Rassmann, Knut – Stevens, Frank – Oross, Krisztián – Marton, Tibor – Osztás, Anett – Serlegi, Gábor – Winkelmann, Kay – Bánffy, Eszter

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in: Bánffy, Eszter (Hrsg.), The environmental history of the Prehistoric Sárköz region in southern Hungary, 11-81.

DOI: https://doi.org/10.34780/eebf-9e67

Herausgebende Institution / Publisher:
Deutsches Archäologisches Institut

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Confinia et Horizontes

THE ENVIRONMENTAL HISTORY OF THE PREHISTORIC SÁRKÖZ REGION IN SOUTHERN HUNGARY

ESZTER BÁNFFY (ED.)

RGK

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CONFINIA ET HORIZONTES VOL. 1

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RÖMISCH-GERMANISCHE KOMMISSION
DES DEUTSCHEN ARCHÄOLOGISCHEN INSTITUTS

ARCHÄOLOGISCHES INSTITUT
FORSCHUNGSZENTRUM FÜR HUMANWISSENSCHAFTEN
EÖTVÖS LORÁND FORSCHUNGSNETZWERK BUDAPEST

ESZTER BÁNFFY (ED.)

The Environmental History of the Prehistoric Sárköz Region in Southern Hungary

Verlag Beier & Beran. Archäologische Fachliteratur, Langenweißbach

With 129 Figures, 19 Tables, and 1 Digital Supplement

Bibliografische Information der Deutschen Bibliothek

Die Deutsche Bibliothek verzeichnet diese Publikation
in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten
sind im Internet über <*http://dnb.de*> abrufbar.

ISBN 978-3-95741-133-4
ISSN 2701-7435
Satz: print + design GbR, Frankfurt am Main
Druck: Beltz Grafische Betriebe GmbH, Bad Langensalza
Verantwortlicher Redakteur: Alexander Gramsch, Römisch-Germanische Kommission
Graphische Betreuung: Oliver Wagner, Kirstine Ruppel, Römisch-Germanische Kommission
Formalredaktion: Kathrin Legler, Ludwigshafen am Rhein, Johannes Gier, Römisch-Germanische Kommission
Übersetzungen und sprachliche Betreuung: Magdaléna Seleanu, Budapest

Printed in Germany
Printed on fade resistant and archival quality paper (PH 7 neutral) • tcf

Inhalt

Lectori salutem!

The launching of a new monograph series is a matter of courage and confidence. Courage that it is worthwhile to publish new books in this digital age of ours, and confidence in readers that they will be willing to take yet newer thick volumes in their hand and use them for their academic work or read them out of pure interest in prehistoric archaeology. The host institute, the Romano-Germanic Commission (RGK) of the German Archaeological Institute, has established, edited, and published several monograph series during its long life since it was founded in 1902: suffice it here to refer to the *Römisch-Germanische Forschun*gen, the *Kolloquien zur Vor- und Frühgeschichte*, the series *Die Ausgrabungen in Manching*, and to the *Limesforschungen*. So, one may rightly ask, wherefore yet another one?

During the past few years, research in the RGK has been organised around two major themes and two logistically separate work teams, which are nevertheless bound by many strands scientifically. Under the umbrella of *Forschungsfeld* 2, the research topics related to the Iron Age and the Roman provincial period, research on the Roman *limes* and on the Barbaricum, i. e. the regions not occupied by the Romans, as well as research on the Late Antique period are addressed through related overarching questions such as "border studies". *Forschungsfeld* 1, established at a later date, brings together fields of research and grand themes that had commanded scholarly interest during the first half of the 20th century and were revived during the past decade as part of the RGK research agenda. These cover the Late Mesolithic and the transition to the Neolithic, alongside themes from the Neolithic to the Bronze Age. Currently, there are several RGK and collaborative projects with various institutions and colleagues based in different countries within the framework of this research group. Similarly to the work group focusing on later prehistoric and early historic periods, the basic research questions in Neolithic and Bronze Age studies are few, but they are closely related to each of the running projects and those in plan.

While members of the *Forschungsfeld* 2 work team have had several options for publishing their findings in the traditional RGK monographs, the early periods could not be fitted into any of the already existing series. Hence the idea of establishing *Confinia et horizontes.* The title of the new series matches the major theme of *Forschungsfeld* 1, "Marginal zones, contact zones". The choice of one Latin and one Greek word was wholly intentional: marginal, liminal zones would be ideal settings for potential interactions between different groups initially separate from each other, which then established contacts through exchanges and trade, and later expanded the contacts to a mutual sharing and transferring of innovations and knowledge. And, as is usually the case, these contacts can be traced in the genetic make-up of the once separate population groups. Our goal is to publish cutting-edge new research: principally the projects of the RGK community, but since the time of individual research and authorship has since long passed, these publications, as a rule, will present the findings of dynamic collaboration with other institutions. The monographs will be grouped according to the various collaborative projects. Although it is not our intention to break up *Confinia et horizontes* into subseries, we shall quite clearly indicate if a major project is published in more than one volume that these volumes are closely related. Even more importantly, individual volumes will never be publications released solely by the RGK, but will be equally owned by our partner institutes. This can also be seen as a symbolic gesture: these days, archaeological research generally involves the joint effort of specialists of fieldwork, environmental and non-invasive landscape research, geo- and bioarchaeology, all brainstorming together. The evaluation will then be based on data coming from each field of investigation. It needs to be repeatedly stressed that there is no difference between the two *Forschungsfelder*, between the different periods and phases of archaeological periodisation. Prehistory and history are equally important chapters of the human past. The ultimate goal of *Confinia et horizontes* is to integrate the data provided by various disciplines and interpret them jointly, in the hope that the result will contribute to a reconstruction and better understanding of the various dimensions of past societies. In other words, we truly hope that our prehistoric data will ultimately lead to history writing.

Eszter Bánffy

Knut Rassmann, Frank Stevens, Krisztián Oross, Tibor Marton, Anett Osztás,
Gábor Serlegi, Kay Winkelmann and Eszter Bánffy

Windows onto the landscape: Prospections on the prehistoric sites at Alsónyék, Fajsz-Kovácshalom, Fajsz-Garadomb, and Tolna-Mözs in the Sárköz region

Keywords: Neolithic, Sárköz region, non-invasive investigations, geomagnetic prospections, spatial analysis, soil chemistry

Schlagwörter: Neolithikum, Sárköz-Region, nicht-invasive Untersuchungen, geomagnetische Prospektion, Raumanalyse, Bodenchemie

Kulcsszavak: Újkőkor, Sárköz, roncsolásmentes vizsgálatok, geomágneses prospekció, térinformatikai vizsgálatok, talajkémia

Introduction

Long-term archaeological research in the Sárköz region and large-scale rescue excavations during the past three decades have yielded rich and valuable archaeological data. This paper will focus on the complex non-invasive (and minimal-invasive) research as well as the magnetic prospections on archaeological sites near Alsónyék, Tolna-Mözs, and Fajsz in the Sárköz region that were undertaken between 2011 and 2015 *(Fig. 1)*[1].

The archaeological setting

Prehistoric research in the heartland of the Carpathian Basin has turned with a growing interest to regions that had not been studied intensively before. Among these areas, the Danube riverine landscape with its adjacent hills in southern Hungary, which proved to be a key region in the cultural exchange and communication network between the northern Balkans and Central Europe, is of a special interest. The region known as the Sárköz is located along the Danube and is made up of two parts: the Tolna Sárköz on the right bank and the Kalocsa Sárköz on the left bank. The region's most prominent feature is the Danube, although it must be noted that river regulations in the late 19th century completely changed the original geomorphological features of the area. Before this, the Danube did not have one main riverbed, but rather consisted of many larger and smaller branches, flowing across a waterlogged marshland dotted with low sandbanks.

The Sárköz region has been researched within the framework of two very different projects. In the eastern part, the Kalocsa Sárköz, systematic and planned research was carried out in the early 2000s, which also involved cross-checking and integrating earlier field walking, and scattered reports on Neolithic sites there (Vadász 1967; Horváth 1972; 1987; Bognár-Kutzián 1977; Kalicz 1994; Wicker et al. 2001; Bánffy 2003). Between 2000 and 2001, a grant from the German Research Fund (DFG) supported our joint work with colleagues from Tübingen[2] to undertake surveys on the Fajsz-Garadomb and Fajsz-Kovácshalom sites, which was followed by a Hungarian Research Fund (OTKA)

1 The prospections between 2011 and 2015 were conducted by Kay Winkelmann, Gábor Serlegi, Maria Ivanova, Carsten Mischka, Martin Furholt, René Ohlrau, Kai Radloff, Frank Stevens, and Wouter Verschoof (Serlegi et al. 2013; Rassmann et al. 2015a; 2015b).

2 Die Besiedlungsgeschichte der Siedlungskammer um Fajsz (Komitat Bács-Kiskun, Südungarn) in der Ältesten Bandkeramik, led by Jörg Petrasch and Eszter Bánffy.

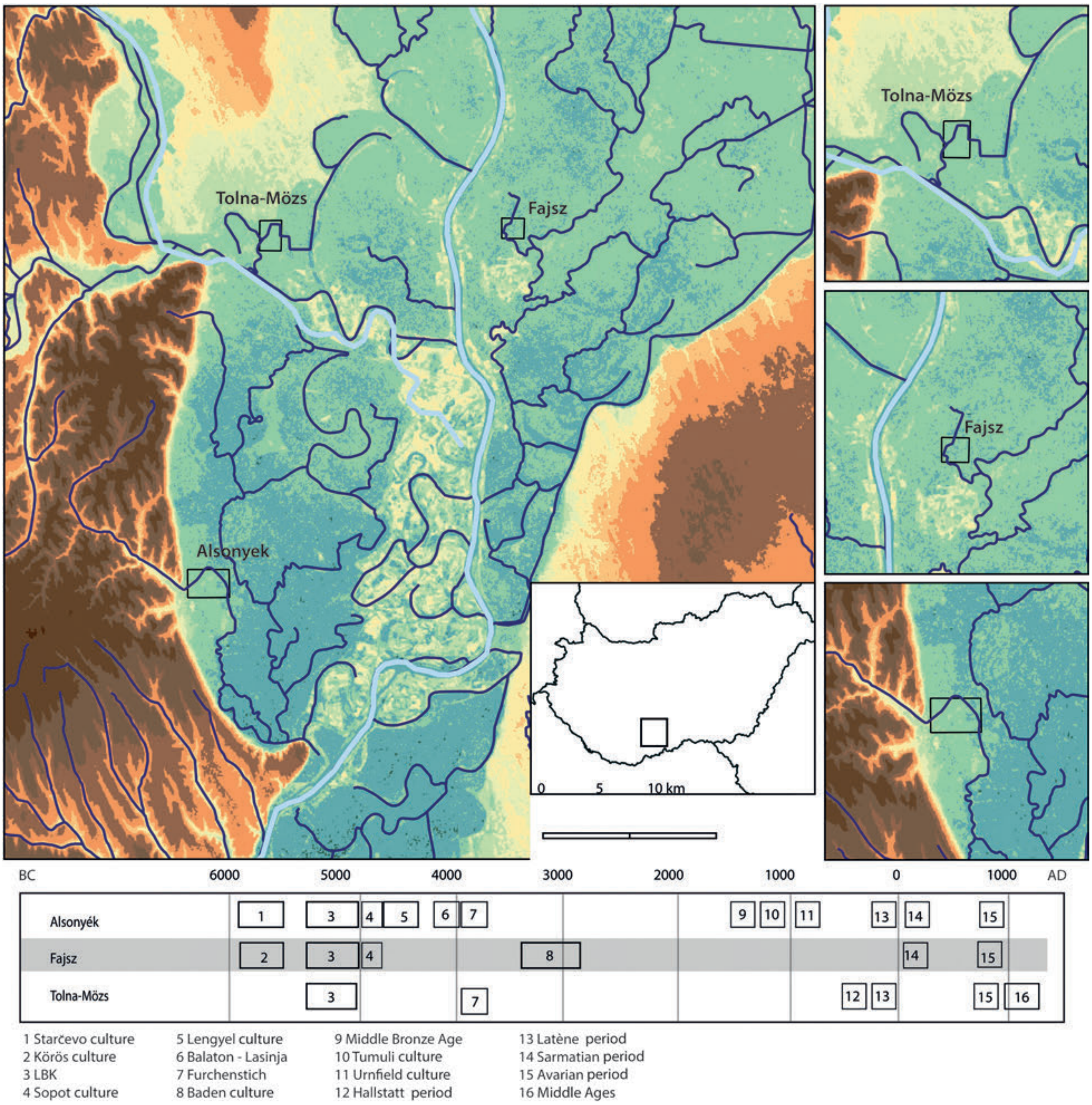


Fig. 1. Overview of the research areas around the multi-period sites of Tolna-Mözs, Fajsz, and Alsónyék with the present periods and archaeological cultures.

project between 2006 and 2010[3], with excavations at the Fajsz-Garadomb (flat settlement) site and surveys on the Fajsz-Kovácshalom (tell) site. After the project, the evaluation proposal remained unsuccessful, but in 2013, a monograph was published about the Early Neolithic of the Danube-Tisza interfluve (Bánffy 2013), which includes a report by Rozália Kustár on the 50 Early Neolithic (Körös culture) sites as well as the evaluation of the Körös settlement at Szakmár-Kisülés.

Parallel to our excavation and assessment of the findings in the eastern, Kalocsa Sárköz area, archaeological work started ahead of the construction of the M6 motorway. The Institute of Archaeology of the Hungarian Academy of Sciences (HAS)[4] was involved in the work and conducted several excavations on the planned mo-

3 Fajsz: The beginnings and early stages of food production in Southern Transdanubia, between Lake Balaton and the Danube valley. K61935, led by Eszter Bánffy.

4 The Institute of Archaeology of the Hungarian Academy of Sciences existed in this form between 1958 and 2012. Between 2012 and 2019 it was part of the Research Centre for the Humanities (RCH) within the Hungarian Academy of Sciences. After 1st September 2019, all Institutes were taken from the Hungarian Academy of Sciences. Today its official name is Institute of Archaeology, Research Centre for the Humanities (RCH). Since the staff and the work has not changed, hereinafter, we shall use the simple name of "Institute of Archaeology".

torway track. Our team worked at several Neolithic sites that lie in the western Tolna Sárköz area, one of which was an exceptionally large site at Alsónyék (Zalai-Gaál / Osztás 2009a; 2009b; Osztás et al. 2012). This settlement and burial place might not only be the largest Neolithic site in Central Europe but also an exceptionally important element of European heritage. The excavation of the site between 2006 and 2009 was followed by extensive analyses, still ongoing, much of it involving international cooperation. This work has been supported by grants from the OTKA fund for post-excavation investigations of various kinds, from the DFG[5] for aDNA analyses, and collaboration with the European Research Council-funded project "The Times of Their Lives" (ToTL)[6]. The Tolna-Mözs-Községi-Csádésföldek settlement became part of a new investigation supported by a new OTKA (NKFI) grant[7] that explores the settlement patterns and contact networks in southern Transdanubia.

Due to the rather fortunate constellation of circumstances, the Sárköz became one of the most intensively researched micro-regions in southern Central Europe, which also provided a good opportunity for inviting the work team for non-invasive landscape surveys from the Römisch-Germanische Kommission (RGK) to the region in order to clarify the human impact on the not yet excavated parts of the settlements. Since 2011, and especially after 2013, with the ties becoming closer, the intensive non-invasive work turned out to be much more than simply a geomagnetic prospection. The present study is an outline of the entire non-invasive research in the Sárköz region.

The significance of the non-invasive research plans

The research agenda at these sites focused on different aspects as the involved sites are different and they had a different agenda in terms of their excavation and post-excavation process. Alsónyék and Tolna-Mözs were chosen because the large-scale rescue excavations at these sites brought to light extraordinarily rich archaeological data from different periods. This already resulted in major publications under the umbrella of the above-mentioned international research projects (Bánffy 2016, 5 f.; Bánffy et al. 2010; 2014; 2016; 2017; Osztás et al. 2016a; 2016b). Fajsz is very important for the Late Neolithic (Sopot culture period) in the Sárköz region owing to the joint presence of both a tell mound and a flat settlement in one micro-region. The site has been under investigation by a joint Hungarian-German project team with a research excavation between 2006 and 2008.

Research design, methods, and equipment

Desk-based assessment: Maps, other GIS data, and archaeological data

Our research frame was the collaboration between the RGK and the Institute of Archaeology of the Hungarian Academy of Sciences (HAS). Since 2014, the cooperation is further supported by the newly founded German Archaeological Institute (DAI)-RGK Research Unit Budapest. The joint investigations starting in 2011 were on the one hand embedded in the RGK's programme of settlement patterns research in Central and Eastern Europe (Rassmann et al. 2014), and on the other hand in the long-term research of the Hungarian Academy of Sciences and its Hungarian partners under the direction of Eszter Bánffy since the early 2000s.

The ambitiously extended prospections were possible through the utilisation of the vehicle-towed 16-channel magnetometer system. This system made it possible to undertake magnetic prospections on the scale of square kilometres rather than square metres, thus enabling the complete investigation of archaeological sites, their closer periphery, and the surrounding landscape.

In order to benefit from the potentials of the magnetic data, they have to be analysed in the context of other data including soil chemistry, aerial photos, topography, etc. The comparison of numerous magnetic anomalies with specific excavated structures is crucial to the interpretation of magnetometric data. In the Fajsz project area, several magnetic anomalies were compared with the thickness and extent of the occupation layers of the Garadomb and Kovácshalom sites by means of borehole sampling.

The interdisciplinary approach is fundamental to classifying magnetic anomalies, to identifying relevant archaeological features, and to enhancing the understanding of magnetic signatures and their archaeological context. Thus, we are able to trace archaeological features from the excavation area into neighbouring prospection areas. An attempt to develop a holistic ar-

5 Bevölkerungsgeschichte des Karpatenbeckens in der Jungsteinzeit und ihr Einfluss auf die Besiedlung Mitteleuropas, led by Kurt W. Alt.

6 The Times of Their Lives: towards precise narratives of change in the European Neolithic through formal chronological modelling (ERC Advanced Investigator Grant 295412, led by Alasdair Whittle and Alex Bayliss).

7 Újkőkori közösségek a Balkán és Közép-Európa érintkezési övezetében a Kr. e. 6. évezred második felében (Neolithic communities in the contact zone between the Balkans and Central Europe in the second half of the 6th millennium BC; grant code: K 112366), led by Krisztián Oross.

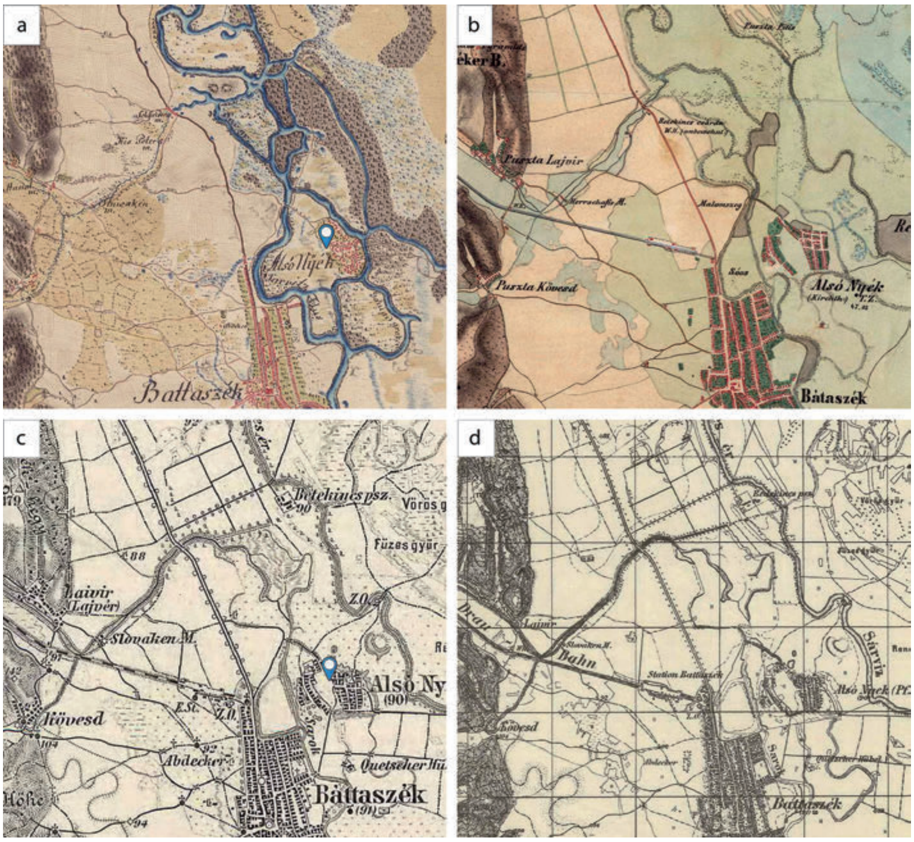


Fig. 2. Alsónyék-Bátaszék. a Josephinian cadastre, 1782–1785; b Franciscan cadastre, 1806–1869; c Franciscan-Josephinian survey, 1869–1887; d Hungarian survey, 1941.

chaeological approach is important to facilitate more precise estimations on settlements sizes, their internal spatial organisation, and their changes over time.

The profound changes in the landscape of the Sárköz and other regions in the Pannonian Basin over the last centuries are clearly visible on historical maps from the 18th and 19th centuries. The first systematic land surveying and topographic mapping in the Kingdom of Hungary was accomplished between 1782–1785 under the reign of Emperor Joseph II and later continued with the Franciscan cadastre from 1806–1869. The Franciscan-Josephinian survey (1869–1887) resulted in maps at the scale of 1 : 25 000 for historical Hungary, Transylvania, and Croatia (Biszak et al. 2017, 204; http://mapire.eu). Older surveys provide particularly valuable insights and data on hydrology and landscape use before the river regulation in the 19th and 20th centuries. They are crucial for both understanding the potentials of the landscape, e. g. modelling carrying capacity, and for estimating the impact of intensive agriculture, increasing urban, commercial, and industrial development, including the development of traffic infrastructure, on archaeological monuments *(Fig. 2)*. Recent landscape data are precisely recorded on topographic maps (scale 1:10 000). For calculating digital elevation models, the data of the Shuttle Radar Topography Mission (SRTM) in a resolution of 1 Arc-Second Global (corresponding to c. 21 m at 46° northern latitude in the Tolna region) were used. Additionally, we used open geodata such as

	scale	resolution
Josephinian cadastre, 1782 – 1785	1:28 800	
Franziscan cadastre, 1806 – 1869	1:28 800	
Franciscan-Josephinian survey, 1869 – 1887	1:25 000	
Hungarian survey, 1941	1:25 000	
Topographical survey 1950s (?)	1:10 000	
Shuttle Radar Topography Mission (SRTM)		1 Arc-Second
Google Earth		c. 0.6 m
Microsoft bing (Digital Globe)		c. 1 – 2 m

Tab. 1. Overview of the topographical and remote sensing data used.

Fig. 3. The vehicle-towed 16-channel magnetometer system (SENSYS MAGNETO®-MX ARCH) at Tolna-Mözs.

Fig. 4. The 5-channel magnetometer (SENSYS MAGNETO®-MX ARCH) in use (with Gábor Serlegi) at Alsónyék. Sensors spaced at 50 cm intervals.

satellite imagery provided by Google Earth and Microsoft Bing *(Tab. 1)*.

Magnetic prospection

The archaeological data of sites in the surrounding of the prospected sites were collected from various archaeological publications and records in the archives of the regional museums in Szekszárd and Kalocsa. The magnetic prospection started in 2011 at Tolna-Mözs and Alsónyék-Bátaszék and was continued with prospection campaigns in 2013, 2014, and 2015 on both sites as well as on the sites of Kovácshalom and Garadomb near Fajsz.

The magnetic prospection was conducted using two 16-channel fluxgate vertical gradiometer magnetometer systems from Sensys GmbH, Bad Saarow (Germany). In large areas, a 16-channel magnetometer system was employed in 2012–2014, whereas in 2015, a 5-channel magnetometer was used for smaller, more targeted prospecting.

MAGNETO® MX ARCH 16-channel system

The 16-channel magnetometer system was mounted on a vehicle-towed, non-magnetic array *(Fig. 3)*. The gradiometers were set at 0.25 m intervals on a 4 m wide sensor array, itself set at right-angles with a 6 m long tow bar. With speeds of approximately 12–16 km / h and a sample rate of 20 readings per second (Hertz), the system provided 15 magnetometer readings per square metre on average. The 16 magnetometers used were FGM-650B tension band fluxgate vertical gradiometers with 650 mm sensor separation, a ± 3000 nT measurement range and 0.1 nT sensitivity. For a precise georeferencing of the magnetometer data, Trimble RTK-DGPS systems consisting of a base station and a rover with the DGPS antenna mounted centrally on the magnetometer array were used. The accuracy of the georeferencing achieved is usually ± 0.05 m.

MAGNETO® MX ARCH 5-channel system

The 5-channel magnetometer was mounted on a push-cart fibreglass array *(Fig. 4)*. The gradiometers were set at of 0.25 or 0.50 m intervals. At a walking pace of c. 4–5 km / h and a sampling rate of 20 samples per second (Hertz), the system provided c. 60–80 magnetometer data points per square metre. The magnetometers used were the same FGM-650B as those on the MAGNETO® MX ARCH 16-channel system. Precise georeferencing with an accuracy of c. ± 0.05 m was similarly achieved through the utilisation of a Leica RTK-DGPS (base / rover) system.

The respective survey base station was precisely positioned using a Leica VIVA GS14. The coordinate reference system used was HD72/EOV (EPSG 23700).

Data acquisition, processing, and analysis

The data acquisition, processing, and analysis have already been published (Rassmann et al. 2015a), and therefore the description here is limited to a short overview.

The SENSYS data acquisition software MonMX® for data acquisition of the 16-channel magnetometer system runs on a ruggedised notebook with Microsoft Windows® operating system. The smaller MAGNETO® MX ARCH 5-channel system data recording is accomplished with a PDA with Windows® Mobile operating system and MXPDA data acquisition software.

The magnetic data were saved on a line by line basis in separate files by SENSYS MonMX® respectively

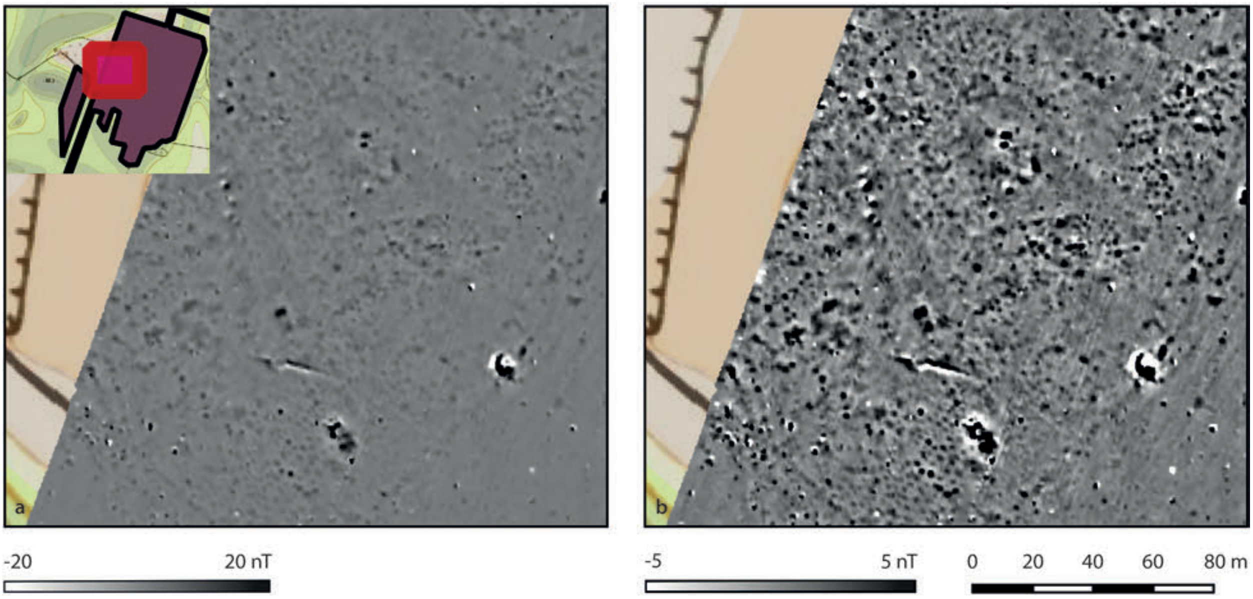


Fig. 5. Fajsz-Garadomb. Magnetic map of the eastern settlement area. a Range of scale: +/- 20 nT. b Range of scale: +/- 5 nT.

MXPDA software. A prospection with the MAGNETO® MX ARCH 16-channel system of an area of 1 ha (100 x 100 m) requires 19 tracks (instrument width 4.00 m; width of the measured track 4.25 m). For the MAGNETO® MX ARCH 5-channel system with gradiometers spaced at intervals of 0.5 m (instrument width 2.0 m; width of the surveyed track 2.5 m), we calculate 40 lines per hectare.

For pre-processing after the conclusion of the survey work in the field, the individual track (line) files were imported into the DLMGPS software and exported into one large ASCII text file for each subsection (survey area). The format of the exported, simple text file is as follows:

X-coordinate	Y-coordinate	nT	track-file	magnetometer-number
34340748.010	5140263.576	-59.5	fa123.prm	1
34340748.092	5140263.340	-3.7	fa123.prm	2
34340748.174	5140263.104	1.8	fa123.prm	3
34340748.257	5140262.868	-4.6	fa123.prm	4
34340748.339	5140262.632	-13.1	fa123.prm	5

The ASCII files were then edited with a text editor. It has to be a high performance editor because 1 ha (100 x 100 m) comprises up to 800 000 data points (lines in the file). The largest files from Alsónyék covering c. 15 ha comprise c. 2.5 million measurements, respectively lines in the ASC file.

In the next step, the TXT file was imported and processed in the Geosoft Oasis montaj® software (version 8) and the final results were later exported as a Surfer 7 grid file that is compatible with various GIS software. The maps presented here were produced with QGIS 2.14–18.

The analytical workflow in Open GIS

The Surfer 7 files imported in QGIS were processed for archaeological interpretation in a multistage workflow, illustrated here by an example from the flat settlement at Fajsz-Garadomb *(Figs 5–6)*. The resulting archaeological interpretation will be discussed in detail below. The design of the raster map can easily be optimised through the style function in QGIS by the selection of the threshold for the colour- or grey-scale and the appropriate minimum and maximum amplitudes for the display of the magnetic field anomalies *(Fig. 5)*. The visualisation of relevant archaeological features by the raster map is the first analytical step, which then has to be followed by the quantification of anomalies and cross-correlation with other relevant data.

Based on the raster map *(Fig. 6.1)*, contour lines emphasising the different field strengths of the magnetic field anomalies in the vertical gradients (unit nT) were extracted at intervals of 0.5–20 nT (0.5 nT levels) using the GRASS-tool *r.countour.step (Fig. 6.2)*. In the next step, the contour lines were compared with clearly visible archaeological features such as settlement ditches, pits, house remains, etc. The relevant level selected for Fajsz-Garadomb is the 2 nT contour line. All 2 nT

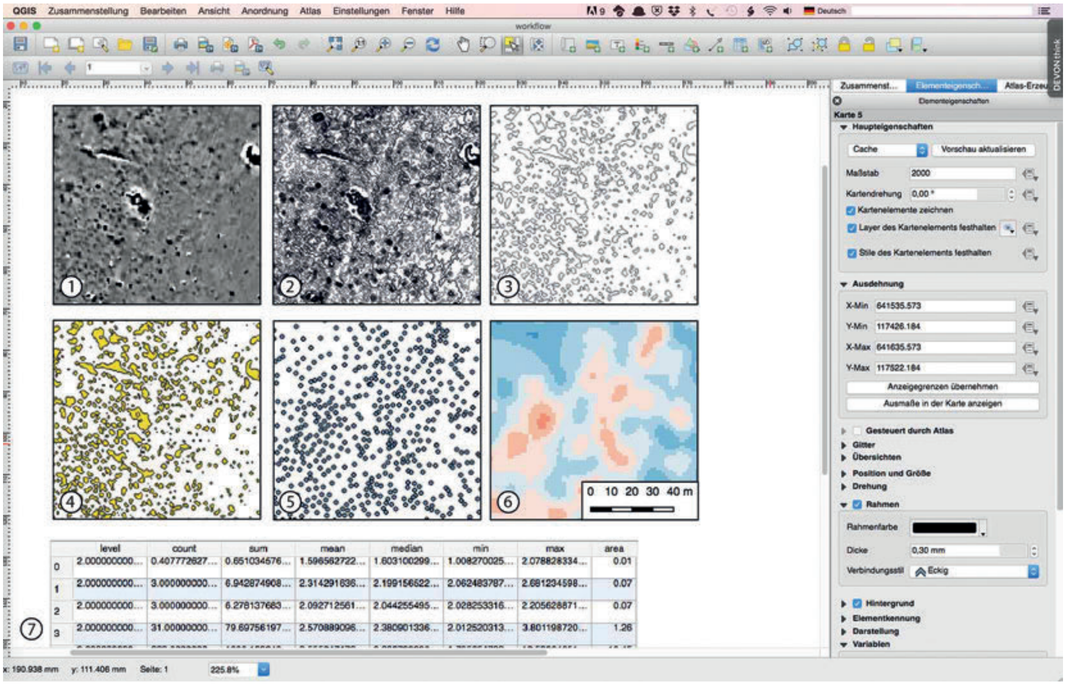


Fig. 6. Workflow for processing the archaeological magnetic prospection data. 1 Magnetic map; 2 calculation of the contour map in steps of 0.5 nT; 3 selection of 1 nT line; 4 conversion of the 1 nT line into polygons; 5 collecting the key values of the magnetic map and calculating the size / area of the anomalies; 6 selecting anomalies and calculating the centroids of the polygons; 7 calculating the kernel density estimation (KDE) of the selected anomalies / centroids.

contour lines were filtered and saved in separate vector shapefiles (*.shp) *(Fig. 6.3)*. By using the GDAL vector geometry tool *lines to polygons*, the contour lines were transformed into polygons *(Fig. 6.4)*. The latter can then be used to calculate the area size of each individual object (spatial anomaly in the magnetometer data). Next, all polygons larger than 0.4 m^2 were selected. The core of the workflow is the QGIS-plugin raster / *zonal statistics*[8].

Using this tool, the vector map was processed in combination with the raster grid of the magnetic prospection data. The tool *zonal statistics* calculates the values of the specific raster cells covered by each polygon.

The following statistics are available for further interpretation:

Count: to count the number of pixels,
Sum: to sum the pixel values,
Mean: to get the mean of pixel values,
Median: to get the median of pixel values,
StDev: to get the standard deviation of pixel values,
Min: to get the minimum of pixel values,
Max: to get the maximum of pixel values,
Range: to get the range (max – min) of pixel values,
Minority: to get the less represented pixel value,
Majority: to get the most represented pixel value,
Variety: to count the number of distinct pixel values.

Our empirical experience indicates that the Mean, Max, and Variety values are the most suitable for archaeological interpretation. The final result contains an attribute table for the polygons as part of the vector shapefile. Each row of the spread sheet corresponds to a polygon, with a different parameter set of the mean, median, minima, and maxima of the covered raster cells. The results are saved in separate columns of the attribute table *(Fig. 6.7)*. The combination of the size of the polygons and the different parameters of the magnetic anomalies serve as basis for their further archaeological interpretation.

To reveal the general tendency in the distribution of archaeological features on a site, significant areas of higher density with archaeological features can be calculated by kernel density estimation (KDE). It is a non-parametric possibility to estimate the probability density function of a random variable and is often used in archaeology to calculate the spatial distribution of various phenomena (Wheatley / Gillings 2002, 186 f.; Herzog 2012, 201). The centroids of the selected polygons which might be archaeological features *(Fig. 6.5)* are the basis for this analysis. The KDE raster was calculated for a radius of 20 m. The selection of the radius depends on the size of the analysed spatial structure and can be derived from the average distance between the centroids.

8 https://docs.qgis.org/2.18/en/docs/user_manual/plugins/plugins_zonal_statistics.html.

In our experience, the KDE raster map reliably quantifies the differences in the distribution of archaeological features. The contour map highlights areas with a higher density of archaeological features, which reveals more substantial settlement areas as *Fig. 6.6* shows.

Pedological studies: Borehole sampling and soil chemistry

The prospections at Fajsz were accompanied by a drilling campaign with a pile core sampling rig (Makita HM1400) and Pürckhauer Auger. The cores acquired with the Pürckhauer were documented in the field, whereas the cores of the pile core sampling were archived in PVC transparent liners with a core diameter of 50 mm and a length of 1 m each. The liners were opened in the RGK laboratory in Frankfurt am Main (Germany), where they were meticulously documented and sampled. The sampling distance for the chemical analysis varies and corresponds to the thickness of the layers identified during the documentation by visual means.

Multi-element chemical analysis was supplemented with magnetic susceptibility measurements of the cores using Bartington susceptibility metres. The equipment used was a Bartington MS3 in combination with the MS2C loop sensor and the MS2K surface sensor. Magnetic susceptibility was measured with both sensors at intervals of 5 cm. The general tendency of the measurements obtained with both sensors is similar. Differences observed are obviously due to the differences of the sensors and their penetration of the sample. The MS2C loop sensor utilises a stronger magnetic field, investigating the core to a depth of estimated 20 mm, whereas the MS2K surface sensor has a small penetration depth of c. 0–3 mm. Therefore, the different volumes were investigated with each sensor and the inhomogeneity in the sample cores.

