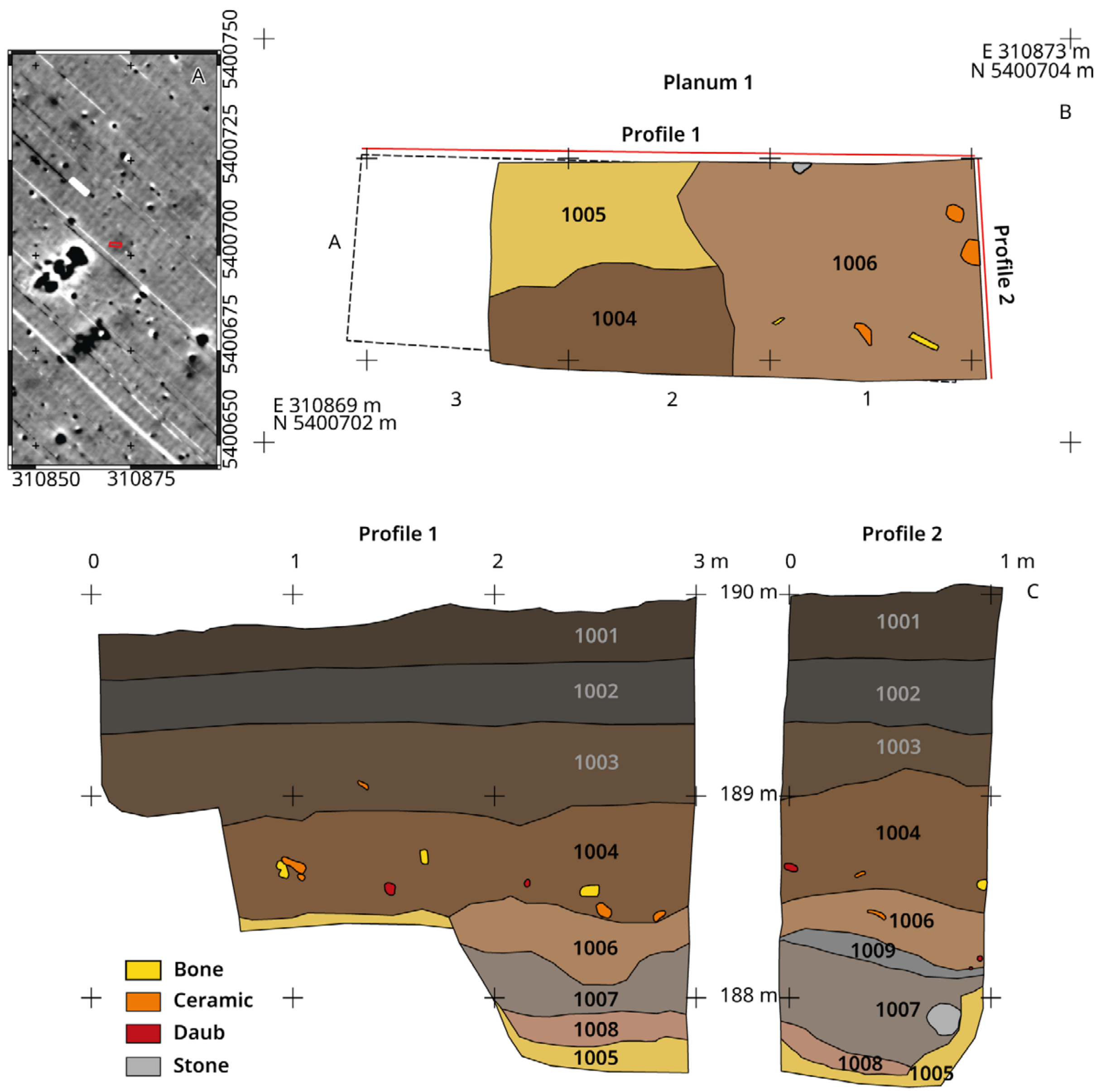

Figure 1. Apolianka, Test Trench 1: (A) localisation of the test trench on the geophysical plan of the site; (B) Planum 1 on the level of artefact cluster (188.33–188.40 m asl) in the pit. Location of Profiles 1 and 2; (C) Profiles 1 and 2, which represent the stratigraphy of pit filling and, partially, the geological stratigraphy within the test trench. Objects: 1001 – light black, yellowish, Chornozem; 1002 – dark black; 1003 – medium black, yellowish; 1004 – grey-yellow; 1005 – light yellow, sandy loess; 1006 – dark brown; 1007 – yellow-grey; 1008 – grey-yellow; 1009 – grey-black.

Rohy

Test excavations were conducted in the north part of the settlement's inner circle (Fig. 3A). Test Trench 1 (3 × 1 m) examined the north-east sector of the pit. The total diameter of the round anomaly of the pit is 9.8 m. It is located 6.0 m to the north-west of the rectangular (14.4 x 6.5 m) anomaly of the building.

The filling of Pit 1 (Fig. 3C) is found 207.3–207.6 m asl deep. It is covered by a thin 1 m layer of black-grey Chornozem (1001, 1002). The upper contexts of the pit's filling (1003, 1004) had small amount of the artefacts, which included fragments of ceramics, daub and bones. Several calcinated bones (1 cm in size) were found in the Feature 1004. Most of the artefacts are located in the bottom part of the

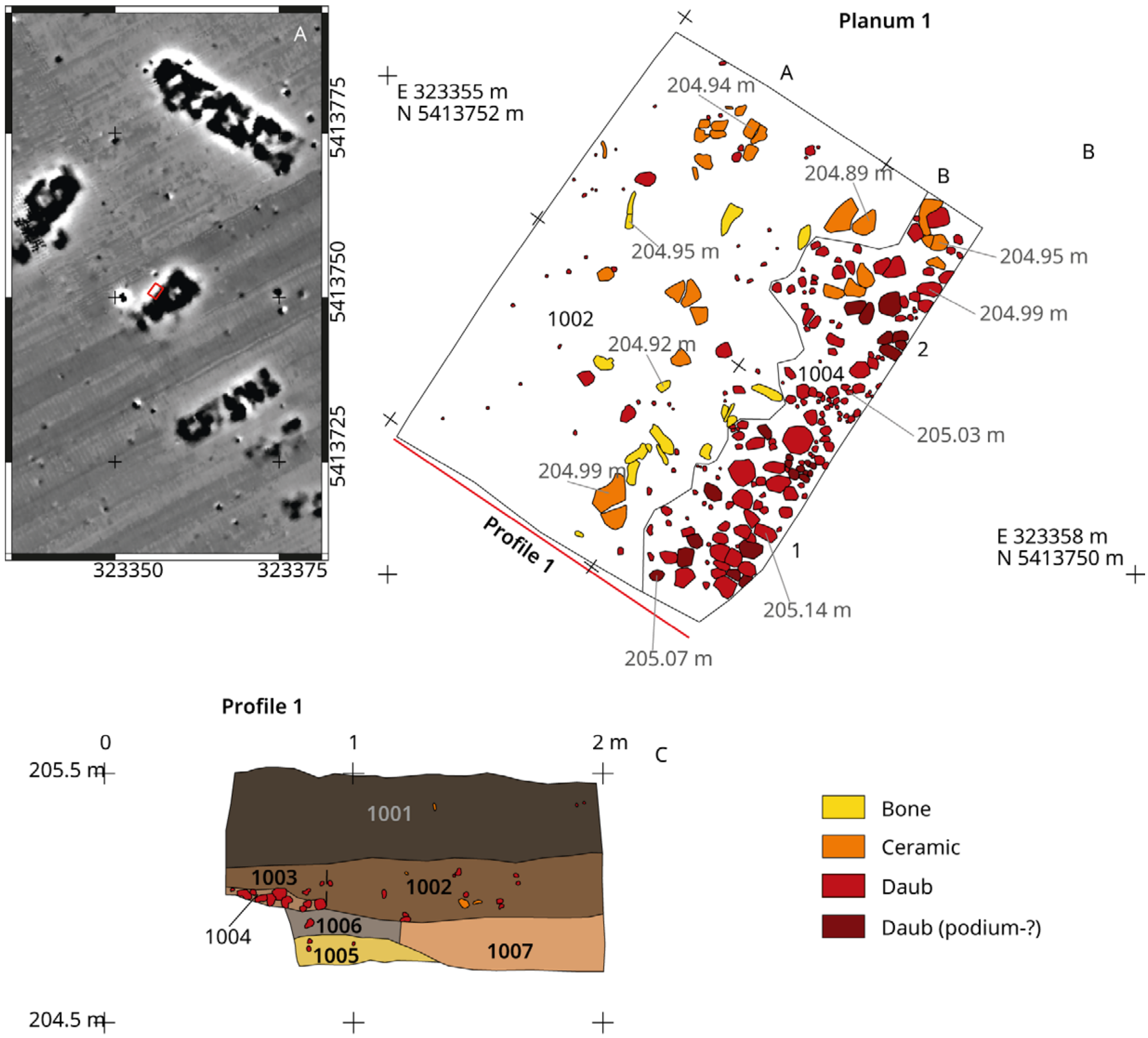

Figure 2. Moshuriv 2, Test Trench 1: (A) localisation of the test trench on the geophysical plan of the site; (B) Planum 1 on the level of collapsed structure (1004) and the artefacts on the ancient step surface (1002) outside the structure. Location of Profile 1; (C) Profile 1, which represents the stratigraphy within the test trench. Objects: 1001 – light black, Chornozem; 1002 and 1003 – black grey, yellowish; 1004 – structure; 1005 – yellow-grey, loam; 1006 and 1007 – grey-yellow.

pit (1004/6a). On Planum 2 (Fig. 3B) clusters of materials were cleaned, including partial clusters of vessel collapse.

The deepest part of the pit is found 206.2 m asl deep in the loess layer. This means that in ancient times the pit was about 1.4 m deep. Its bottom was probably not solid, but had a number of small holes. The walls of the pit in the north part were not found as its radius is larger than the length of the test trench.

Talne 3

The south-west sector of an oval anomaly (4.4 × 3.0 m) was examined by *Test Trench 1* (5 × 1 m). The anomaly is located in the northern part of the settlement, between anomalies of buildings which belongs to the building circle (Fig. 4A). However, the anomaly is situated south of the buildings line towards the centre of the settlement. During the reconstruction of the site structure, the anomaly was interpreted as a