In the near future, we plan to utilise the MS2H downhole sensor for measuring magnetic susceptibility *in situ* in boreholes created with a gouge auger or Pürckhauer and the pile core sampling equipment during field campaigns. This will substantially increase the volume investigated, and thus further eliminate the effects of small inhomogeneity in the samples. Each core was documented by a sketch at a scale of 1 : 10 and a normalised description of the opened core. The main tool for multi-element chemical analysis was X-ray fluorescence spectroscopy (XRF) using a portable instrument (pXRF). For analysis, the pXRF sample material was dried, ground, and homogenised down to a particle size of below 20 mm. The material was analysed as a condensed powder filled in sample cups covered with 6 µm polypropylene foil. The samples were analysed using the

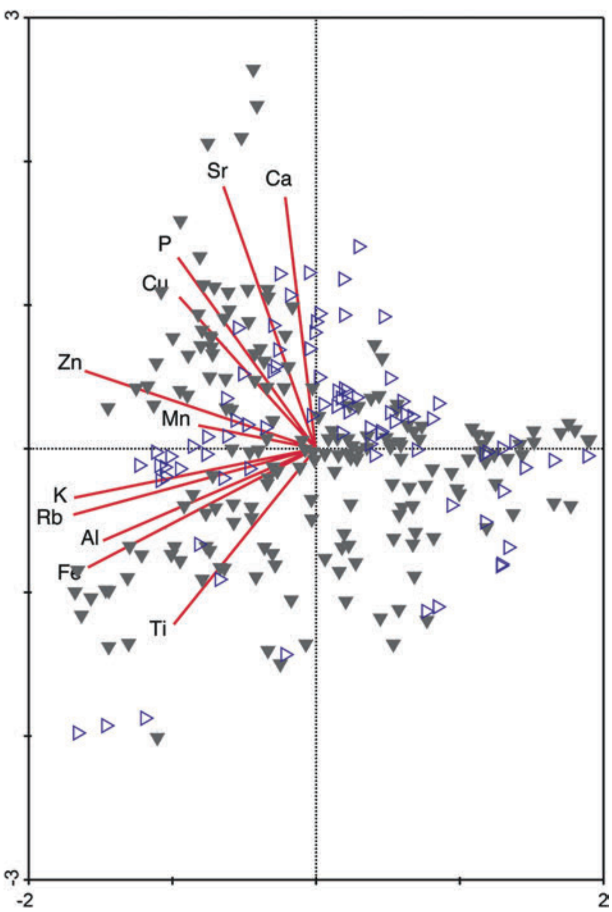


Fig. 7. Fajsz. Principal component analysis (PCA) of the chemical analysis of soil samples from the drilling cores from Garadomb (blue triangles) and Kovácshalom (grey triangles) (software Canoco 4.5).

portable XRF instrument XL3 t 900-series GOLD produced by Thermo Scientific Niton Analysers. The instrument is equipped with an X-ray tube containing a silver anode and is able to run at tube voltages of 6e50 kV and beam currents of up to 200 mA (maximum output power: 2 W). The instrument incorporates a 6-position filter wheel. Unfortunately, their composition and thickness are not provided by Thermo Scientific Niton Analysers. A helium purge enhances the quantitative measurements of light elements, most importantly of phosphorous.

During all analyses, the pXRF instrument was fixed in a mobile test stand in order to provide reproducible measurement conditions. The measurement routine developed in this project runs four excitation conditions with an overall measurement time of 150 s: (1) main filter, 30 s; (2) low filter, 30 s; (3) high filter, 30 s; and (4) light filter, 60 s. But in fact, the measuring time could be changed because the quantification is based on cps / mA. The spectra were quantified using a fundamental parameter algorithm that comes with a specific measuring mode implemented in the device ('mining Cu / Zn mode'). The total amount of the light elements that cannot be determined by XRF using the instrument is returned as 'balance'. It is estimated by calibrating the sum of the truly measured elements in real samples against the respective Compton peaks. The measured data as well as the balance value are normalised to 100 %. In a second step performed by the user in order to optimise the results, the data for each element, except for the balance values, were empirically adjusted against the factory calibration by measurement of certified reference materials. These correction factors are specific to the XRF device used. During each measurement series, at every ten samples, the soil standard TILL 4 was measured as a reference.

The results of the analyses are presented in *Tables 2–3*. To reveal the general tendency in the data, a principal component analysis (PCA) was calculated for the XRF data *(Fig. 7)*. Three groups of elements are evident in the data. The first comprises phosphorus (P), strontium (Sr), calcium (Ca), and copper (Cu). These elements are an indication of the human impact. The interpretation of P, Sr, and Ca is often used for the analysis of data from settlements (Gauss et al. 2013; Nowaczinski et al. 2013), whereas the interpretation of Cu is more difficult. At Fajsz, all soil samples have Cu concentrations of 50–100 ppm. The interpretation of an environmental effect is reasonable. The second group of elements comprises potassium (K), rubidium (Rb), titanium (Ti), iron (Fe), and aluminium (Al). These elements are typical components of the environmental background signature. A third group of elements including zinc (Zn) and manganese (Mn) likely indicates a separate autochthone signal.

To improve our topographic data, a survey with a drone (DJI Phantom III) was conducted at Fajsz[9]. The surveyed area extended over 3.5 km^2 around the flat settlement of Garadomb and the Kovácshalom tell. A total of 384 photos were taken with an average overlap of 40 %. The resolution of the resulting orthophotos created from this data set is 10 x 10 cm and a digital elevation model (DEM) was derived. The accuracy of the digital elevation model was evaluated by a mesh of c. 4 x 2 m resulting from the 1 PPS RTK-DGPS data points acquired with the MAGNETO® MX ARCH 16-channel system inside the magnetic prospection area. Both data sets appeared to be consistent with each other.

Magnetic prospections, UAV-photos, magnetic susceptibility measurements, coring, and multi-element chemical analysis provide a multi-dimensional space of data which is fundamental to planning an excavation and clarifying research questions. Thus, the prospection following the desk-based assessment is the second stage in a field project, while the excavation is the third and final stage. At Fajsz, Alsónyék, and Tolna-Mözs the prospection took place after the completion of previous excavations (rescue excavations during large-scale infrastructure projects). In this reversed context, prospections are of value for setting the excavation results into a broader context, while the excavation data contribute to a better understanding of the magnetic prospection.

Results

Fajsz-Kovácshalom and Fajsz-Garadomb

Location, topography, and archaeological research

The Neolithic settlement mound of Fajsz-Kovácshalom is located on the Danubian floodplain. Due to modern agriculture, its archaeological structures are endangered. Therefore, the settlement mound is under protection since 2007, yet, in the past few years, the mound has been ploughed again for growing seasoning paprika. The tell mound is still visible, albeit probably in a strongly eroded state, rising no higher than 2.8 m above the floodplain. In the vicinity of the tell settlement, at a distance of 800 m (as the crow flies) lies the flat settlement Fajsz-Garadomb with its overwhelmingly Late Neolithic occupation that can be considered to be co-eval with Kovácshalom. The surface of the tell site is rather densely covered with lithics, many of them produced from Transdanubian red radiolarite and even some obsidian artefacts from the Tokaj-Zemplén Mountains in north-eastern Hungary. The hundreds of potsherds can be predominantly assigned to the Sopot 2-Vinča B2–C period, alongside many pottery fragments from the Late Roman / Sarmatian period. Some Late Medieval vessel fragments and a coin from this period confirm that land use remained continuous until modern times, and the few metres high elevation – especially in flat alluvial lowland – seemed to be suitable for a (probably) Late Medieval cemetery, from which scattered bones could be seen in the ploughed area, also an indication of the strongly eroded surface.

The tell site was measured and cored in the early 2000s, indicating the presence of multiple burnt layers at several points and, also, a probable oxbow of the Danube flowing around the western half of the mound. The coring was carried out by Pál Sümegi and his team from the University of Szeged and was used later for his comprehensive overview of the Sárköz region (cf. Sümegi et al. in the present volume).

The multi-period site Fajsz-Garadomb has been under investigation by the Institute of Archaeology of the

9 Survey and postprocessing were executed by Johannes Kalmbach, RGK.

drilling core	depth below surface (m)	P	Sr	K	Ca	Ti	Rb	Mn	Zn
K02	0	1897	194	15554	91570	2269	73	157	69
K02	0.1	1800	187	15560	88371	2563	82	259	60
K02	0.2	1826	177	15717	85432	2258	79	480	69
K02	0.3	1677	182	14787	91838	1840	69	237	58
K02	0.4	1311	146	13134	69890	2377	60	264	35
K02	0.5	1116	139	10147	70856	1895	46	0	15
K02	0.6	503	160	10373	79003	2002	43	348	15
K02	0.7	581	164	9263	78947	1647	42	123	17
K02	0.8	516	181	11989	103655	2133	49	114	24
K02	0.9	520	195	12484	120199	2521	50	0	34
K02	1	516	194	10865	108748	2134	51	101	18
K02	1.1	1092	171	14586	78689	2180	69	343	49
K02	1.2	314	237	14200	170492	1890	62	0	50
K02	1.3	399	130	12250	59024	1351	49	0	0
K02	1.4	231	110	9774	40148	1030	41	0	0
K02	1.5	345	188	15120	98002	1810	68	380	47
K02	1.6	305	213	14931	137924	2214	64	480	41
K02	1.7	289	210	15016	125569	2362	65	603	44
K02	1.8	230	199	14254	118345	2545	64	390	37
K02	1.9	498	204	14369	118385	4520	61	504	43
K02	2	244	222	16791	124928	2568	72	538	47
K02	2.1	435	158	11012	82968	3009	46	588	38
K02	2.2	312	132	11772	61920	1700	50	448	0
K02	2.3	326	148	13186	72246	1752	48	453	0
K02	2.4	248	152	12708	73681	1756	44	0	26
K02	2.5	308	142	10475	68057	1963	43	0	0
K02	2.6	344	110	10171	35447	1031	39	0	0
K02	2.7	222	112	10977	39775	1633	38	421	0
K02	2.8	164	107	10851	43753	985	37	0	0
K02	2.9	175	151	11100	67429	1842	42	449	0
K02	3	396	154	12644	68200	1883	50	411	32
K04	0	2093	294	18381	129150	2541	87	551	110
K04	0.1	2689	308	18267	135791	2559	82	536	105
K04	0.2	2219	294	18623	132932	2911	89	456	96
K04	0.3	2331	290	18437	132185	2404	84	500	97
K04	0.4	2884	302	18295	124435	2045	89	592	113
K04	0.5	3015	303	18246	123668	2538	92	528	123
K04	0.6	2752	307	18364	118624	2304	82	433	114
K04	0.7	1309	225	18756	105774	2298	93	412	73
K04	0.8	2324	250	19074	106499	2342	96	348	101
K04	0.9	3992	376	17664	152484	1441	84	383	136
K04	1	4716	264	19252	111678	2292	94	452	108
K04	1.1	2290	294	18404	131255	2387	90	484	96
K04	1.2	2044	268	18306	122428	2515	88	492	95
K04	1.3	2125	310	17828	157198	2096	83	533	70
K04	1.4	1828	118	20025	36846	2246	83	497	77
K04	1.5	1419	131	17956	50508	2738	76	458	48
K04	1.6	1714	177	17639	92658	2405	70	480	61
K04	1.7	3857	157	14194	72433	1811	51	365	51
K04	1.8	677	149	12275	69293	1602	47	0	0
K04	1.9	702	179	15969	84767	2315	61	435	25
K04	2	962	194	16155	113207	2330	59	503	37
K52	0	2206	269	18792	123569	2601	89	534	83
K52	0.1	2126	264	19110	122558	2460	91	579	103
K52	0.2	2204	274	18805	124259	2333	91	575	96
K52	0.3	2341	273	18490	122091	2591	92	553	88

Tab. 2. pXRF analyses of percussion drillings in Fajsz-Garadomb (G) and Fajsz-Kovácshalom (K) with 10 cm sampling. For the position of the drilling see *Fig. 15*. Concentrations are given in ppm.

drilling core	depth below surface (m)	P	Sr	K	Ca	Ti	Rb	Mn	Zn
K52	0.4	2493	275	18178	123553	2766	97	509	100
K52	0.5	2708	288	18551	123459	2807	90	584	104
K52	0.6	2783	283	17714	126981	2273	90	554	95
K52	0.7	2749	277	18679	116523	2484	100	583	118
K52	0.8	3016	288	18461	121178	2118	85	476	100
K52	0.9	3160	211	18796	82404	2695	83	428	90
K52	1	2115	165	18490	65394	2889	78	420	79
K52	1.1	1479	179	17211	77048	2633	95	491	79
K52	1.2	1436	183	17184	81530	2914	95	452	78
K52	1.3	2365	195	17399	76142	2791	98	791	88
K52	1.4	1351	181	17074	79586	2827	97	692	98
K52	1.5	1499	187	16335	74414	2568	96	365	90
K52	1.6	1217	179	16119	76726	2346	87	0	80
K52	1.7	1043	190	16222	91426	2767	78	329	73
K52	1.8	1059	193	16028	96267	2400	75	556	64
K52	1.9	738	180	16686	92944	2599	79	336	67
K52	2	560	182	16904	85638	3027	79	713	80
K52	2.1	2029	230	18813	100589	2609	92	566	97
K52	2.2	1813	234	18838	100357	2758	99	594	92
K52	2.3	2149	230	19030	104299	2293	94	586	79
K52	2.4	2023	227	18775	101644	2747	91	592	89
K52	2.5	1993	227	18852	97102	2812	99	651	97
K52	2.6	2057	207	18521	88214	2539	94	691	103
K52	2.7	1626	191	18166	80598	3182	101	529	90
K52	2.8	1517	186	17507	79161	2665	96	490	85
K52	2.9	2112	195	17504	87758	2744	95	574	77
K52	3	1740	173	17774	74158	2564	104	656	67
K66	0	1269	166	18900	61571	2821	93	634	70
K66	0.1	1287	165	18806	59725	2896	96	508	77
K66	0.2	1566	167	18689	63526	2612	97	542	74
K66	0.3	1247	174	19219	64448	2870	95	481	78
K66	0.4	884	129	17538	29726	3191	101	382	71
K66	0.5	701	124	16778	31215	3224	90	0	52
K66	0.6	1167	116	16774	33446	3045	86	0	58
K66	0.7	1541	112	17468	28596	3200	91	428	62
K66	0.8	1119	119	18411	34808	3596	94	348	78
K66	0.9	730	122	17114	53566	3124	92	568	70
K66	1	602	160	15257	113883	2911	77	397	58
K66	1.1	1090	165	18417	70588	2835	96	562	75
K66	1.2	480	200	15082	166737	2349	68	427	60
K66	1.3	407	212	15102	161054	2277	66	582	57
K66	1.4	411	211	14463	172507	1877	69	597	60
K66	1.5	419	216	15476	147442	1872	71	689	66
K66	1.6	428	197	15789	115075	2147	74	0	59
K66	1.7	484	165	14938	89904	1658	62	0	41
K66	1.8	330	161	13791	89507	2151	60	0	28
K66	1.9	388	194	12961	114712	2241	58	297	41
K66	2	596	155	12236	99454	1953	53	114	29
G11	0	1060	254	18735	112013	2141	102	508	76
G11	0.1	835	263	18275	111126	2445	91	503	71
G11	0.2	762	254	17095	107416	2457	93	524	71
G11	0.3	678	252	17504	108949	2204	91	519	74
G11	0.4	275	349	15517	138501	1696	79	480	53
G11	0.5	528	304	15194	143151	2230	68	640	49
G11	0.6	273	316	15016	149555	1768	69	842	50
G11	0.7	279	321	15671	147491	1933	70	836	54

Tab. 2. (continued).

drilling core	depth below surface (m)	P	Sr	K	Ca	Ti	Rb	Mn	Zn
G11	0.8	374	278	14812	152179	2085	62	560	52
G11	0.9	377	214	13526	109358	2521	54	381	42
G11	1	301	249	14195	146749	1916	62	479	49
G14	0	1224	197	19634	97653	2222	102	685	91
G14	0.1	1357	195	19669	97759	2634	105	648	88
G14	0.2	1292	200	19638	101511	2242	105	645	98
G14	0.3	1423	212	19390	106839	2724	101	665	92
G14	0.4	436	315	16603	168688	2258	90	345	70
G14	0.5	436	279	16868	159787	1723	86	586	61
G14	0.6	289	306	16558	164868	2222	81	563	60
G14	0.7	260	290	16521	157262	2404	80	600	68
G14	0.8	326	297	15906	162507	2826	65	538	61
G14	0.9	338	274	16043	151135	2525	72	554	57
G14	1	481	244	15509	135637	2121	61	561	50
K26S	0	1042	192	20827	80516	2910	108	795	90
K26S	0.1	816	193	20607	80297	3064	109	782	93
K26S	0.2	872	183	20511	79275	3271	105	821	92
K26S	0.3	613	186	21107	75543	3709	117	846	94
K26S	0.4	366	199	20573	93862	3391	106	998	79
K26S	0.5	302	196	20617	91512	2761	102	856	80
K26S	0.6	337	184	18158	83543	3315	95	649	62
K26S	0.7	607	171	17915	77926	2960	86	517	67
K26S	0.8	599	172	16869	81266	3115	86	588	62
K26S	0.9	870	178	17524	85867	2976	88	534	76
K26S	1	1772	198	15989	96044	2357	81	518	85
K26S	1.1	1282	194	15593	102183	2911	72	900	62
K26S	1.2	951	207	14784	113090	2329	69	519	59
K26S	1.3	739	213	14891	131950	2007	67	562	61
K26S	1.4	514	223	14438	137883	2256	60	531	37
K26S	1.5	145	235	13789	164390	1603	57	535	43
K26S	1.6	405	240	14390	162725	2093	58	1065	44
K26S	1.7	507	223	14950	135157	1574	63	384	43
K26S	1.8	381	217	14181	136063	2046	64	601	45
K26S	1.9	312	208	13791	117064	2111	61	306	40
K26S	2	485	205	15515	109861	2860	73	369	42
K57	0	1125	188	20064	80303	2737	110	665	92
K57	0.1	899	191	21257	80405	3003	108	718	93
K57	0.2	1133	193	20855	81060	3286	101	791	98
K57	0.3	1184	195	20891	81703	3783	105	828	97
K57	0.4	962	188	20844	78649	2380	112	801	96
K57	0.5	518	203	19677	91647	2953	100	834	74
K57	0.6	626	195	20163	85797	3267	100	592	86
K57	0.7	546	203	19351	89510	2892	93	776	84
K57	0.8	457	198	19284	88793	3175	94	654	78
K57	0.9	516	191	20661	85927	2926	100	627	89
K57	1	590	189	18167	88064	2386	86	493	67
K57	1.1	328	188	18423	87872	3076	84	438	62
K57	1.2	485	181	17684	86747	2790	83	415	57
K57	1.3	510	182	18828	81207	2806	89	341	72
K57	1.4	339	169	19414	72790	3083	113	656	79
K57	1.5	412	188	18290	100917	2774	94	411	69
K57	1.6	361	195	18423	108926	3134	86	868	61
K57	1.7	510	201	17301	114600	2773	75	544	47
K57	1.8	544	195	17246	109038	2754	81	416	68
K57	1.9	515	210	17524	127368	2964	78	788	68
K57	2	490	209	18187	115747	2831	83	600	69

Tab. 2. (continued).

drilling core	depth below surface (m)	P	Sr	K	Ca	Ti	Rb	Mn	Zn
G16	0	1342	197	20300	96537	2670	105	658	89
G16	0.1	1354	198	20319	96462	2558	100	636	99
G16	0.2	1707	196	20402	97263	2619	105	699	88
G16	0.3	1399	202	20399	98273	2581	100	722	89
G16	0.4	1460	211	19001	110630	2382	93	636	85
G16	0.5	1096	329	15800	172400	397	77	451	66
G16	0.6	711	300	15806	149217	2140	71	505	56
G16	0.7	426	220	14293	115591	2147	57	378	38
G16	0.8	456	259	15107	135063	2436	59	503	45
G16	0.9	478	246	14987	129147	2315	64	386	50
G16	1	420	269	14926	135959	2372	65	397	49
G09	0	913	213	18377	106255	2325	81	657	74
G09	0.1	949	219	18643	107625	1956	81	611	74
G09	0.2	1230	215	18912	104905	2360	78	553	74
G09	0.3	945	222	17244	114472	2259	70	531	69
G09	0.4	383	231	15049	119877	1764	58	461	49
G09	0.5	480	198	13699	95444	2013	48	455	37
G09	0.6	539	198	12052	103017	2520	41	412	35
G09	0.7	360	223	13802	119432	2382	54	376	33
G09	0.8	408	261	15050	138125	2312	53	393	37
G09	0.9	330	170	11714	89627	2595	44	440	20
G09	1	393	163	13264	86278	2234	48	398	30
G10	0	1613	199	19462	104737	2351	95	602	100
G10	0.1	1515	195	19087	102171	2169	93	618	88
G10	0.2	1550	192	18738	104718	2111	102	535	92
G10	0.3	1438	201	18559	107289	2083	101	576	84
G10	0.4	738	280	15406	180923	1610	80	358	53
G10	0.5	563	265	16805	150347	2064	91	462	57
G10	0.6	425	245	17386	133782	1903	94	451	69
G10	0.7	442	243	16096	139632	2284	80	506	55
G10	0.8	346	246	15830	150694	1749	75	500	40
G10	0.9	515	227	15233	134051	2272	65	433	39
G10	1	398	234	15653	129698	2640	64	501	37

Tab. 2. (continued).

Hungarian Academy of Science (HAS) and its project partners from the University of Tübingen since 2001. At Fajsz-Garadomb, a 6 x 110 m trench was excavated between 2007 and 2008, yielding a large number of archaeological features of different periods, from the Neolithic to the Late Roman / Sarmatian and Early Medieval / Avar period. The majority of the features can be dated to the Sopot culture, at the beginning of the Late Neolithic.

Fajsz-Kovácshalom has only been investigated through drilling campaigns by Pál Sümegi (cf. in the present volume) and Frank Stevens (Rassmann et al. 2015b, 5 f.). Additionally, in 2009, a surface collection was conducted to survey both sites.

The state of the current preservation of the tell mound allows some estimations with respect to the extent of the erosion (and thereby the associated risk with respect to the preservation of the Neolithic material). One can assume that the Neolithic layers would erode at a rate of 2–4 cm a year since the introduction of modern agriculture, i. e. over the past 100 years, resulting in a total erosion of 2–4 m over a century. This is massively destructive to any potential Neolithic discoveries. In this sense, the two-dimensional information provided by geomagnetic exploration has an even greater value.

On the Garadomb settlement, excavations were carried out between 2006 and 2008. Apart from some surface finds and parts of a heavily burnt house (or oven), indicating that Garadomb was occupied by the semi-mobile groups of the Körös culture as part of their dense settlement pattern in the Kalocsa Sárköz (Bánffy 2013), the features belonged to a smaller extent to the early (but not the earliest / formative) Linearbandkeramik (LBK) culture, while the vast majority of the Neolithic features could be assigned to the later Neolithic Sopot culture.

drilling core	depth below surface (m)	P	Sr	K	Ca	Ti	Rb	Mn	Zn
G12	0.20	1799	201	15823	106852	2377	85	447	69
G12	0.40	1568	384	11483	174872	1728	58	219	46
G12	0.51	1164	329	12127	155396	2088	64	337	46
G12	0.64	807	254	11802	137147	2331	52	357	26
G12	0.77	788	157	8559	99253	2467	38	402	0
G12	0.83	807	216	11098	122020	2452	50	328	21
G12	0.89	633	274	11881	138369	2328	52	452	33
G12	0.95	715	213	11125	116184	2778	50	309	26
G13	0.15	1377	204	14137	97712	1974	88	475	62
G13	0.25	1709	212	16580	116393	2558	89	447	63
G13	0.34	1222	281	13096	174131	1915	65	262	42
G13	0.45	1455	324	12583	175033	1871	63	252	45
G13	0.60	525	207	11934	119843	2026	49	225	15
G13	0.73	320	261	12476	137229	2035	51	389	21
G13	0.85	397	215	11982	118999	2136	49	315	23
G13	0.93	281	127	8512	94598	1924	36	494	0
G13	0.97	598	210	10957	127081	2597	48	365	21
G15	0.25	1737	196	16795	99295	2600	95	558	69
G15	0.35	1863	190	16645	99123	2567	94	524	70
G15	0.56	2207	327	13229	182059	1927	68	341	56
G15	0.72	1979	334	14165	155349	2137	76	335	61
G15	0.83	884	344	12314	163253	2025	60	369	42
G15	0.92	909	290	12590	142951	2216	61	418	34
G15	0.97	709	272	12048	137739	2228	54	373	31
G15	1.17	880	262	12772	138359	2235	54	368	25
G15	1.26	719	178	11246	107833	2403	44	388	15
G15	1.33	859	212	10293	115517	2295	48	324	19
G15	1.44	722	251	12315	124552	2633	54	344	29
G15	1.50	624	349	11011	156571	2050	48	428	24
G15	1.54	492	119	8511	89900	2764	37	375	0
G15	1.61	457	116	8026	70648	1921	34	235	0
G15	1.72	710	135	6978	98544	3811	34	365	0
G15	1.85	534	112	7240	68688	1834	35	143	0
G15	1.95	440	147	6812	92934	2784	36	273	0
K37	0.10	2698	265	15486	125237	2492	84	390	85
K37	0.35	3318	253	18243	97577	2527	100	509	105
K37	0.43	3779	303	15440	154375	2105	80	362	80
K37	0.45	2815	252	16804	106501	2488	93	531	105
K37	0.50	3062	346	15125	154405	2309	71	317	79
K37	0.60	2828	303	15786	131350	2357	76	357	81
K37	0.77	2361	276	16811	129149	2448	83	368	66
K37	0.92	1521	198	17383	107017	2624	90	355	57
K37	1.20	1665	173	17848	93717	2575	88	421	55
K37	1.25	997	154	16801	78670	2503	84	368	45
K37	1.40	1175	176	17262	95417	2611	84	381	52
K37	1.60	782	200	13319	130871	2043	54	303	17
K37	1.77	652	160	9893	98539	2039	41	390	0
K37	1.95	241	148	8939	73921	1500	38	91	0
K05	0.20	3176	266	15360	129796	2401	81	439	77
K05	0.33	3484	291	15833	133169	2368	81	368	71
K05	0.45	2588	235	14051	94062	1991	74	361	77
K05	0.60	3300	273	15430	114711	2352	75	415	89
K05	0.69	3238	258	16440	108206	2627	89	473	99
K05	0.72	3427	237	15281	90675	2319	83	440	89
K05	0.79	3266	305	13950	158013	2227	70	262	60
K05	0.86	4329	260	14571	104084	2042	78	345	93

Tab. 3. pXRF analyses of percussion drillings in Fajsz-Garadomb (G) and Fajsz-Kovácshalom (K) with sampling per layer. For the position of the drilling see *Fig. 15*. Concentrations are given in ppm.

drilling core	depth below surface (m)	P	Sr	K	Ca	Ti	Rb	Mn	Zn
K05	0.95	2562	259	15549	109845	2233	72	336	61
K05	1.15	3044	252	15016	118568	2096	74	317	68
K05	1.19	3392	202	14687	66434	2151	79	555	110
K05	1.23	2719	222	14888	104293	2428	67	385	60
K05	1.40	896	186	12101	106363	1926	51	235	19
K05	1.70	332	123	9725	72599	1304	41	103	0
K25	0.15	2924	257	15910	127485	2319	85	477	80
K25	0.30	2579	227	14676	115674	2076	81	411	67
K25	0.47	3146	253	15314	118847	2084	85	478	91
K25	0.58	2930	268	13631	133895	1889	73	324	69
K25	0.68	3689	260	15979	120536	2216	86	493	88
K25	0.80	4707	306	15687	121747	2295	81	307	108
K25	0.88	3372	206	16088	80145	2223	77	377	75
K25	0.97	2113	157	16327	66860	2136	73	345	58
K25	1.17	1653	144	15532	62874	2461	67	317	50
K25	1.25	1676	146	13667	74926	1919	62	292	45
K25	1.33	1552	145	12601	83223	1802	58	269	24
K25	1.50	758	141	10819	87443	1873	50	255	0
K25	1.66	728	164	12506	102038	1816	56	273	18
K25	1.85	779	183	12376	111180	2396	54	268	26

Tab. 3. (continued).

The archaeological research of the Sopot culture began rather late in Hungary. The formation of the group probably goes back to the early Vinča period in the western part of its distribution area. The Sopot culture was first identified and described in northern Croatia (Slavonia) and it was considered to be a local facies, a mixture between the Vinča and the Lengyel cultures (Dimitrijević 1968; 1969). The appearance of Sopot pottery and some burials suggested that some groups had migrated from the south along the Danube; their best-known site in the northern Danube area was found at Bicske, Fejér county (Makkay et al. 1996). Following the discovery of Sopot sites in northern Transdanubia (Regenye 1996) and during the fieldwork ahead of motorway construction projects along the southern shore of Lake Balaton (Barna 2017), rich assemblages were found in the Sárköz region at Fajsz and Alsónyék (Osztás et al. 2012; Bánffy et al. 2014: these sites were included in both the ToTL dating projects as well as in the aDNA project mentioned in the introduction). Sopot groups crossed the Drava and moved northward in Transdanubia, as far as the Danube Valley and southern Transdanubia from the south, sometime before the turn of the 6th to 5th millennium cal BC and partly co-existed with the earliest Lengyel culture in Transdanubia (Oross et al. 2016c).

Parts of a large circular ditch, remains of two unburnt Neolithic (probably Sopot) houses, and a Late Bronze Age house along with many settlement pits (quite frequently in multiple superpositions) were uncovered during the Fajsz-Garadomb excavations. The thickness of the Sopot layers amounted to 80 cm in some spots. Three graves with a rather unusual funerary ritual for the Neolithic of the region were also brought to light. The robust skeletons lay on their back in an extended position. In terms of their ancestry, the Preneolithic genetic composition was remarkably high among the Sopot individuals (Szécsényi-Nagy et al. forthcoming). An unusual, secondary burial was also found, carefully deposited in a refuse pit, along with two small clay figurines, one of which had a compound decoration style of the Tisza culture and so may have been imported from the Tisza region (Bánffy et al. 2017). The site was also occupied in later prehistoric periods: during the Baden period and in the Late Bronze Age (Urnfield culture), as well as during the Late Roman / Sarmatian period, indicated by a high number of stray finds. First to be discovered at the site were high numbers of Early Medieval / Avar graves and it was therefore initially reported as an Avar cemetery (Horváth 1972). The assessment of the large amount of pottery and other finds is currently still in progress (for an evaluation of the environmental background, see Kreuz et al. in the present volume).

The magnetic prospections were carried out in two campaigns, on February 19–20, 2013, and November 13–15, 2015 *(Figs 8–10)*. In 2013, the area was prospected with the MAGNETO® MX ARCH 16-channel system. The fieldwork was complicated by ploughed

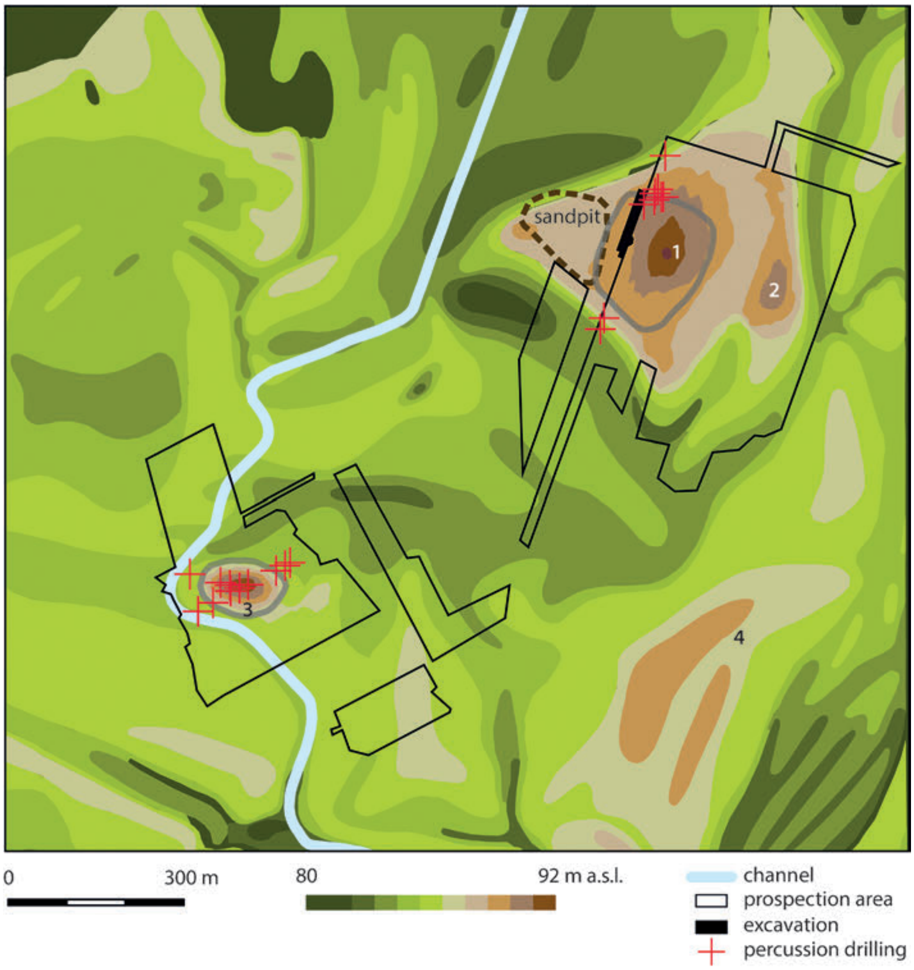


Fig. 8. Fajsz. Digital elevation model (DEM) and the location of the magnetic prospection and percussion drillings. 1 Fajsz-Garadomb; 2 Fajsz-Lipovác; 3 Fajsz-Kovácshalom; 4 Fajsz-Östövér (Wicker et al. 2001, 47 f.). DEM based on the topographic map 1 : 10 000 / Sheet 25 141.

fields and high soil moisture due to intensive precipitation. Nevertheless, in spite of these adverse conditions, data were acquired for approximately 6 ha. The settlement mound (area c. 130 x 80 m) was also fully surveyed. The area that was surveyed in addition to the settlement mound extends a further 200 m to the northwest (Rassmann et al. 2015a). A second campaign was planned for 2015 in order to cover larger areas around the tell and on the flat settlement. Data for an area of around 20 ha were acquired with the MAGNETO® MX ARCH 16-channel system. The settlement mound was prospected again with the same system, involving overlapping areas with the MAGNETO® MX ARCH 5-channel system with different sensor spacing of 25 cm and 50 cm to evaluate the accuracy of the different systems and configurations.

The prospected surface of c. 20 ha covers the complete potential settlement area. The comparison of the digital elevation model (DEM) and the magnetic prospection data allow the reconstruction of the size of the settlement. A large number of circular low magnetic amplitude anomalies – most likely pits – are visible on the magnetic map in addition to a small number of anomalies with higher magnetic amplitudes, presumably the remains of burnt houses. The excavation revealed a variety of archaeological features belonging to different periods, namely the Neolithic, the Bronze Age, the Late Roman / Sarmatian period, and graves of the Early Medieval / Avar period. The interpretation of the circular ditch as the remains of a Sarmatian barrow is very likely (cf. *Fig. 11.1*). The Avar graves were not evident in the magnetic data, but were only discovered during the excavation. While most of the relevant archaeological structures were evident in the magnetic prospection data, this demonstrates that most, but certainly not all relevant archaeological features are detectable through a magnetic prospection survey. The crucial question is the dating of the numerous, more than 2000 less characteristic anomalies evident in the magnetic prospection data that could not yet be directly correlated with the finds of

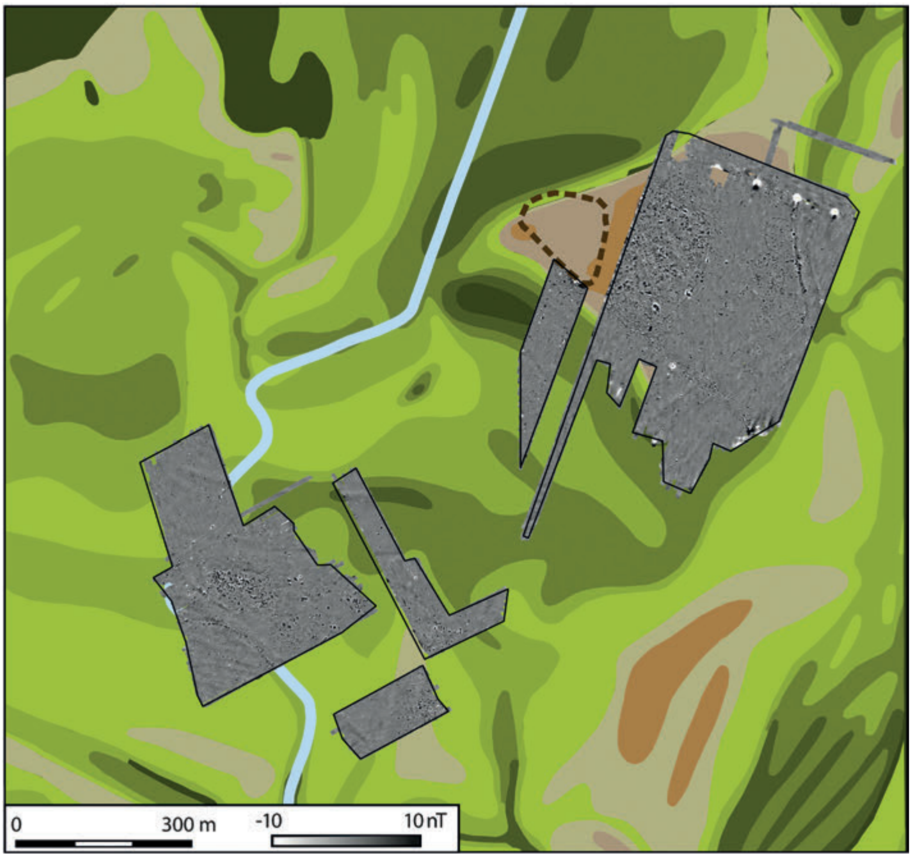


Fig. 9. Fajsz. Overview of the magnetic prospection at Fajsz-Garadomb and Fajsz-Kovácshalom.

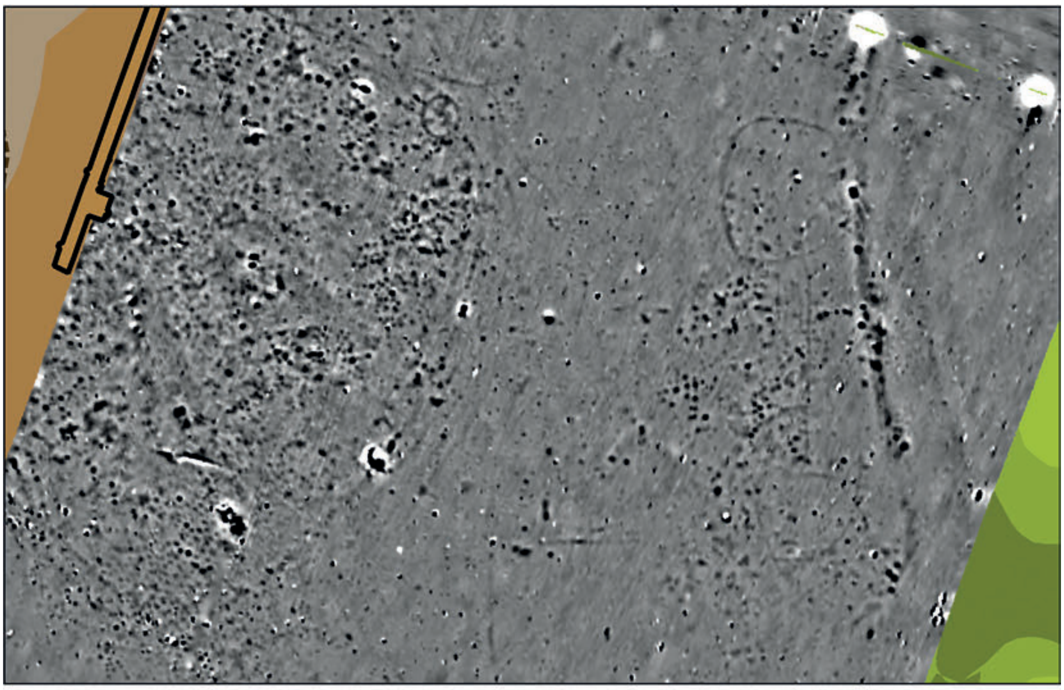


Fig. 10. Fajsz-Garadomb. Result of the magnetic prospection with 16-channel magnetometer with gradiometers spaced at 0.25 m intervals. Interpolation of the raster grid 20 x 20 cm. Scale ± 10 nT.

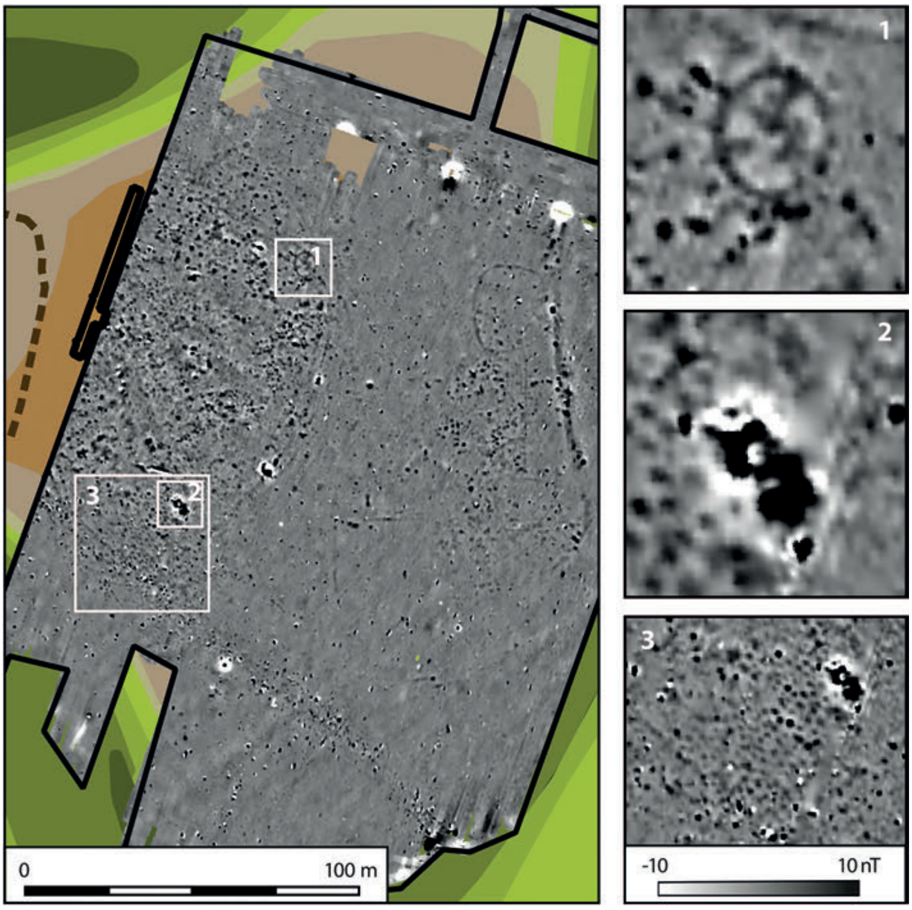


Fig. 11. Fajsz-Garadomb. Significant archaeological anomalies (basic data as in *Fig. 10*).
1 Ring ditch of a Sarmatian grave; 2 Late Bronze Age (?) house; 3 Late Bronze Age (?) house, and a cluster of settlement pits.

the excavations *(Fig. 12)*. To select relevant features, the 2 nT magnetic anomaly contour line was calculated and converted into polygons. By calculating the size of the anomalies, all anomalies larger than 0.5 m^2 were selected by filtering *(Fig. 13a)*.

The filtered polygons were combined with the raster map of the vertical gradient magnetic anomaly data. By using the QGIS-plugin *zonal statistics,* the pixels covered by the selected polygons of the vector layer were analysed. Based on *zonal statistics*, we filtered all objects (anomalies) with amplitudes of less than 20 nT in order to exclude dipole signatures caused by ferrous objects such as modern steel scrap (lost agricultural machinery parts, unexploded ordnance, civilian scrap distributed with manure, etc.) from our map.

For the selected objects, centroids were created. The centroids were then used to perform a kernel density estimation (KDE) *(Fig. 13b)*. The KDE map indicates seven areas with higher density. All these are part of an area enclosed by linear anomalies, presumably a ditch system *(Figs 13a; 14)*. The spatial coincidence of the calculated kernels and the ditches makes an identical chronological background reasonable. One obvious question is how old are these features? To answer this, we have to consider the excavation data. The excavation data suggest a remarkably higher density of Neolithic features in the northern part of the trench. This tendency clearly correlates with the KDE map *(Figs 13b; 14)*. The obvious assumption is to date the majority of nT-anomalies behind the seven 'kernels' to the same time slice. The strong correlation between the kernels and the ditch system is a clear indication that the latter can also be dated to the Neolithic.

A second clear tendency in the excavation data is the prevalence of Bronze Age features in the southern trench. Again, the magnetic dataset indicates a similar tendency (cf. *Fig. 11.3*). In the southern prospection area, we observed a remarkable concentration of circular anomalies with similar size and magnetic amplitudes. Their average diameter is between 1–2 m. Shape, size, and magnetic amplitudes very likely indicate settlement pits. The pit cluster is intersected by the southern ditch *(Fig. 14)*, indicating that these anomalies might belong to different occupation horizons. Considering the ex-

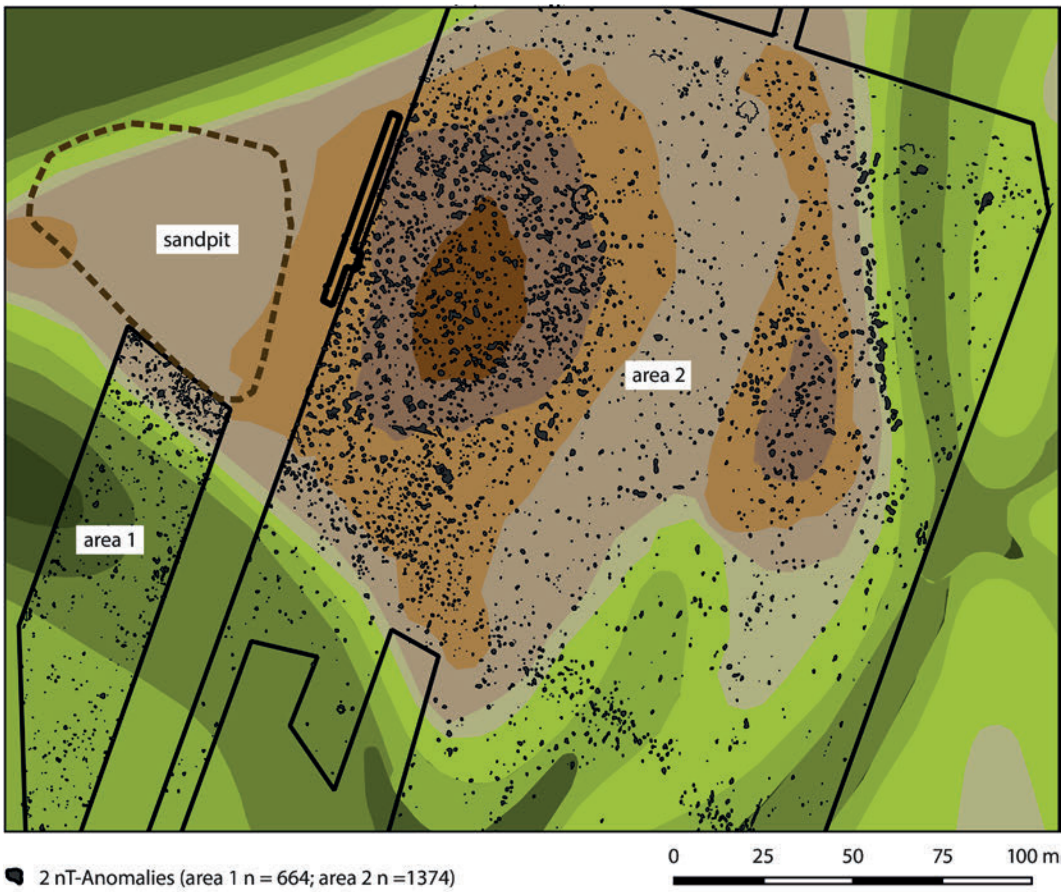


Fig. 12. Fajsz-Garadomb. Map with magnetic anomaly contour lines (polygons) of 2 nT amplitude.

cavation results, the settlement pits likely belong to the Bronze Age occupation, and the small number of house remains might date from the same period. At least, this appears to be much more likely for these features than a Neolithic date.

The KDE map indicates a second activity area eastwards of the flat settlement with clear indications of human activity (cf. *Figs 12–13*). Behind this kernel numerous anomalies resemble the cluster of Bronze Age settlement pits. Their distribution correlates with a slight rise. Indications of houses are not visible. The shape of the ditches does not correlate with the topography and the distribution of the settlement pits. Their interpretation remains open.

In sum, the magnetic data acquired at Garadomb as well as the excavation indicate three main chronological horizons. The majority of the anomalies can be dated to the Neolithic. The settlement pits in the southern part of the area and the burnt house remains date to the Bronze Age, while the circular ditch dates to the Sarmatian period.

The drilling campaign in 2015 focused on the tell settlements of Kovácshalom and Garadomb *(Fig. 15)*. The drilling cores and auger profiles provide information on the sequence of the settlement layers and the sediments in the vicinity of the settlement. All drilling cores from Garadomb indicate a relatively thin settlement layer of up to 1 m. Unsurprisingly, this correlates with the excavation data. In addition to the conventional classification auger profiles, the cores obtained from the percussion drilling pile core sampling and Pürckhauer sampling were investigated by multi-element chemical analysis and magnetic susceptibility measurements. Both datasets clearly indicate the settlement layers by P-values above 1000 ppm and significantly higher magnetic susceptibilities. The magnetic susceptibility of the cores was measured in detail with a sampling distance of 5 cm along the cores. The density of chemical analysis is much lower. We only sampled visually discernible layers.

The multi-element chemical analysis provides additional information that allows the identification of different and additional strata. Not surprisingly, the differences between the various layers that are not discernible visually are also evident in the magnetic susceptibility values. In some layers, the variation of the magnetic susceptibility values is higher than the visual differences. The fact is well known and has been comprehensive-

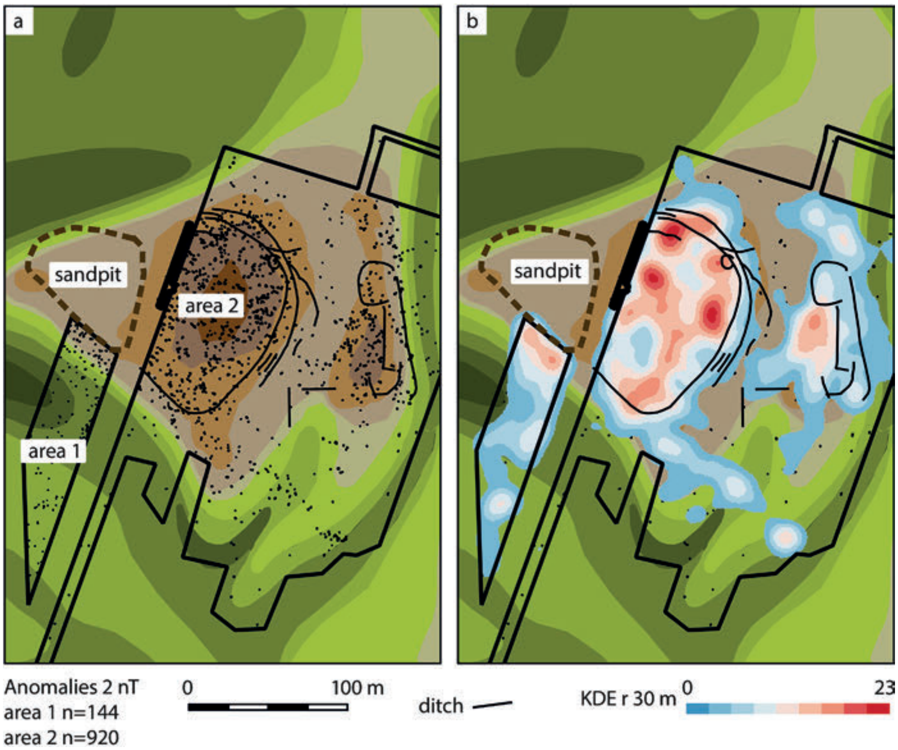


Fig. 13. Fajsz-Garadomb. a Selection of specific 2 nT-magnetic anomalies (criteria: area 0.5–10 m², magnetic mean 2–20 nT). b Kernel density estimation (KDE) map of the centroids of the selected polygons.

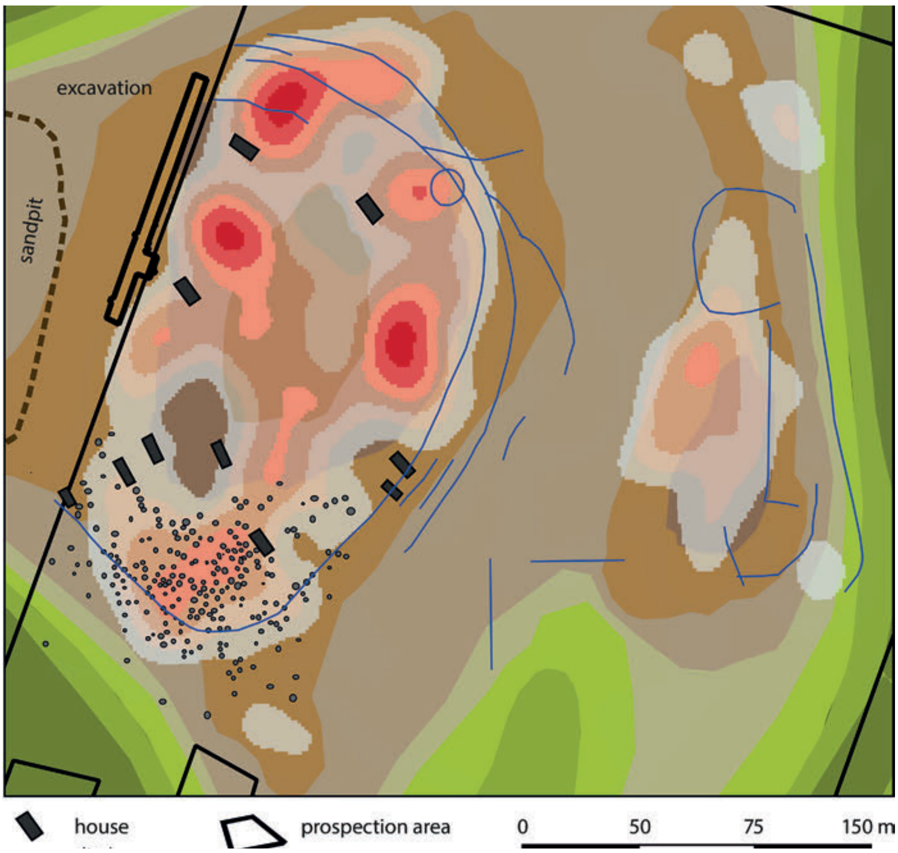


Fig. 14. Fajsz-Garadomb. Kernel density estimation (KDE) map of ditches, Late Bronze Age houses (?), and settlement pits (criteria of anomalies: area 0.4–1 m², magnetic mean 1–4 nT).

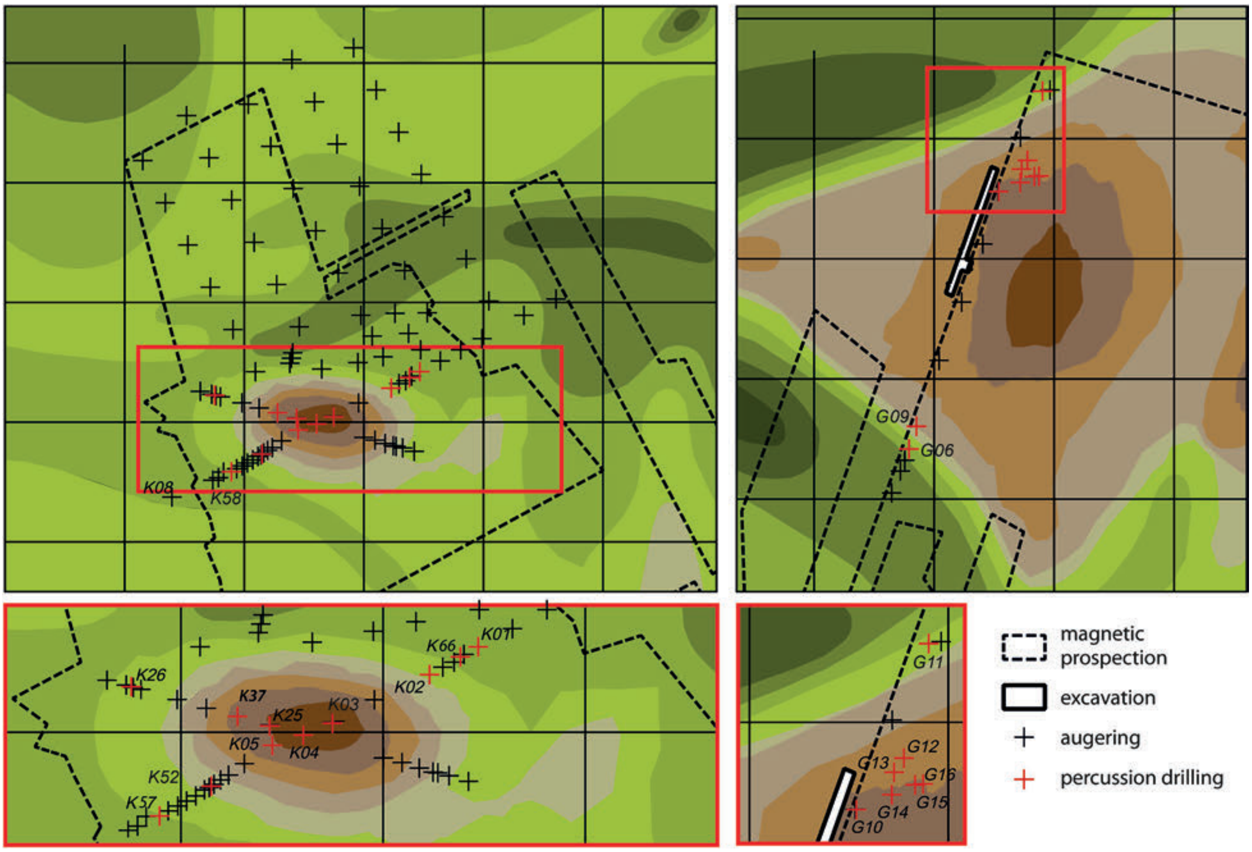


Fig. 15. Fajsz. Overview of the pile core samplings and Pürckhauer auger sampling at Fajsz-Garadomb and Fajsz-Kovácshalom (see *Fig. 8*; measuring grid 100 × 100 m). Only the pile core samplings are marked with numbers.

ly described, *inter alia* by Neubauer (2001, 56) and Frenzel (2014, 11). Therefore, an optimal sampling for chemical analyses should be rather based on a preliminary measurement of magnetic susceptibilities with a small sampling interval along a core than on the visual identification of strata.

The area of the settlement mound is marked by numerous magnetic anomalies *(Figs 16–19)*, belonging to different periods. Few of the anomalies are possibly post-Neolithic – considering the dating of the surface material – presumably of Late Roman / Sarmatian and to a large extent of Medieval date. The former include three clearly visible ring ditches (diameters between 8–18 m). In addition, numerous pit-like anomalies are also evident. Their diameters vary between 2–3 m and some are probably settlement pits. Other pits with low magnetic anomaly amplitudes suggest that they might represent grave pits. Apart from a few dipoles, only two represent layers of burnt daub. The small number of potentially burnt houses is typical for tells, as was the case during prospections at Uivar, Timiş county, Romania (Schier / Draşovean 2004, 151 fig. 3), and Pietrele, Giurgiu county, Romania (Hansen et al. 2004, 95 fig. 18), although there are examples for heavily burnt complete occupation phases, as at Berettyóújfalu-Herpály, Hajdú-Bihar county (Kalicz / Raczky 1984; 1987; Kalicz et al. 2011). One cannot assume that Neolithic features were destroyed by human activity during later periods (e. g. the digging of Sarmatian or Medieval graves). Instead, it can be concluded that burnt houses – at least in the upper settlement layers – were truly a rarity at this tell site. Based on the proximity between the Kovácshalom and the Garadomb sites as well as the Late Neolithic phases of both, physical traces of the assumed communication were investigated. Yet, no evidence of paths or trackways leading to the Fajsz-Garadomb settlement was found. Geological signatures as well as the aforementioned archaeological anomalies provide evidence for the silted backwaters of the Danubian tributaries.

Kernel density estimation (KDE) is used to investigate the general tendency in the distribution of relevant anomalies. The KDE is based on the centroids of anomaly classes defined by 1 nT, 2 nT, and 4 nT magnetic anomalies that were calculated from the data *(Figs 18–19)*. A higher density of magnetic anomalies clearly marks the settlement mound in its entirety. Westward of the settlement mound, a linear agglomeration of anomalies indicates a former river or channel bed. In the eastern periphery, an area with a higher density of anomalies presumably indicates a satellite settlement.

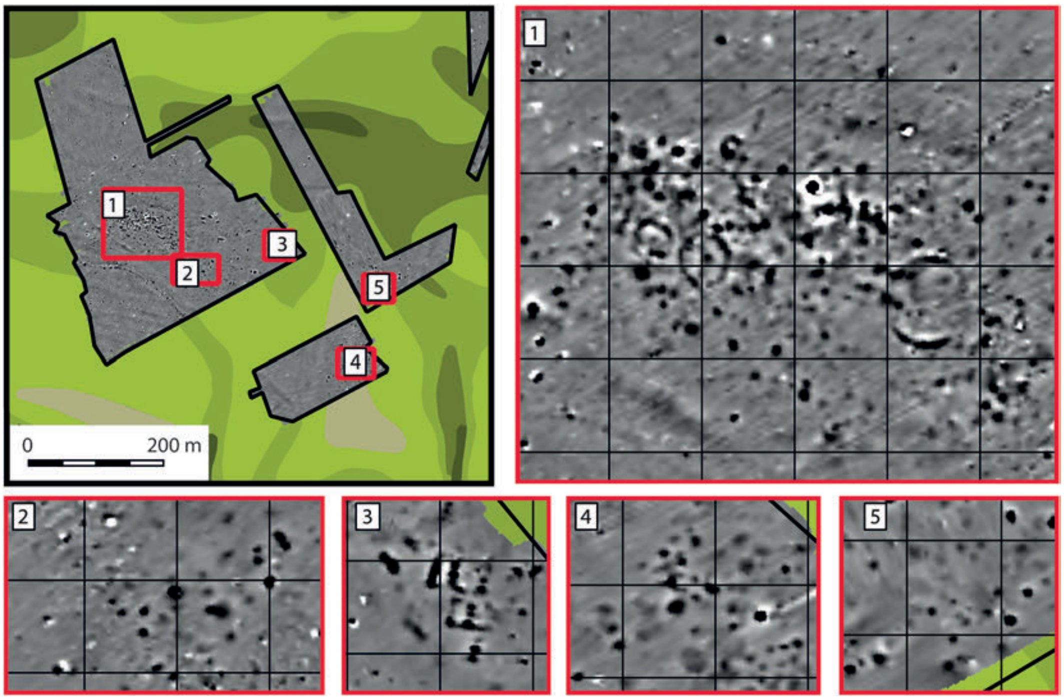
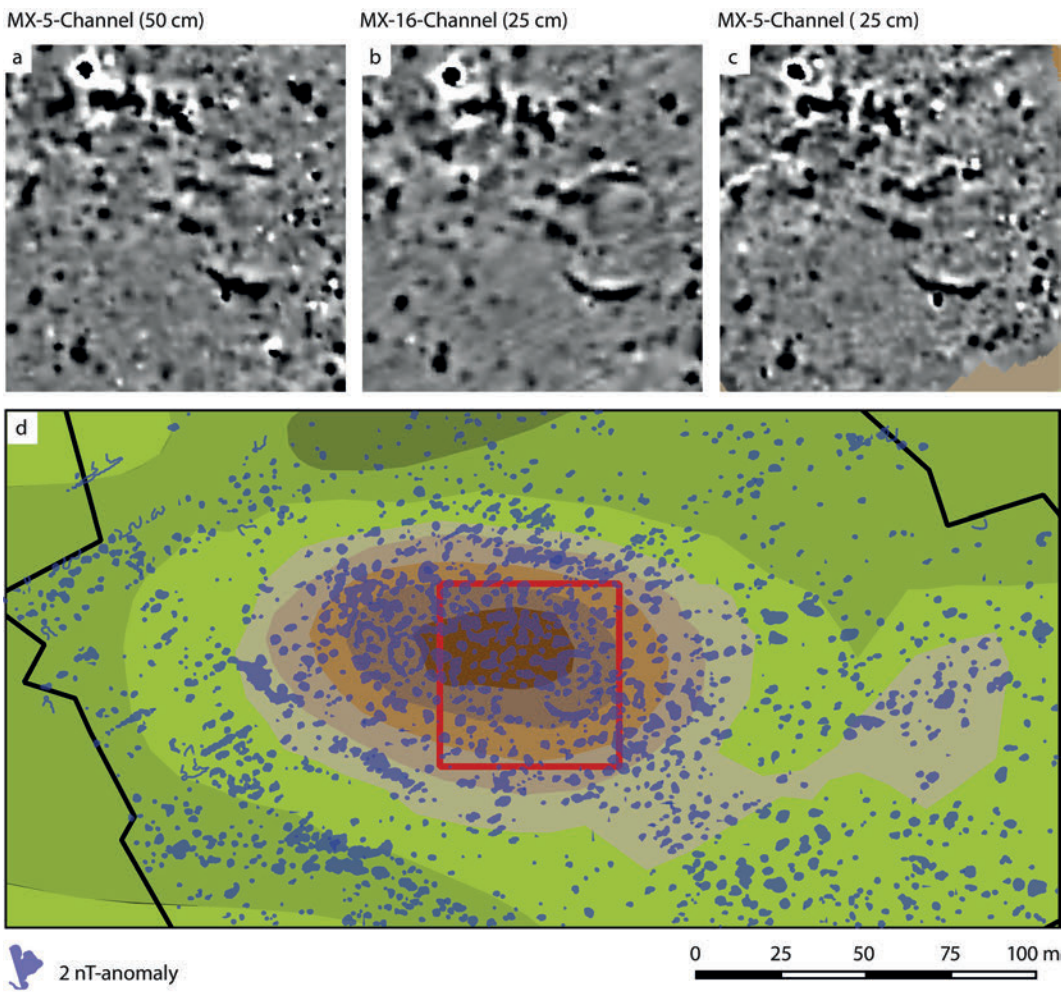


Fig. 16. Fajsz-Kovácshalom. Overview of the magnetic prospection with a selection of the magnetic anomalies of pits and houses. 1 Settlement mound; 2 settlement pits in the southern periphery of the mound; 3 house remains (date ?); 4–5 settlement pits.



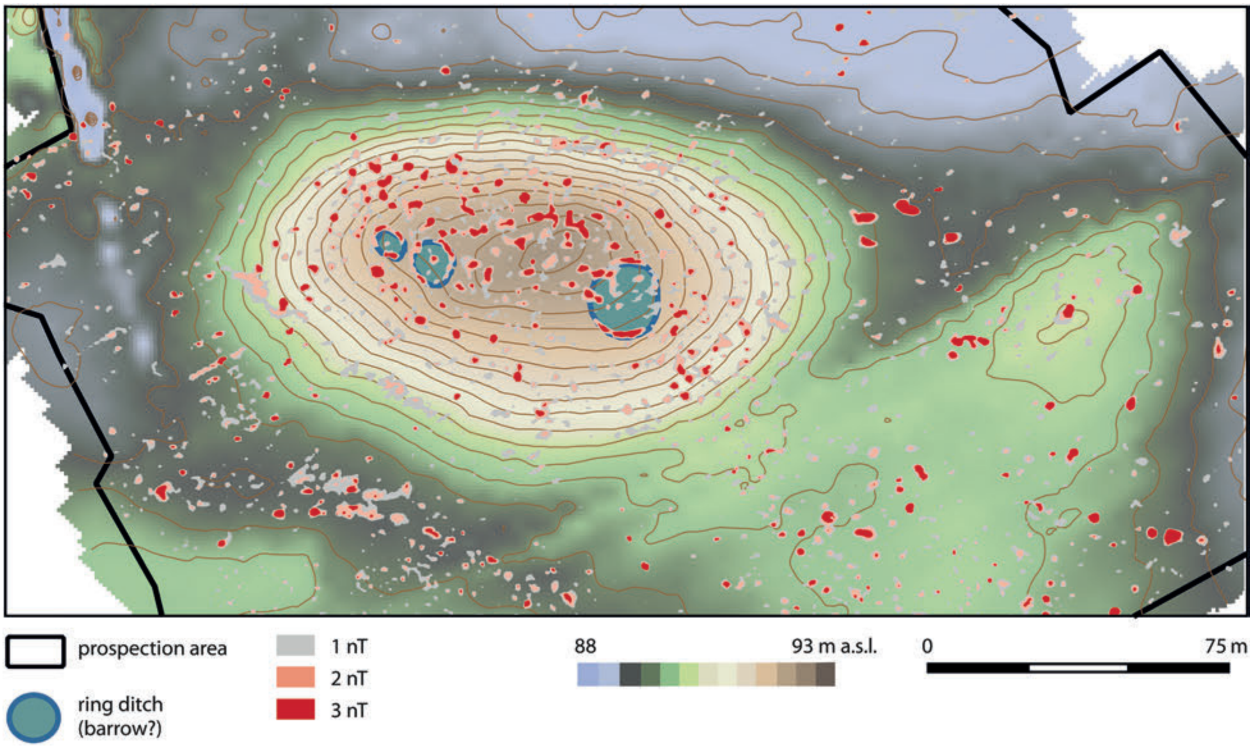


Fig. 18. Fajsz-Kovácshalom. Magnetic anomaly classes: 1 nT, 2 nT, 3 nT *vs*. the digital elevation model (DEM).

The multi-element chemical analysis of the cores provided the data that enable a comparison between the flat settlement Garadomb and the settlement mound of Kovácshalom. The phosphorus values of Kovácshalom are much higher than on Garadomb *(Figs 20–21)*. The highest values of up to 6000 ppm indicate a strong anthropogenic impact. For the majority of the samples, the phosphorus concentrations are in the range between 2000–3000 ppm, a characteristic dimension for settlement layers (Gauss et al. 2013). The lower phosphorus concentrations from Garadomb with values ranging between 1000–2000 ppm are quite remarkable, presumably the result of the lower density of people or buildings per hectare on the flat settlement. At the same time, the magnetic susceptibility values at both settlements are similar, which is quite noteworthy. The soil samples with higher susceptibility generally indicate occupation layers. At the same time, higher magnetic susceptibility values do not directly indicate a stronger anthropogenic impact. The analysis of the overall magnetic susceptibility datasets indicates that susceptibility is a strong indicator, for example, for burnt clay, as may be found in the locations of burnt houses, fireplaces, ashes, ovens, or kilns.

Strontium correlates directly with phosphorus, as shown by the PCA of the XRF analysis data (cf. *Fig.* 7). It is a commonly observed phenomenon (Gauss et al. 2013). Furthermore, the multi-element chemical analysis of cores generally indicates higher calcium concentrations in layers with higher concentrations of phosphorus and strontium.

The A-layer of all cores shows regularly increasing magnetic susceptibility values *(Appendices 1–2)*. In some cores such as in sample K66, we measured high magnetic susceptibility values again in deeper settlement layers, in particular in layers with house daub and burnt clay. Unfortunately, the Bartington magnetic susceptibility metre was only used for the analysis of samples in the laboratory. In the future, we will include *in situ* magnetic susceptibility measurements into our fieldwork as part of our standard operating procedure. We anticipate that for the investigation of prehistoric sites on intensively used agricultural land, susceptibility measurements in boreholes (downhole sensor measurements), and high density grid measurements in vertical and horizontal surfaces beneath the agricultural layer will be of particular value for archaeological investigations. We will continue to use the Bartington MS3 instrument with MS2 sensors

◁ Fig. 17. Fajsz-Kovácshalom. Comparison of different magnetic data from the centre of the settlement mound and filtered anomalies of > 2 nT. a MAGNETO® MX ARCH 5-channel system, sensor separation 50 cm; b MAGNETO® MX ARCH 5-channel system, sensor separation 25 cm; c MAGNETO® MX ARCH 16-channel system, sensor separation 25 cm; d digital elevation model (DEM) and magnetic anomalies > 2 nT.

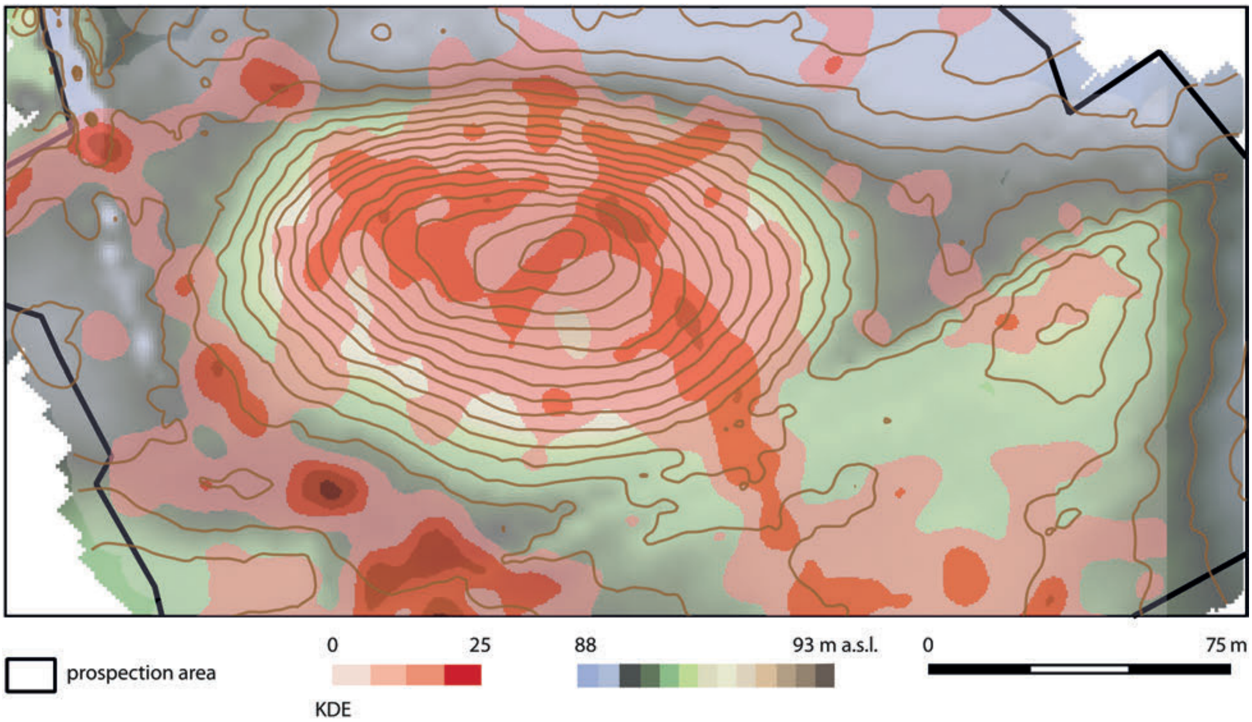


Fig. 19. Fajsz-Kovácshalom. Kernel density estimation (KDE) of the potential pits and house daub (range 10 m) *vs.* the digital elevation model (DEM).

for this task. One option is to measure every borehole with the MS2H downhole sensor. In addition, all cores retrieved by means of pile core sampling should be measured using the MS2C sensors loop configuration for core investigations. Single soil samples should be analysed using the MS2K surface sensor.