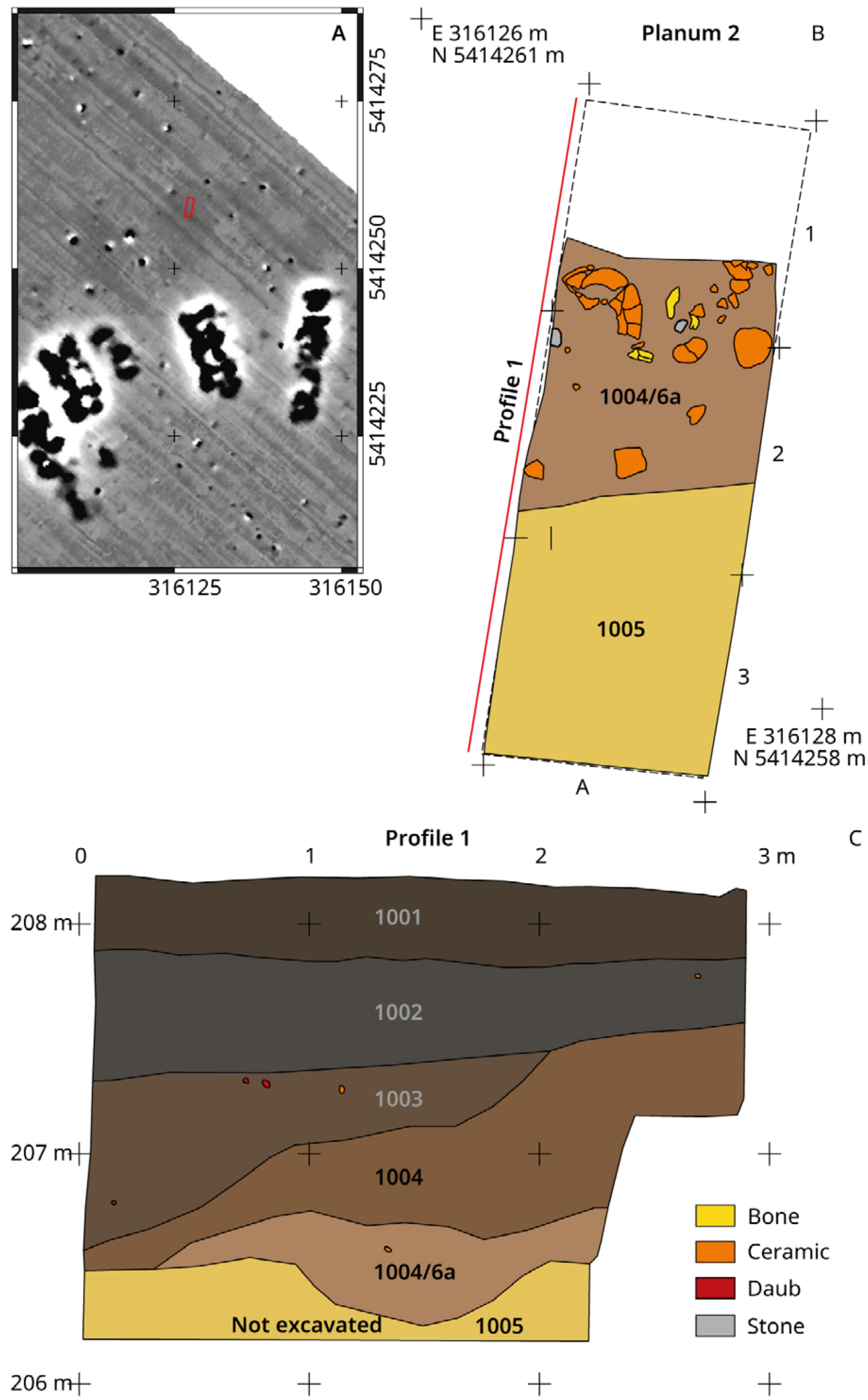

Figure 3. Rohy, Test Trench 1: (A) localisation of the test trench on the geophysical plan of the site; (B) Planum 2 on the level of the artefact cluster (206.46–206.68 m asl) in the bottom part (1004/6a) of the pit. Location of Profile 1; (C) Profile 1, which represents the stratigraphy of pit filling and, partially, the geological stratigraphy within the test trench. Objects: 1001 – black greyish, Chornozem; 1002 – black-grey, light Chornozem; 1003 – black-grey; 1004 – black-grey, yellowish; 1004/6a – black-yellow; 1005 – dark yellow, loess.

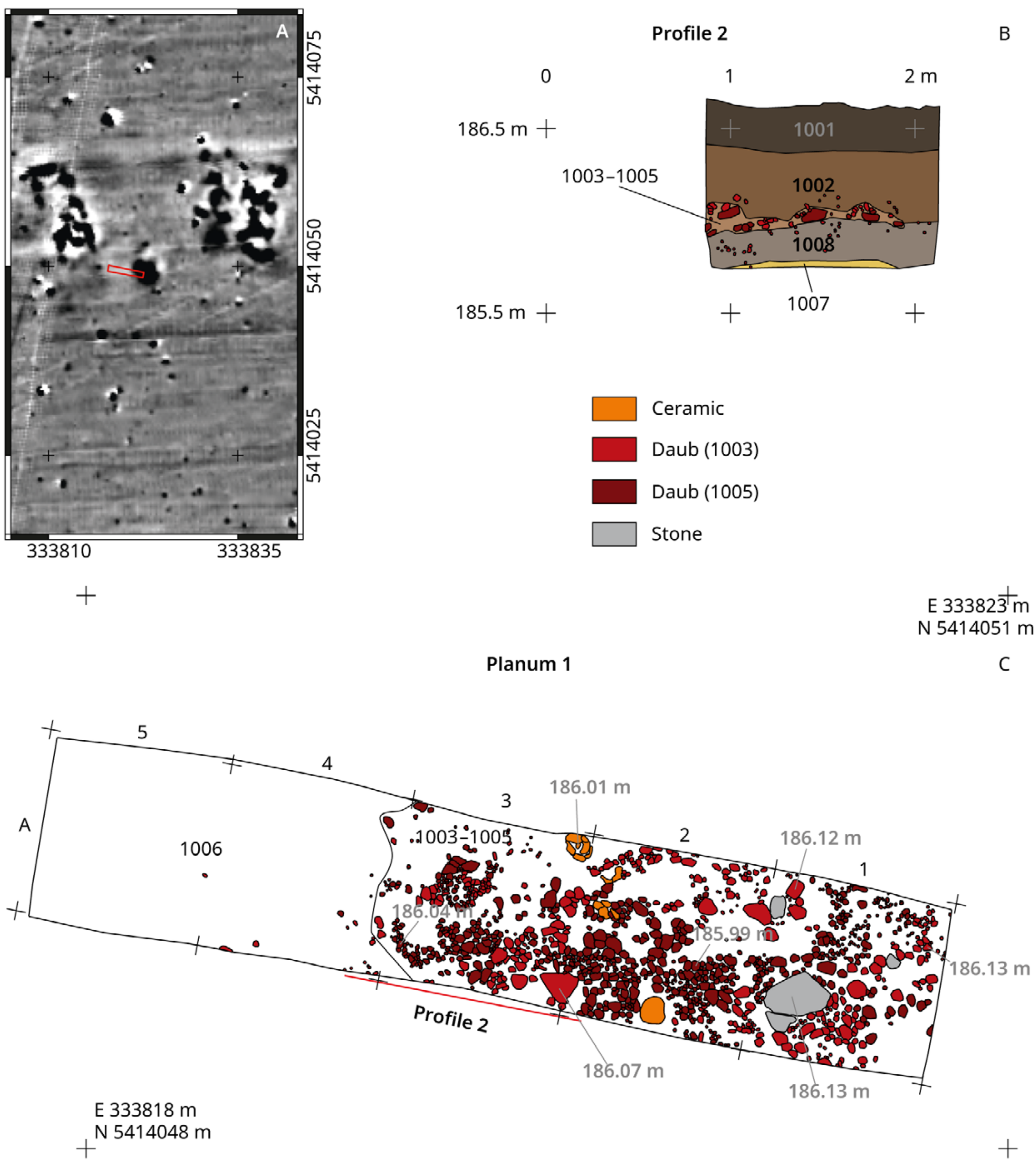

Figure 4. Talne 3, Test Trench 1: (A) localization of the test trench on the geophysical plan of the site; (B) Profile 2, which represents the stratigraphy within the central part of the test trench. Objects: 1001 – light black, Chornozem; 1002 – black grey, yellowish; 1006 – black-yellow; 1007 – yellow-grey, loam; 1008 – grey-yellow; (C) Planum 1 on the level of collapsed structure (1003–1005) and artefacts on the ancient step surface (1006) outside the structure. Location of Profile 2.

pit. Near the anomaly, to the south and north there are other small anomalies. Their complex can be interpreted as one object 8.0 × 3.7 m in shape.

In the test trench at 186.05–186.13 m asl deep a cluster of burnt clay was found (Fig. 4C). It is covered with black-grey and yellowish soil (1002) 27–36 cm thick (Fig. 4C). Above that is a layer of light-black Chornozem (1001). The cluster, which is probably the ruins of a wood-clay building, consisted of two daub layers and covered an area of 3.2 × 1.0 m in the east part of the test trench.

The upper layer (1003) consisted of amorphous fragments of burnt daub 2–5 cm thick, with organic admixtures. Only ten fragments which are located as a compact cluster in the south-west corner of Grid 1/A had imprints of wood on the underside. These imprints were of twigs and narrow split wood, lying in a north-south line.

The lower layer of the ruins of the building (1005) is made of two sub-layers, which are separated from each other. The lower (1005b) is 2 cm thick and is made of clay with admixture of sand. The upper (1005a) is up to 1.5 cm thick and is made in two stages. First came a layer of the clay with the admixture of chaff (up to 1 cm thick) and then the surface was smoothed by a layer of clay with the admixture of sand (up to 0.3 cm thick). Both sub-layers are found only in Square 3/A. The rest of the area had only a lower layer which is 5 cm thick in some places; its surface is flat. The fragments are burnt on all sides and mostly located in one mass, however there are some areas where fragments are located chaotically or on the sides. Traces of red painting are found on the flat surface of several fragments of daub from Layer 1005. The grinding stone and the clusters of broken kitchenware are found above Layer 1005 (Context 1004). The almost unharmed table goblet (Fig. 15: 8) is found there as well.

The removal of fragments from Layer 1005 was performed only in the western part – up to the eastern edge of Profile 2. On the lower side of the fragments the traces of having been put on the soil or layer of clay are found. It is possible that such a clay layer has not been preserved. The area (1006) outside the remains of the building in the western part of the test trench was examined as well. Here, in the layer of grey-yellow soil, located in one level with building remains, only fragments of clay crumb were found. Below (185.73 m asl) a fragment of bone (Find-ID 1005) was found.

Test Trench 2 (3 × 1 m) was located in the north-east part of the elongated anomaly (11.4 × 5.0 m) which was interpreted as the pit (Fig. 5A). It is parallel to the edges of two building anomalies which belong to the cluster of four buildings located in the centre of the site.

It seems that the layer of anthropogenic filling (2006) of the pit is no more than 30 cm thick (Fig. 5B, 5C). It is located on the slope and the bottom of the pit and contains only some fragments of burnt daub. Above it there are two layers of black soil; this appearance is probably the result of natural erosive processes. The lower layer (2004) contains a few fragments of ceramic, daub and the bone (Find-ID 2003) while the upper layer (2002) contains only clay crumbs. The artefacts in Layer 2003 approximately mark the ancient step surface at about 186.40 m asl. The deepest part of the pit within the test trench is 185.34 m asl, which means that in ancient times the pit was about 1 m deep. It was dug in the layers of loam (2007) and loess (2005).

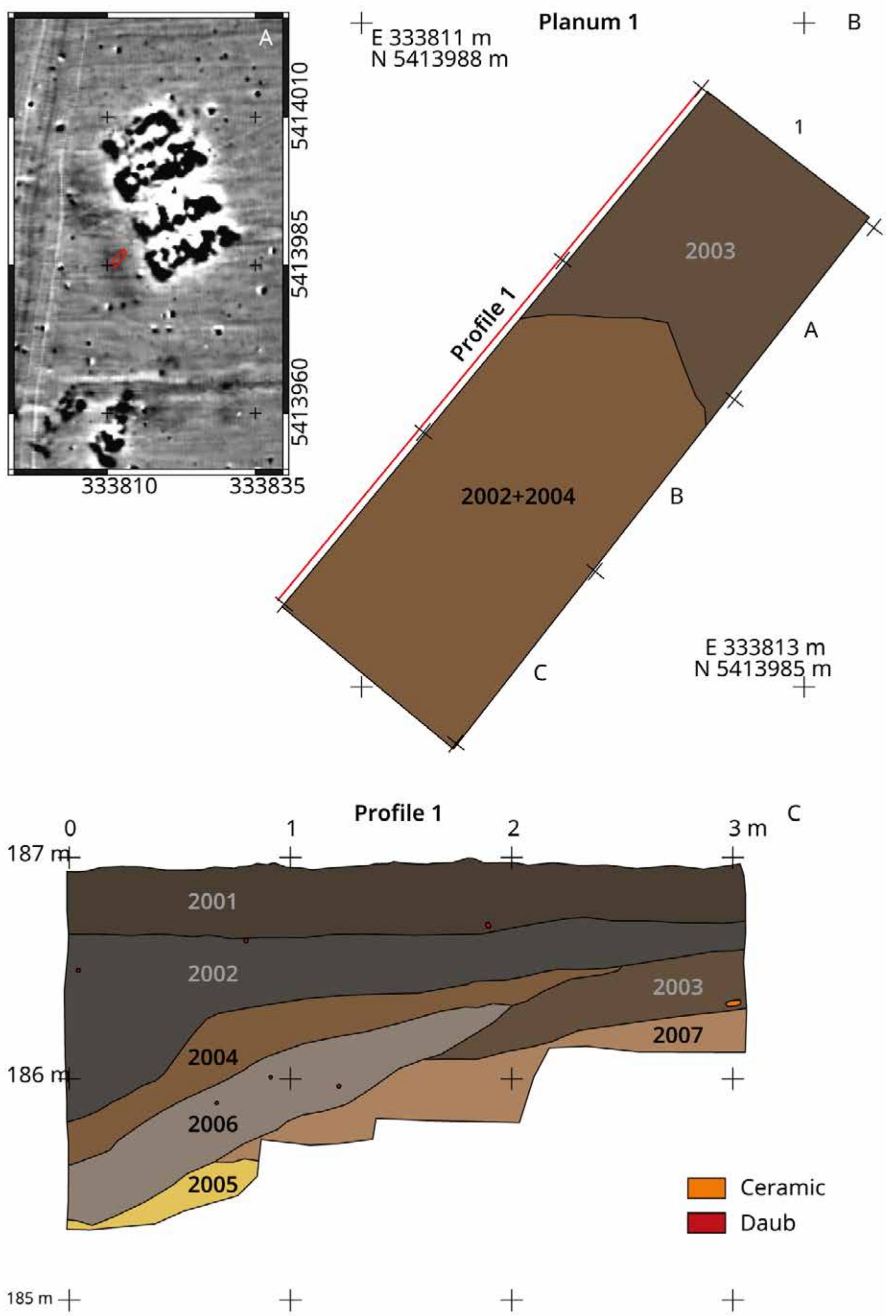

Figure 5. Talne 3, Test Trench 2: (A) localization of the test trench on the geophysical plan of the site; (B) Planum 1 on the level of 186.29–186.35 m asl of the pit. Location of the Profile 1; (C) Profile 1, which represents the stratigraphy of pit filling and, partially, the geological stratigraphy within the test trench. Objects: 2001 – light black, Chornozem; 2002 – black-grey; 2003 – black, yellowish; 2004 – black-grey; 2005 – dark yellow, loess; 2006 – black-yellow; 2007 – black-grey, yellowish.