The advantage of susceptibility measurements is that only little time is required and that a large number of samples can be analysed in a short time.

Fajsz-Kovácshalom, profile A-A' *(Fig. 22)*

Natural sediments

The central sediments (a) are the basis of the mound. It consists of a moderately fine-grained, moderately silty sand of light-grey to yellow colour and contains oxidised iron compounds *(Figs 22–23)*. Based on qualitative tests using hydrochloric acid, it contains virtually no calcium carbonate and is therefore likely an aeolian sediment, or has been decalcified over time. This is only apparent within the upper 75 cm of the sediment, below which obviously autochthonous layers of silt (b and c) begin to appear. These silt layers as well as some (but not all) of the lower sand layers do react when exposed to hydrochloric acid, and thus indicate a calcium carbonate content. It is likely an alluvial sediment or has been re-deposited through very strong aeolian or fluvial activity.

Both (b) and (c) are deposits that consist of yellow to light yellowish-grey, very sandy silt. Both react strongly to hydrochloric acid, and thus contain carbonate, most likely calcium carbonate. These are classified as alluvial sediments.

Three related, but nevertheless different sediments could be distinguished on the left side of the profile. Sediment (d1) consists of very coarse, light yellowish-grey, very silty sand containing complete shell fragments as well as smaller shell fragments. The upper part of this sediment in Core K7 graded into moderately coarse, moderately silty sand with humic layers, while the upper 20 cm contain a layering of sand and clay.

Sediment (d2) is greyish-brown very silty clay with much humus and shell fragments. In addition, pieces of daub and minute charcoal particles were found in this sediment.

Sediment (d3) represents light yellowish-brown very silty clay with shell fragments.

Deposited on top of these related sediments is sediment (e) which is similar to (b) and (c). Sediment (j) consists of light greyish-yellow, extremely silty sand, with light greyish-yellow, extremely silty clay layers which are fairly thick. The bottom of these sediments shows an erosive transition to the underlying sediments (d1).

A more uniform layering could be observed on the north-eastern side of the mound. The sediments encountered here consist of very silty clay of greyish-brown colour (k) mainly due to humic material. More eastward

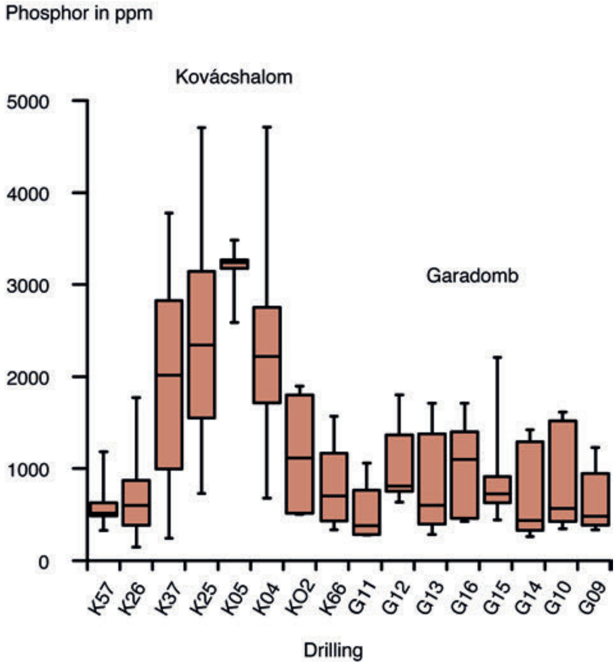


Fig. 20. Fajsz-Garadomb and Fajsz-Kovácshalom. Boxplot comparison of the P-values of the pile core sampling cores.

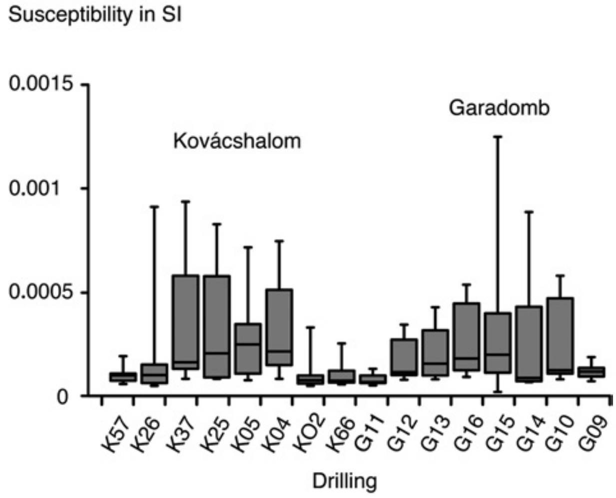


Fig. 21. Fajsz-Garadomb and Fajsz-Kovácshalom. Boxplot comparison of the magnetic susceptibility measurements of the pile core sampling cores.

(Core K20), several thick layers containing large quantities of humic material were observed. Sediment (k2) is also a very silty clay, although it has a dark brown colour, mainly due to high humus inclusions. Overlying is sediment (l) consisting of moderately sandy clay of a greyish-brown colour. Sediment (l2) is also moderately sandy clay of dark brown colour with high humus content. Sediment (l3) has a similar appearance, but contained cultural material in the form of daub and specks of charcoal.

Signs for the presence of a stable groundwater level were observed in cores K20 and GR. Beginning at a depth of 2.5 m below the modern surface, the conditions become reducing with little oxidised iron compounds compared to the upper layers with large quantities of oxidised iron compounds.

Fajsz-Kovácshalom, profile B-B' *(Fig. 23)*

The majority of the features are similar to the ones in profile A-A' (cf. *Fig. 22*). Therefore, see above for descriptions of sediments (a), (b), (c), and (j). Sediment (h2) consists of very sandy clay of dark brown to black colour with large quantities of humus. It contains both a lot of daub and shell fragments, and burnt bone was also identified. It has an erosive transition to the underlying sediment (c). Calcium carbonate concretions have been found in large numbers in the lower parts of this sediment, which might indicate that the erosive contact is natural and caused by fluvial activity. Organisms which live on the bottom of rivers and streams produce calcium carbonate concretions.

Interpretation

Concerning the natural formation, it appears possible that a river dune (a) was covered by floodplain sediments (b) and (c). On the southern side, this was cut by a river arm (called a palaeo-channel in sedimentology) (d) with a fairly shallow riverbed. It is probably indicative of a wider river (a prolonged discharge of large volumes of water). Sediment (k) most likely represents a residual gully. This sediment indicates a water mass that hardly moved and filled up gradually, with some more stable to stagnant phases, which enabled the formation of sediment containing a lot of humus, as evident in Core K20. The layered appearance of these sediments indicates fluctuation in the water intake of the probable basin. Sediment (l) represents the final phase of the residual gully, which apparently had an increase in water velocity, suggested by the sand inclusions throughout the upper part of the sediment. Ultimately, this arm was cut off completely from the river and filled up.

Sediments (h) and (h2) seem to be contemporaneous with sediment (l), although with a large amount of cultural remains in comparison. The sandy nature of the clay sediments (l, l2, h, and h2) is likely to be alluvial, but an aeolian origin is also possible.

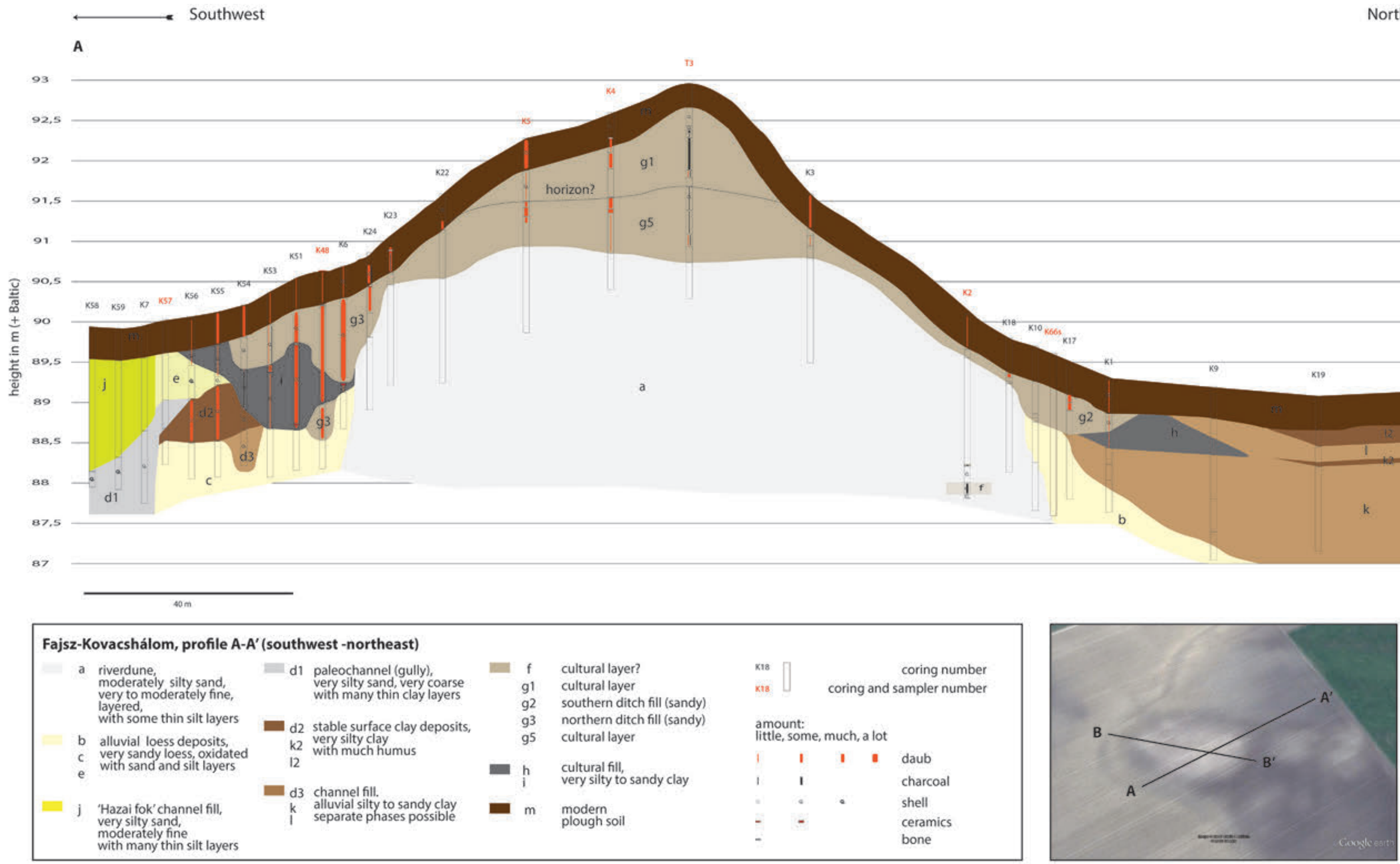


Fig. 22. Fajsz-Kovácshalom. Profile A-A' shows the profile after the interpretation based on the descriptions of the sediments. First, the naturally deposited sediments will be described (even though some have cultural artefacts in them) followed by the description of the cultural layers.

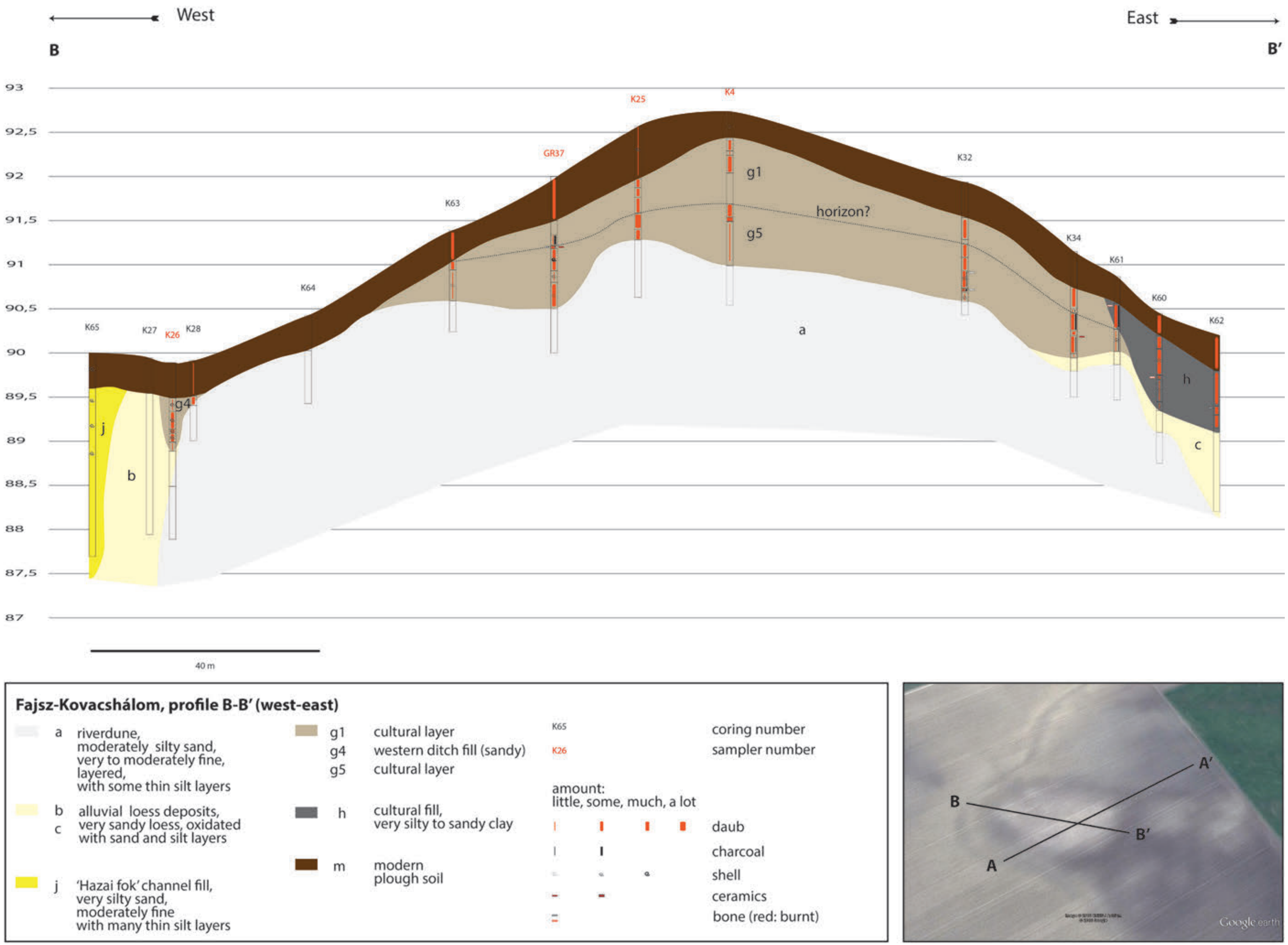


Fig. 23. Fajsz-Kovácshalom. Profile B-B' shows the interpreted profile based on the descriptions of the sediments.

Cultural layers

The potentially oldest layer (f) was found in a single core (K02) at a depth of c. 2.2 m below the topsoil. It appears to represent a layer where a moderate degree of soil formation has taken place. Some charcoal fragments were found in this layer.

It is impossible to reconstruct and qualify the cultural layers at the top of the mound. Due to the number of features that are observed in the magnetic prospection results, it is likely that the observations cannot be properly linked between boreholes. The variety in appearance also gives no indication of comparability. However, a horizon can be postulated between the stages of occupation / utilisation, which is mainly based on a large number of cultural indicators at those depths. Therefore, the description of layers (g1) and (g5) cannot be generalised, despite them consisting mainly of silt and sand.

The natural sediments on the southern flank are culturally interesting because of the possible riverbank (d2 and d3). Here, cultural material is found within the sediment. However, it remains unclear whether these are remains fragmented *in situ* or fluvially deposited materials. On top of the riverbank, natural alluvial sediment (e) is found. This implies that the cultural material represents an early or the earliest phase of the site. After this period, heavy fluvial activity of the Danube covered these remains, after which the area was arable again.

The ditch or trench (i, i2, and g), which could represent a fortification of the mound, had been dug through this accumulated material and gradually filled up since. Initially composed of non-humic greyish-yellow moderately sandy silt (i2), it gradually grades into layer (I). This layer (I) has a very sandy clay fill which, close to the mound, contains large quantities of humus and is dark greyish-brown, but it contains little humus and is light greyish-brown near the outer edge. The accumulation of humus near the mound is likely related to activity on the mound. It contains a lot of debris, daub, charcoal, and (probably) Neolithic sherds as well. The lowest layer (g3), due to its erosive border with the underlying layer, probably represents a rejuvenation of the ditch / trench. This also contains a lot of daub fragments, and (probably) Neolithic sherds were noted immediately below the topsoil.

Layer (g4) in the left part of profile B-B' is most certainly a ditch or trench. It is located on the western side of the mound and is vaguely visible on the geomagnetic image as well. Based on the geomagnetic image in *Figs 16–17*, layers (g3), (g4), and (g5) appear to be contemporaneous, they are connected and form a ditch or moat around the mound. The differing fills can likely be explained by the connection with the gully located on the mound's eastern side. If there was an open access to this main river gully, coarse material would have been deposited closer to the gully, while more fine-grained material would have been deposited farther away from it. The soil colouration in the aerial images also confirms this observation.

Layer (m) is the modern topsoil. It consists of silty sand, sandy silt, or sandy clay depending on the underlying sediments. Around the mound, the soil contains a lot of archaeological debris such as daub, bone material (on the surface and in the sediment), ceramic sherds, pieces of flint (both exclusively on the surface), and shell fragments.

Conclusions

A very complex sediment history mixed with a palimpsest of cultural activity could be noted across the research area. It is likely that all observed sediments were formed during the Holocene, but it remains unclear in which time-frame. Only sediments (a), (b), and (c) might have an older origin. Because of the artefacts on top of this presumed river dune, it confirms the pre-Neolithic origin of the sediments. All other sediments are unlikely to be older than the Neolithic. The mound has a natural origin, but it remains unclear whether this is solely due to fluvial activity or whether aeolian activity also had an impact.

The available information is insufficient for understanding the development of the landscape after the mound was formed. Obviously, the Danube has continually and frequently changed its course. Different sediments ranging from very coarse, very silty sand to very silty clay deposits can be found, reflecting a large variety in sedimentation environments. Gullies with fast-flowing water (d1) to stagnant water-bodies (k) can be postulated, both based on the appearance and morphology of these sediment types. Erosion, sedimentation, and post-depositional alterations have been encountered.

There was open water on all sides of the mound, although it is unclear whether simultaneously or at different moments in time. The humic clay found at a depth of 1 m north of the mound is indicative of a so-called residual gully. While its total extent has not been determined, it appears to have been more than several hundred metres wide. A river-bed was located at some point on the southern side, but it remains unclear how deep and wide this river arm was. It was only identified in the last three cores at the end of profile A-A'.

What makes this situation unique is that it appears to have been buried under a metre of natural sediment. As far as is known, this is unique for the region. A buried landscape could be present not only here, but also in other parts of the region as well.

East of the mound there appears to have been erosion that cut through parts of the mound. Calcium carbonate concretions provide evidence of contact with oxygen-rich water, and it can be postulated on the testimony of these characteristics that parts of the site had been inundated in this area. As can be seen on the geomagnetic images, two smaller mounds lie farther to the east, but these have not been explored so far.

A roughly 1.7 m thick cultural deposit can be found on the top of the mound, which had originally been thicker, although it remains unclear how much thicker. We were told by local farmers about the difficulty of ascending the mound with tractors. They mentioned an attempt to flatten the mound which was stopped when it was identified as an archaeological site.

During this attempt to flatten the mound, many human bones were found, some possibly originating from Sarmatian graves and from the Late Medieval cemetery. As noted above, the estimated depth of the graves of the latter period lay 2 m below the surface, and, thus, it can be assumed that this cultural deposit has already been eroded or removed as shown by these bones. Because of the lack of the dating of the sediments, a precise chronology of events cannot be determined at this point.

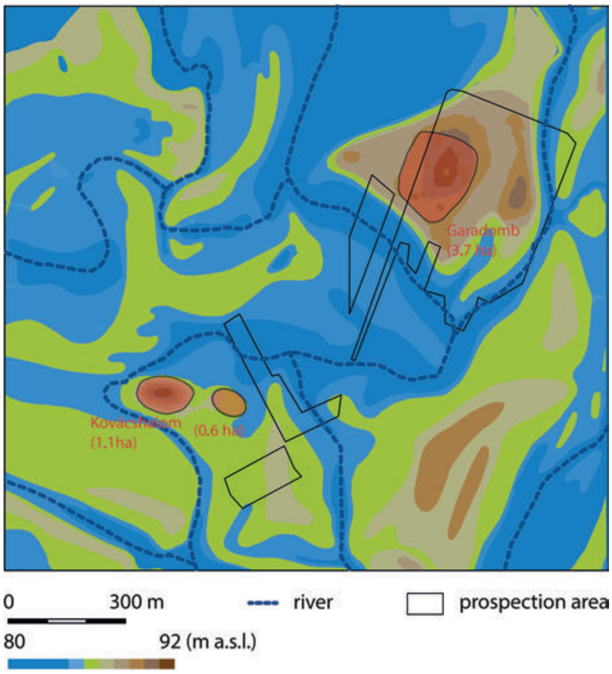


Fig. 24. Fajsz-Garadomb and Fajsz-Kovácshalom. Digital elevation model (DEM). Highlighted in blue are the potentially flooded areas, while the settlement areas are marked in red.

Synthesis

The analysis of different prospection datasets and the integration of the main excavation data revealed general tendencies with respect to the use of both sites over the past 7000 years. These include settlement activities in earlier periods of the Neolithic and Bronze Age and ritual or burial activities in the 1st millennium AD by Sarmatian, Avar, and later Hungarian rural populations. Our prospections enable us to reconstruct the size of the Late Neolithic settlement areas. Fajsz-Garadomb is around 3.7 ha and Fajsz-Kovácshalom around 1.1 ha with a satellite settlement of 0.6 ha.

The settlement area on Garadomb is enclosed by ditches. Some of the ditch anomalies are hardly visible in the magnetic prospection data, an indication that they are presumably shallow. The difference in the visibility of the ditches on the magnetic image might indicate that they are not contemporaneous. Nevertheless, all ditches are enclosed in an area well visible in the digital elevation model (DEM) *(Fig. 24)*. Inside the ditches the KDE revealed significantly higher concentrations of relevant magnetic anomalies. These could indicate small house clusters. A high density of houses as on the Vinča sites such as Stubline, municipality of Obrenovac, Belgrade (Crnobrnja 2011), and Okolište, municipality of Visoko, Bosnia and Herzegovina (Müller et al. 2011), is highly unlikely. The southern area of the Neolithic settlement was again occupied in the Bronze Age. The building density again remained low. The magnetic data most likely indicate seven houses. However, it remains an open question whether all of them originate from the Bronze Age. The high number of Bronze Age settlement pits in the southern area indicates intensive economic activities. As expected, the magnetic data of the settlement mound of Kovácshalom are complicated. A tell site is an accumulation of different regularly overlying settlement layers, resulting in overlapping magnetic anomalies of the overlapping archaeological features. The clear patterns observed at Okolište (Müller et al. 2011) are more of an exception, caused by burnt house remains in the upper layer. The multiple layers at the two investigated sites of Fajsz-Garadomb and Fajsz-Kovácshalom reflect an occupation over different periods. The indication of a small satellite settlement on the western periphery is also a new discovery. The example of the floodplain landscape around Fajsz shows the great value of historical maps. They provide valuable information for the reconstruction of the ancient terrain situation *(Fig. 25)*.

Tolna-Mözs-Községi-Csádés-földek

Location, topography, and previous archaeological research

The prospected area is located south of the small town of Tolna. The route of motorway M6 passes a slightly elevated area west of the present-day town and continues southward over an extensive floodplain with embedded low plateaus *(Fig. 26)*. The remains of a large LBK settlement with an area of approximately 45 ha were discovered on one of these.

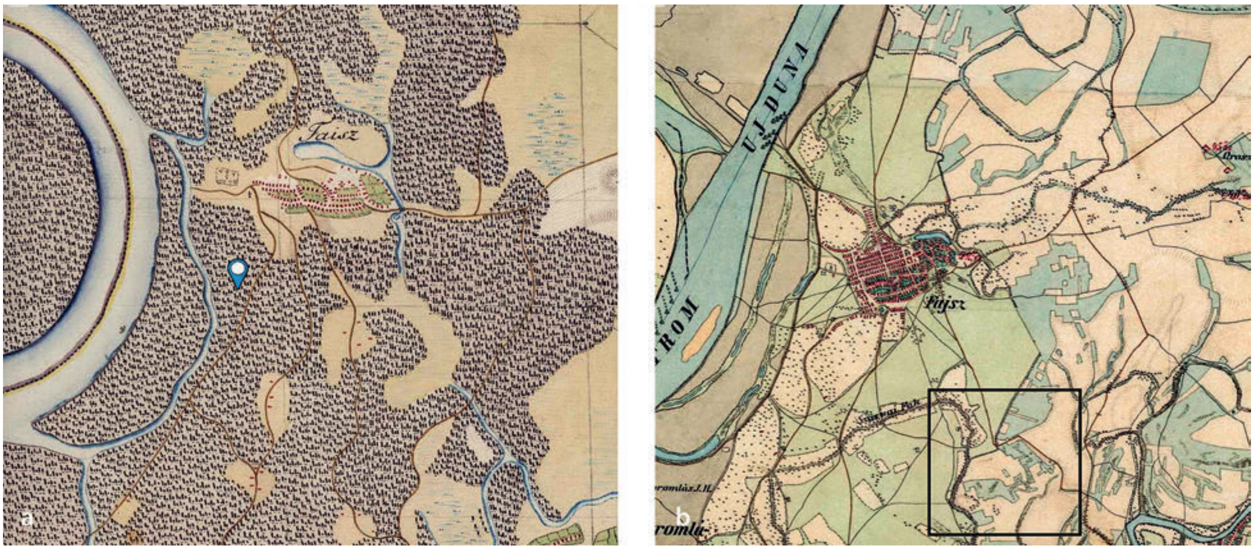


Fig. 25. Fajsz. Sections from maps from a Josephinian cadastre, 1782–1785; b Franciscan cadastre, 1806–1869.

Large-scale rescue excavations were conducted in 2008–2009 by the Institute of Archaeology. The excavation trenches followed the nearly north-south running line for approximately 750–800 m. The width of the investigated area measured c. 70–100 m.

Three spatially separate groups of houses were investigated during this rescue excavation, albeit only partially. To reconstruct the overall extent of the settlement to the east and west better, the team opted, once again, for large-scale geomagnetic prospections (cf. *Figs 33–34*).

Prospection and working conditions

An area of 79 ha within this selected study zone was prospected in two campaigns: in 2011 (November 18–21) and in 2013 (February 21–March 6). As the focal area is currently used for agriculture, we planned to acquire data in the prospection area right after harvesting (and only a minimal ploughing in some areas) in 2013. In spite of excessive rain and soggy soil conditions, the ground was passable.

The prospected area covered nearly the entire plateau, except for the areas covered by the M6 motorway in their central part *(Figs 26–29)*. As at Fajsz, the magnetic prospection was conducted with a vehicle-towed MAGNETO® MX ARCH 16-channel system.

Magnetic prospection: Anomalies, spatial analysis, and modelling

General description of the anomalies (Figs 30–31)

The most common finds revealed by the magnetometer results were the elongated pits flanking obvious LBK houses. These pits appear to have been placed in relation to the house groups that were noted during the excavations. The elongated pits form clusters across the low plateau. Between them are zones without clear evidence of settlement remains. The variation in the building density on the plateau is clearly visible in the magnetic data and was already observed during the excavation.

The elongated pits are obviously in different states of preservation. They are well visible in the south-western and the north-eastern area, whereas they are less clear in the north-eastern part of the area close to the M6 motorway. It could be assumed that the less well-preserved elongated pits associated with houses were partly eroded. Traces of postholes, sometimes observed on LBK settlements (Bihler et al. 2015, 171), are not visible.

The question arises as to how reliable magnetic data are for the reconstruction of the settlement structure and for the estimation of the number of houses, the latter based mainly on the elongated pits. Our interpretation has to consider that not every house is accompanied by two flanking pits, as we know from the excavations at Tolna-Mözs, Alsónyék-Bátaszék, and on other LBK sites in Hungary (Oross 2016b, 125 fig. 2). There is a prevalent pattern of two elongated pits per house, alongside a smaller number of houses with only one elongated pit or, in rarer instances, without any elongated pits. We may therefore contend that the lack of any elongated pits is more of an exception than a recurring variant in regional LBK architecture, even more so because even though elongated pits dug into the prehistoric soil occur most frequently among the archaeological features associated with longhouses, shallow elongated pits can occasionally also be observed. In other words, the lack of elongated pits can in some cases be explained by erosion or by the mechanical topsoil removal preceding an excavation. The results of the rescue excavation are crucial for the

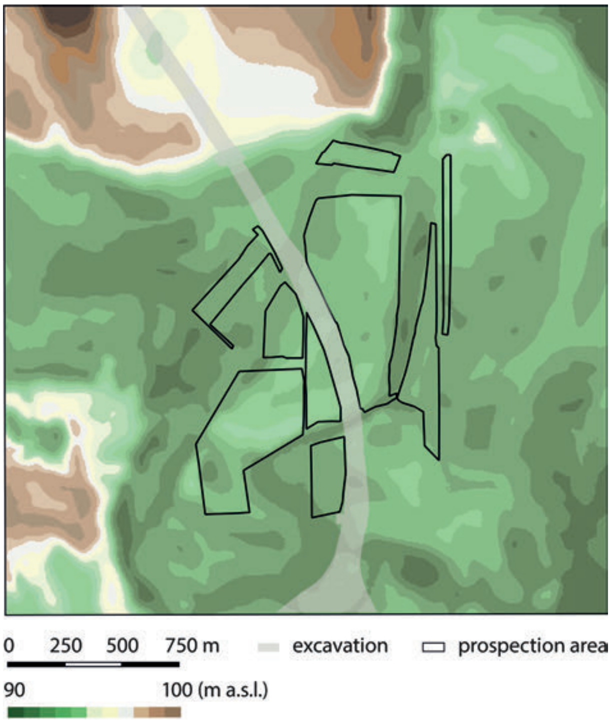


Fig. 26. Tolna-Mözs-Községi-Csádés-földek. Overview of the magnetic prospection areas surveyed in 2011–2013 near the M6 motorway. Digital elevation model (DEM) based on the 1 : 10 000 topographic map / sheets 25 131, 25 133.

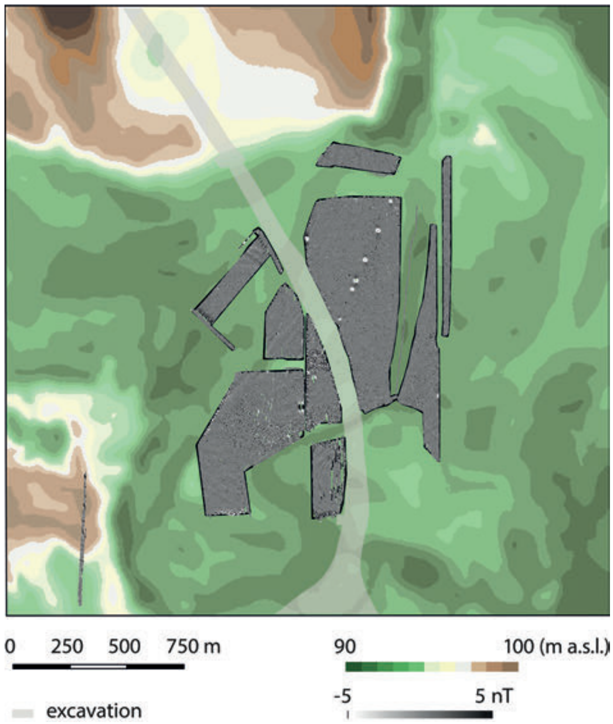


Fig. 27. Tolna-Mözs-Községi-Csádés-földek. Overview of magnetic prospection results from areas surveyed in 2011 and 2013.

Fig. 28. Tolna-Mözs-Községi-Csádés-földek. Overview of magnetic prospection results from the northern area.

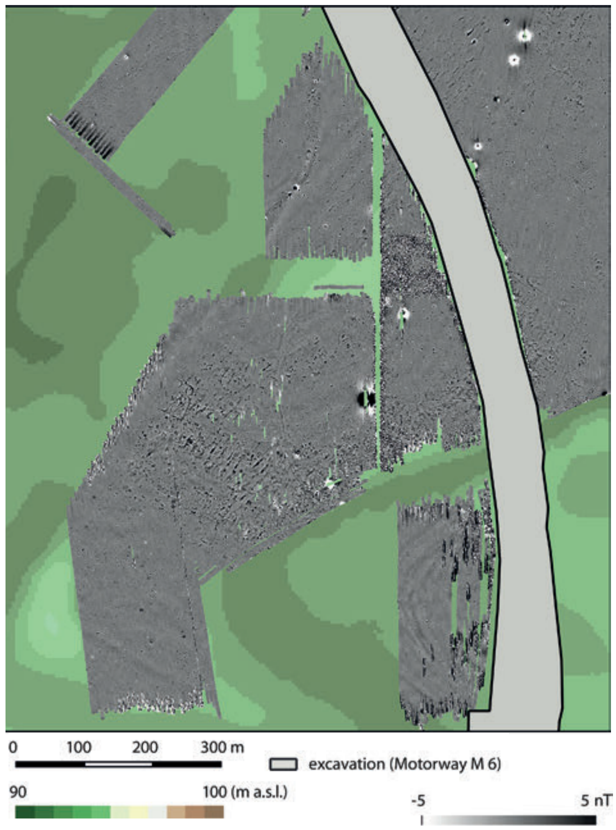


Fig. 29. Tolna-Mözs-Községi-Csádés-földek. Overview of magnetic prospection results from the south-western area.

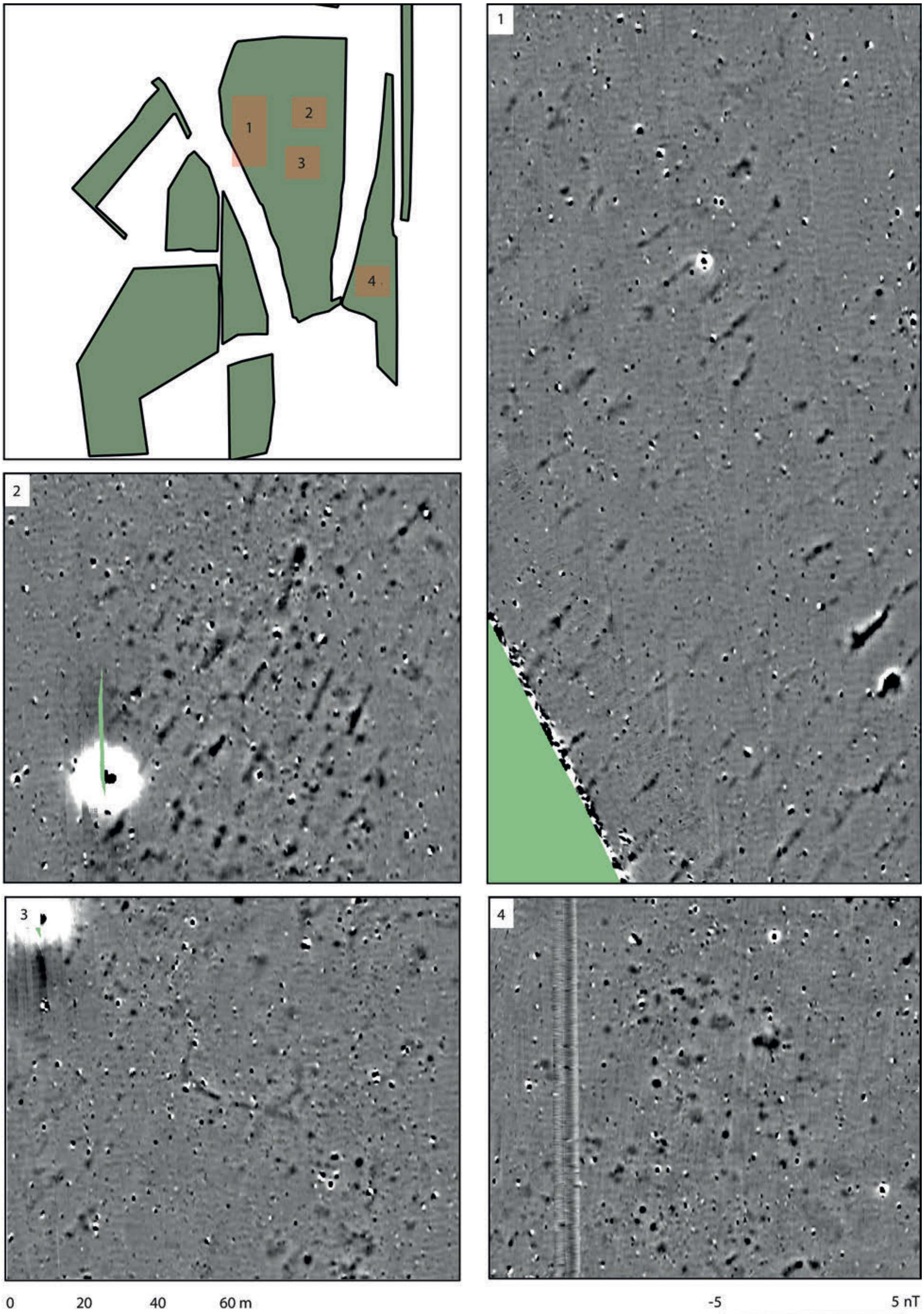


Fig. 30. Tolna-Mözs-Községi-Csádés-földek. Details show elongated pits flanking houses and settlement pits in the north-eastern areas (1–3) and the south-eastern area (4).

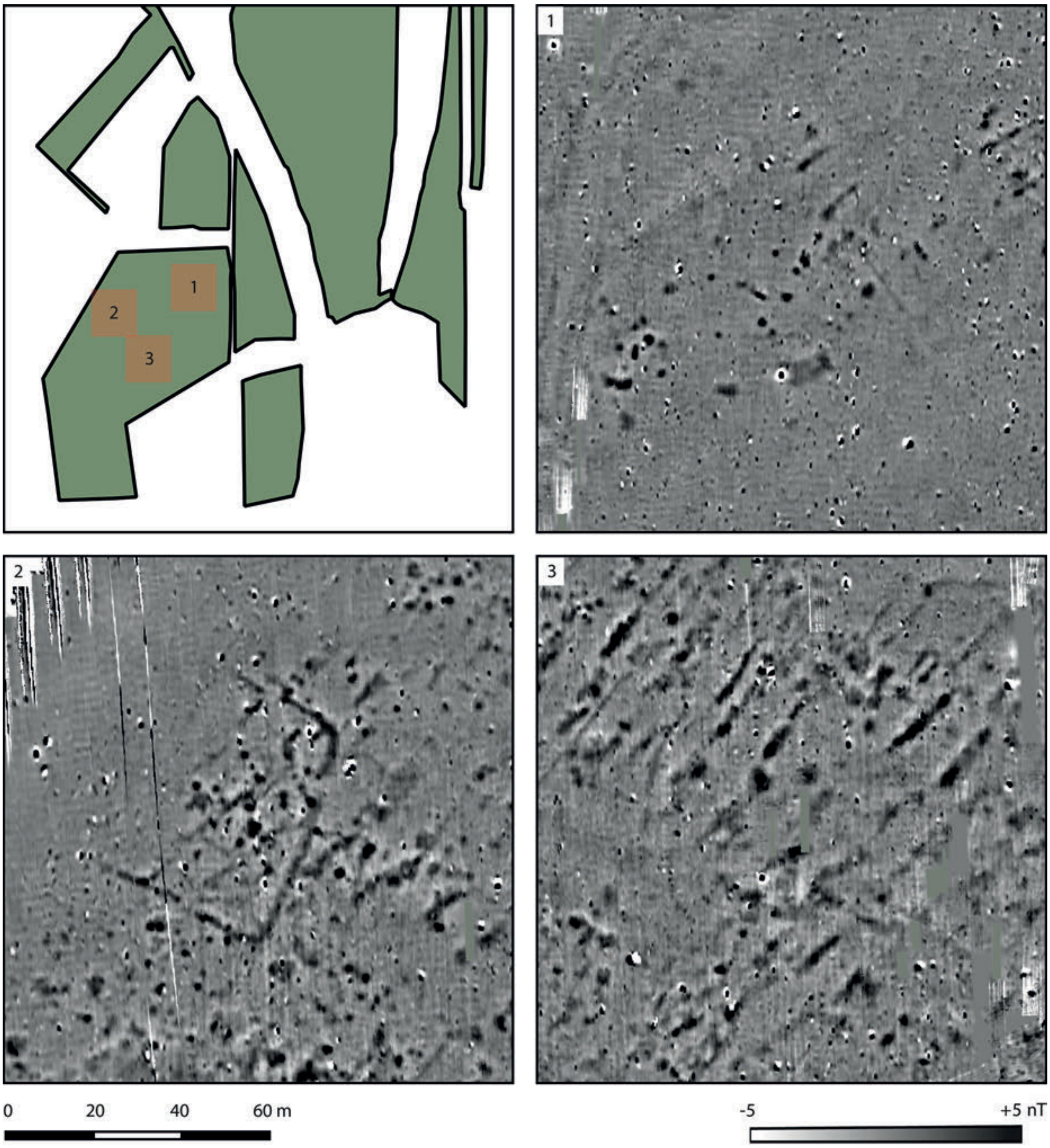


Fig. 31. Tolna-Mözs-Községi-Csádés-földek. Different magnetic anomalies in the south-western area. 1 Settlement pits; 2 ditch enclosure with rounded corners and two entrances and settlement pits; 3 elongated pits.

settlement reconstruction at Tolna-Mözs. Based on these data, we are optimistic that the magnetic data indicate the number of houses and their orientation rather precisely, and thus allow a reconstruction of the settlement structure.

Beside the elongated pits in the southern area, circular anomalies with a diameter of c. 1–4 m are found in clusters. Their distribution clearly differs from the anomalies of the LBK settlement. These anomalies can most likely be dated to the Bronze Age *(Fig. 30.4)*.

Further anomalies of probable settlement pits were found in the south-western area. Traces of a rectangular ditch system are clearly detectable on the plateau's western slope. Their continuation towards the west is not preserved, as it is cut by the slope and very likely eroded. The eastern half is clearly visible, with an entrance in the north-east *(Fig. 31.2)*.

Analysis of the magnetic anomalies *(Figs 32–34)*

As noted above, the magnetic contrast of the elongated pits varies. The 0.5 nT contour line was calculated for their majority *(Fig. 32)*. The main orientation of elongated pits is north-east to south-west with slight deviations. In some areas, the elongated pits overlap, possibly indicating several construction phases. The superposition is limited to larger house clusters and areas with a possibly higher density of houses. The variation in the building density and in the size of the house clusters might correlate with the duration of the occupation in the area.

The kernel density estimation (KDE) method was used for the analysis of the distribution of the anomalies and their density. A radius of 80 m was used to identify the more general structure. A clear tendency is visible in the difference of the distribution of the elongated pits and the settlement pits *(Figs 33–34)*.

Houses and house clusters *(Figs 35–36)*

In the wake of the large-scale excavation and the extensive geomagnetic prospection, some 150 buildings arranged in eleven house groups could be identified during the preliminary assessment of the data. Three of these could be correlated with the three house groups investigated during the excavation. One smaller and two larger house groups lay in the settlement's south-western part, while another house group could be identified west of the excavated area. According to the first model, the settlement's northern part was made up of four other house groups located east of the excavated area (Rassmann et al. 2015a; 2015b).

In the present study, the KDE with a radius of 80 m indicated seven groups, whereas a radius of 60 m leads to a more detailed visualisation of the internal structure of the house groups *(Figs 34–35)*. The house groups in part conform to the groups of the previous model, while others are actually made up of several earlier groups. A total of 186 buildings could be identified *(Fig. 36)*.

The seven house groups are not evenly distributed on the plateau. We assume three larger occupied areas. The largest occupied area on the northern plateau with an area of 19 ha consists of four house groups: The smallest of these is located in the south-east (3.2 ha), which has a single house group, while a third occupation area of 7.7 ha and two house groups can be found in the south-west. The overall size of the plateau is 45 ha, but the settled area is only 30 ha.

The size of the seven house groups varies from 1 ha to 5.6 ha. It can be reconstructed that each house group comprised between 4–63 houses.

The largest group of 63 houses (no. 2) is located in the north and the second largest of 46 buildings lies in the south (no. 7), indicating an occupation of several house generations.

The geomagnetic data can be combined with the excavation results to produce an initial model of the settlement size and its development. The chrono-typology of the ceramic assemblage from the excavation indicates a chronological shift within the houses from south to north (Marton / Oross 2012, 232 f.). The earliest houses (reflecting various late Starčevo traits and the strongest Vinča impact in the pottery) were located in the southern excavated house group. The central excavated house group is generally characterised by Bíňa-Bicske-style finds. Assemblages associated with some of the northern houses included Bíňa-Bicske ceramics, while other house units of that group could be dated on the strength of their Milanovce-style material. Finally, some houses in the same group were erected in the later LBK period as shown by sherds with Keszthely- and *Notenkopf*-style ornamentation.

We can interpolate these observations onto the house groups detected in the magnetic prospection with a certain degree of probability. We conducted several field surveys on the site as part of an ongoing research project focusing on the period's southern Transdanubian communities. Our preliminary findings confirm that the site was a long-lived settlement occupied during several successive generations dating from the final third of the 6th millennium cal BC and that the buildings of the northern settlement section are probably later than some house groups of the southern section. We opened a small sounding in the settlement's northern part in 2016 in a location with a house to clarify its stratigraphy, in the course of which we could also confirm the reliability of the data gained from the magnetic prospection.

The geomagnetic survey results have contributed greatly to our general understanding of the spatial organisation of this LBK settlement. Certainly, cross-comparison with the excavation results will help to draw more detailed conclusions about the structures that were made visible by the magnetics. In the future, the evaluation of the excavation findings, combined with the results of a radiocarbon dating programme, will offer an excellent verification of the geophysical prospections in terms of the temporal structure of these house groups. The fact that the magnetic prospection was conducted over large areas on the periphery of the LBK settlement confirmed our reconstruction. The comparison with the digital elevation model (DEM) indicates a clear correlation (cf. *Figs 35–36*). The settlement area is precisely limited by the flooded area, well visible also on the historical maps: the Josephinian cadastre and Franciscan cadastre *(Fig. 37)*.

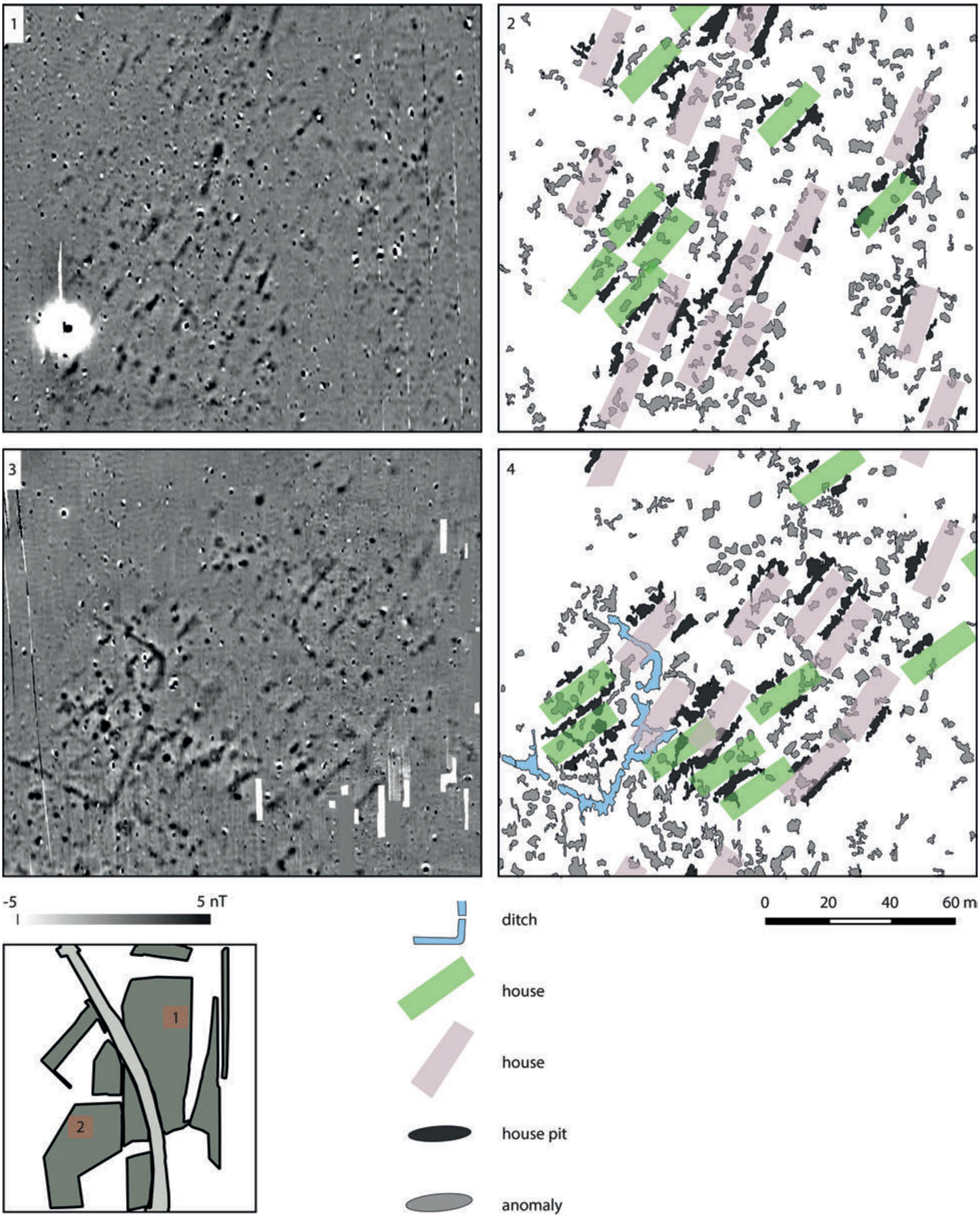


Fig. 32. Tolna-Mözs-Községi-Csádés-földek. Reconstruction of differently oriented houses. 1–2 North-eastern area; 3–4 south-western area.

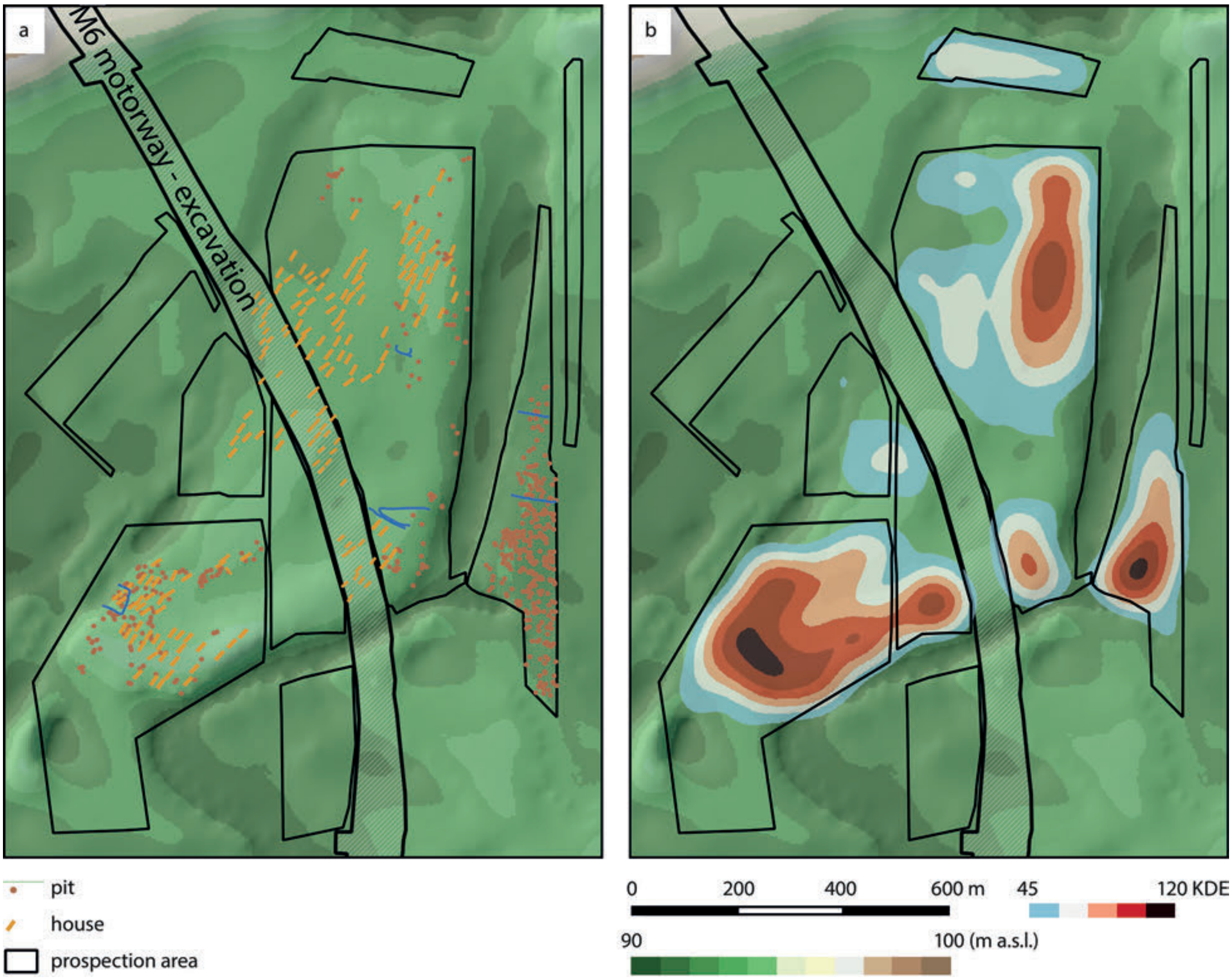


Fig. 33. Tolna-Mözs-Községi-Csádés-földek. Interpretation of the magnetic prospection. a Settlement pits and houses of the LBK settlement revealed by the excavation and magnetic prospection; b kernel density estimation (KDE) (r 80 m) of all magnetic anomalies: size 2–50 m^2; mean 1–10 nT.

The spatial structure of the LBK settlement: An approach from southern Transdanubia

In the previous sections, we deliberately used the neutral 'house group' expression for describing the spatial patterning of the houses and features identified during the excavation and the geomagnetic prospection. For a long time, the independent homestead model (yard model, *Hofplatzmodell*) elaborated for the Rhine region in Germany was the generally accepted model for describing the development of LBK settlements and for establishing the sequence in which the houses were erected (Boelicke et al. 1988; Zimmermann 2012). The settlement row model *(Zeilensiedlungsmodell)* challenging the former model and highlighting some of its contradictions was essentially based on the visual inspection of site plans and lacked detailed chronological confirmation (Rück 2007; 2012). It nevertheless became clear that the independent homestead model could not be applied to certain easterly regions of Central Europe (Lenneis 2012).

We found that on the settlements investigated in Transdanubia, the groups made up of three to seven houses were generally arranged in rows. The term 'house clusters' aptly describes these groups. Although house clusters are not necessarily made up of contemporaneous buildings, they do broadly date from the same period, and some were certainly occupied at the same time.

Several adjacent house clusters form a settlement part, which can be most aptly be described as a 'ward' as defined by Pieter van de Velde in the final report on the LBK settlement at Geleen-Janskamperveld (van de Velde 2007), while one or more wards make up a larger occupation area. One of the major findings of the magnetic prospections conducted at the Tolna-Mözs-Községi-Csádés-földek site is that they provide an outline of the various levels of the site's spatial organisation and that the observations conform to other regional patterns.

The diverse landscape offered prehistoric societies various resources for animal husbandry, farming, hunting, and fishing. However, the availability of arable land on

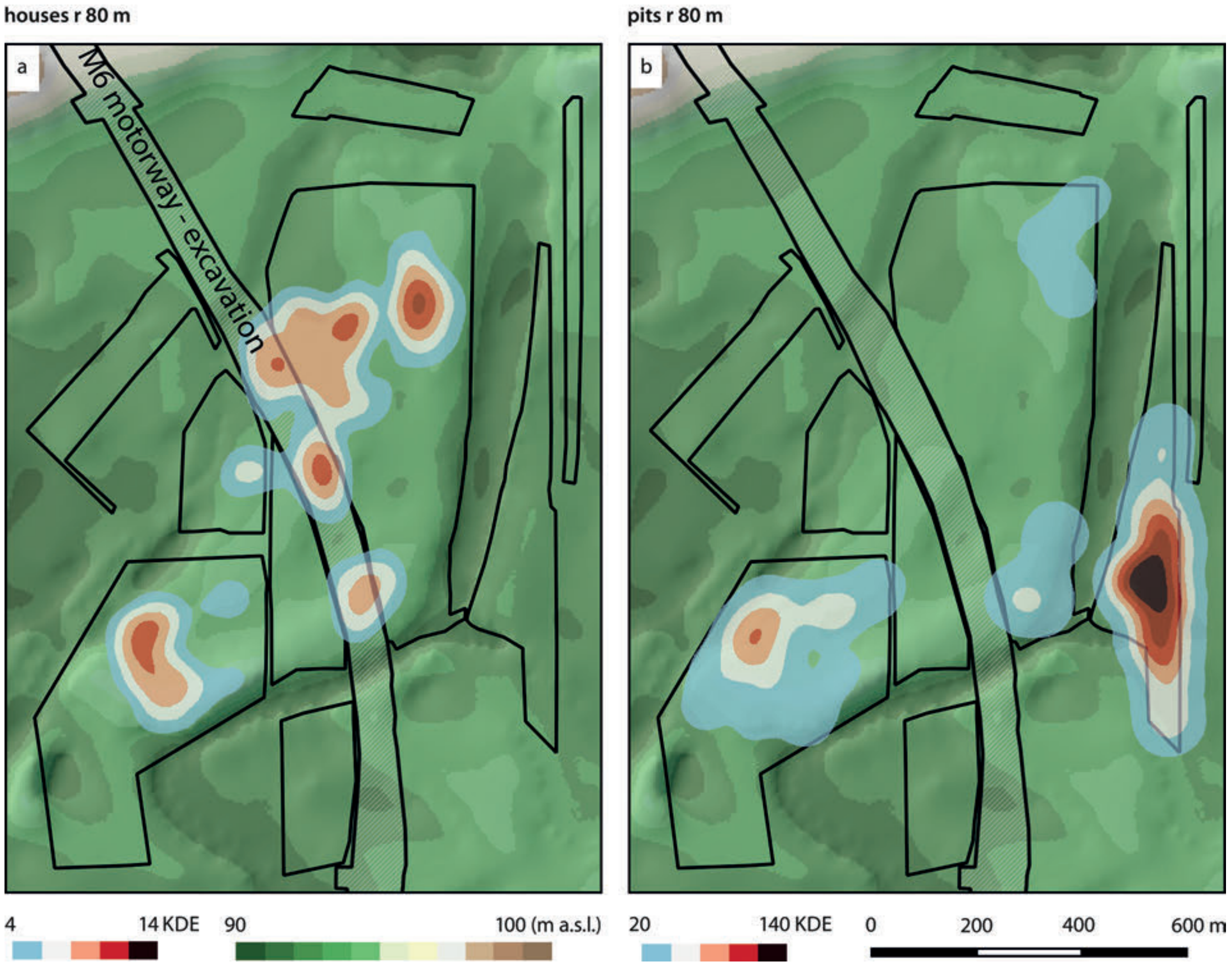


Fig. 34. Tolna-Mözs-Községi-Csádés-földek. Kernel density estimation (KDE). a Houses revealed by the excavation and magnetic prospection (KDE r 80 m); b pits revealed by the magnetic prospection (KDE r 80 m).

the floodplain was limited. This presumption should be investigated in more detail using archaeobotanical data.

Alsónyék-Bátaszék

Location, topography, and archaeological research

Alsónyék-Bátaszék in the Sárköz region, the fourth site investigated within the framework of the joint project of the RGK and the Institute of Archaeology (in cooperation with further institutions), is not a single site, but rather a site complex *(Fig. 38)*. It has a very long sequence of occupation, from the first farmers' settlement in the 58th century BC over the entire span of the Neolithic until the final phase of the Lengyel culture in the 44th century BC. The right bank of the Danube is covered with waterlogged floodplains dissected by oxbow lakes up to the Szekszárd Hills that are often under water in wet periods. Alluvial terraces aside, this was the only land suitable for farming since the lower-lying areas were covered with gallery woods (cf. Sümegi et al. in this volume with further literature).

Similar to Tolna-Mözs, Alsónyék was investigated in the course of the M6 motorway project between 2006 and 2009. Several parts of the site complex, initially considered to be different sites, began to be excavated separately, but eventually the individual segments for the Lengyel period proved to belong to one single huge settlement with an extent of 80 ha. About one-third, 250 000 m^2, of this vast area has been excavated; a series of publications has already appeared and many more are currently in preparation (e. g. Zalai-Gaál / Osztás 2009b; Zalai-Gaál et al. 2012; Bánffy et al. 2010; Osztás et al. 2012; Bánffy 2016 and the entire volume 94 of the Bericht der RGK, published in 2016).

Without speaking of later (scattered) occupation phases, the Starčevo, LBK, Sopot, and Lengyel settlements alone are represented by more than close to 15 000 features and over a million finds. The post-excavation work and especially the evaluation are still ongoing and will last for another few years. Meanwhile, Alsónyék was

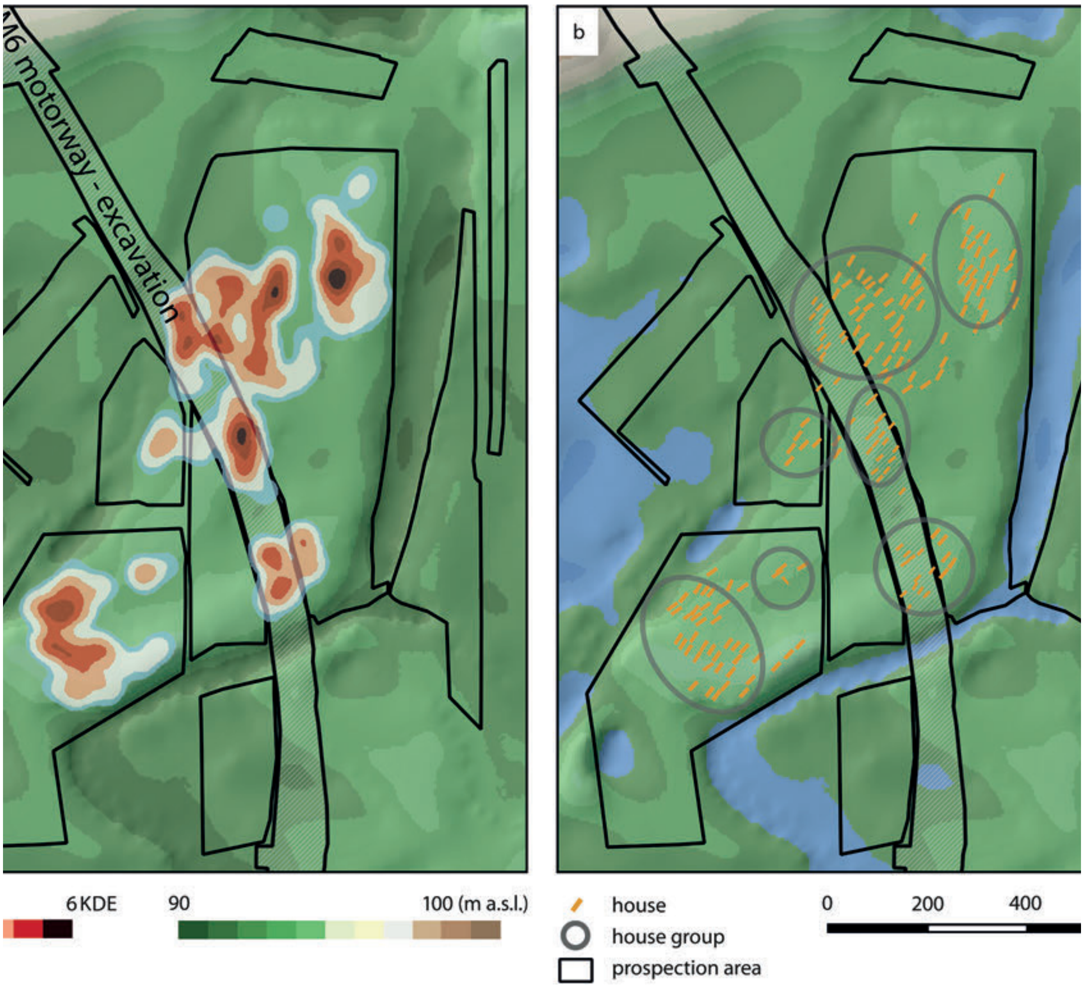
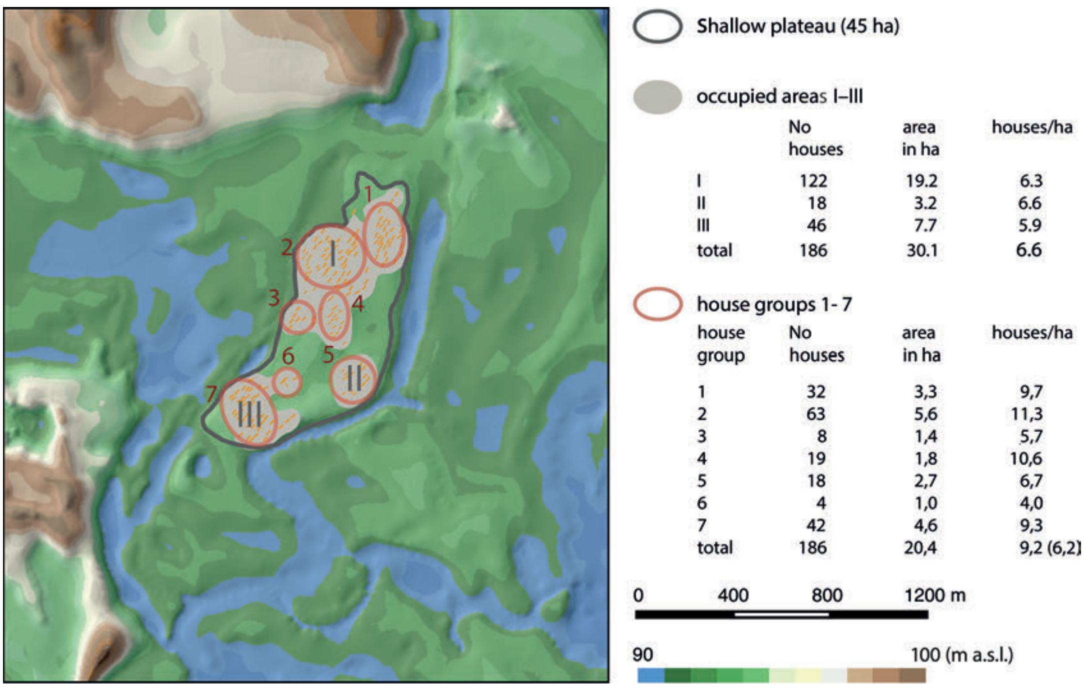


Fig. 35. Tolna-Mözs-Községi-Csádés-földek. Interpretation of the magnetic prospection. a Kernel density estimation (KDE) (r 60 m) of the houses revealed by the excavation and magnetic prospection; b houses and assumed house clusters.



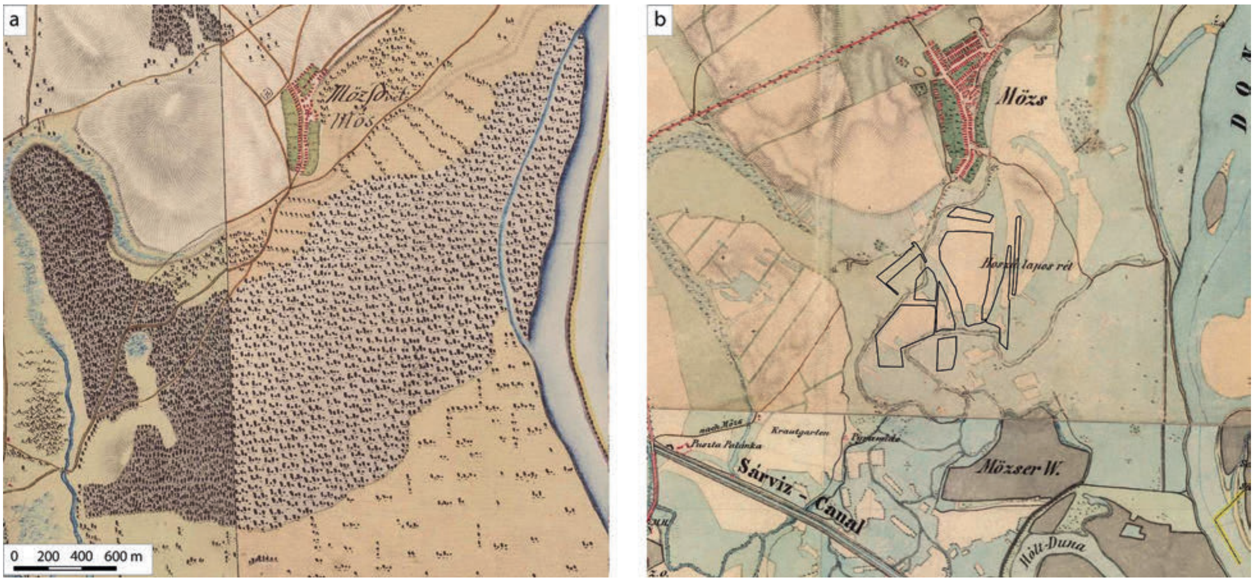
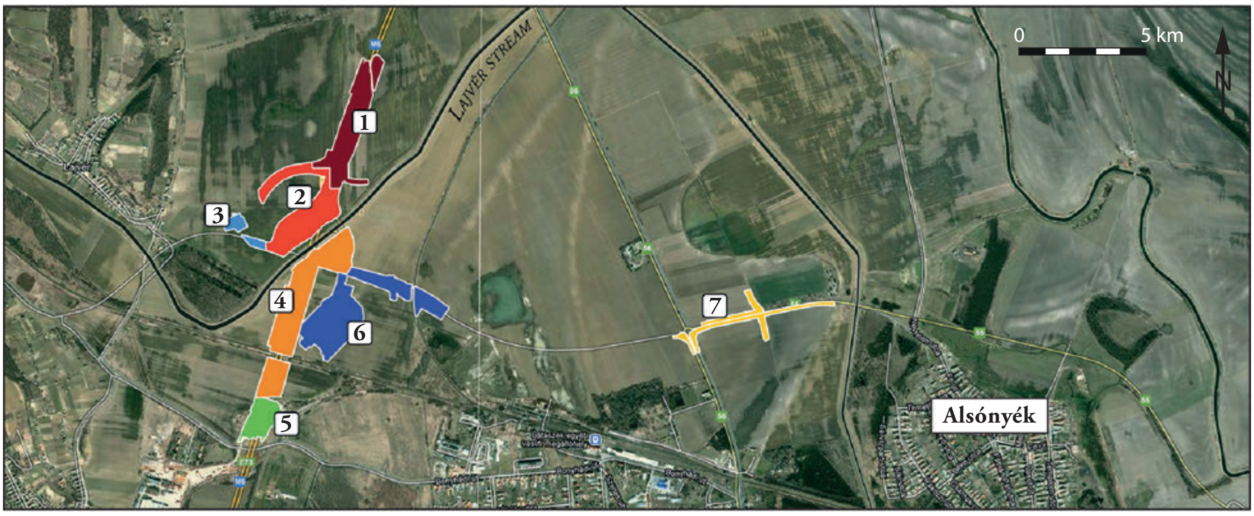


Fig. 37. Tolna-Mözs-Községi-Csádés-földek. Historical maps. a Josephinian cadastre 1782–1785; b Franciscan cadastre 1806–1869 with magnetic prospection areas.



Areas	Subsites	Name of excavated areas	Excavation team
1	10B	Alsónyék-Kanizsa-dűlő (M6 TO 10/B)	Institute of Archaeology of HAS-Archeosztráda Ltd., led by Anett Osztás and István Zalai-Gaál (2006–2008)
2	10B	Alsónyék-Kanizsa-dűlő (M6 TO 10/B)	Ásatárs Ltd., led by Zsolt Gallina (2006–2007)
3	46	Lajvérpuszta (M6 TO 046)	Field Service for Cultural Heritage, led by Vera Majerik (2008–2009)
4	11	Bátaszék-Malomréti-dűlő (M6 TO 11)	Ásatárs Ltd., led by Péter Hornok and Zsolt Gallina (2006–2007, 2009)
5	11	Bátaszék-Malomréti-dűlő Magtár (M6 TO 11)	Field Service for Cultural Heritage, led by Vera Majerik (2008–2009)
6	5603	Bátaszék-Mérnökségi Telep and Bátaszék-56-os út (M6 TO 5603/1)	Institute of Archaeology of HAS-Archeosztráda Ltd., led by Anett Osztás (2008–2009)
7	5603/2	Alsónyék, Hosszú dűlő (M6 TO 5603/2)	Wosinsky Mór County Museum, led by János Gábor Ódor (2008–2009)

Fig. 38. Alsónyék. Plan of the excavations, and the areas and subsites covered by the different excavation teams.

◁ Fig. 36. Tolna-Mözs-Községi-Csádés-földek. Interpretation of the magnetic data. Reconstruction of the LBK settlement. The main groups (I–III) are based on the general structure of the kernel density estimation (KDE) of the houses with a larger radius of 80 m. The smaller house groups resulted from the KDE of the houses with the smaller radius of 50 m.

the focal area of the three research grants mentioned in the introductory part and several MA and PhD theses will evaluate parts of the material.