Finds

Apolianka

Pottery

Technologically the pottery is divided into two groups: kitchen ceramics and table ceramics. The first group includes only up to 7% of finds. It is made of clay with coarse-grained admixtures. The products are represented by fragments of pots of different size (Fig. 6: 13–26). Some of them have vertical deepened bands on the neck (Fig. 6: 13, 18, 20), but in most cases they are not decorated (Fig. 6: 14–16, 19, 22–25). Some fragments have imprints of a stamp – both at the rims (Fig. 6: 16, 18, 25), and at the lower part of the neck (Fig. 6: 21, 24). On the shoulders and the lower part of the vessel neck some products have conical knobs, both single and double (Fig. 6: 13, 19).

Tableware ceramics make up most of the finds (Fig. 6: 1–12; Fig. 7–10). Vessels were made of fine structured clay with coarse-grained admixtures and have been fired to a pink or red colour. A small number of fragments made of kaolin clay with admixture of sand was found as well. The surfaces of the artefacts are covered with yellow-brown and reddish slipware. Mostly dark-brown paint was used for decoration. Fragments with bichrome painted ornamentation, where red colour was added, were also found (Fig. 6: 5, 9).

It is possible to reconstruct the following morphological types of vessels: truncated cone bowls, semi-spherical bowls, S-profile bowls, bowls on legs, goblets, spherical-conical vessels, pots, lids, vessels on legs (Fig. 10: 6).

Truncated-cone form bowls (Fig. 7: 3) are painted inside. The ornamental compositions are made with wide lines, the space between them sometimes filled with narrow lines. Under the rims there are small inverted triangles (Fig. 8: 1, 5, 11, 15) or zigzags (Fig. 8: 10).

Semi-spherical bowls are represented by a large amount of fragments. They are painted inside, or sometimes both inside and outside (Fig. 9). The ornamental compositions are made using wide lines, the space between them sometimes filled with narrow lines. Under the rims there are small up-side-down triangles or small semicircles. Truncated-cone and semi-spherical bowls are mostly decorated with figure-of-eight motifs. Festoons are common on external parts of the semi-spherical bowls.

S-profile bowls are represented by one fragment, painted on the outside. It may be the fragment of the lid (Fig. 8: 2).

The goblets are small vessels, (Fig. 10: 1–6) with rounded ribs, except for one fragment (Fig. 10: 5). The ornamental compositions consist of wide lines and semi-circles.

Spherical-conical vessels are represented by a large amount of fragments which include pieces of quite large vessels (Fig. 10: 12–35; 6: 5). The products had cylindrical or funnel-shaped throats and some of them handles and knobs at the shoulders (Fig. 10: 34, 35). The ornamental compositions consist of wide lines, sometimes complemented by narrow, triangles, circles and festoons mostly painted dark-brown. In two cases red lines were added (Fig. 6: 5).

The pots are represented by fragments of rims (Fig. 6: 1–4). The rounded bodies may also belong to them (Fig. 6: 7–9).

The helmet-like lids are represented by only a fragment with two handles; the painting was not preserved (Fig. 10: 7).

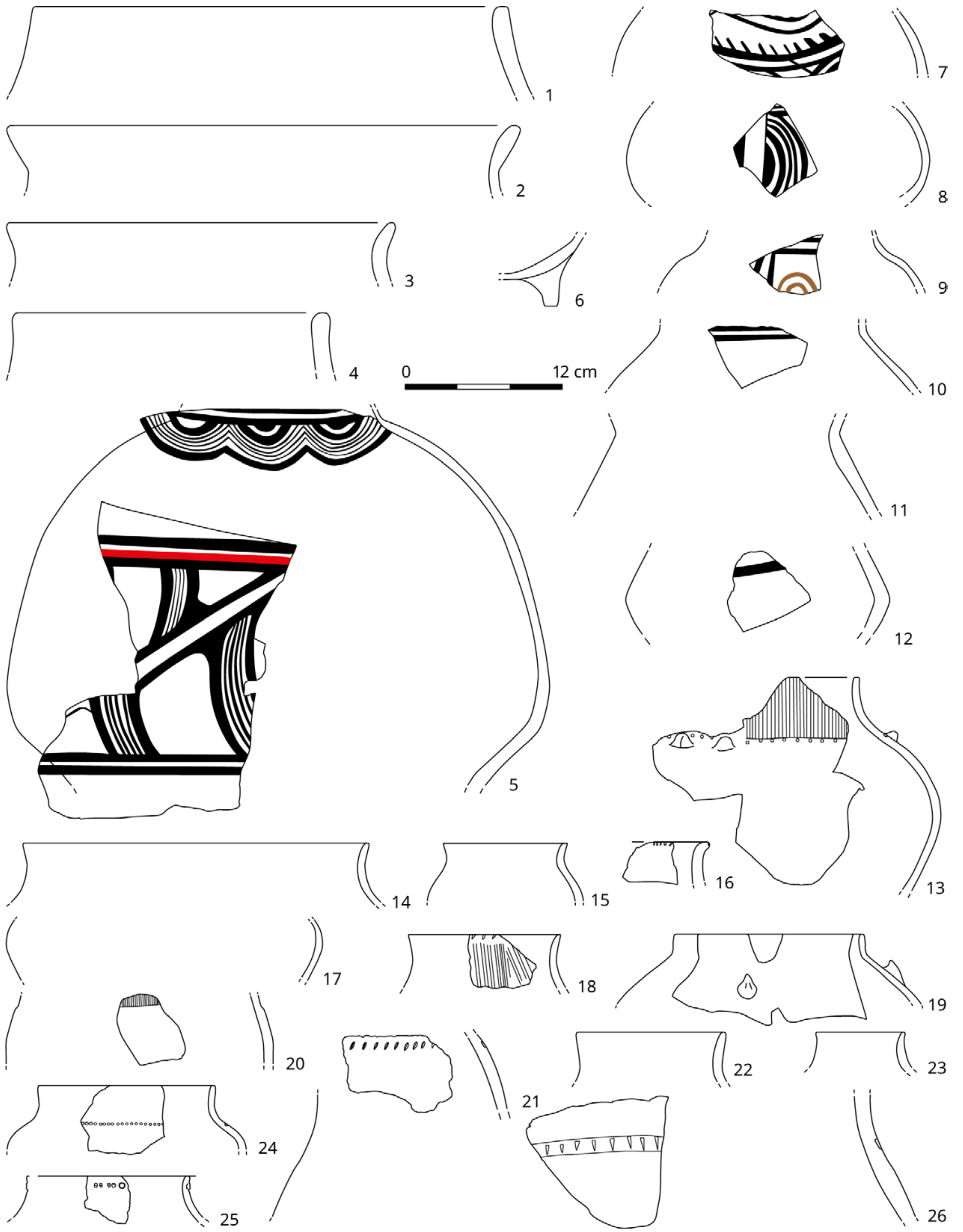

Figure 6. Apolianka: tableware (1–12) and kitchenware (13–27) ceramics from Test Trench 1 and surface collection (2, 10, 11, 17, 20, 26). Feature-ID: 1006 (1, 15, 21), 1004 (3, 4, 7, 14, 25), 1007 (5, 8, 18, 19), 1003 (6, 9, 12, 13, 16, 22, 23, 24). Find-ID: 1204 (1, 15, 21), 1173 (3, 25), 1080 (4), 1228 (5, 8, 19), 1095 (6, 13, 16, 22, 23, 24), 1168 (7), 1058 (9, 12), 1122 (14), 1244 (18).

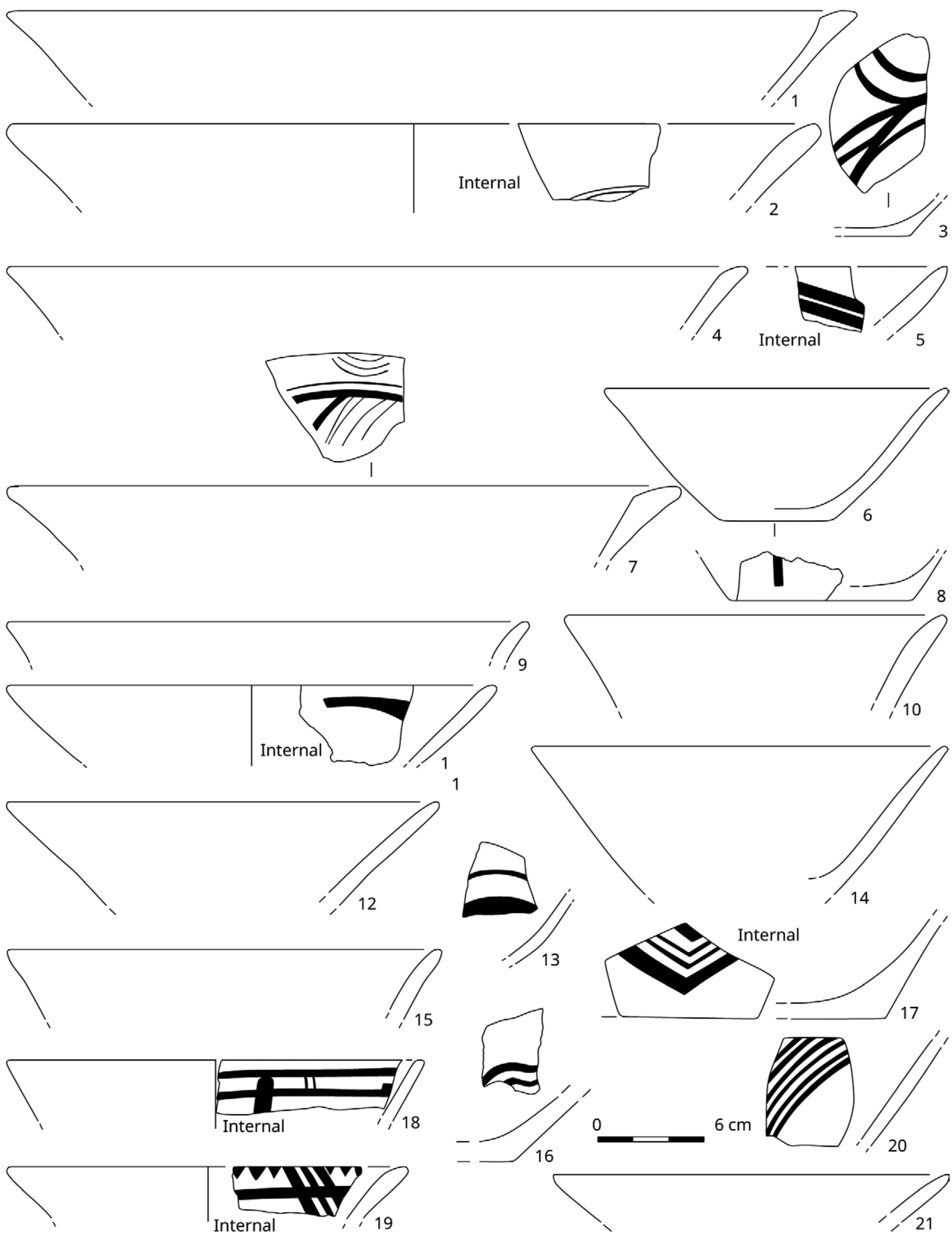

Figure 7. Apolianka: tableware ceramics from Test Trench 1 and surface collection (8, 15, 16). Feature-ID: 1003 (1, 2, 7, 9, 11, 20), 1004 (3, 4, 5, 6, 13, 17, 18), 1007 (10), 1006 (12, 14, 19, 21). Find-ID: 1064 (1), 1058 (2), 1168 (3, 5), 1167 (4, 18), 1275 (6, 17), 1077 (7), 1032 (9), 1244 (10), 1095 (11, 20), 1204 (12, 14, 19, 21), 1173 (13).

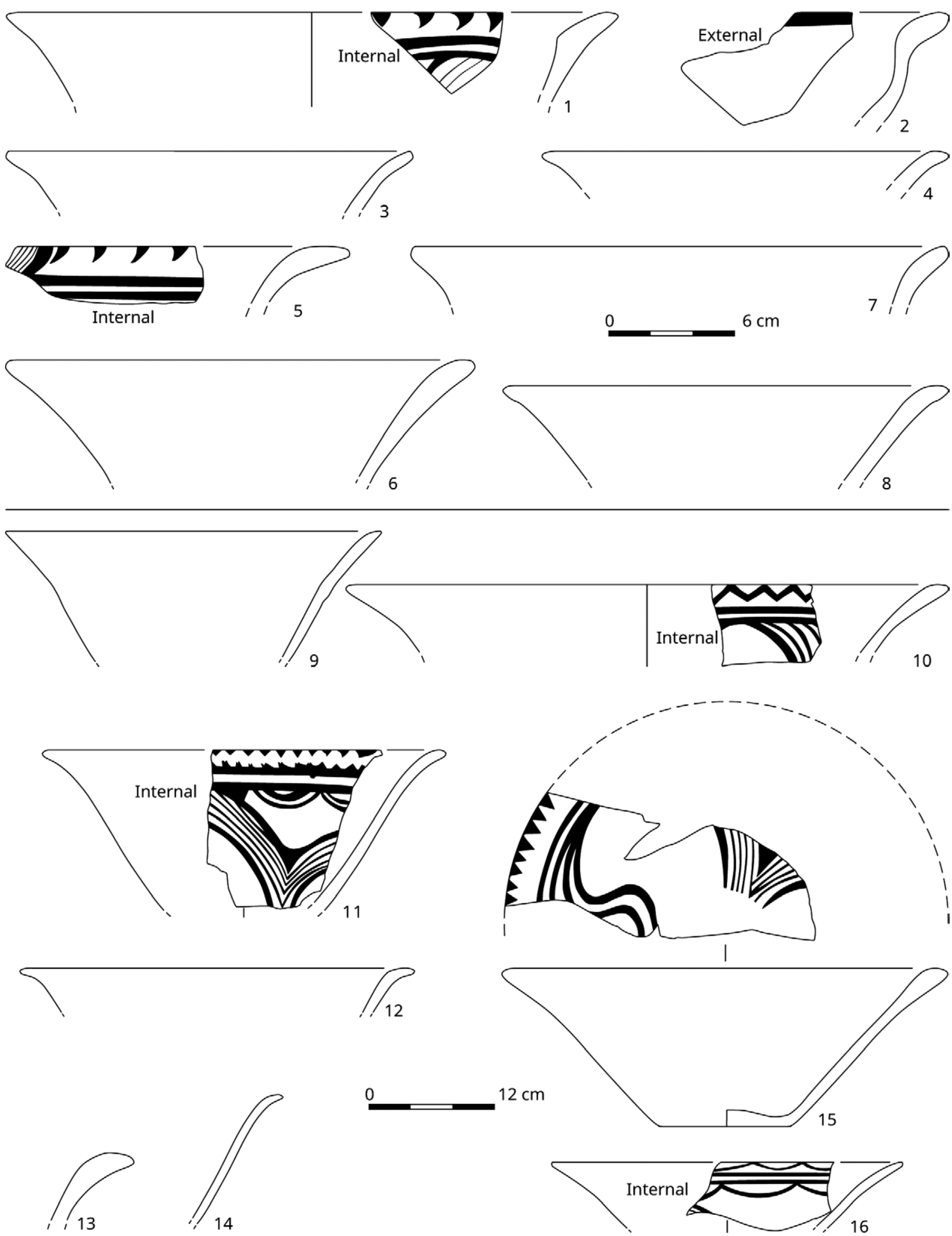

Figure 8. Apolianka: tableware ceramics from Test Trench 1 and surface collection (6, 12, 13). Feature-ID: 1003 (1, 3, 8), (2), 1002 (4), 1007 (5, 9), 1006 (7, 10), 1004 (11, 14, 15, 16). Find-ID: 1032 (1, 3, 8), 1030 (2), 1003 (4), 1240 (5), 1058 (7), 1228 (9), 1218 (10), 1277 (11), 1204 (14, 15), 1168 (16).

Figure 9. Apolianka: tableware ceramics from Test Trench 1 and surface collection (2, 3, 13, 14). Feature-ID: 1006 (1, 10), 1004 (4, 12, 5, 9, 6, 7, 8), 1007 (11). Find-ID: 1204 (1), 1168 (4, 12), 1173 (5, 9), 1085 (6), 1122 (7), 1167 (8), 1220 (10), 1228 (11).

Figure 10. Apolianka: tableware ceramics from Test Trench 1 and surface collection (29, 33). Feature-ID: 1003 (1, 2, 4, 8, 10, 11, 14, 16, 21, 23, 25, 26, 27, 30, 35), 1006 (3, 18, 28), 1004 (5, 6, 13, 15, 17, 19, 20, 22, 24, 31, 32, 34), 1002 (7), 1007 (9, 12). Find-ID: 1064 (1, 2, 4, 8, 14, 21, 26, 30), 1204 (3, 18, 28), 1168 (5, 6, 13, 15, 22, 24, 31), 1037 (7), 1228 (9, 12), 1077 (10, 11), 1032 (16, 27), 1122 (17), 1198 (19, 20), 1030 (23), 1080 (25), 1173 (32, 34), 1085 (35).

Figurines

The pit contained anthropomorphic and zoomorphic figurines. The anthropomorphic figurines are represented by five fragments, two of which are unclear (Fig. 11: 2, 4), and three are part of slim female figurines, standing upright. They are made of a fine-grained clay matrix and fired under oxidising conditions. All of the figurines have modelled hips and two of them are pierced (Fig. 11: 1, 5). The hips are surrounded by a deep line. A similar line is used for the Venus triangle. Two figurines have the triangle filled with roughly-made deep imprints using a stamp (Fig. 11: 1, 5). Such work has analogies among female figurines of a wide chronological range from Cucuteni A settlements Tigăneşti (Monah 2012, Fig. 92: 5), Cucuteni AB/Trypillia BI–BII Yablona (Sorokin and Borziac 2001, Fig. 9: 3–4, 6, Fig. 10: 8), Trypillia BII Konivka, to Trypillia CII Kolodiazhyn (Burdo 2014, Fig. 21: 13, 20–21) and a male (androgynous?) figurine from the Koshylivtsi layer of Verteba cave (Ţurcanu 2013, Pl. 150).

There are specific details on the large figurine fragment with smooth outlining of the hips (Fig. 11: 5). There is a line drawn on the back of the figurine, along the

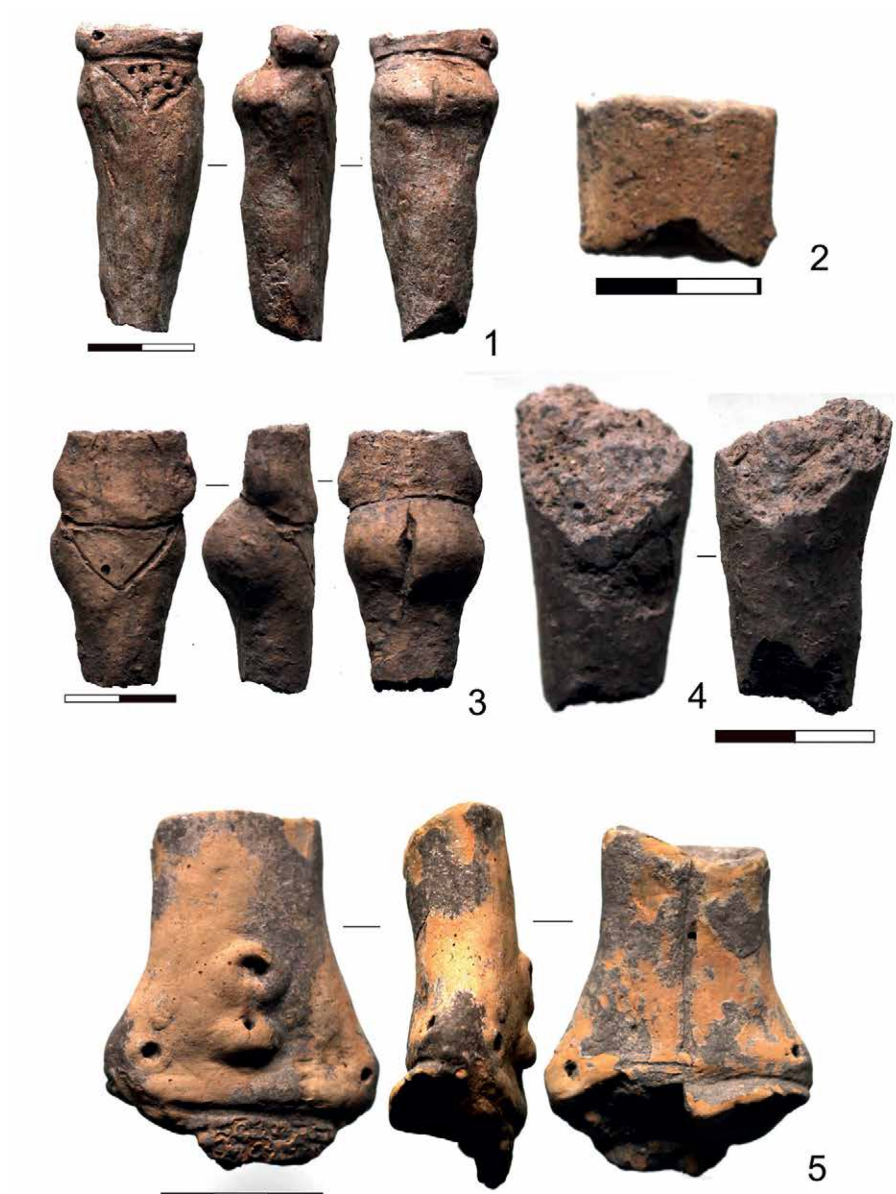

Figure 11. Apolianka: anthropomorphic figurines.

spine. There are two rounded bulges on the belly. The upper has a deep pit in the centre, the lower a vertical slit. According to these specific details the figurine from Apolianka has analogies in plastics of Cucuteni AB/Trypillia BI–BII stages, firstly from the Yablona settlement (Sorokin and Borziac 2001, Fig. 10: 8, Fig. 2: 2, 5, Fig. 7: 2, 4–5), and also Traian (Monah 2012, Fig. 111: 6, Fig. 114: 2, 5–6, Fig. 115: 1, Fig. 125: 14, Fig. 128: 5), Polyvaniv Yar II settlements (Pogoševa 1985, Figs. 498 and 506), and Cucuteni B/Trypillia BII from Lipcani (Monah 2012, Fig. 133: 3), Calu-Piatra Şoimului (Monah 2012, Fig. 135: 2, 4, Fig. 136: 1, 3, Fig. 138: 1, 8), Poduri (Monah 2012, Fig. 145: 4, Fig. 158: 7, Fig. 167: 1), Moldova (Monah 2012, Fig. 150: 8, Fig. 151: 2, Fig. 152: 8), Rakovets (Pogoševa 1985, Fig. 547), Volodymyrivka (Pogoševa 1985, Fig. 557), Brânzeni VIII sites (Sorokin 2001, Fig. 1: 6), as well as in plastics from the Koshylivtsi settlement of the beginning of Trypillia CII stage (Pogoševa 1985, Figs. 868 and 913).

The fragments of anthropomorphic figurines found in Apolianka contain archaic features inherent in sculpture of Cucuteni AB, B/Trypillia BI–BII, BII and CI stages. Among the figurines of the early period of the CII Trypillia stage, the closest analogies can be found at the settlements of Kosenivka group Vilkhovets (Videiko 1997, Fig. 1: 4), Kosenivka (Kruts *et al.* 2005, Fig. 65: 5), Kolodiazhyn and Koshylivtsi groups.