The earliest Neolithic inhabitants were the early farmers arriving from the northern Balkans. Besides smaller settlement traces (probably 5775–5525 cal BC; 68 % probability), the Starčevo settlement lies in the eastern part (named as 5603), and this settlement section provides the most data for the evaluation. The irregular pits, often large pit complexes, contained not only vast amounts of pottery and animal bones, but also over 2 t of burnt daub, many with imprints of the timber structures of the houses. Lying among these features were some 30 burials, some placed in niches into the side walls of pits. This rich skeletal material became the basis of scientific analyses, including pathology, isotope analyses (Depaermentier et al. submitted), and DNA.

The only gap in the Neolithic sequence at Alsónyék is before the LBK occupation. The most probable reason for this is that the culture's formative period is attested north of the Sárköz (Bánffy 2004); accordingly, the start of the Alsónyék LBK occupation represents the early, but not the earliest LBK phase (start: Alsónyék LBK settlement, probably 5335–5280 cal BC; 68 % probability). The entire LBK settlement comprises a total of 50 longhouses with flanking pits located in the centre of the excavated area. Notably, the Alsónyék LBK site is not only one of the most southerly settlements of this phase, but the material is imbued with early Vinča elements, a phenomenon that deserves a special attention (see Jakucs et al. 2016; 2018).

The Sopot phase at Alsónyék reflects the heritage of a migrant group arriving from the northern Balkans with somewhat different burial customs and material culture (probably 5095–4750 cal BC; 68 % probability). Very interestingly, as was demonstrated in the 2016 report on the absolute chronological position of the Sopot occupation, the Sopot settlement appears to have been synchronous with the latest LBK houses and was located fairly close to the earliest Lengyel feature. This chronological position of the Sopot group largely confirms the archaeological evidence that the early Lengyel culture stems mostly from the late LBK, although it evolved under strong southern impacts. The Sopot occupation at Alsónyék is east of the central excavated area and its discovery was due to the construction of a slip road leading to the motorway. The small excavated section yielded some burials, remains of an enclosure of four parallel ditch sections and also a well, while the complementary geomagnetic prospections revealed much of the occupation pattern.

The Lengyel settlement and cemetery, spanning the earlier 5th millennium BC (from c. 4800–4600 cal BC to until c. 4400 cal BC in some areas), proved to be not only the largest and most intensive occupation phase at Alsónyék, but also by far the most extensive Lengyel site as well as one of the largest Neolithic sites in Europe. The excavated part of the site brought to light 122 robust houses and more than 2300 burials. Lengyel features dotted the eastern, Starčevo part of the site; the southern part was also occupied, but the most intensive part of the settlement is in the north called 10B *(Fig. 38)*. Typically, the humus layers also contained features, and thus the upper layers had to be removed by the machines twice. The graves formed clusters in various parts of the settlement, ranging from a few dozen burials to nearly a hundred. The grave goods shed light on an extremely broad exchange network extending across Europe: obsidian knives from the Tokaj-Zemplén Mountains, Spondylus jewellery from the Mediterranean, jadeite axes from the western Alps, and flint raw materials from nearly all directions (Biró et al. 2017; Szilágyi 2019). Even copper items were found in the latest graves. Some of the richest burials revealed a unique, unparalleled feature, a 'house of the dead' erected over the grave, with four robust timber posts at the corners. In the light of these unique phenomena, it was an exciting challenge to see how the non-invasive methods would enrich the information on the unexcavated areas of this extraordinary site. The present report focuses on the areas that lay beyond the motorway track, and thus remained intact.

Magnetic prospections on the site complex of Alsónyék-Bátaszék

Diagnostic fieldwork and large-scale excavations were carried out at Alsónyék-Bátaszék by the Institute of Archaeology, in cooperation with the Tolna County Museum. These archaeological investigations covered both the main route of the M6 motorway as well as the slip roads north of the village of Bátaszék. Settlement remains and graves from different historic periods were discovered in the road construction area.

The largest excavations took place along the M6 motorway at Alsónyék-Kanizsa-dűlő (areas 1 and 2), Lajvérpuszta (area 3), Bátaszék-Malomréti dűlő (area 4), and Bátaszék-Mérnökségi Telep (area 6). The north-western excavation site of Alsónyék Kanizsa-dűlő (areas 1 and 2) was dominated by remains of the Lengyel culture (Bánffy et al. 2014; Osztás et al. 2016a; 2016b), while numerous features of the Starčevo culture and the LBK were excavated in addition to the remains of the Lengyel culture at the south-western excavation site of Bátaszék-Malomréti dűlő (area 4) and Bátaszék-Mérnökségi Telep (area 6). A settlement of the Late Neolithic Sopot culture was discovered at a distance of c. 1.5 km from Alsónyék, Hosszú dűlő (area 7; *Fig. 38*).

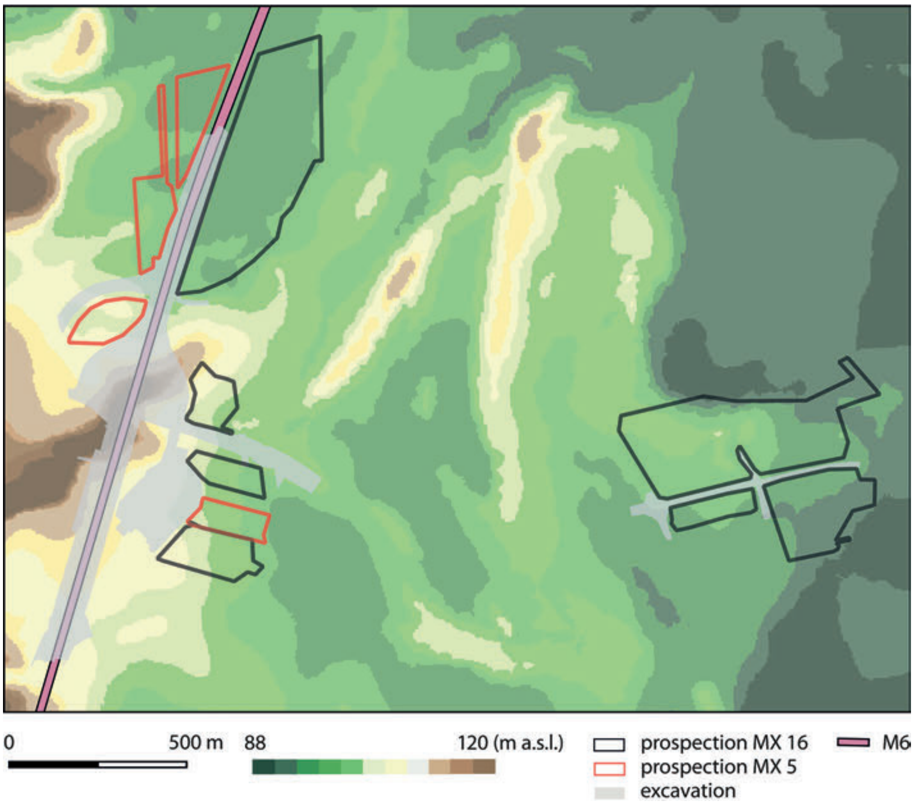


Fig. 39. Alsónyék. Overview of geomagnetic prospection areas examined between 2011 and 2014. Base map DEM.

The overall investigated area of both excavation areas follows the road construction. It opens a valuable transect on prehistoric sites of different periods in the region. While the large-scale excavations enriched our knowledge of the Neolithic and Late Neolithic in western Hungary, some questions have remained unanswered such as, for example, the crucial one of how far the settlement areas continued into the unexcavated areas. Further research in the peripheral areas of the rescue excavations is needed to answer the latter question. Large-area magnetic prospection was used to enrich our knowledge in this respect.

The magnetic prospection in Alsónyék was organised in the context of our investigations in Tolna-Mözs and Fajsz. It was conducted from November 15 to 17, 2011, on March 7, 2013, and from February 4 to 6, 2014 (Serlegi et al. 2013; Rassmann et al. 2015a; 2015b). Our prospections provided data for the periphery of both excavation areas (nos 1–7; *Figs 38–41*) and covered almost the entire periphery of area 7 in the east. Regarding the surroundings of the excavation on the M6 motorway (areas 1–6; *Figs 38–39*), the magnetic data are representative of the eastern and north-eastern periphery of the excavation area. There is still a gap south-westward of the M6 motorway excavation *(Fig. 39)* due to the fact that we did not have access to the fields.

The prospections in 2011 and 2013 using the 16-channel system covered 40 ha in total. When we returned in 2014, we operated with the 5-channel equipment on smaller areas of around 7 ha *(Fig. 39)* in the north-west and on the northern periphery. The magnetic data revealed numerous archaeological features (e.g. a ditch – *Fig. 41.1*) correlating with the excavated ones.

The Starčevo settlement at Bátaszék-Mérnökségi telep (area 6)

The southern portion of the rescue excavations brought to light numerous pits that can be dated to the Early Neolithic Starčevo culture (Osztás et al. 2016a, 12 f. fig. 4; Oross et al. 2016a, 102 fig. 5). The settlement features of the Starčevo culture are concentrated in clusters. Numerous features consist of burnt clay, especially of oval ovens (Bánffy et al. 2010, 42 fig. 6). Archaeological features of burnt clay are usually easily detectable in magnetic prospections. In the course of the present work, we opened four windows onto the southward lying area in addition to the excavations *(Fig. 40)*. The size of the prospected areas ranges from 1.5 ha to 2.8 ha. The southern prospection area of 2.8 ha is immediately adjacent to the excavated Starčevo settlement. Inside

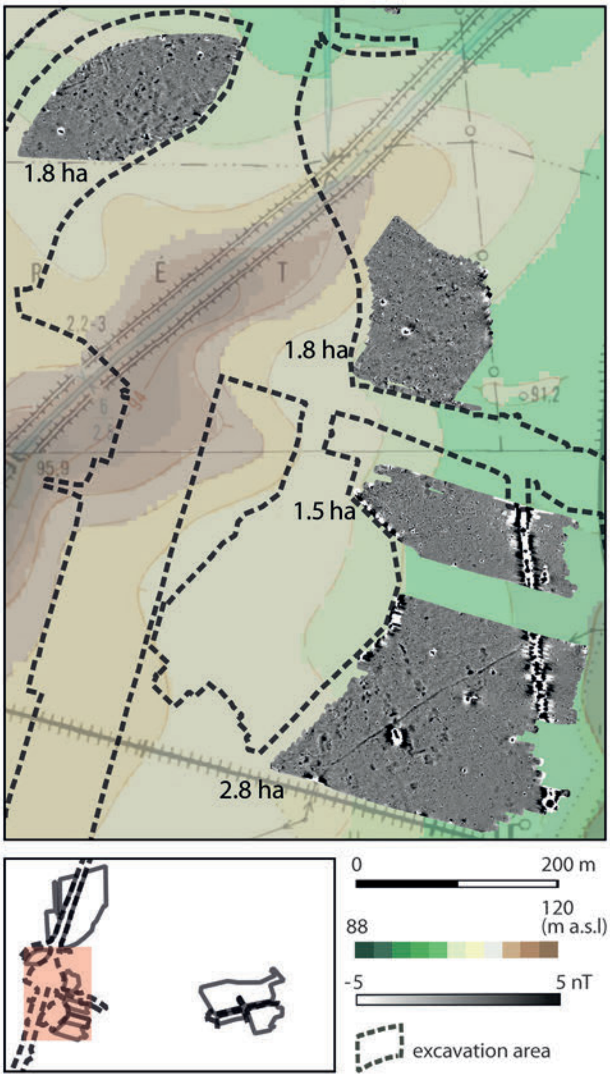


Fig. 40. Alsónyék. Alsónyék-Kanizsa-dűlő (area 2), Bátaszék-Malomréti dűlő (area 4), and Bátaszék-Mérnökségi Telep (area 6). Overview of the eastern prospection areas showing anomalies mainly connected to the LBK (north) and the Lengyel culture (south). Base map DEM.

this prospection area, more than 1000 anomalies can be interpreted as archaeological features *(Figs 41–42)*. The majority of these features can be assigned to the Early Neolithic with a high probability.

Irregularly shaped anomalies with higher magnetic amplitudes (nT) have the highest probability of belonging to the Starčevo culture (c. 3–15 nT). The excavation on the Starčevo settlement brought to light many structures such as the above-mentioned ovens and indefinable house remains of burnt clay (Bánffy et al. 2010, 38 fig. 1). The analysis of the burnt structures, specifically of the burnt daub, is part of an ongoing research project (Bánffy / Höhler-Brockmann accepted). There are indications that some of the daub came from houses. However, the form and layout of the houses remain to be clarified. The distribution of the architectural features in the excavation is largely uneven. There are some indications for paths (linear corridors without archaeological features) and clusters of obviously archaeological features. Similar patterns can be discerned in the magnetic data. Irregular, large anomalies with a size between 2 and 20 m^2 are the most characteristic. These anomalies are characterised by a mean magnetic amplitude of 3–5 nT *(Fig. 42c–d)*, the maximum often surpassing 8 nT.

A linear ditch is clearly visible in the prospection area. The ditch is interrupted by a small gap *(Fig. 41.1)*. The gap is accompanied by a semi-circular ditch. Both elements indicate an entrance. There are three other circular anomalies in the same area. At first glance, the distribution of the circular anomalies does not appear to have any spatial order. However, a kernel density estimation (KDE) revealed two concentrations and one area with a higher density around the entrance *(Fig. 42c–d)*. A correlation might indicate they are contemporaneous with the ditch.

The fact that the ditch crossed the anomalies of the Starčevo culture directly indicates a later, Lengyel period date for this structure (Osztás 2019).

One crucial question that might be answered by the magnetic prospection concerns the size of the Starčevo settlement. Considering the noise in the data and the uncharacteristic distribution of the anomalies, the spatial analysis by KDE is obvious (cf. *Fig. 42*). Therefore, we used the standard workflow as applied to the data from Fajsz and Tolna (cf. *Fig. 6*). By processing the 1 nT polygons, we count 983 anomalies with an area upwards of 1 m^2. When using the centroids of these objects for the KDE, two concentrations become evident. The KDE was calculated using all filtered anomalies on the map as shown in *Figure 42*. The KDE used a radius of 40 m and was weighted by the size of the magnetic anomalies. One small area with high density is located around the entrance of the ditch and a second one in continuation of the excavated Starčevo settlement.

The well visible area with the higher density of anomalies is precisely in the continuation of the excavated Starčevo settlement. The picture becomes clearer by mapping selected polygons larger than 2 m^2 and maximum magnetic amplitudes higher than 5 nT. We can note a clear correlation between these anomalies and the KDE map. Obviously, the majority of the filtered anomalies correlate with the settlement area of the Starčevo culture *(Fig. 42)*. The magnetic data allow for an optimised reconstruction of the settlement area. When integrating the excavation data and the results of the magnetic prospection, the size of the settlement area can be estimated as 5.8 ha.

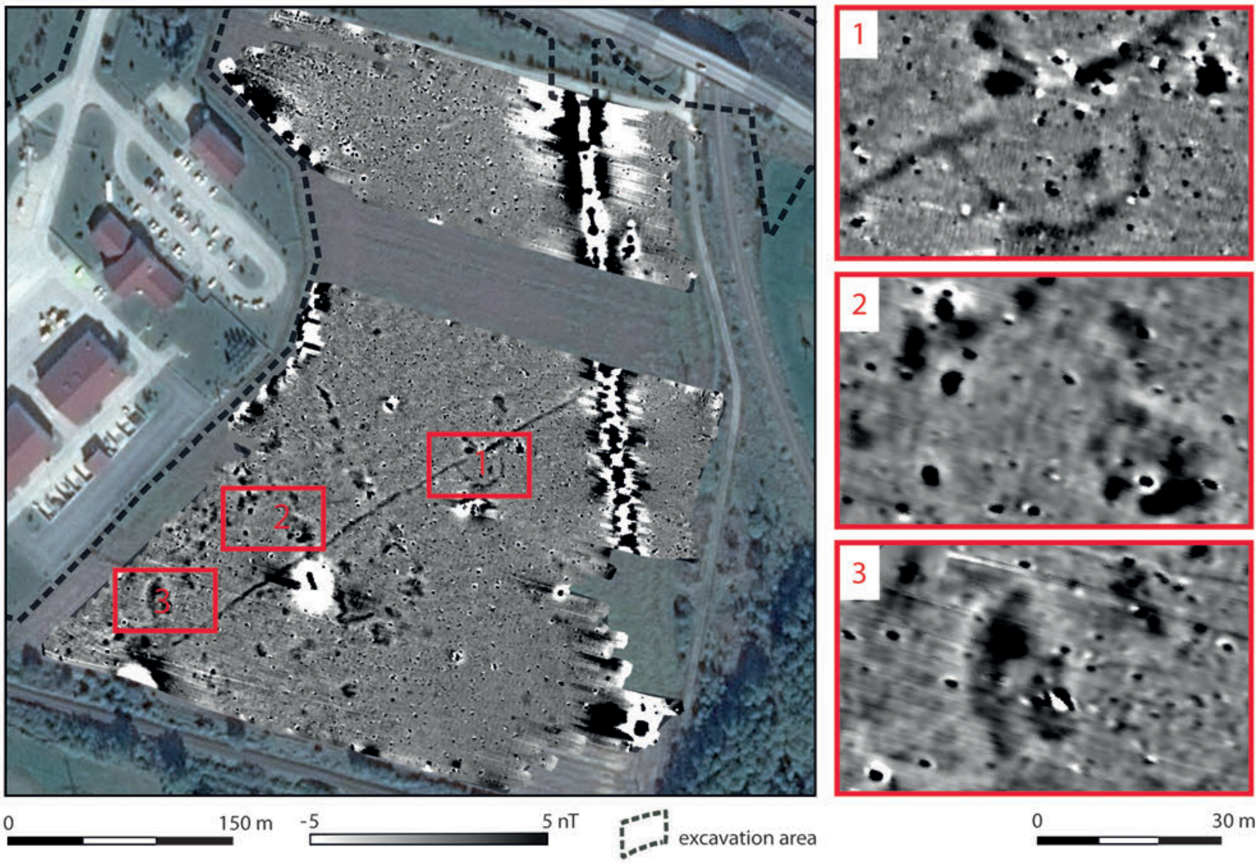


Fig. 41. Alsónyék-Bátaszék-Mérnökségi Telep (area 6). 1 Linear magnetic anomaly and an entrance-like feature; 2–3 irregular magnetic anomalies, presumably features of the Starčevo culture, possibly caused by burnt clay.

The magnetic data are too noisy for answering any further questions on the internal spatial structure of the settlement. However, there is a potential to gain a greater insight by the use of other non- or minimum intrusive methods such as soil chemistry in combination with drillings and geophysical methods such as ERT (electrical resistivity tomography) and GPR (ground penetrating radar). These are useful methods for which an appropriate excavation and fieldwork design should be developed.

The Linearbandkeramik (LBK) settlement near Alsónyék-Kanizsa-dűlő (area 2) and Bátaszék-Malomréti dűlő (area 4)

Numerous LBK features could be identified in the central part of the rescue excavation on the M6 motorway construction site (Oross et al. 2016b, 124–130) as shown by the overview map *(Fig. 43)*. The settlement remains of the LBK extend from area 2 and in the northern part of area 4. The excavation revealed a large number of elongated pits originally flanking the long sides of the timber framework of the LBK houses. Altogether, 50 of these could be reconstructed, whose majority (46) were found in area 4. Beside the elongated pits, numerous other features were excavated, in part belonging to other periods. Only some postholes correlating with the elongated pits were excavated.

The 46 houses in area 4 formed different clusters consisting mainly of two to four houses (Oross et al. 2016b, 124). One key observation for the reconstruction of the area of the LBK settlement is the remarkable concentration of 90 % of the houses in area 4. The density of LBK features in area 2 is much lower.

The magnetic data from areas 2 and 4 are very noisy. Unlike at Tolna-Mözs, significant structures such as houses or elongated pits are not visible. There are 964 anomalies with an area of 1 m² and an amplitude of more than 1 nT. When selecting polygons larger than 2 m² and magnetic maxima below 20 nT, only 234 objects remain. However, all of them are uncharacteristic. The methodological challenge is to find indications for the boundary of the LBK settlement in the noisy data. We tried KDE based on the 934 1 nT anomalies, but did not find any significant patterns. Our interpretation of

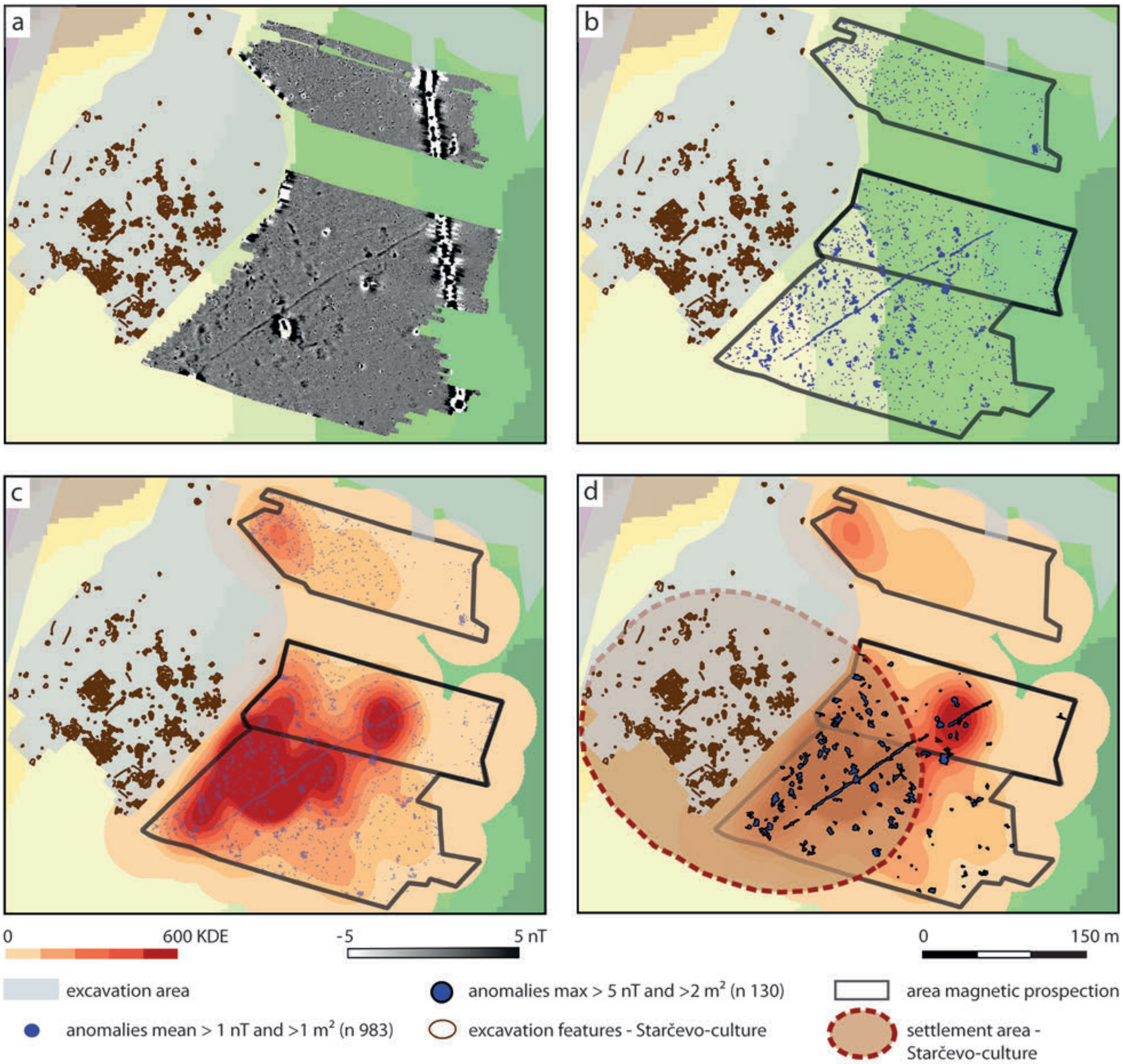


Fig. 42. Alsónyék-Bátaszék-Mérnökségi Telep (area 6). Prospection and excavation data in the south-eastern area showing settlement features of the Starčevo culture and a linear ditch with an entrance. a Excavated settlement features of the Starčevo culture and magnetic data. b Excavated settlement features of the Starčevo culture and the generated anomalies following the 1 nT contour line. c Excavated settlement features of the Starčevo culture and the generated anomalies following the 1 nT contour line and a kernel density estimation (KDE) based on the centroids of the 1 nT anomalies > 1 m^2. d Excavated settlement features of the Starčevo culture and the generated anomalies following the 1 nT contour line with an area > 2 m^2 and maximum magnetic amplitudes > 5 nT, and the estimated area of the Starčevo settlement.

this indefinable picture is that it reflects the overlap of numerous anomalies from different occupation periods from the Early Neolithic to the Medieval period.

In conclusion, there are some uncertainties in our estimate for the size of the LBK settlement area. The lack of elongated pits in the magnetic data might indicate that these areas were one part of the LBK settlement. Based on this assumption, an estimate of around 10 ha is very optimistic, but a much smaller one is more realistic as we can see from the concentration of house remains in the southern part of the excavation area *(Fig. 42)*. A specific weighing of the distribution of the house clusters in the excavation area might lead to a settlement size of 3–6 ha.

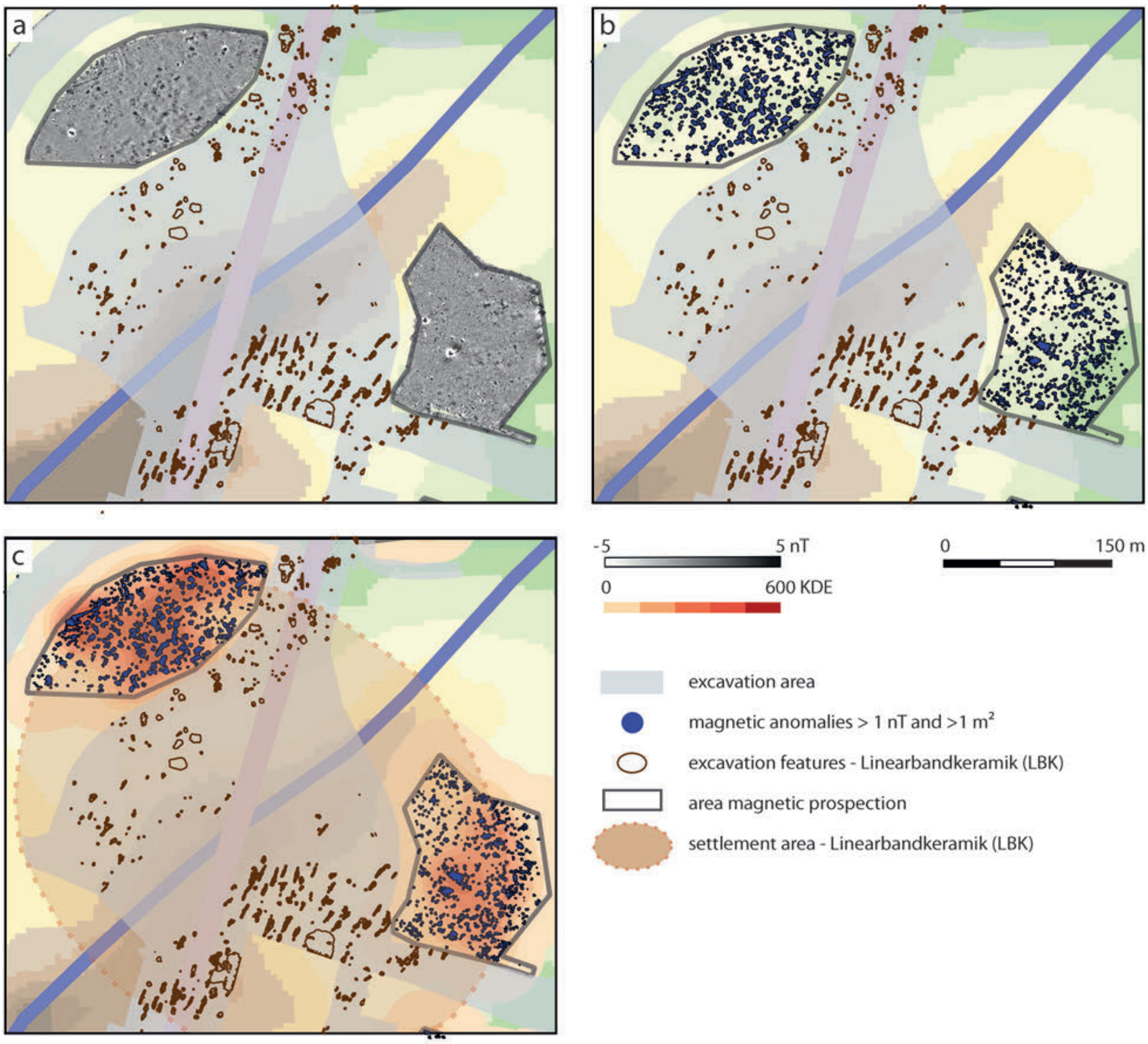


Fig. 43. Alsónyék. Alsónyék-Kanizsa-dűlő (area 2) and Bátaszék-Malomréti dűlő (area 4). Overview of the excavation and the magnetic prospection results of the LBK settlement area. a Overview of the magnetic prospection; b magnetic anomalies with 1 nT and higher with an area > 1 m^2; c kernel density estimation (KDE)-calculation of the magnetic anomalies in comparison to the excavation features of the LBK.

The Lengyel settlement at Alsónyék: Alsónyék-Kanizsa-dűlő (areas 1 and 2), Bátaszék-Malomréti dűlő (area 4), and Bátaszék-Mérnökségi Telep (area 6)

The 15 000 features uncovered during the excavation are dominated by the 9000 features of the Lengyel culture. The richness of settlement features is indicated by the 122 houses whose timber framework is marked by postholes and the nearly 2300 burials of the same period (Osztás et al. 2016b). The majority of the settlement features can be found in the northern part of the excavation area at Alsónyék-Kanizsa-dűlő (areas 1 and 2), Bátaszék-Malomréti dűlő (area 4), and Bátaszék-Mérnökségi Telep and Bátaszék-56-os út (area 6). The magnetic prospection investigated larger areas on the north-eastern and north-western periphery of the Lengyel settlement. Whereas the density of relevant archaeological anomalies is low in the western prospection area, it is high in the north-eastern area.

House remains are clearly visible in the magnetic prospection data (*Figs 44; 45.1–2*). Their size and shape indicate similarities to the 122 excavated houses. Obviously, the internal structures are much less detailed in the magnetic prospection data, particularly the postholes found in large numbers during the excavation, which

Fig. 44. Alsónyék. Alsónyék-Kanizsa-dűlő (areas 1 and 2). Overview of the magnetic prospection in the north-western areas showing anomalies mainly dating to the Lengyel culture and later periods (Middle Bronze Age?). Base map DEM.

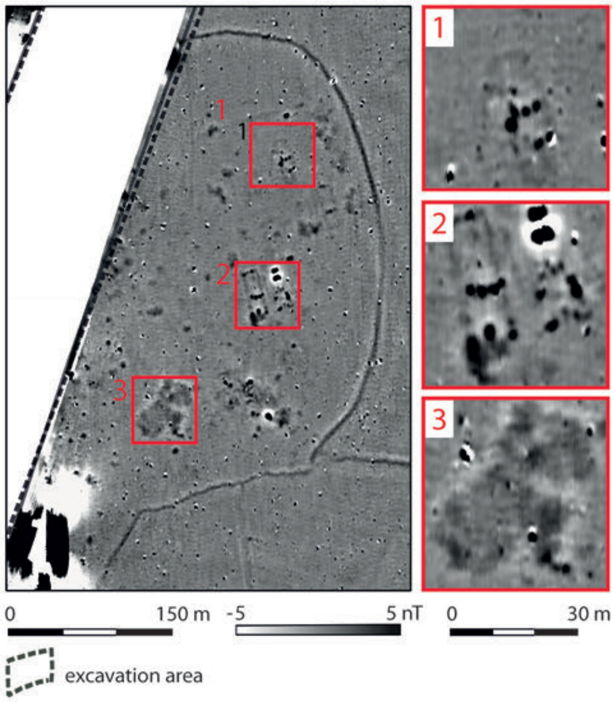


Fig. 45. Overview of the prospection in the north-eastern areas with ditches, house remains, and pits. 1–2 House anomalies; 3 a large structure, possibly a pit for clay extraction.

rarely showed up in the magnetic data *(Fig. 45.1–2)*. Besides the small number of postholes, indications for ovens and linear structures aligned to house walls are visible in the magnetic data. These indicate rows of postholes (Osztás et al. 2016b, 194 fig. 9). Large pits with a diameter between 1.5–1.8 m are clearly visible in the middle of the houses. Their size and position inside the house are similar to the excavated houses (Osztás et al. 2016b, 194 fig. 9).

Further relevant features are indications of pits for clay extraction *(Fig. 46)*. An extraordinarily large structure is visible in the southern part of the north-eastern prospection area *(Fig. 45.3)*. Smaller, similar structures are unevenly distributed. The magnetic contrast is low, some of them are framed by the 0.5 nT contour line. On this level, there is also a lot of indifferent noise *(Fig. 46.1)*. Therefore, the precise identification of the clay extraction pits is difficult, it is more likely for structures larger than 6 m^2 (cf. *Fig. 43c*). Despite some uncertainties, they are clearly more frequent than the houses. An optimistic interpretation of the magnetic data in the north-eastern prospection area allows the reconstruction of a larger number of houses. The number of possible pits for clay extraction is probably more than twice that number. In some areas, we observed a specific correlation between house remains and the occurrence of larger pits *(Fig. 46.1–3)*. In some areas in the north, more pits than houses are evident, the latter observation suggesting that only a part of the house remains are visible in the magnetic data (cf. *Fig. 48* below*)*, and that their real number must be higher.

An exceptionally high number of Lengyel burials were brought to light during the rescue excavation along the M6 motorway (Osztás et al. 2016b, 182 figs 2–3), making the assemblage one of the most important in the European Late Neolithic because of the large number of well-preserved skeletons. The human bodies were buried mainly in grave pits and very rarely in settlement features independent of the houses. Their sizes vary between 2.5–4.0 m^2. Around 2300 graves clustered in 92 burial groups were found (Osztás et al. 2016b, 184). The grave pits contain the skeletal remains and grave inventories, which, however, do not result in a detectable contrast in the magnetic data. Only the refilling of the grave

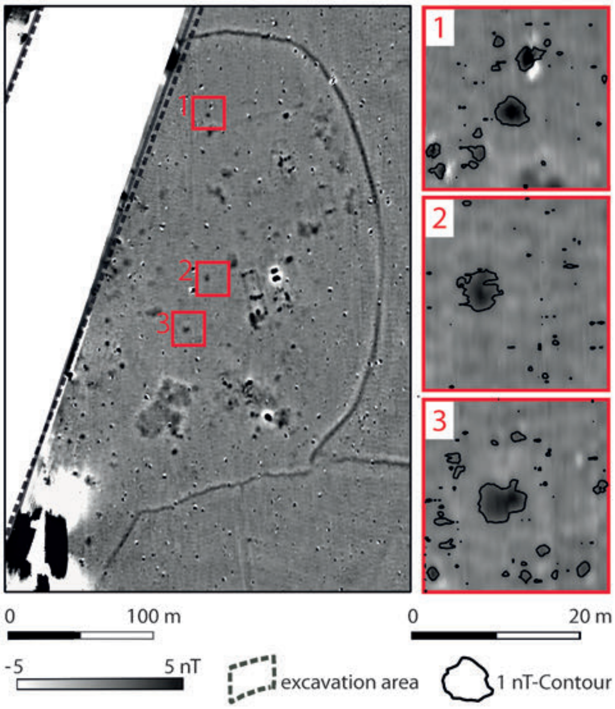


Fig. 46. Overview of the prospections in the north-eastern areas. 1–3 The highlighted areas might indicate clay extraction pits.

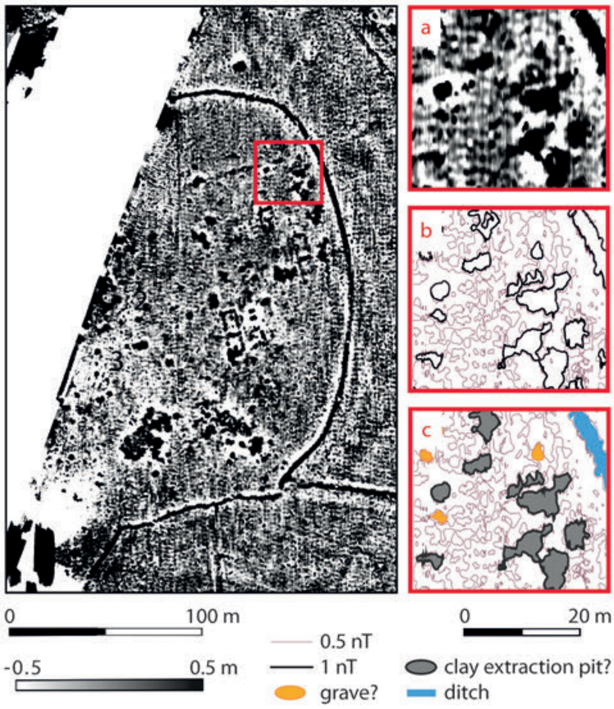


Fig. 47. Overview of the magnetic prospection in the north-eastern areas. Anomalies interpreted as pits. a Magnetic data; b calculated contour lines 0.5 and 1 nT; c interpretation of the anomalies.

pits – sometimes after the later robbing of the graves – might cause a contrast, probably in a similar range of between 0.5–1.0 nT as the clay extraction pits.