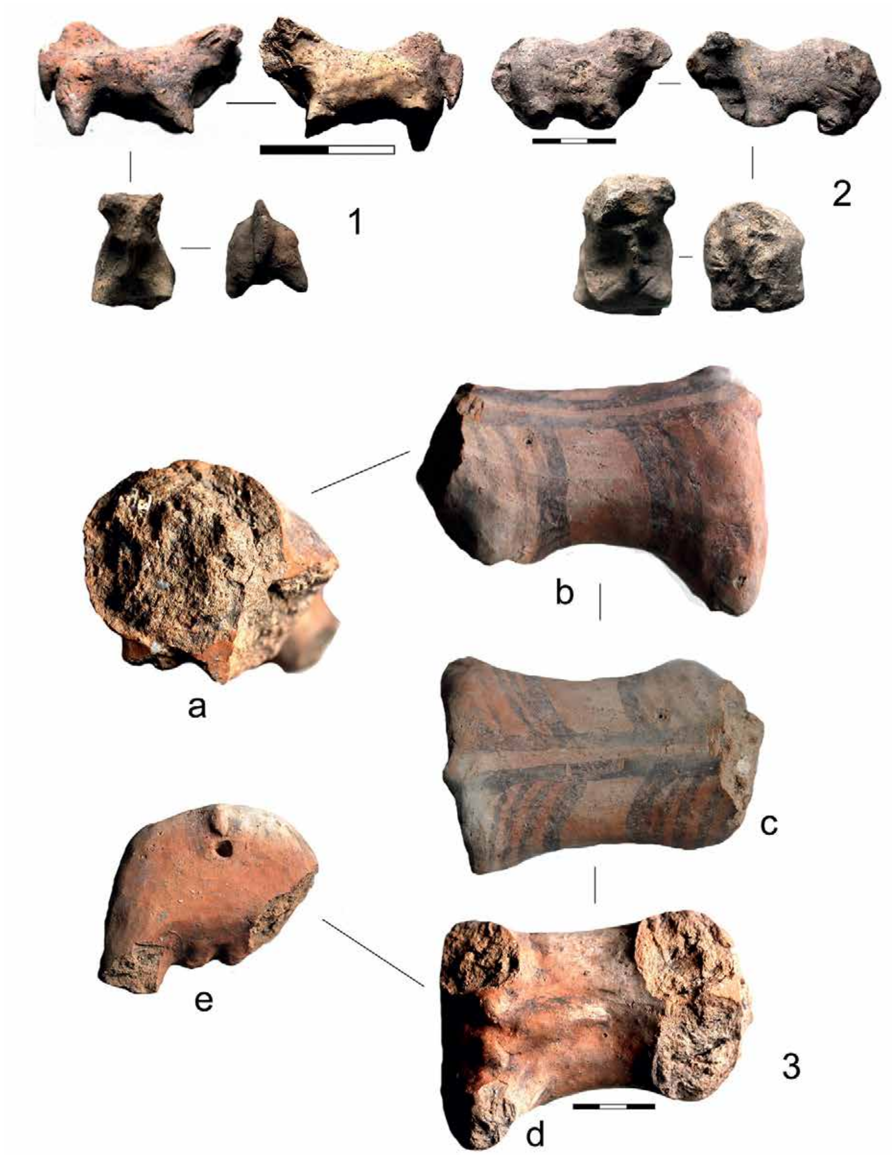

Figure 12. Apolianka (1, 3) and Rohy (2): zoomorphic figurines.

From the Kosenivka group sites Vilkhovets (Videiko 1997, Fig. 1: 7) and Sobkivka (Movsha 1984, Fig. 6) figurines with a disk-shaped head with perforation on the edge are known. Such figurines are common in plastics of Trypillia CII sites of the Kolodiazhyn type, and Brynzeni-Zhvanets, Troianiv, Horodsk and Vykhvatyntsi (Ofatinți) groups (Burdo 2014, 328–332).

The zoomorphic figurines from Apolianka are represented by the small-size bull with naturalistic details (Fig. 12: 1). Also, a piece of a large painted zoomorphic figurine was found in Apolianka; its head was not preserved. It is made of finely structured clay with the admixture of large grains of quartzite (Fig. 12: 3a). The sex features and the tail of a bull (probably) are naturalistic (Fig. 12: 3e, 3d). The surface of the figurine is smoothed and covered with red slipware. The ornaments are painted black. There are two parallel lines on the spine, from which two vertical parallel lines of different width come (Fig. 12: 3b, 3c). The scheme of painting has parallels in the decoration of zoomorphic and ornithomorphic artefacts (Balabina 1998, Fig. 101) and anthropomorphic (Sorokin 2001, Fig. 8: 1, 3) plastics at Cucuteni B/Trypillia BII settlements – Konivka and Brânzeni VIII.

Moshuriv 2

Pottery

The pottery (Fig. 13) is divided into two groups – kitchenware and tableware ceramics. The first group is smaller. The kitchenware ceramics are made of clay with coarse-grained admixtures. These products are represented by the fragments of pots of different sizes (Fig. 13: 16–22). Some of them have a neck with vertical deepened lines (Fig. 13: 17, 19), in most cases it is smoothed. One of the pots has the line of imprints of a stamp like a horseshoe turned upside-down, at the lower part of its long neck (Fig. 13: 16). Some products have single or double conical knobs on the shoulders or at the lower part of the neck (Fig. 13: 17, 21, 22).

Most of the finds are tableware ceramics (Fig. 13: 1–15). These are made of fine structured clay with coarse-grained admixtures. After firing, the vessels became pink or light orange in colour. The surface of the products is covered with yellow-brown and reddish slipware. Dark-brown and red paints were used. Based on the study of the fragments the following forms were reconstructed: truncated-cone bowls, semi-spherical bowls, spherical-conical vessels, and pots.

Small and large truncated-cone bowls (Fig. 13: 1–5, 8–10) were painted inside, and one both inside and out (Fig. 13: 1). Ornamental compositions are made with wide lines, the space between them sometimes filled with narrow lines. In one case there is bichrome red and black painting (Fig. 13: 2).

Semi-spherical bowls are represented by the fragments of rims; the painting was not preserved (Fig. 13: 2). Spherical-conical vessels are represented by fragments of rims and presumably the upper part of the body (Fig. 13: 11–15).

Rohy

Pottery and Figurine

Pottery from Rohy is represented by pieces of clusters and fragmented tableware ceramics. The pottery is made of clay with coarse-grained admixtures which became pink and light orange after firing. The surface of the products is covered with yellow-brown and reddish slipware. Dark-brown paint was used. Based on the study of the

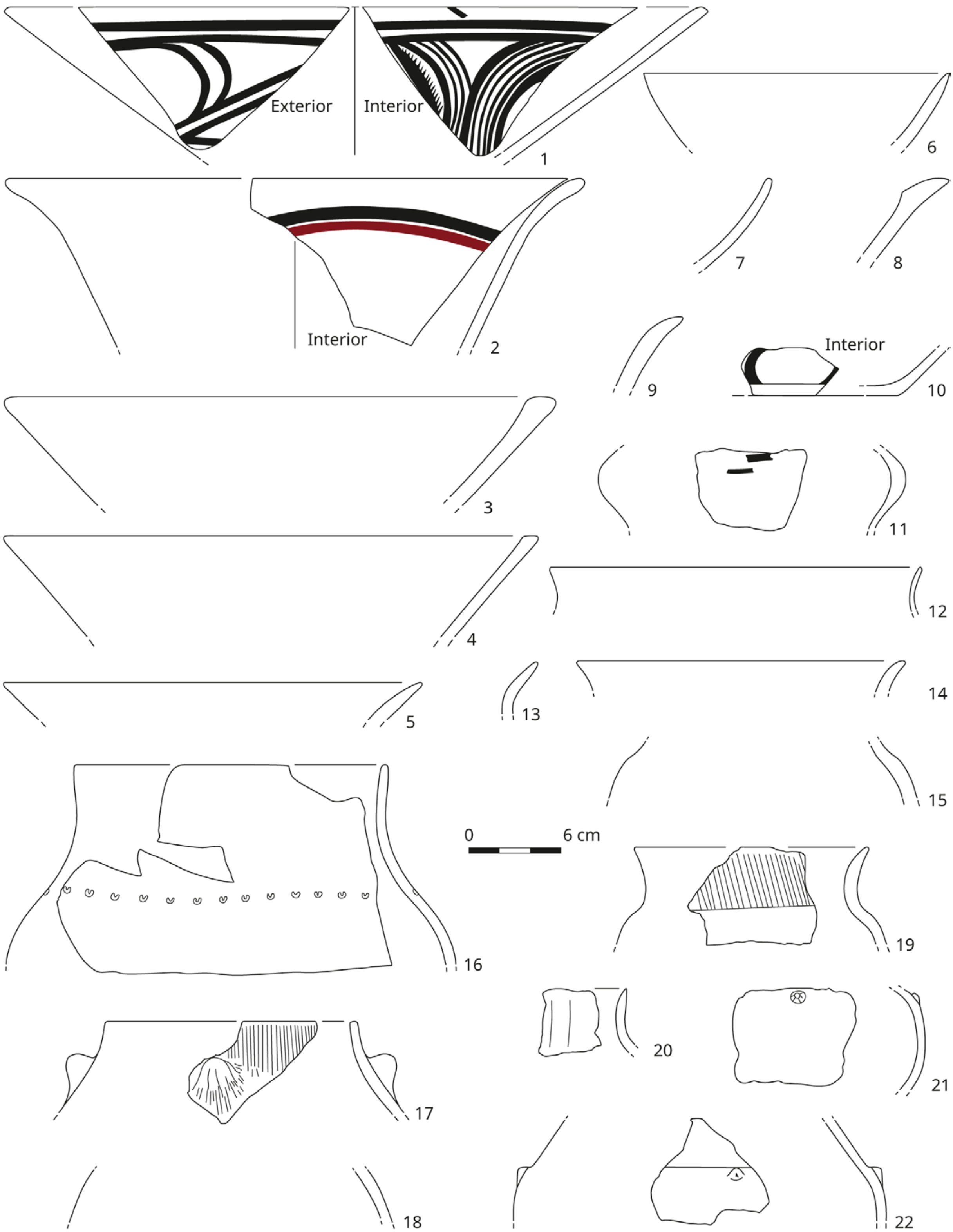

Figure 13. Moshuriv 2: tableware (1–15) and kitchenware (16–22) ceramics from Test Trench 1 and their Find-ID. Feature-ID: 1002 (1–3, 5–10, 12–15, 17, 19, 20, 22), 1004 (4, 11, 16, 21). Find-ID: 1057 (1, 8, 15, 20, 22), 1056 (2, 3, 7), 1053 (4, 11, 16, 21), 1017 (5, 10, 12, 17), 1029 (6, 9), 1012 (13, 14), 1049 (19).

fragments, the following forms were reconstructed: truncated-cone bowls, semi-spherical bowls, spherical-conical vessels, and pots.

The traces of painting were not preserved on truncated-cone bowls (Fig. 14: 1–3, 11). Semi-spherical bowls are represented by fragments of rims (Fig. 14: 9). Spherical-conical bowls are represented by parts of vessels and fragments of rims (Fig. 14: 12–15). A fragment of the middle part of a small pot was also found (Fig. 14: 8).

Zoomorphic *plastic* is represented by the figurine of small bull with naturalistic details (Fig. 12: 2).

Talne 3

Pottery

The pottery from Talne 3 is divided into two groups, kitchenware ceramics and tableware ceramics (Fig. 15). The kitchenware ceramics are 10% of the finds, represented by small pots (Fig. 15: 14–17). One had handles on the upper part (Fig. 15: 14), the other had knobs on the shoulders (Fig. 15: 13). The pots are decorated with imprints of a stamp on the shoulders and under the rims.

Most of the finds are tableware ceramics. The finds from the remains of the building have traces of secondary firing (Fig. 15: 1–12). The surface of the pottery is covered with dark-red and orange slipware and is painted dark-brown. The following forms of the vessels were found: truncated-cone bowls, goblets, spherical- and biconical vessels, pots, crater-shaped vessels.

Truncated-cone bowls are painted inside (Fig. 15: 1–5). One of the fragments was painted with two bands (Fig. 15: 5). The goblets are represented by fragments of their middle parts with some remains of painting – wide and narrow lines (Fig. 15: 9–10). Spherical- and biconical vessels are represented by fragments of rims and middle parts with traces of painting in wide and narrow lines (Fig. 15: 6–7). An almost complete pot was found (Fig. 15: 8). It is decorated with painting above the shoulders. The composition includes lines, triangles and 'leaves'; the edge of the rims is decorated with pitting. The fragments of a bigger pot or crater-shaped vessel were found (Fig. 15: 12).

All in all, such an assemblage of vessels can be related to the Tomashivka local-chronological group of stage CI. The closest site with similar vessels is Talne 2, located on the other side of the stream (Kruts and Videiko 1991, 31–32, Fig. 1). Both of the settlements resemble the Maidanetske mega-site in their ceramic vessel collections (Shmagliy and Videiko 2001–2002, Fig. 2B).

Radiocarbon dating

From the four settlements discussed in this paper, a total of 13 samples were examined, but only ten of them yielded any results and one probably represents an outlier (Suppl. 1 in Chapter 19, this work, Vol. II). On principle, dating was performed using bones, as these were more likely to have remained at the site of their primary or secondary deposition than much smaller botanical macro-remains. Using the software OxCal 4.4 the samples were calibrated and modelled with stratigraphic prior information using calibration curve IntCal20 and the function *boundary* (Bronk Ramsey 2009; Reimer *et al.* 2020).

Figure 14. Rohy: ceramics from Test Trench 1 and their Find-IDs. Find-ID: 1010 (1), 1022 (2–5, 12), 1031 (6, 10, 11, 13), 1019 (7), 1023 (8), 1030 (9, 15), 1021 (14).

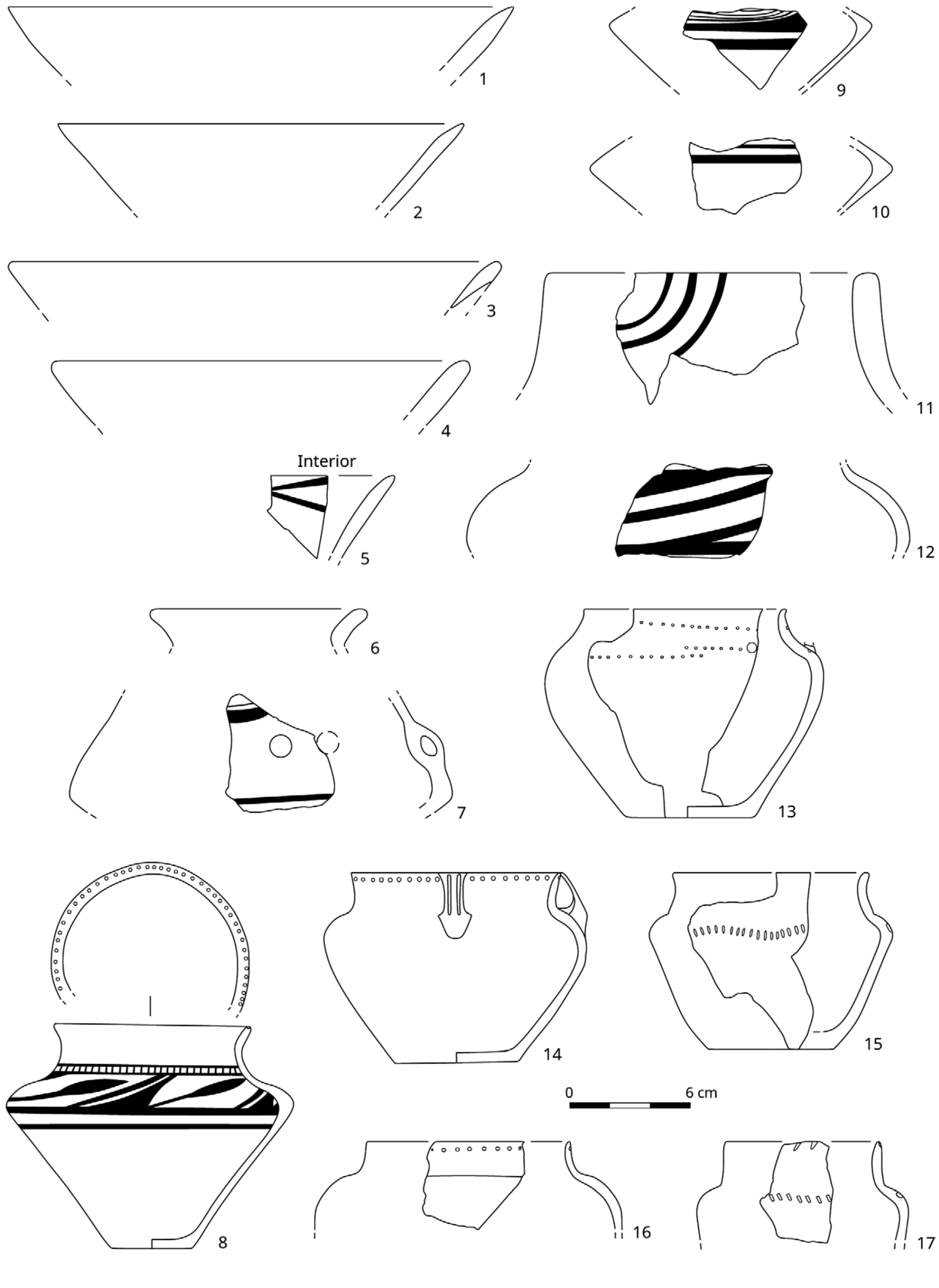

Figure 15. Talne 3: tableware (1–12) and kitchenware (13–17) ceramics from Test Trenches 1 and 2 and surface collection (1, 8, 10, 11). Feature-ID: 1002 (2, 15–17), 1004 (4, 7, 9, 12–14), 2004 (3, 5–6). Find-ID: 1004 (2), 2002 (3), 1006 (4, 9, 12), 2002 (5–6), 1007 (7, 13–14), 1001 (15), 1002 (16–17).

Apolianka

From the test trench in Apolianka, two of five samples were successfully dated. These are samples Poz-114541 from the upper part of the pit backfill (Feature-ID 1003) and sample Poz-114172 from the deepest infilling layer that contained finds (Feature-ID 1007).

A Bayesian model, in which the differently coloured backfill layers are interpreted as the result of different filling events, has a probability of A_{model}=102 and is therefore satisfactory. According to this model, the backfilling of the pit with the highest probability started around 3700 BCE and was completed by approximately 3600 BCE (Fig. 16; Tab. 1).

Moshuriv 2

The three largely consistent dates Poz-114173, Poz-114215 and Poz-114214 were obtained from the area outside the burnt house investigated in Moshuriv 2. Bones from a large mammal, a cow or horse, and another cow served as sample material. According to a Bayesian model, the bones were deposited in the period between 3756 and 3516 BCE (68.3%) or, according to the highest probability, between 3695 and 3620 BCE (Fig. 17; Tab. 2). According to this model, the settlement was used in a late phase of the occupation of neighbouring mega-sites such as Maidanteske (3900–3630 BCE), Dobrovody (3820–3720 BCE) and Talianki (3810–3670 BCE; cf. Chapter 19, this work, Vol. II).

Rohy

The three largely consistent dates Poz-114216, Poz-114217 and Poz-114218 were obtained from different depths of the pit fill investigated in Trench 1. Bones of large mammals and a cow served as sample material. The samples were taken from three different depths in the lower part of the pit backfill. A Bayesian model of this data has an acceptable probability with A_{model} of 114.5 and $A_{overall}$ of 114.3. According to this model, backfilling of the analysed pit occurred between 3765 and 3483 (68.3%) or in median between 3713 and 3539 BCE (Fig. 18; Tab. 3).

Talne 3

From Talne 3, one date was obtained from each of the Trenches 1 and 2. The sample Poz-114221 was dated from Trench 1 taken from a long bone from a medium-sized mammal found in Square M4 outside the burnt house (Feature 1006). Sample Poz-114220 was taken from the mandible of a pig and was recovered from the lower part of the upper pit fill (Feature 2004). The sample from Section 1 dates to the medieval period and thus probably represents a contaminated sample or a more recent deposit. In contrast, the sample from Trench 2 dates on median to around 3750 BCE or to the period between 3795–3659 BCE (68.3%; Fig. 19).

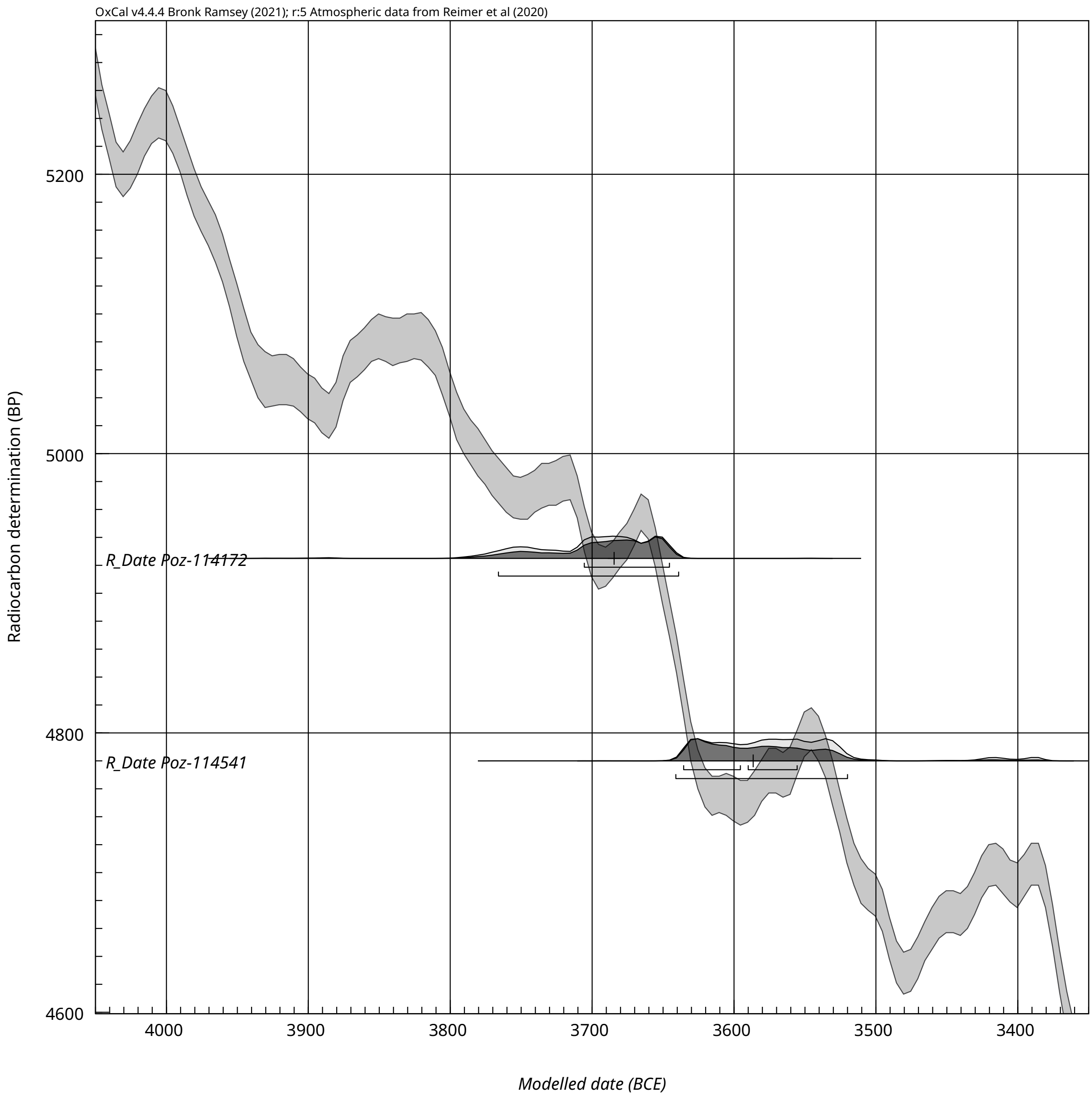

Figure 16. Apolianka: plot of the modelled ^{14}C dates on the calibration curve.

Event	68.2%	95.4%	Median	Highest
Start 1007	3816–3656	4293 (0.1%) 4268 4271 (0.5%) 4241 4231 (94.8%) 3642	3749	3685 or 3710
Duration 1007	0–182	0–631	111	50 or 75
Transition 1007–1003	3686–3590	3741–3557	3641	3635
Duration 1003	0–176	0–596	110	10 or 70
End 1003	3638–3458		3526	3625 or 3565

Table 1. Apolianka: results of the Bayesian modelling of ^{14}C dates BCE with indication of different dating probabilities.