Taking the low magnetic contrast features into account, we calculated two contour lines with 0.5 and 1 nT. The 0.5 nT contour line presumably revealed relevant archaeological features. However, these are embedded in a noisy set of more than 30 000 features, which are dominated by indeterminable features reflecting largely extended disturbances of the SUV. This noise is evident as a ripple-line pattern in the data *(Fig. 47)*. It is obviously caused by vertical movements of the magnetometer array or low-current inductions in the magnetometer system. Of higher relevance is the 1 nT contour line. The 1 nT line framed as above reveals large clay extraction pits as well as possible grave pits *(Fig. 47.a–b)*. The latter are much smaller, with a size ranging between 3–6 m^2. There is a small number of c. 30 anomalies inside the ditch. The magnetic contrast is low, with around 1 nT. The difficulties of filtering relevant features from the north-eastern prospection area is evident when considering the relation of the total of around 30 000 anomalies to the number of only about 23 houses, c. 40 clay extraction pits, and c. 30 pits that might classify as grave pits.

Ditches enclosing the house clusters are easier to recognise in the dataset. This might be an indication that the ditches can be dated to the same occupation period, but they may as well date to the Bronze Age.

We may conclude that the house remains in the prospection area are a continuation of the houses observed in the excavation area and that the houses are surrounded by the large ditch. The ditch enclosing the settlement narrows towards the south *(Fig. 48)*.

Analysis of the magnetic anomalies

The features described above as house remains and clay extractions pits are clearly visible in the magnetic data. In order to calculate the area of Lengyel culture settlement, the information acquired with the magnetic prospection and the excavation has to be set into context. Based on the prospection alone, it remains uncertain whether the features can be dated to the Starčevo or the Lengyel settlement phase. The ditch might belong to the Lengyel culture. As a matter of fact, inherent to the magnetic data are uncertainties with respect to dating them. Despite these uncertainties, broad reconstructions are possible.

The graves and the settlement remains indicate different patterns in the excavation area along the M6 motorway. Some of these differences might reflect the specific conditions of the rescue excavation and should be discussed in more detail in the future. However, with respect to the reconstruction of the general spatial pattern, it might be negligible.

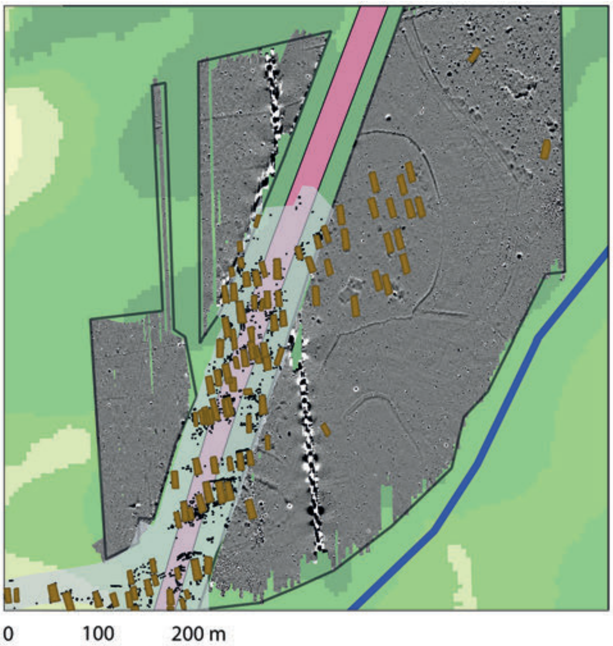


Fig. 48. Alsónyék-Kanizsa-dűlő (areas 1 and 2). Overview of the magnetic prospection in the northern areas showing anomalies mainly from the Lengyel cultures. Base map DEM.

The kernel density estimation (KDE) of the grave centroids indicates groups in the south at Bátaszék-Malomréti dűlő (area 4) and Bátaszék-Mérnökségi Telep (area 6). In the north, at Alsónyék-Kanizsa-dűlő (areas 1 and 2), there is only one large concentration *(Fig. 49a)*[10]. Outside these areas with a high density of graves, some further graves were found during the excavation, but the latter were of a considerably lower density. When evaluating the KDE of the grave centroids, we have to bear in mind that no data from the magnetic prospection were considered. Therefore, the KDE map only provides information based on the distribution in the excavation area.

For house remains, data from both the excavation and the magnetic prospection were processed *(Fig. 49b)*. The house remains of the Lengyel culture are widely distributed in the excavation area. However, in the magnetic data they are only evident in the north (cf. *Fig. 48*). The area with a high density is limited to the northern part at Alsónyék-Kanizsa-dűlő (area 1; *Fig. 49b*).

The differences in the general spatial distribution of graves and houses are clearly evident. Additionally, the KDE map can be used to estimate the general distribution of graves in both settlement areas. The question marks indicate areas around the excavation on the M6 motorway where no magnetic prospection data were available *(Fig. 49c)*.

Based on the KDE for both datasets (graves and house remains), the size of the Lengyel site could be roughly estimated despite some persistent uncertainties. The graves and settlement features are distributed unevenly in clusters. The size of the territory covered by the graves and the settlement is roughly 23.5 ha and 24.0 ha, respectively. Bridging the gaps between the clusters, the Lengyel culture is distributed at least over a total area of c. 47.5 ha. The overall territory might be larger because of the gap in the magnetic prospection data in the south-west.

Undated, presumably Middle Bronze Age features in the north-east

Interestingly enough, no settlement remains were observed in a c. 50 m wide zone in the outer periphery of the ditch *(Fig. 50)*. Besides the clear indications of settlement remains, wide areas without any evidence for archaeological features are visible. The absence of clear settlement features indicates the boundary of the Lengyel settlement eastwards of the excavation area. Behind a double line feature, we found an area with a higher density of circular anomalies, presumably pits, which might originate from the Middle Bronze Age.

The pits are of different sizes *(Fig. 50.1)*, the largest of which is approximately 5 m in diameter, suggesting an interpretation as a storage pit, while the high contrast possibly indicates a secondary function as a refuse pit for settlement waste.

Similar to the area of the Lengyel settlement, some large indifferent and irregular anomalies can be identified as possible pits for clay extraction. More significant are the remains of two houses *(Fig. 50.2–3)*. As in the Lengyel settlement, the house forms are outlined by the bedding trenches. Their internal structure and the distribution of postholes differ from the buildings of the Lengyel settlement. The dating of the house features remains unclear at this time. An argument against their context in the Lengyel culture is their location far beyond the ditch of the Lengyel settlement.

The area around the eastern slip road of the M6 motorway at Alsónyék, Hosszú dűlő, area 7

1.2 km east of the prospection area along the main route of the M6 motorway, approximately 30 ha of farmland were prospected along the eastern slip road *(Figs 51–52)*. Rescue excavations brought to light several ditches and graves of the Sopot culture (Oross et al. 2016c). The

10 A recent analysis of the Lengyel settlement pattern modifies some statements of this KDE analysis (Osztás 2019).

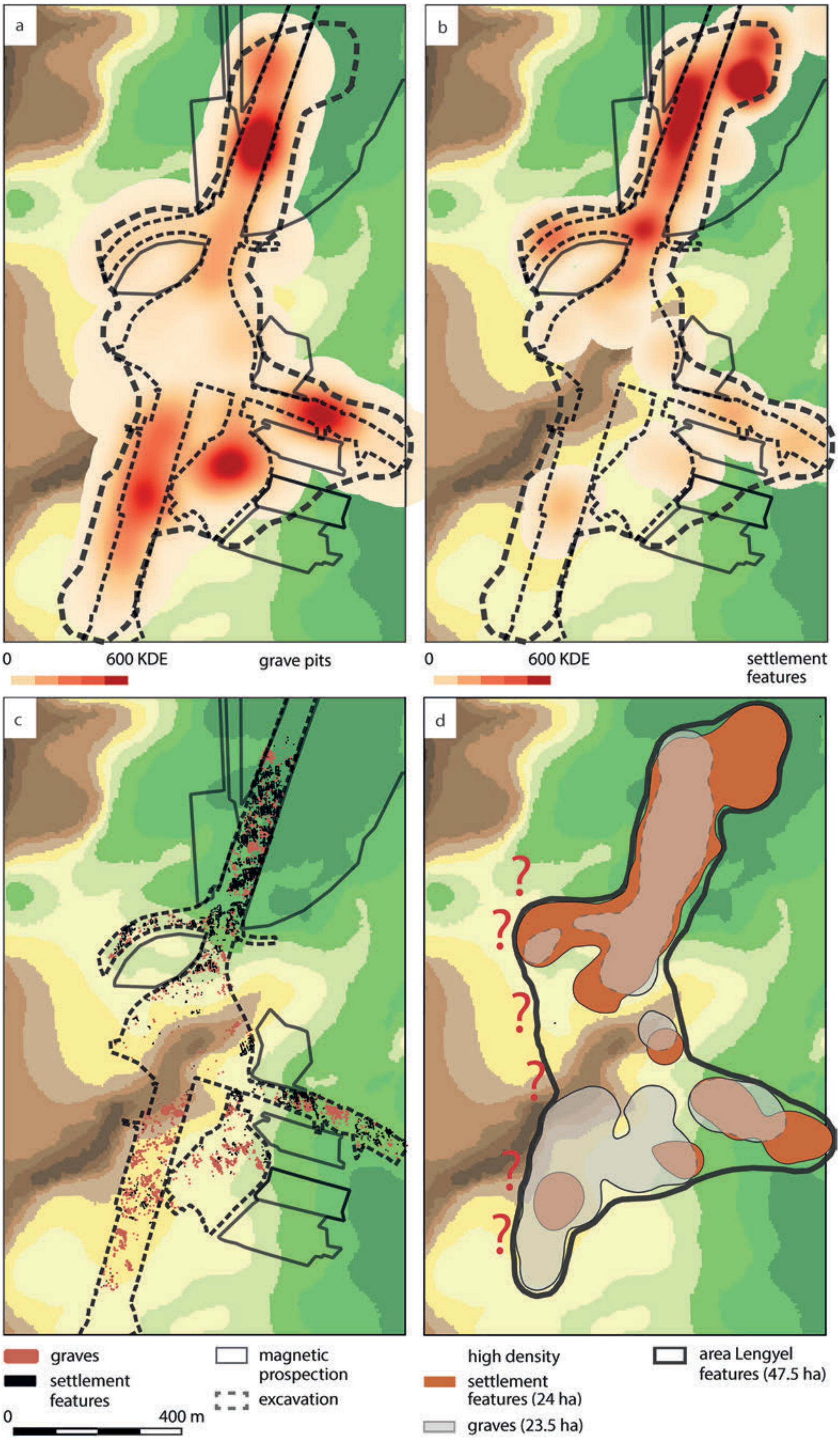


Fig. 49. Kernel density estimation (KDE) of the Lengyel culture houses and graves. a KDE of grave centroids from the excavation; b KDE of the house remains of the excavation and magnetic prospection; c overview of the graves and the settlement features in the excavation area; d generalised model of the grave and house clusters of the Lengyel culture based on the KDE contour map. Base map DEM.

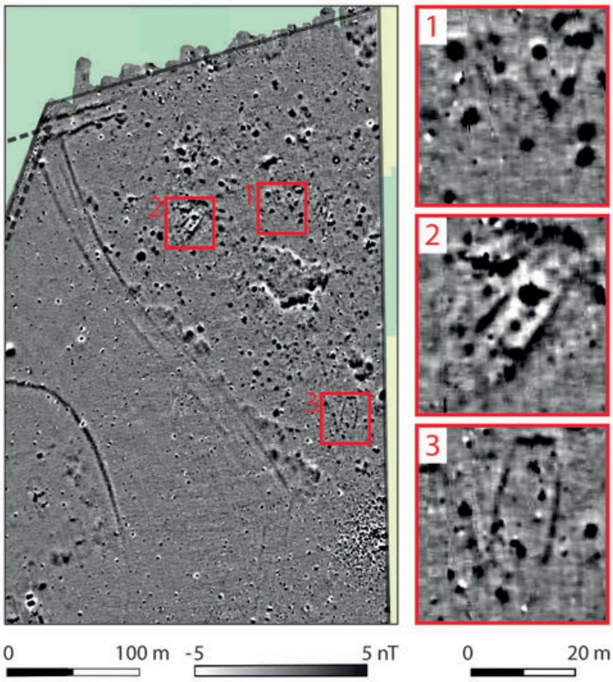


Fig. 50. Alsónyék-Kanizsa-dűlő (area 1). Overview of the magnetic prospection in the north-eastern areas showing anomalies mainly from the Lengyel cultures. Base map DEM.

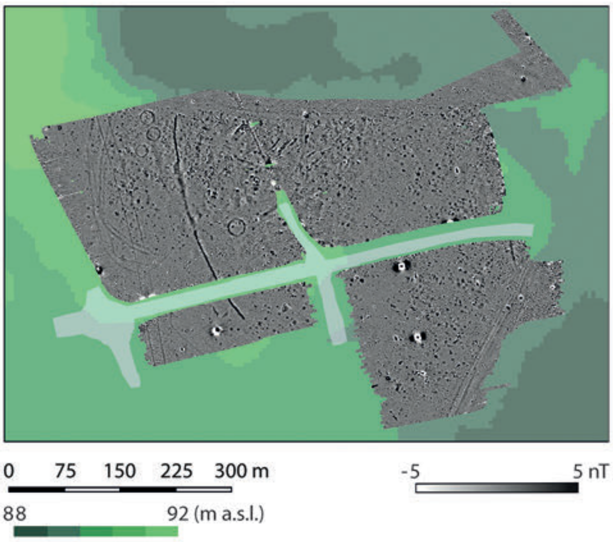


Fig. 51. Alsónyék, Hosszú dűlő (area 7). Overview of the eastern prospection areas showing settlement features of the Sopot culture and later prehistoric, probably Iron Age barrows. Base map DEM.

magnetic prospection investigated the area north- and southwards of the rescue excavation and revealed a high density of anomalies that was remarkably higher than in the western area close to the M6 motorway. The magnetic anomalies indicate a wide range of archaeological features such as ditches, various pits, house remains, and circular ditches / barrows. The data clearly show settlement activities and the existence of a burial ground. The different types of pits and house remains reflect activities in different periods. On the one hand, the clear evidence from the rescue excavations highlighted the presence of the Sopot culture, while on the other hand, some of the features might date to the Late Bronze Age. The larger number of pits in the eastern and south-eastern area remains to be investigated through further research.

The site lies in a characteristic topographical location on a flat elevation surrounded by a former riverbed, virtually forming a peninsula as we know from the maps from the 18th and 19th centuries (cf. *Fig. 57a–b*).

Permanent access to the plateau was probably available only from the west. Exactly in this zone, the magnetic prospection revealed a ditch perpendicular to the peninsula. The size and the shape of the ditch varied. The topography and the ditches indicate that the location was chosen for its potential for defence against intruders.

The linear features *(Fig. 52, nos 1–7)* differ in magnetic contrast, shape, and size. The linear features nos 3–6 can probably be associated with the Sopot settlements. The double linear feature (no. 2) most likely indicates an old road clearly visible on the Josephinian cadastre *(Fig. 57a)*. The double line feature (no. 7) in the south-eastern part of the prospection area might be considered as an additional road *(Fig. 52)*. The linear features nos 3 and 4 with a much lower contrast than no. 1 are precisely parallel, as often observed in the case of Lengyel enclosures, for example at Sormás (Barna / Pásztor 2010, 119 f.). They curve eastwards, but here they are overlapped by a circular ditch of an Iron Age (?) barrow. Close to the rescue excavation, the magnetic signature is only partly visible, but still strong enough to see it connected to the ditch line of the magnetic prospection with the evidence of the excavation. Farther to the east, one weak linear anomaly indicates the final course. Despite the gaps between the ditch segments, the magnetic data clearly allow the reconstruction of the general structure of the ditch system. The existence of the two double ditches nos 3–4 and 5–6 and their counterparts in the excavation indicate at least two phases. At present, only a single radiocarbon date is available for a single grave from ditch 211 (no. 4 in the magnetic data). A more precise evaluation of the ditches and their chronology remains a task of future investigations.

Besides the linear ditches, circular ditches enclosing Iron Age barrows can be identified *(Fig. 53)*. They are of the same size and shape as a structure found at Fajsz (cf. *Fig. 11.1*). The barrows are completely eroded. Only the ditches around the former barrows are preserved and evident in the magnetic data. The ditch of the largest barrow with a diameter of 22 m *(Fig. 53.2)*

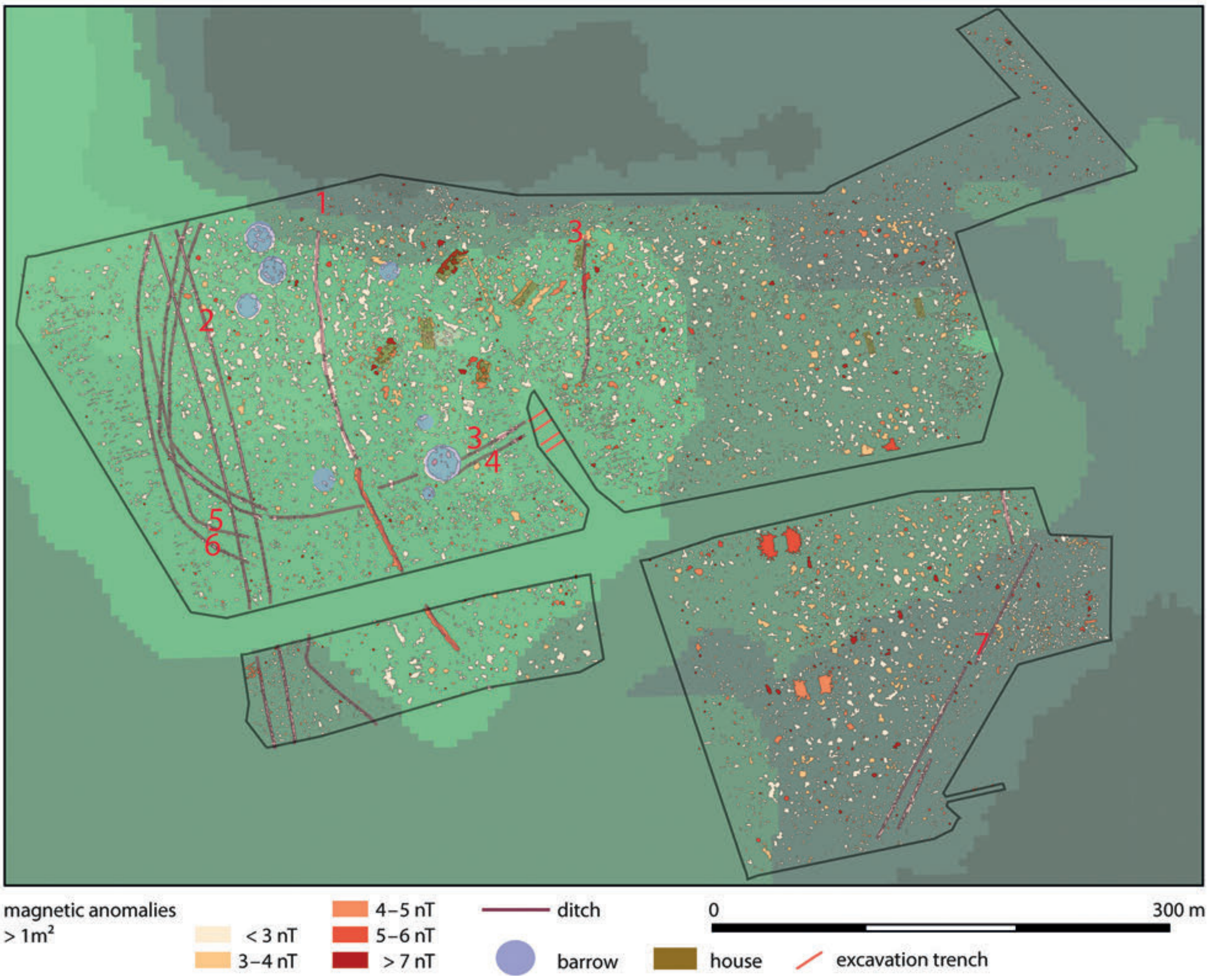


Fig. 52. Alsónyék, Hosszú dűlő (area 7). Interpretation of the magnetic data of the eastern prospection areas showing settlement features of the Sopot culture and later prehistoric, probably Iron Age barrows. Base map DEM.

is better preserved than the small round ditches in its neighbourhood to the north-west and south-west. These three smaller ditches with diameters between 15–17 m *(Fig. 53.1)* indicate a similar stage of preservation. The correlation of visibility, magnetic contrast, and preservation (?) might be explained by the use of the ditch as source of material for the construction of the barrow and its subsequent slow refill with material with a higher magnetic susceptibility. Generally, it can be assumed that a smaller barrow has a shallower ditch, whereas a larger one has a deeper ditch and a larger volume of material with a higher magnetic susceptibility, resulting in better visibility in the magnetic prospection data.

Several houses are revealed by the magnetic prospection in the northern prospection area (no. 7). Five of them are located within ditch 3 *(Figs 52; 54.1–3)*. The houses are different in size, orientation, layout, and internal structure. Four houses were identified within the prospection area on the basis of the post structures. Interestingly, each of these houses was oriented differently. The largest one can be estimated to have been 20 m long and 8 m wide *(Fig. 54.2)*.

Some of the differences might be caused by the different stages of preservation of the house remains or the process of the house's destruction. The houses might belong to the Sopot culture, but this needs to be verified by excavation with at least small test trenches.

Two house remains were found on the eastern periphery of the Sopot settlement *(Figs 52; 56)*. The dating of these houses is uncertain. We might assume that they belong to the same chronological horizon as the numerous pits in their neighbourhood (Late Bronze Age?).

The majority of archaeological features uncovered during the excavation were burials of the Sopot culture (Oross et al. 2016c). Taking the information of the excavation into account, we expect a weak magnetic contrast for graves. It is a similar situation as the one for the graves of the Lengyel culture discussed above. By

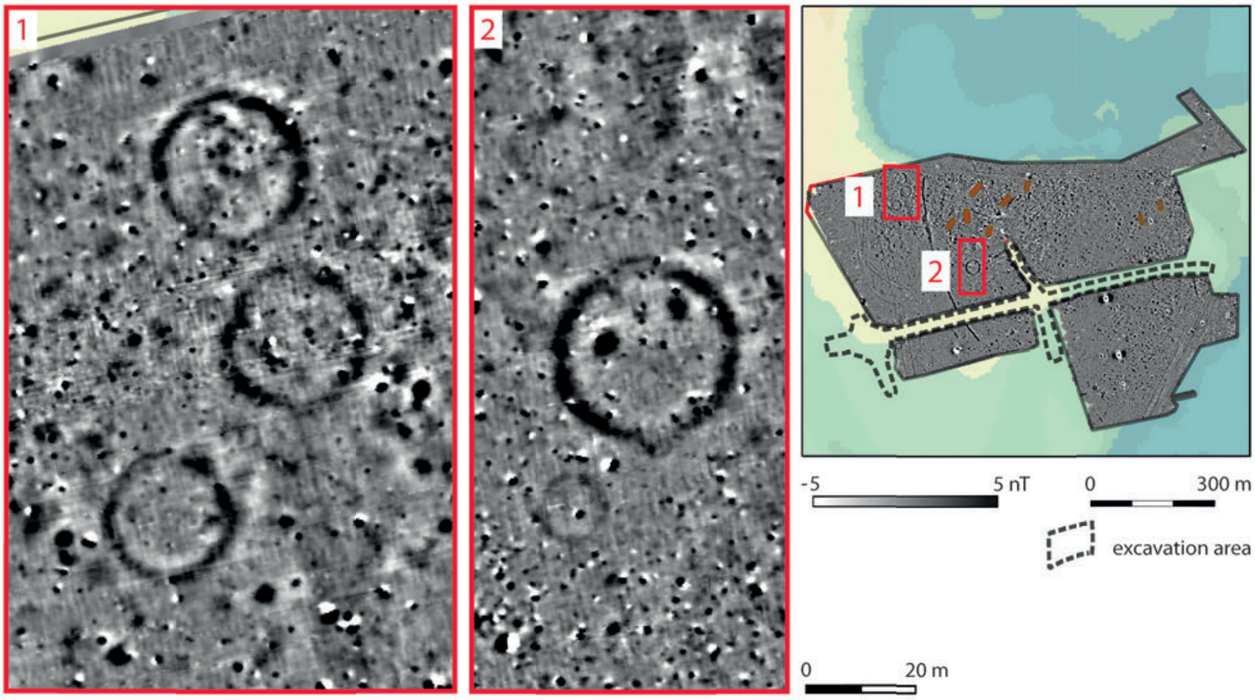


Fig. 53. Alsónyék, Hosszú dűlő (area 7). Details of the eastern prospection areas showing probable Iron Age barrows. Base map DEM.

calculating the polygons of the 1 nT contour line with an area larger than 1 m², over 7500 objects were calculated. Based on these data, a filtering of all objects within an area of between 2–6 m² resulted in more than 2500 objects. Hidden in this noise cloud of polygons, we also assume a large number of grave pits of the Sopot culture, but the reliable dating of pits based solely on the magnetic data is impossible.

A large number of settlement pits were revealed by the prospection in the eastern prospection area. Because of the uncertainties with respect to the differentiation of grave pits from small settlement pits, we selected all polygons with a magnetic amplitude of more than 3 nT and larger than 3 m². We assume that the majority of pits over 3 m² might be classified as settlement pits. By this we filtered 1399 anomalies larger than 3 m², up to 18 m². The anomalies are distributed in classes as follows: 3–6 m² = 1037; 6–9 m² = 174; 9–12 m² = 54; 12–15 m² = 39; 15–18 m² = 62. The pits are of varying magnetic contrast, with 50 % of them having a mean peak amplitude of < 4.4 nT *(Fig. 55)*.

The pit anomalies seem to have an even spatial distribution. We tested it again by kernel density estimation (KDE). The KDE highlights four areas with a higher density. The largest of these areas in the north-west is fairly big and enclosed by ditches 3 and 4 of the Sopot culture. There are four houses in the centre of this cluster. The spatial coincidence indicates an internal coherence and date in the Sopot culture. By this, we are able to reconstruct the boundary of the Sopot settlement, which only partially covered the elevation. The area enclosed by ditches 3 and 4 covers an expanse of 4.8 ha. The three other areas of higher density of anomalies might be contemporaneous with the settlement pits in these areas. Our hypothetical dating to the Late Bronze Age has to be proven by further research. Ditch 1 extended across the western plateau and might be seen in this context *(Fig. 56)*. Its function was very likely to control access from the west.

Implications. The 6th and 5th millennium BC on the basis of geomagnetic prospections at Alsónyék: From the Starčevo to the Lengyel period

The multi-period site Alsónyék lies in a diverse landscape that can be called liminal or marginal. To the west, the Szekszárd Hills with an elevation of up to 250 m a.s.l. mark the western boundary of the floodplain of the Danube and its tributaries. The different archaeological sites are located a little above the floodplain, around 92–94 m a.s.l. The area on the western boundary of the valley might be used as arable land, whereas the landscapes on the floodplain and in the Szekszárd Hills were suitable for animal husbandry in different seasons (Depaermentier et al. submitted). The maps from the late 18th and the earlier 19th century illustrate the diversity

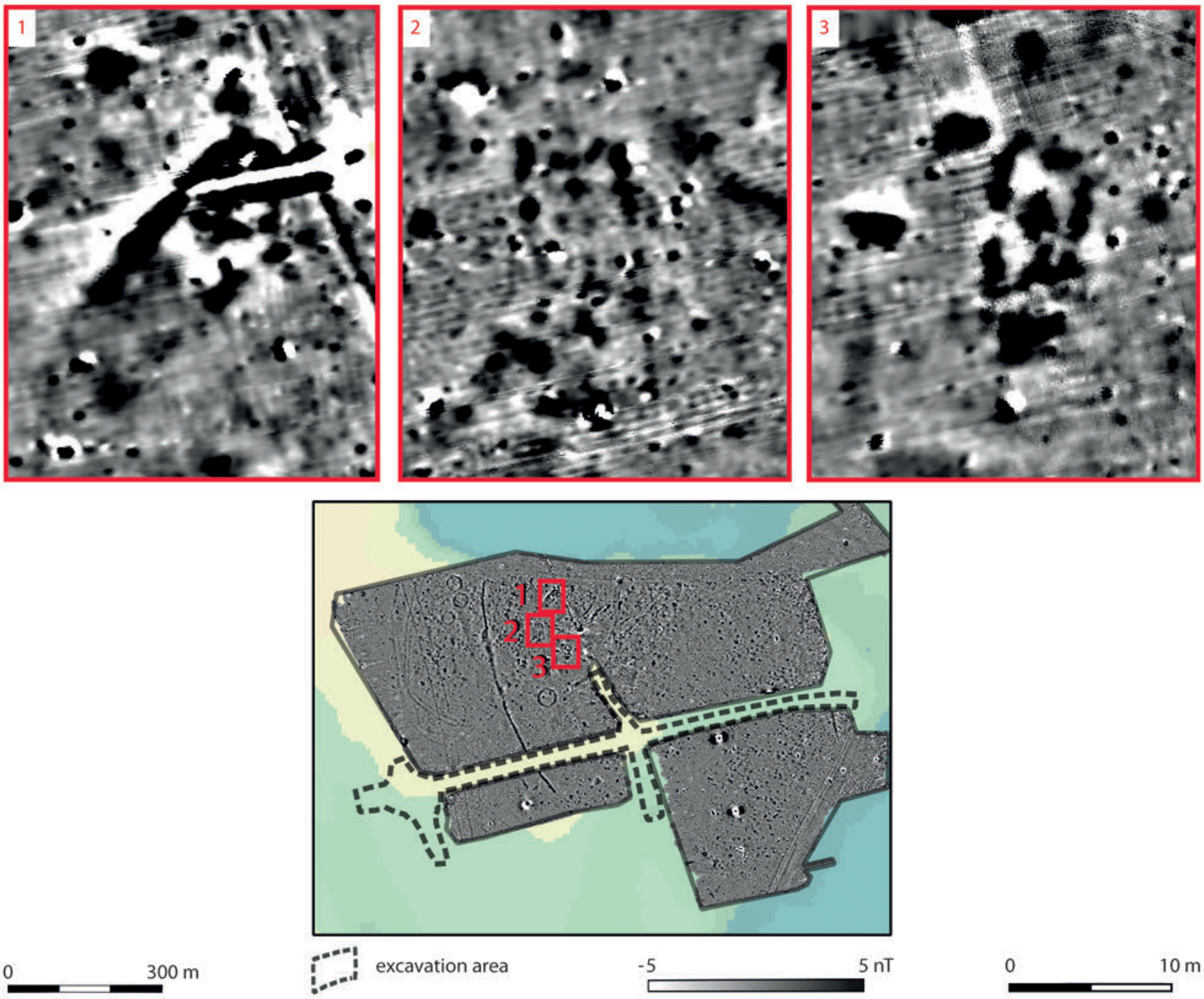


Fig. 54. Alsónyék, Hosszú dűlő (area 7). Details of the eastern prospection areas showing magnetic anomalies of houses.

and the changes in the landscape as discussed above (see Bánffy / Sümegi 2012; cf. Sümegi et al. in the present volume).

The magnetic data revealed numerous archaeological features from prehistoric periods until recent times. One of the latest features are the remains of a road visible on the Josephinian cadastre, whose course shifted decades later, as evident from the Franciscan cadastre 1806–1869 *(Fig. 57)*. The earliest features can be dated to the Starčevo culture.

The settlement remains mark the beginning and early period of human occupation in this landscape (cf. *Fig. 59*). The magnetic data revealed different concentrations of settlement remains. The combination of excavation and magnetic data can be used to reconstruct the total area of the Starčevo settlement of around 5.8 ha. The Starčevo occupation can be dated to between 5775 cal BC and 5525 cal BC (cf. *Fig. 59*). The next occupation horizon by LBK communities started around 5340 cal BC after a gap of some 200 years and lasted until 4915 cal BC (68 % probability).

The LBK settlement was located more northwards, although at a distance of less than 100 m. This might indicate an intention not to use the location of the previous Starčevo settlement. It is always an intriguing question, if this was indeed the case, to what extent people of later centuries recognised their forebears' settlement remains and, if so, what their attitude towards those remains might have been. Was this merely a practical matter to avoid bothering with the immense amount of burnt remains (which still weighed more than 2000 kg in the 21st century)? Or did it have something to do with respect, imposing certain constraints? A rather clear case for the first scenario could be noted at the Transdanubian site of Szentgyörgyvölgy-Pityerdomb, when a group of the more developed LBK phase returned to the heavily burnt remains of the settlement dating from the initial, formative LBK phase after some 150 years, perhaps

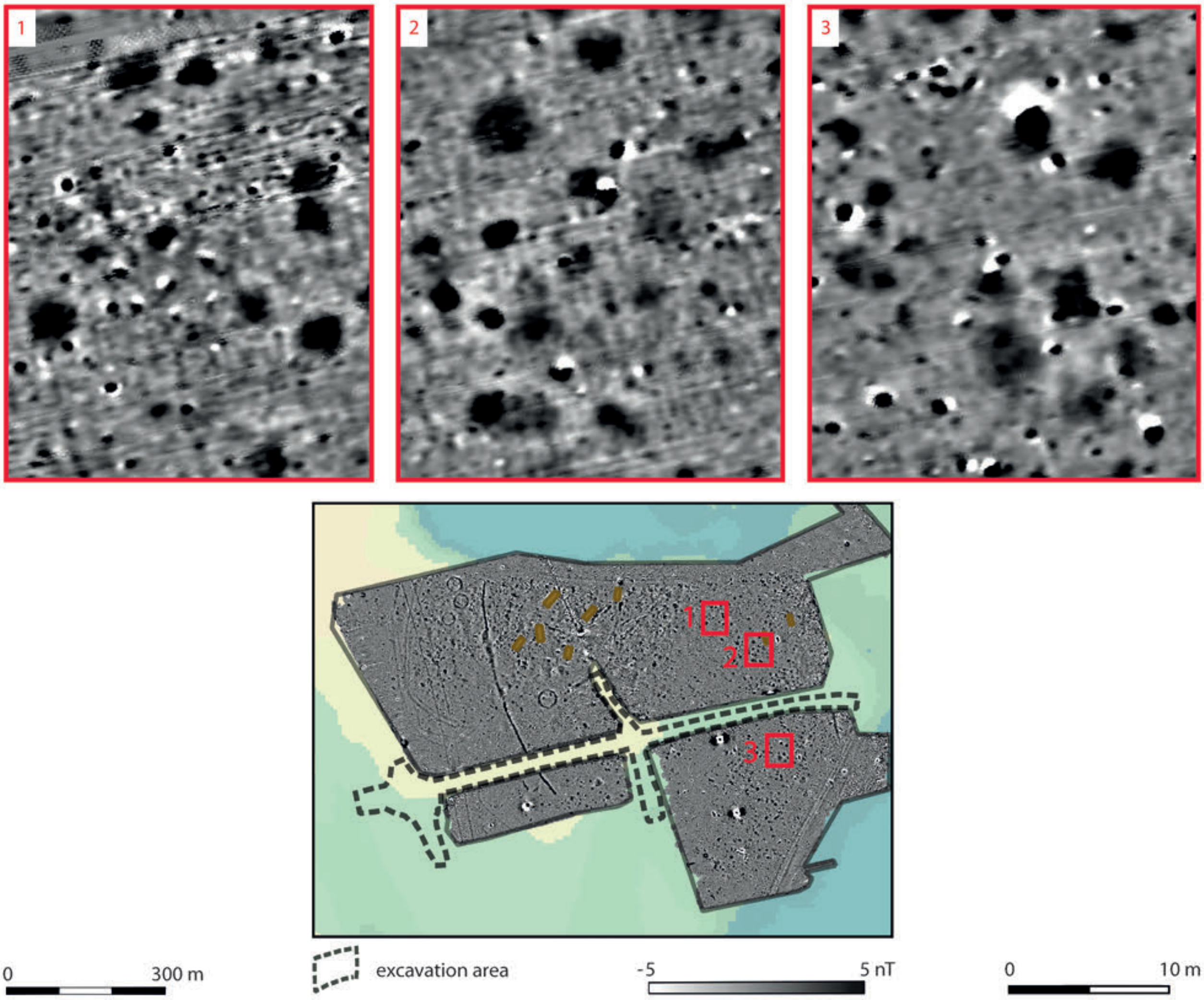


Fig. 55. Alsónyék, Hosszú dűlő (area 7). Details of the eastern prospection areas showing magnetic anomalies of settlement pits.