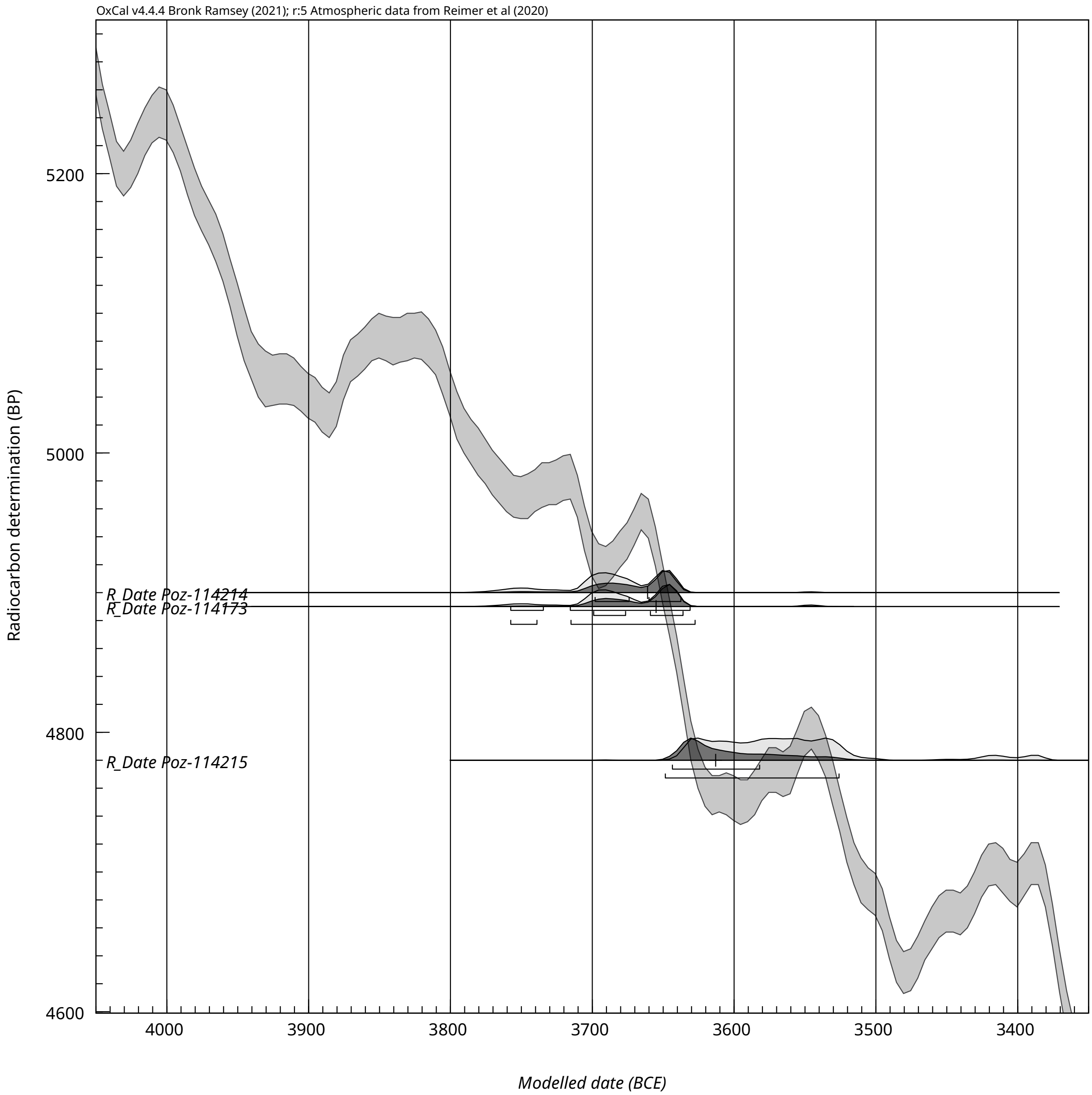

Figure 17. Moshuriv 2: plot of the modelled ¹⁴C dates on the calibration curve.

Event	68.2%	95.4%	Median	Highest
Start house use	3756–3650	4046–3638	3714	3695
Duration house use	0–235	0–748	156	75
End house use	3648–3516	3689–3213	3572	3620

Table 2. Moshuriv 2: results of the Bayesian modelling of ^{14}C dates BCE with indication of different dating probabilities (A_{model} 101.7; $A_{overall}$ 101.9).

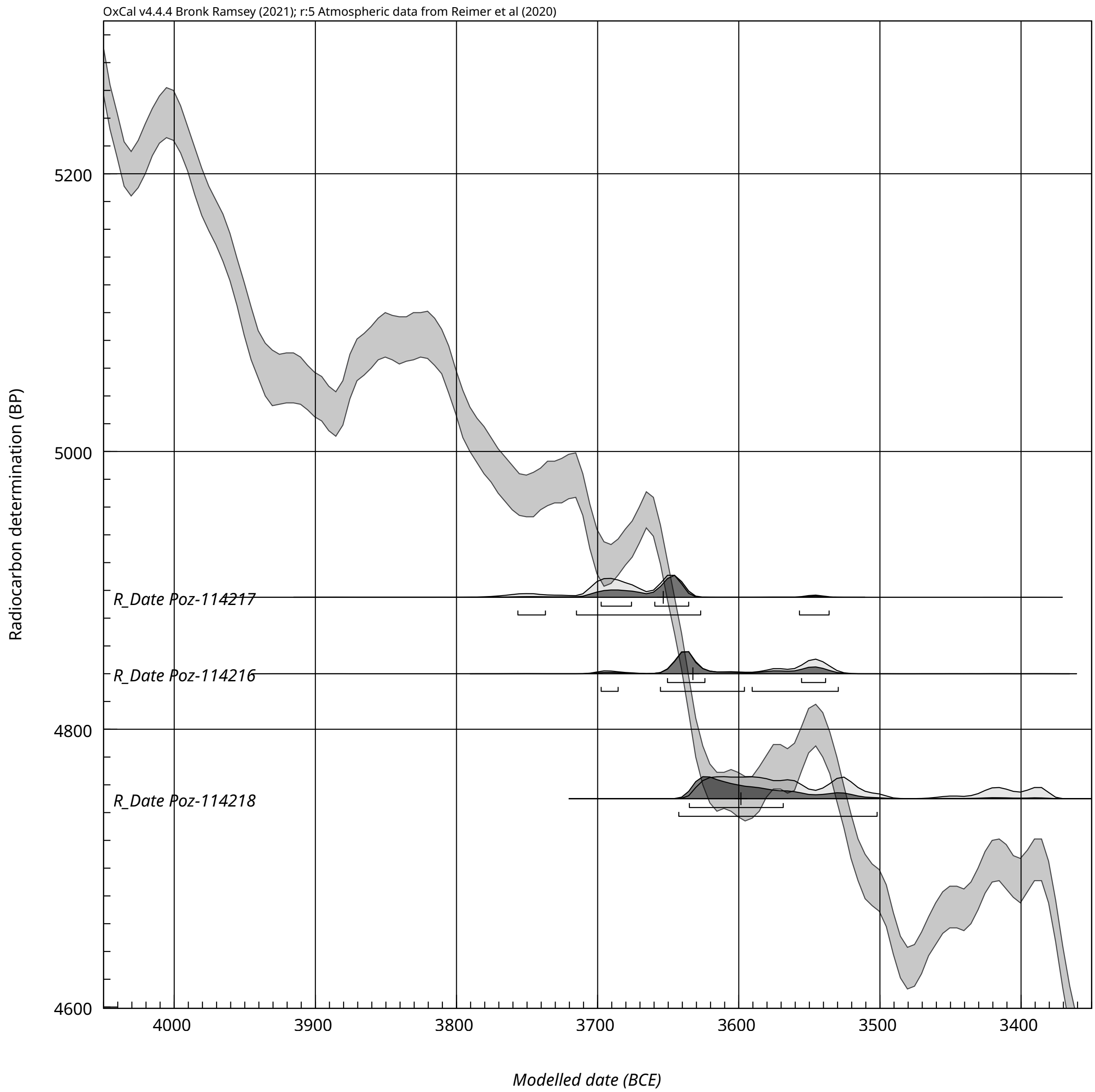

Figure 18. Rohy: plot of the modelled ^{14}C dates on the calibration curve.

Event	68.2%	95.4%	Median	Highest
Start house use	3765–3646	3138 (94.5%) 3633 3589 (0.9%) 3545	3713	3670–3650
Duration house use	20–292	0–893	187	35–65
End house use	3635–3483	3647–3119	3539	3615

Table 3. Rohy: results of the Bayesian modelling of ^{14}C dates BCE with indication of different dating probabilities.

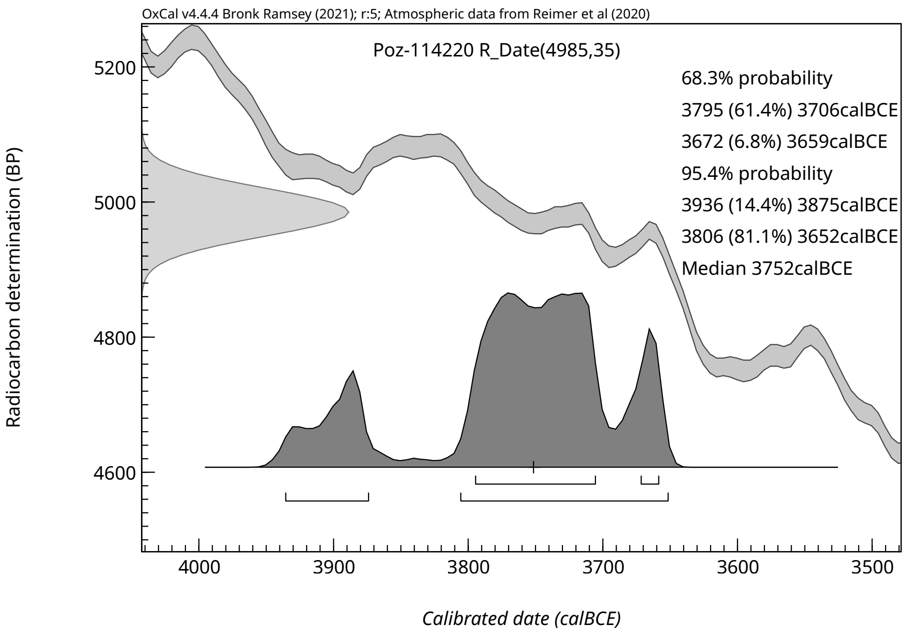

Figure 19. Talne 3: calibration plot of the dating Poz-114220 from Trench 2.

Discussion

Pits and structure interpretation

The excavated pits are located in the vicinity of the buildings and were probably dug in order to extract the clay for building construction. The use of mainly local clay for this purpose was documented earlier (Shevchenko and Ovchinnikov 2005, 105). It is not by accident they all descend more than 1.0 m deep – into the loess level needed for construction. Afterwards the pits were used for waste disposition, judging by the fragmentary state of found artefacts: mostly fragments of vessels, broken tools, crushed animal bones *etc.* Anthropomorphic and zoomorphic figurines may have been perhaps deposited for ritual purposes.

The filling of the examined pits was a result of a continuity process, with the exception of Context 1007 from Pit 1 from Apolianka which reflects a discontinuity in the anthropogenic process of the pit filling.

We assume that domestic and ritual activity within one pit was conducted by the residents of the nearest building. Therefore, the artefacts in the pit were accumulated mostly during the functioning of that building.

At the Moshuriv 2 site an extremely small part of the structure was examined. Therefore, it is too early to make any firm interpretations. However, the presence of interior details located on the layer of the clay with the admixture of chaff, is probably the platform – the floor of the upper store. The detail of the interior may be the podium, assuming that the entrance to the building was at the south-west edge.

The interpretation of the building examined with Test Trench 1 at the Talne 3 site is difficult. On one hand, the daub Layer 1005 can be interpreted as the remains of the ‘platform’ – the floor of the upper store. This is supported by the equal firing temperature of the fragments and sometimes chaotic pattern of spatial distribution. However, the absence of wood imprints on the bottom of the fragments as well as an atypical mixture of clay for a platform may indicate that Layer 1005 is in fact the house ground floor smoothed with clay. Also the artefacts within the building are located only on the surface of Layer 1005. Regardless of these ambiguities, it seems clear that the daub of Layer 1003 consists of the remains of wooden-clay architectural constructions (for example wall, ceiling). The area of the building could have been 4.4–8.0 × 3.0–3.7 m. Interpretation of Layer 1005 as a house ground floor looks more realistic. In this case, a storage building was excavated at the Talne 3 site. Such kind of a building could have been used for economic purposes, as is known for Klishchiv, Kamianets-Podilskyi and Voloshkove 6 sites (Chernovol 2019, 166–171).

A building with such a localisation in the site structure (between two buildings of the circle and slightly moved towards the centre of the settlement) is also known in the south-east part of the Talne 3 site. One of the interpretations for these clusters can be the following: all three buildings, as well as nearby pits, are related to one household complex.

Relative chronology

The relative chronology of these four sites may be determined by comparing the ceramics vessels. Based on that, the Talne 3 settlement of the Tomashivka local group of CI Trypillia stage can be considered the earliest. Later settlements are Apolianka and Moshuriv 2 of the Kosenivka group. In our opinion, this is supported by the fact that their pottery complexes includes kitchenware ceramics with vertical lines on the neck (Fig. 6: 13, 18, 20; Fig. 13: 17, 19), which was widespread in previous stages. The fact that such vessels were not found at the Rohy settlement (Fig. 15) allows to make assumptions of its later existence. This assumption is supported by the collection of forms of painted tableware ceramics from this site, which is different in the number of features (Fig. 15: 5, 7, 10, 15) from the Apolianka and Moshuriv 2 settlements. The earlier age of Apolianka in the system of the Kosenivka group is also supported by the collection of anthropomorphic figurines with archaic features, not attributed to the CII stage.

Therefore, the sequence of the said settlements' existence, based upon the analysis of found ceramics vessels and figurines, is as in Tab. 4.

Radiocarbon dating

The results of absolute dating completely correlate with the sequence of sites which is based upon archaeological finds: Talne 3 (3790–3700 BC) – Apolianka (3710–3565 BCE) and Moshuriv 2 (3695–3620 BCE) – Rohy (3670–3615 BCE). The long time-span of the Apolianka settlement – 145 years, from the radiocarbon dates, can be explained by the nearby flint natural resources. It is located in the gully which surrounds the Apolianka settlement from the north and lies only 5 m deep beneath the modern surface, as was established by P. Shydlovsky's fieldwalking. The presence of local processing is supported by the flint waste gathered at the settlement (Shydlovsky *et al.* 2004, 362, Fig. 3).

The Apolianka and Moshuriv 2 settlements can be synchronised with the Vilkhovets settlement due to the collection of vessels and figurines. The Apolianka and Moshuriv 2 settlements can be related to the early phase of the Kosenivka group. They precede the Kosenivka and probably the Rohy sites. The latest – based on both archaeological materials and radiocarbon dates (Kushtan 2015) – must be the Sharyn settlement.

Stage	Site	Local group
Trypillia CI	Talne 3	Tomashivka
Trypillia CI/II	Apolianka, Moshuriv 2	Kosenivka
	Rohy	Kosenivka

Table 4. Relative chronology of the investigated sites.

The absolute chronology of the settlements raises some questions in several aspects. Previously dates from sites of the Tomashivka group were obtained (Müller *et al.* 2016, list 1). These dates overlap when shown above the dates of sites of the Kosenivka group. This means that early sites of the Kosenivka group should have co-existed with late settlements of the Tomashivka group. Ideas about this matter, based upon some archaeological materials, have been suggested before, for example by T. Tkachuk (2011, Fig. 4). We have this situation when radiocarbon dating may be safely verified by archaeological sources.

In that case the archaeological complexes of Maidanetske and Apolianka could have mutual imports. As of today, the only such product is the bowl from Maidanetske (Shmagliy and Videiko 2001–2002, Fig. 42: 2). On the other hand, among fragments of vessels from Apolianka there is a small amount of pottery made of kaolin clay, typical for the Tomashivka group. At the Talianki settlement (Tomashivka group) the materials of the Kosenivka group have not yet been discovered, even though more than 50 buildings were examined. The small amount collected from the Kosenivka group settlements Moshuriv 2 and Rohy makes it, however, impossible to make a definitive comparison of archaeological materials.

References

Balabina 1998: Балабина, В.И., 1998. *Фигурки животных в пластике Кукутень-Триполья*. Москва: Российская Академия Наук, Институт Археологии.

Bronk Ramsey, C., 2009. Bayesian Analysis of Radiocarbon Dates. *Radiocarbon,* 51 (1), 337–360. Available from: https://doi.org/10.1017/S0033822200033865

Burdo, N., 2014. Anthropomorphic plastic art of Trypillia culture: dialectic of similarities and differences. In: C.-E. Ursu and S. Țerna, eds. *Anthropomorphism and symbolic behaviour in the Neolithic and Copper Age communities of South-Eastern Europe*. Suceava: Editura Karl A. Romstorfer, 303–364.

Chernovol 2019: Черновол, Д.К., 2019. *Інтер'єр будівель трипільської культури. Кваліфікаційна наукова праця на правах рукопису.* [Unpublished PhD thesis. Національна Академія Наук України].

Kruts and Videiko 1991: Круц, В.А. and Видейко, М.Ю., 1991. Раскопки Тальянковского отряда Трипольской экспедиции. *In:* С.Д. Крижицкий, В.М. Зубар, Д.Н. Козак and Р.В. Террпиловський, eds. *Археологічні дослідження на Україні у 1990р*. Київ: Інститут археології НАН України, 31-32.

Kruts *et al.* 2005: Круц, В.А., Корвин-Пиотровский, А.Г., Рыжов, С.Н., Бузян, Г.Н., Овчинников, Э.В., Черновол, Д.К. and Чабанюк, В.В., 2005. *Исследование поселений-гигантов трипольской культуры в 2002-2004 гг*. Киев: Институт археологии НАН Украины.

Kushtan 2015: Куштан, Д., 2015. Керамічний комплекс пізньотрипільського поселення Шарин III. *In:* О. Дяченко, Ф. Менотті, С. Рижов, К. Бунятян and С. Кадров, eds. *Культурний комплекс Кукутень-Трипілля та його сусіди. Збірка наукових праць пам'яті Володимира Круца.* Львів: Астролябія, 429–439.

Monah, D., 2012. *Plastica antropomorfă a culturii Cucuteni-Tripolie*. Bibliotheca Memoriae Antiquitatis XXVII. Piatra-Neamț: Editura "Constantin Matasă".

Movsha 1984: Мовша, Т.Г., 1984. Хронология Триполья-Кукутени и степные культуры эпохи раннего металла в ее системе. *In*: И.Ф. Ковалева, ed. *Проблемы археологии Поднепровья*. Днепропетровск: Днепропетровский государственный университет, 60–83.

Movsha and Kolesnikov 1982: Мовша, Т.Г. and Колесников, А.Г., 1982. *Отчет о работе Доброводского отряда Трипольской экспедиции в 1982 г*. Київ: Науковий архів Інституту археології НАН України. [Unpublished excavation report in the archive of the Institute for Archaeology of the National Academy of Science of Ukraine (IA HAHУ), archive signature: 1982/21 г].

Müller, J., Hofmann, R., Brandtstätter, L., Ohlrau, R. and Videiko, M., 2016. Chronology and Demography: How Many People Lived in a Mega-Site? *In*: J. Müller, K. Rassmann and M. Videiko, eds. *Trypillia Mega-Sites and European Prehistory 4100-3400 BCE*. Themes in Contemporary Archaeology 2. London, New York: Routledge, 133–170. Available from: https://doi.org/10.4324/9781315630731

Ohlrau, R. and Rud, V., 2019. Testing Trypillian site development via geomagnetic survey – New "mega-structures" and plans of smaller sites. *In*: D. Mischka, C. Mischka and C. Preoteasa, eds. *Beyond Excavation. Geophysics, Aerial Photography and the Use of Drones in Eastern and Southeastern European Archaeology. Proceedings of the International Colloquium, 5-8 December 2016, Piatra-Neamț, Romania*. Bibliotheca Memoriae Antiquitatis 40; Erlanger Studien zur Prähistorischen Archäologie 3. Piatra-Neamț: Editura "Constantin Matasă", 87–113.

Pogoševa, A.P., 1985. Die Statuetten der Tripolje-Kultur. *Beitrage zur allgemeinen und vergleichenden Archäologie*, 7, 95–242.

Rassmann, K., Ohlrau, R., Hofmann, R., Mischka, C., Burdo, N., Videjko, M.Y. and Müller, J., 2014. High precision Tripolye settlement plans, demographic estimations and settlement organization. *Journal of Neolithic Archaeology*, 16, 96–134. Available from: https://doi.org/10.12766/jna.2014.3

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Bronk Ramsey, C., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C., van der Plicht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Fogtmann-Schulz, A., Friedrich, R., Köhler, P., Kudsk, S., Miyake, F., Olsen, J., Reinig, F., Sakamoto, M., Sookdeo, A. and Talamo, S., 2020. The IntCal20 Northern Hemisphere Radiocarbon Age Calibration Curve (0–55 cal kBP). *Radiocarbon*, 62 (4), 725–757. Available from: https://doi.org/10.1017/RDC.2020.41

Rud *et al.* 2016: Рудь, В., Улрау, Р. and Манігда, О., 2016. Геомагнітна зйомка та географічне моделювання у вивченні поселення Тростянчик. *Вісник рятівної археології (Acta Archaeologiae Conservativae)*, 2, 55–76.

Rud, V., Hofmann, R., Kosakivskyi, V., Zaitseva, O. and Müller, J., 2019. Trypillia Megasites West of the River Southern Buh: Preliminary Results of Bilyi Kamin Site Investigation in 2018. *Journal of Neolithic Archaeology*, 21, 27–60. Available from: https://doi.org/10.12766/jna.2019.2

Ryzhov 2001-2002: Рижов, С.М., 2001–2002. Позднетрипольские памятники Буго-Днестровского междуречья. *Stratum Plus*, 2001–2002 (2), 187-196.

Shevchenko and Ovchinnikov 2005: Шевченко, Н.А. and Овчинников, Э.В., 2005. Минералого-петрографическое исследование материалов из раскопок 2002-2004 гг. На поселении трипольской культуры у с. Тальянки. *In:* В.А. Круц, А.Г. Корвин-Пиотровский, С.Н. Рыжов, Г.Н. Бузян, Э.В. Овчинников, Д.К. Черновол and В.В. Чабанюк, eds. *Исследование поселений-гигантов трипольской культуры в 2002-2004 гг.* Киев: Институт археологии НАН Украины, 94–106.

Shmagliy and Videiko 2001–2002: Шмаглий, Н.М. and Видейко, М.Ю., 2001–2002. Майданецкое – трипольский протогород. *Stratum Plus*, 2001–2002 (2), 44–140.

Shydlovsky *et al.* 2004: Шидловський, П.С., Пічкур, Є.В. and Чорновол, Д.К., 2004. Археологічні дослідження поблизу села Аполянка на Уманщині. *Археологічні відкриття в Україні*, 2002-2003, 361–364.

Sorokin, V., 2001. Plastica antropomorfă din aşezarea cucuteniană dela Brânzeni VIII, jud. Edineţ. *Memoria Antiquitatis*, 22, 137–155.

Sorokin, V. and Borziac, I., 2001. Plastica antropomorfă a aşezării cucuteniene Iablona I, jud. Bălţi. *Memoria Antiquitatis*, 22, 115–136.

Stefanovych and Didenko 1968: Стефанович, В.А. and Диденко, О.П., 1968. *Археологические памятники Уманщины*, Vol. 1. Київ: Науковий архів Інституту археології НАН України. [Unpublished report in the archive of the Institute for Archaeology of the National Academy of Science of Ukraine (IA НАНУ), archive signature: Ф.12, №569].

Tkachuk T., 2011, Local groups with painted pottery of Trypillia-Cucuteni Culture (stages BII – CII, 4200-3300 BC). *Trypillian Civilization Journal*. Available from: https://www.trypillia.com/2011/90-2011-2-archaeology-local-groups-with-painted-pottery-of-trypillia-cucuteni-culture-stages-bii-cii

Ţurcanu, S., 2013. Anthropomorphic and zoomorphic plastic art. *In:* S. Kadrow, ed. *Bilcze Złote. Materials of the Tripolye culture from the Werteba and the Ogród Sites*. Kraków: Muzeum Archeologiczne Krakowie, 53–85.

Videiko 1991: Відейко, М.Ю., 1991. Дослідження пізньотрип ільського поселення Тальне 3. *In*: С.Д. Крижицкий, В.М. Зубар, Д.Н. Козак and Р.В. Террпиловський, eds. *Археологічні дослідження на Україні у 1990р*. Київ: Інститут археології НАН України, 11–12.

Videiko 1997: Відейко, М.Ю., 1997. Розкопки поселення трипільської культури біля с Вільховець. *Археологічні дослідження в Україні*, 1993, 30–33.

Videiko *et al.* 2017: Видейко, М., Улрау, Р., Слесарев, Е. and Видейко, М.М., 2017. Новые исследования на поселении трипольской культуры этапа BI-II Коломийщив Яр. *Tyragetia, serie nouă*, 11 [26] (1), 55–66.

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