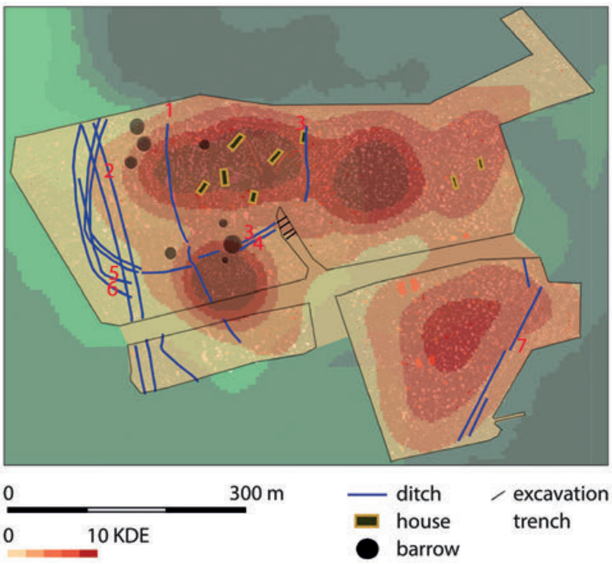


Fig. 56. Alsónyék, Hosszú dűlő (area 7). Kernel density estimation of anomalies > 3 nT and an area > 3 m².

around the late 54th to 53rd centuries BC (Bánffy 2004; Jakucs et al. 2016), and spent some time at the place, although without establishing their own settlement with longhouses. The time-gap is similar to the Alsónyék case. Judging from the rich surface finds it seems highly probable that at Pityerdomb the later LBK people, perhaps even distantly related to the first farmers, were aware of what they had found. These short visits to places that were obviously still visible may have been part of the process of constructing collective memories. This is but one possible explanation; however, the issue of avoidance *vs.* overlap between distinct periods of the Alsónyék occupants implies that this question needs to be raised separately for each case.

The archaeological features of the LBK are more widely distributed than those of the Starčevo culture. The rich excavation data for the LBK houses indicate a concentration at subsite 11 (Oross et al. 2016b, 124; 125 figs 1–2). Outside this area, the distribution of LBK

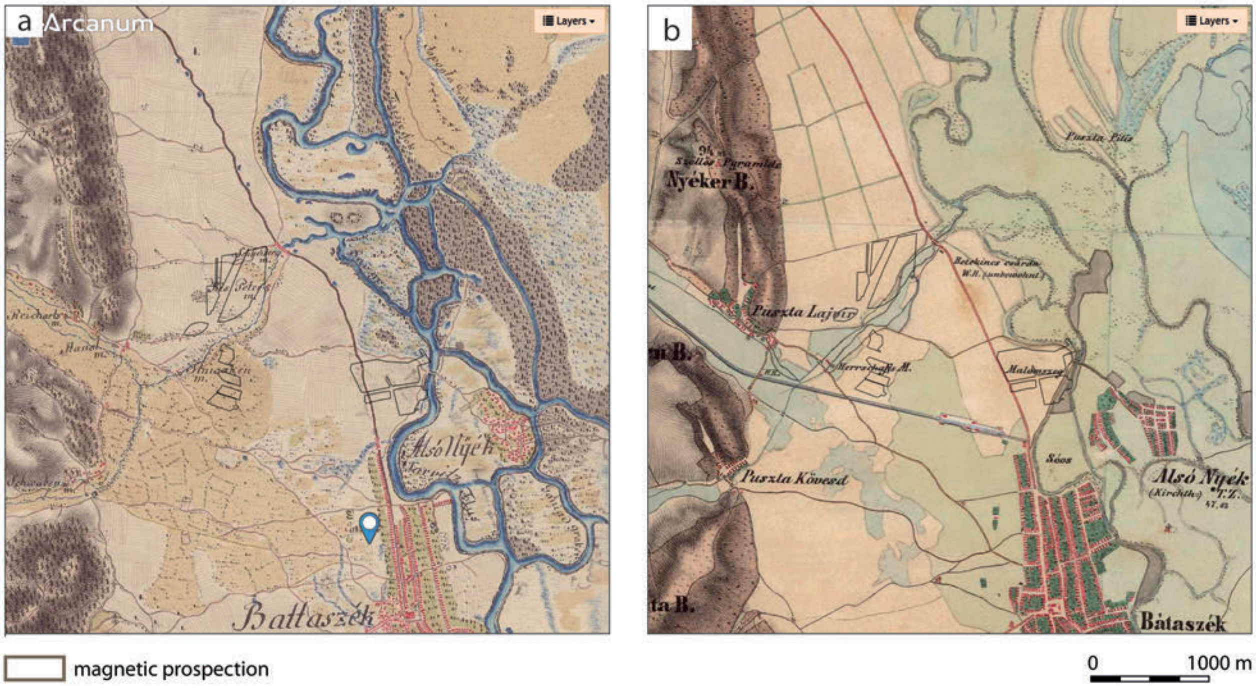


Fig. 57. Alsónyék, Alsónyék-Bátaszék. a Josephinian cadastre, 1782–1785. b Franciscan cadastre, 1806–1869. Both showing the prospection areas between the Szekszárd Hills and the floodplain.

features is less dense. Between the areas with some LBK features are large gaps without any evidence of an LBK presence. The majority of the houses are concentrated in the south (subsite 11). Taking the magnetic data into account, we are able to reconstruct the outer boundary of the LBK settlement and confirm the uneven distribution of LBK features. Very likely, the reconstructed 10 ha for the LBK settlement only marks the overall territory with LBK features, while the houses are actually distributed over a much smaller area of only 5–6 ha. If only the house areas are taken into account, the LBK settlement has a roughly similar size as the Starčevo settlement.

The next occupation phase was marked by the Sopot culture. In contrast to the relation between Starčevo and the LBK, there is no chronological gap between these occupation horizons. The overlap between the LBK and the Sopot culture is clearly evident. The Sopot culture began around 5060 cal BC and ended around 4750 cal BC (with 68 % probability) *(Figs 58–59)*. In contrast to the change from Starčevo to LBK, the new settlement was not established in the neighbourhood of the previous one. The two settlements lie at a distance of more than 1 km *(Fig. 58)*.

The final occupation at Alsónyék started with the Lengyel culture around 4800 cal BC. The settlement features and burials of the Lengyel culture are most widely distributed over an area of some 50 ha *(Fig. 58)*. The settlement features and burials indicate a clear overlap (cf. *Fig. 49*), but there are also some differences. The highest density of settlement features is in the northern area at Alsónyék-Kanizsa-dűlő (areas 1 and 2). The radiocarbon dates indicate an earlier beginning for the Lengyel occupation in the south and in the north, roughly around 4800 cal BC (Osztás et al. 2016b, 223 fig. 25). Taking these results into account, the circular ditch around the Lengyel settlement was not constructed at the beginning of the Lengyel occupation, but some three or four generations later.

The uneven distribution of the archaeological features of the Lengyel culture might be interpreted either as a shift of the settlement, or as the contemporaneous existence of different house clusters. The fact that the area with the highest density of houses is the place with the shortest occupation period of less than 50 years, whereas the areas in the south-east with low building density are characterised by an occupation lasting nearly 350 years, has implications for the calculation of settlement size and the calculation of the population change. Here, the magnetic prospection possibly raises more questions than giving answers. The probable dissolution of the converse estimations will be hopefully resolved in the dissertations focusing on Lengyel settlement patterns and buildings at Alsónyék. Most probably, an intra-site population shift should also be taken into consideration, certainly at around 4730 cal BC when the northern, 10B part of the Alsónyék Lengyel settlement (cf. *Fig. 38*) suddenly began to grow, until the aggregation reached a previously unobserved size, with some 50 times as many people moving to

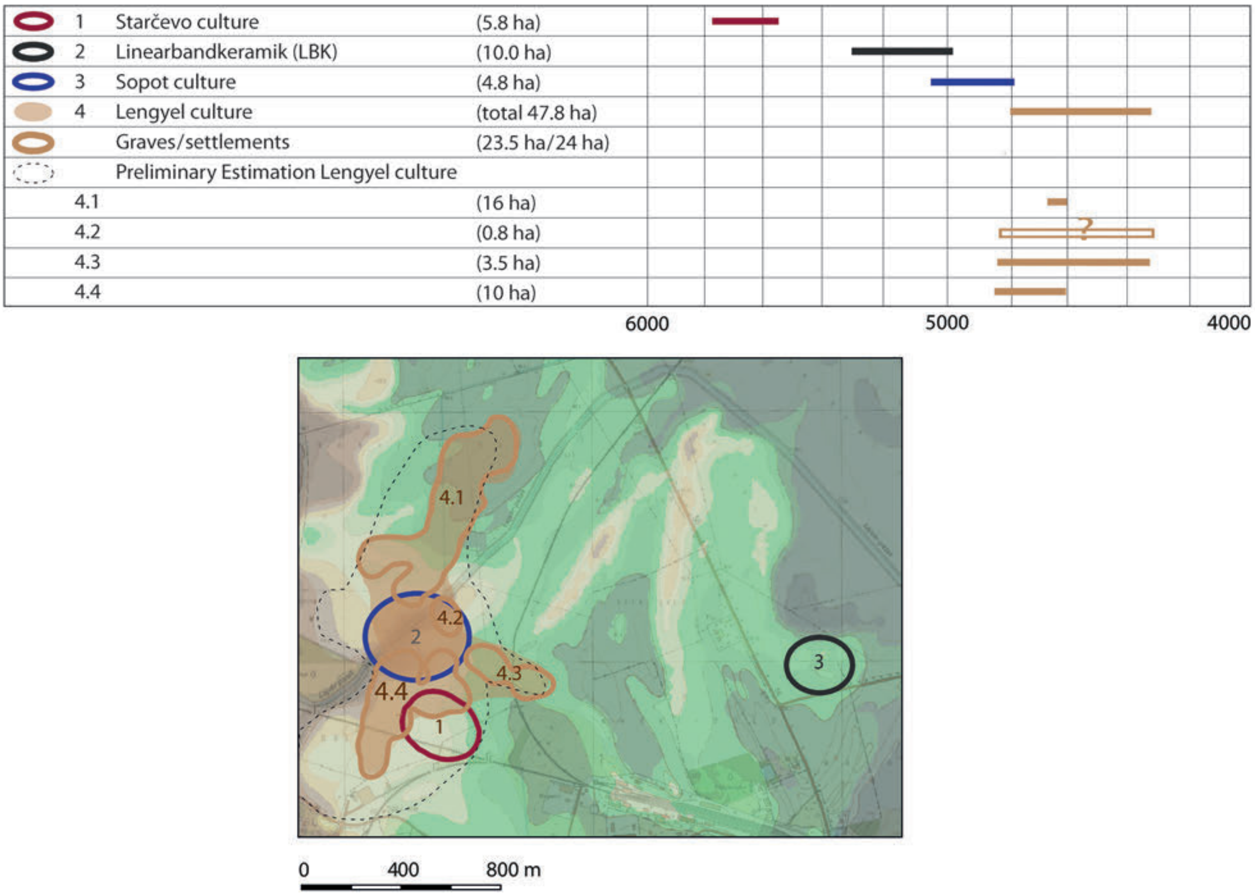


Fig. 58. Alsónyék. Overview of the sizes of occupation areas and a generalised chronological model of the occupation horizons. Starčevo culture; LBK, Sopot culture; Lengyel culture.

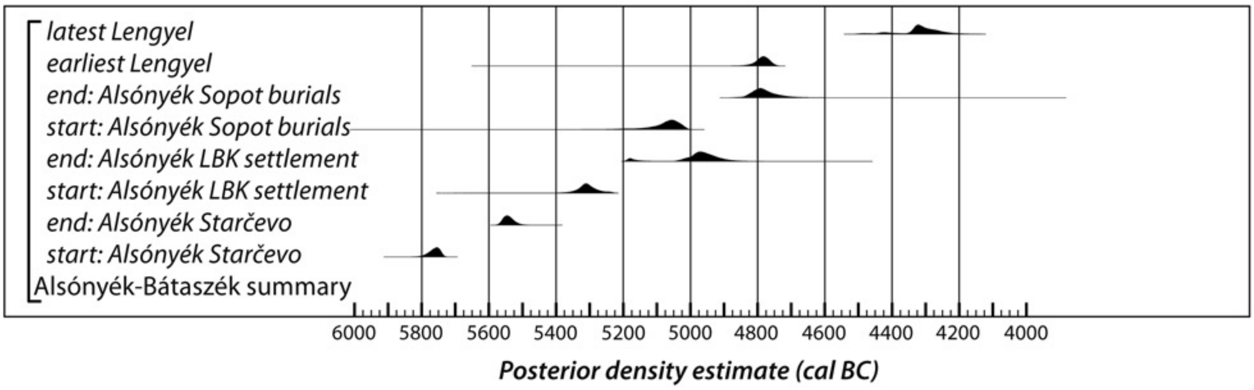


Fig. 59. Probability distributions for the start and end of the settlements of different cultural groups in the Alsónyék landscape.

the area than in the earlier phase of the Lengyel settlement (Bánffi et al. 2016). However, even the excavations record might prove insufficient for pinpointing the causes underlying this aggregation. Nevertheless, the overarching study that takes other early and synchronous Lengyel sites into consideration sought to find at least some answers for the population shift and aggregation (Regenye et al. 2020).

A comparison of the three micro-landscapes with the sites of Fajsz-Garadomb, Fajsz-Kovácshalom, Tolna-Mözs, and Alsónyék highlights certain differences. The Starčevo and the LBK settlements at Tolna and Alsónyék lie on a fault line between the Szekszárd Hills area and the floodplain, while the Sopot settlement is located on slight elevations within the floodplain both at Fajsz and Alsónyék.

In terms of their sizes, the same or very similar dimensions are apparent in the case of the Starčevo settlement at Alsónyék, the LBK settlement at Tolna-Mözs and Alsónyék, and also regarding the Sopot settlements at Fajsz-Garadomb and Alsónyék. The smallest site is Fajsz-Kovácshalom with 1.2 ha, but this is a tell mound, making Kovácshalom less comparable with the others that are all horizontal sites. By far the largest settlement is that of the Lengyel period at Alsónyék. The preliminary estimate of 80 ha might be necessary to be corrected. The general territory covered is around 50 ha (without the prospection of the southern part), although there are a few more densely settled areas within this area. The Bayesian modelling of the radiocarbon dates sheds light on the fine chronology of the Lengyel phases, which also provided answers to the question of how many houses may have been contemporaneous. Based on these studies (Bánffy et al. 2016, 304 fig. 11), the highest population (perhaps in the entire European Neolithic) can be found on the Alsónyék Lengyel settlement, at least for a few generations' time.

The circular ditches of the Sopot culture can be compared given that they were found both at the Alsónyék and the Fajsz-Garadomb settlement. The fact that both groups settled on small elevations rising above the floodplain and mostly surrounded by marshland might indicate the deliberate search for a topographic location with good conditions for the possible defence of the settlement. Not much information is available about the social structure and the possibly hostile behaviour of Sopot groups from other communities, or perhaps even their own groups may have competed with each other. The fact that the construction of ditches around settlements becomes fairly common over the entire territory of southern Transdanubia in the early 5th millennium BC might be an indication of the appearance of conflicts (cf. Zalai-Gaál 1990; Bertók / Gáti 2011; Barna et al. 2016; 2019; s. a. Literski / Nebelsick 2012). The archaeological evidence also speaks for the rise of inequality and the emergence of elite social groups (Osztás et al. 2012; Bánffy et al. 2016). The two observations corroborate each other.

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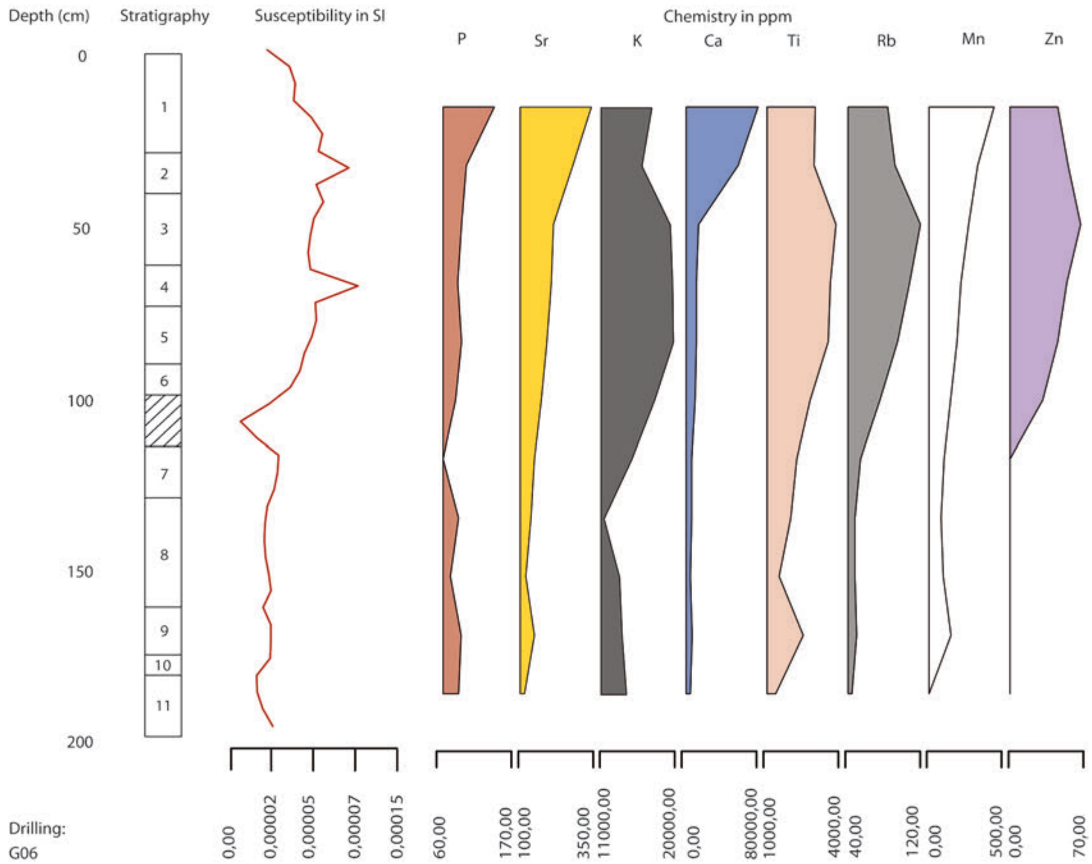
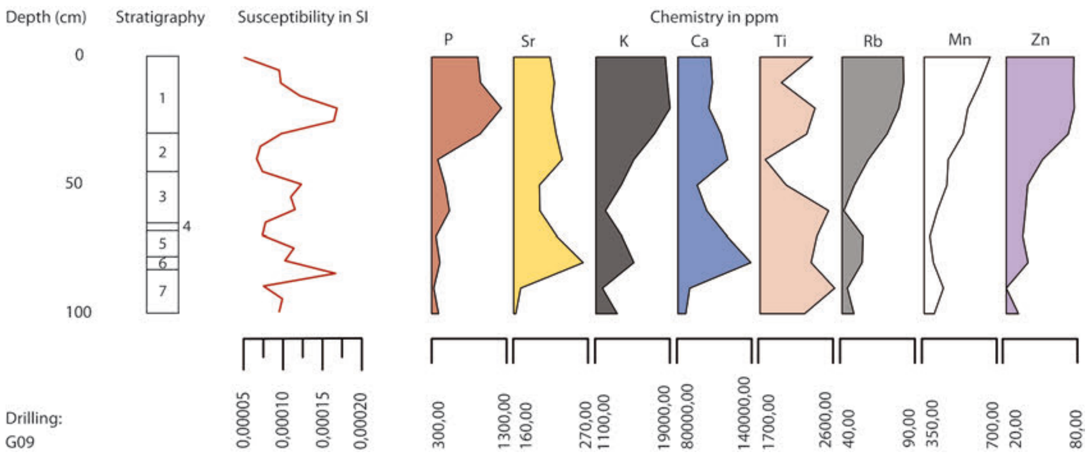
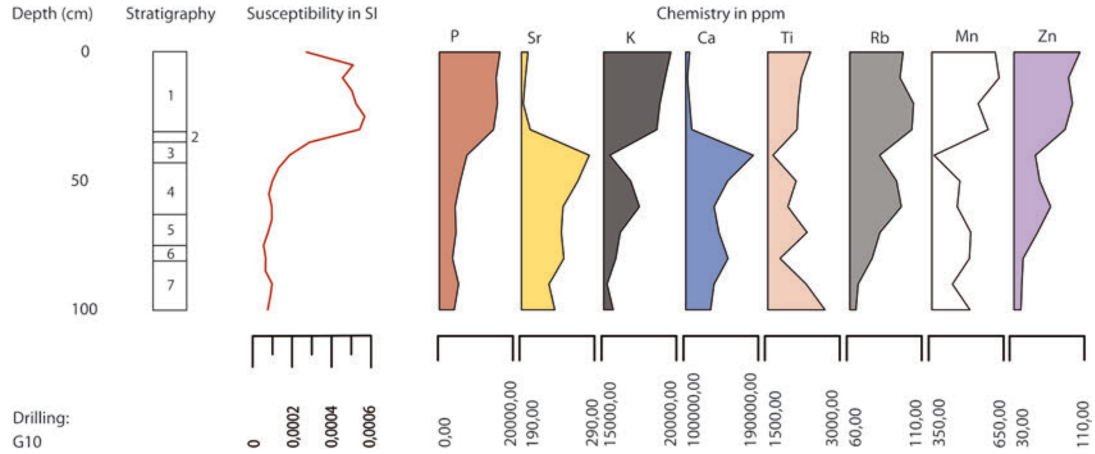
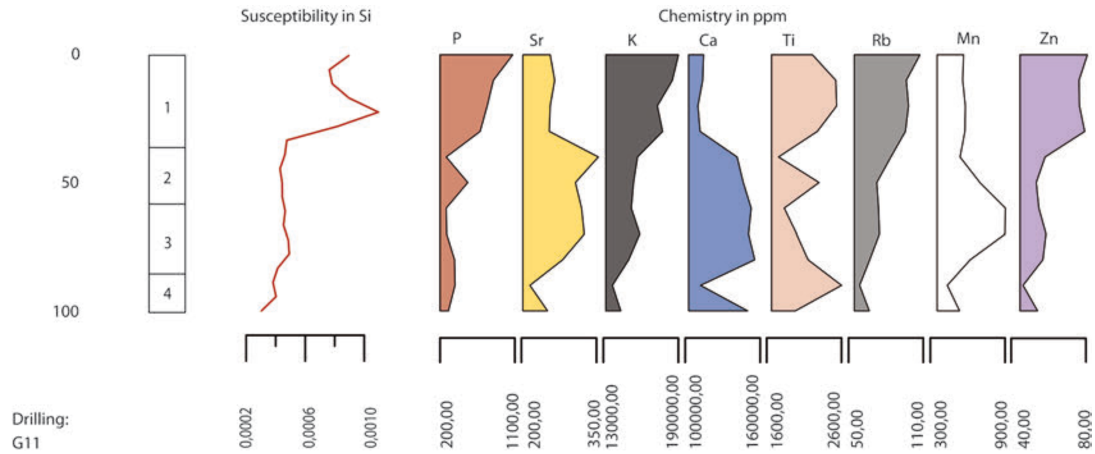
Appendices

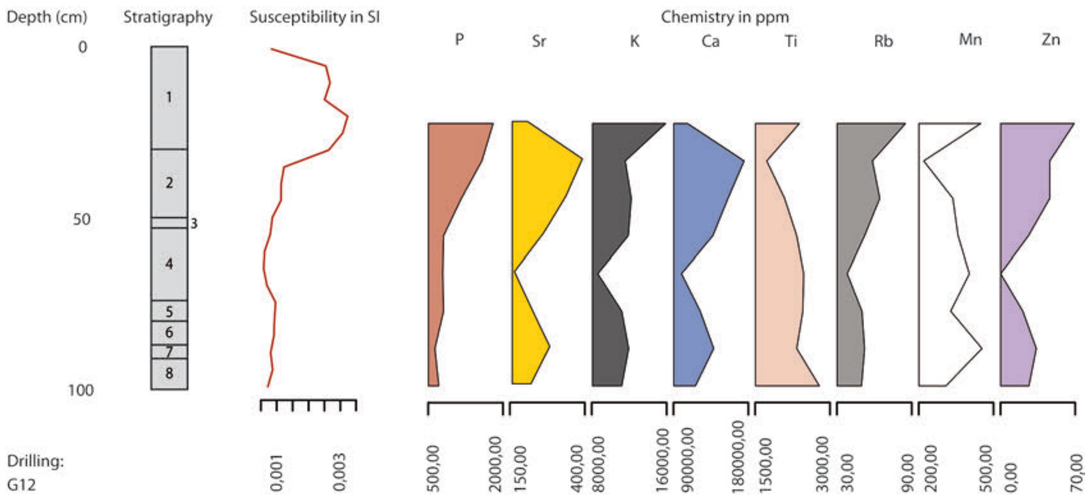
Appendix 1. Fajsz-Garadomb. Magnetic susceptibility and multi-element chemical analysis results of Cores G06, G09–G16.

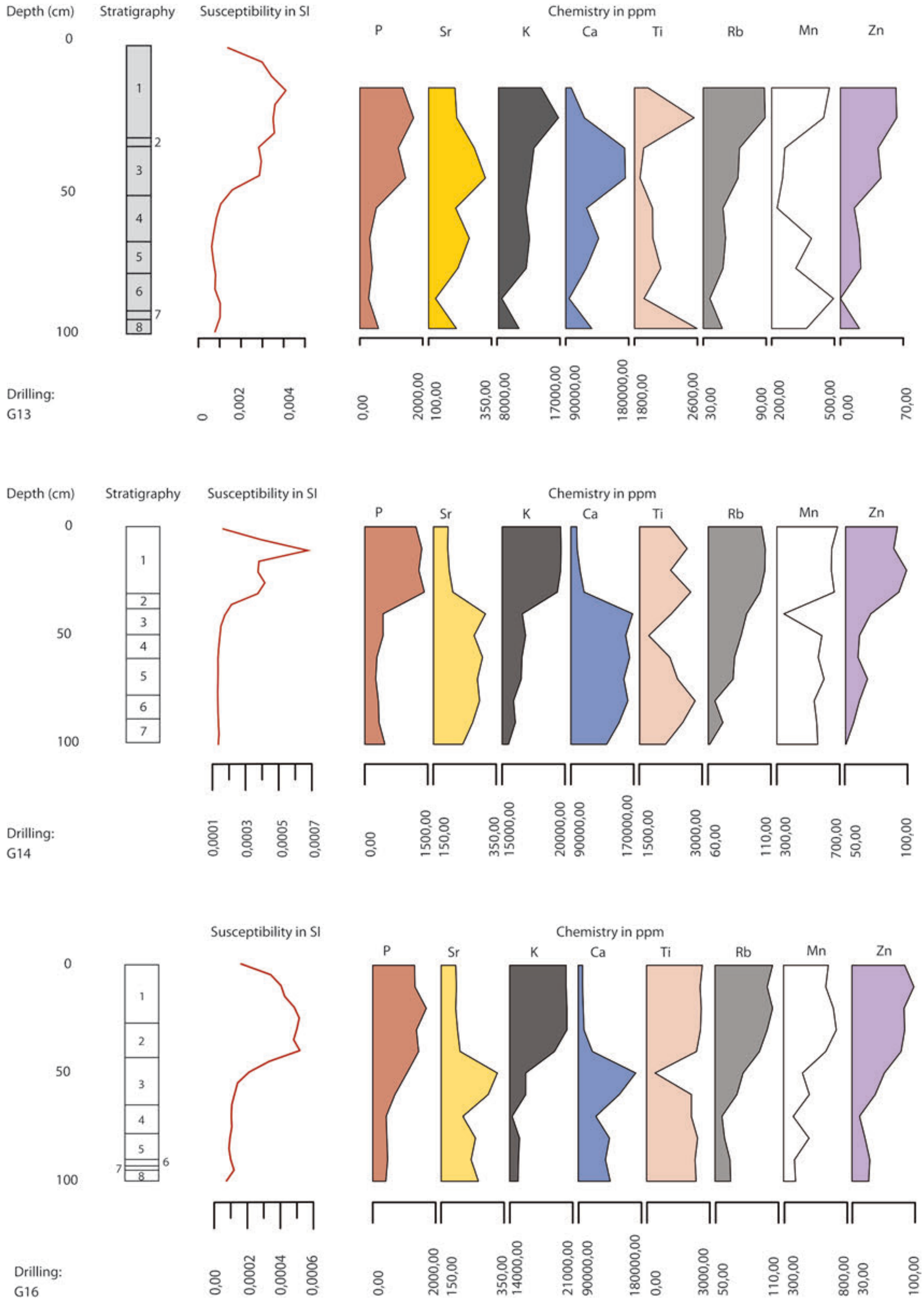


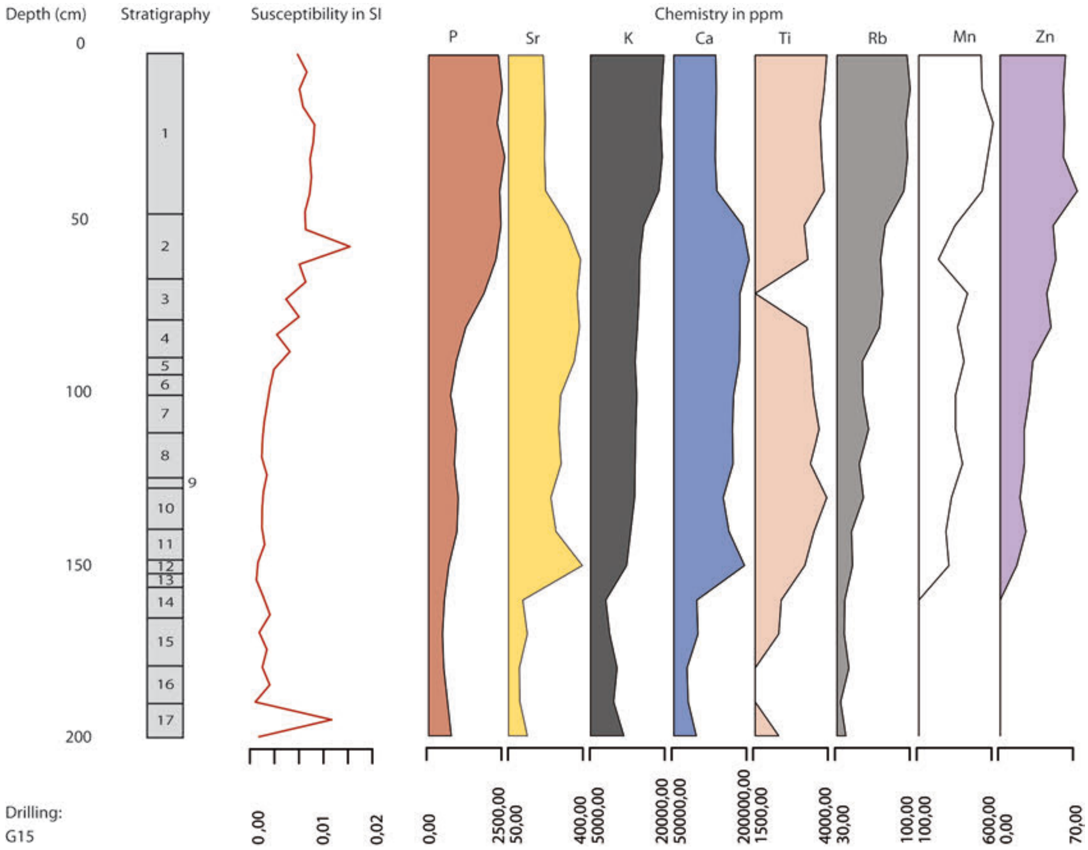



Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P Sr K Ca Ti Rb Mn Zn
0 50 100
1 2 3 4 5 6 7
Drilling:
G10
0 0,0002 0,0004 0,0006
0,00 20000,00 190,00 290,00 15000,00 20000,00 100000,00 190000,00 1500,00 3000,00 60,00 110,00 350,00 650,00 30,00 110,00

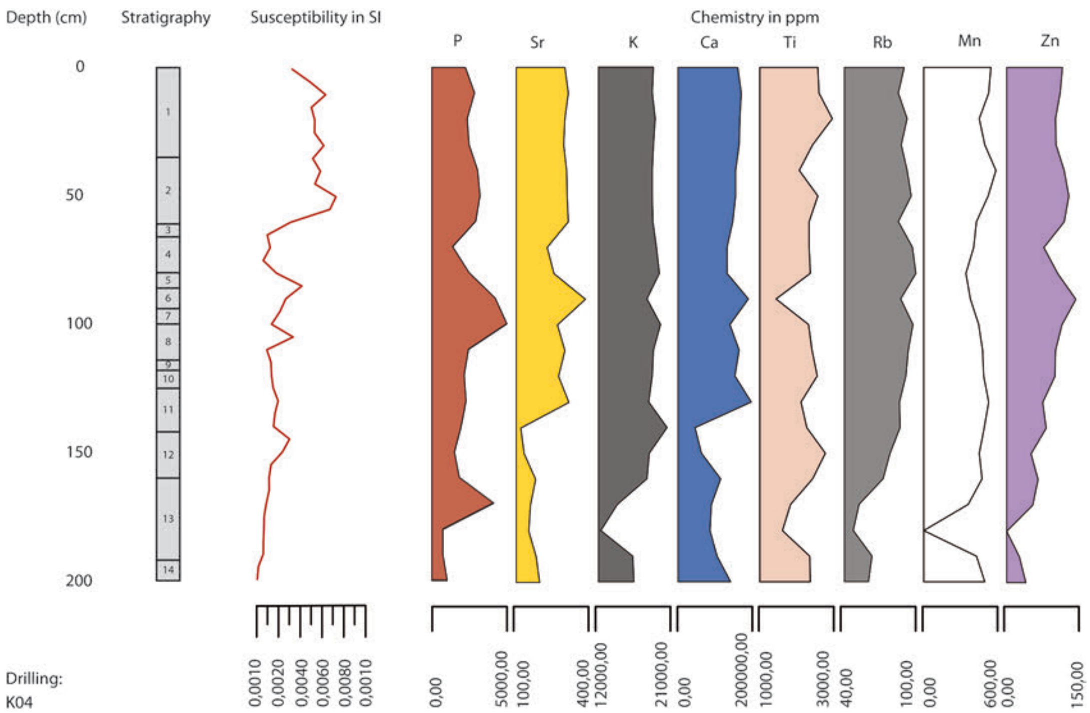

Susceptibility in Si
Chemistry in ppm
P Sr K Ca Ti Rb Mn Zn
0 50 100
1 2 3 4
Drilling:
G11
0,0002 0,0006 0,0010
200,00 1100,00 200,00 350,00 13000,00 190000,00 100000,00 160000,00 1600,00 2600,00 50,00 110,00 300,00 900,00 40,00 80,00

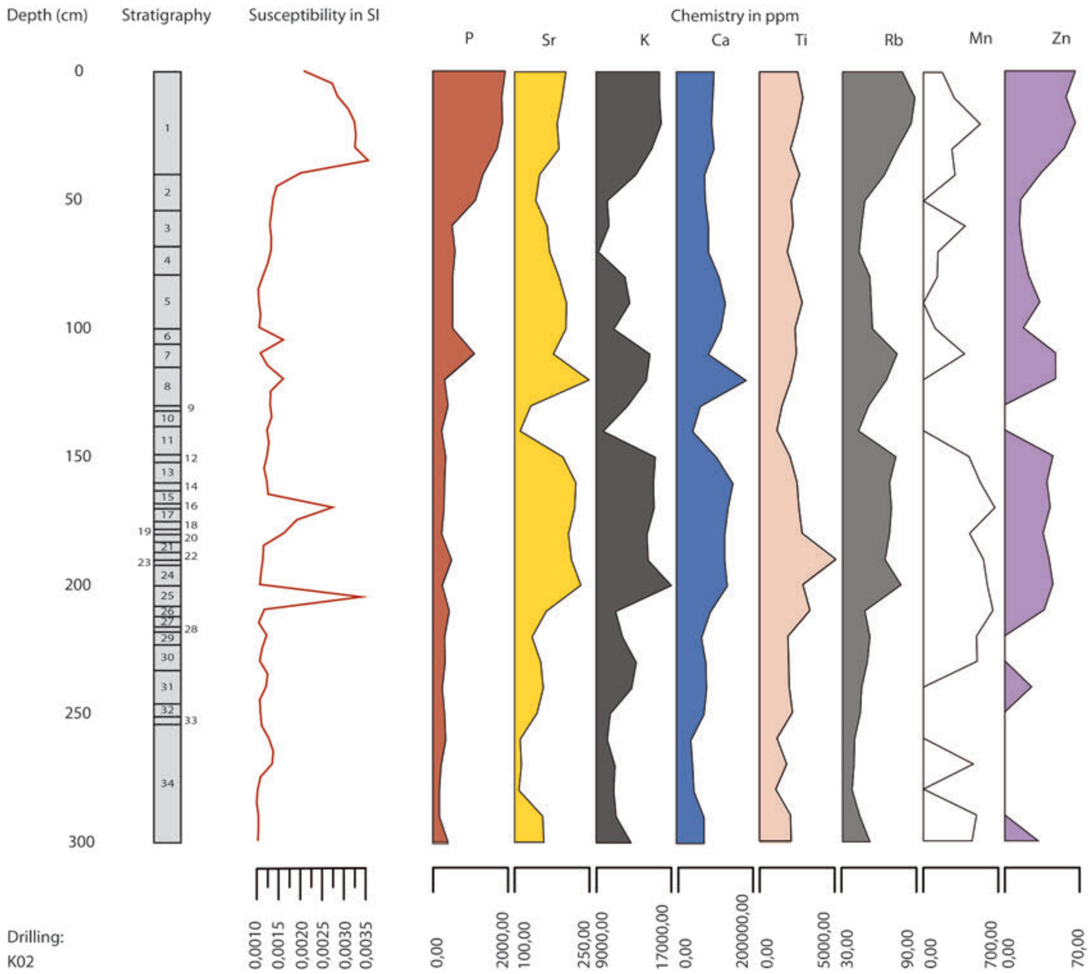

Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P Sr K Ca Ti Rb Mn Zn
0 50 100
1 2 3 4 5 6 7 8
Drilling:
G12
0,001 0,003
500,00 2000,00 150,00 400,00 8000,00 16000,00 90000,00 180000,00 1500,00 3000,00 30,00 90,00 200,00 500,00 0,00 70,00

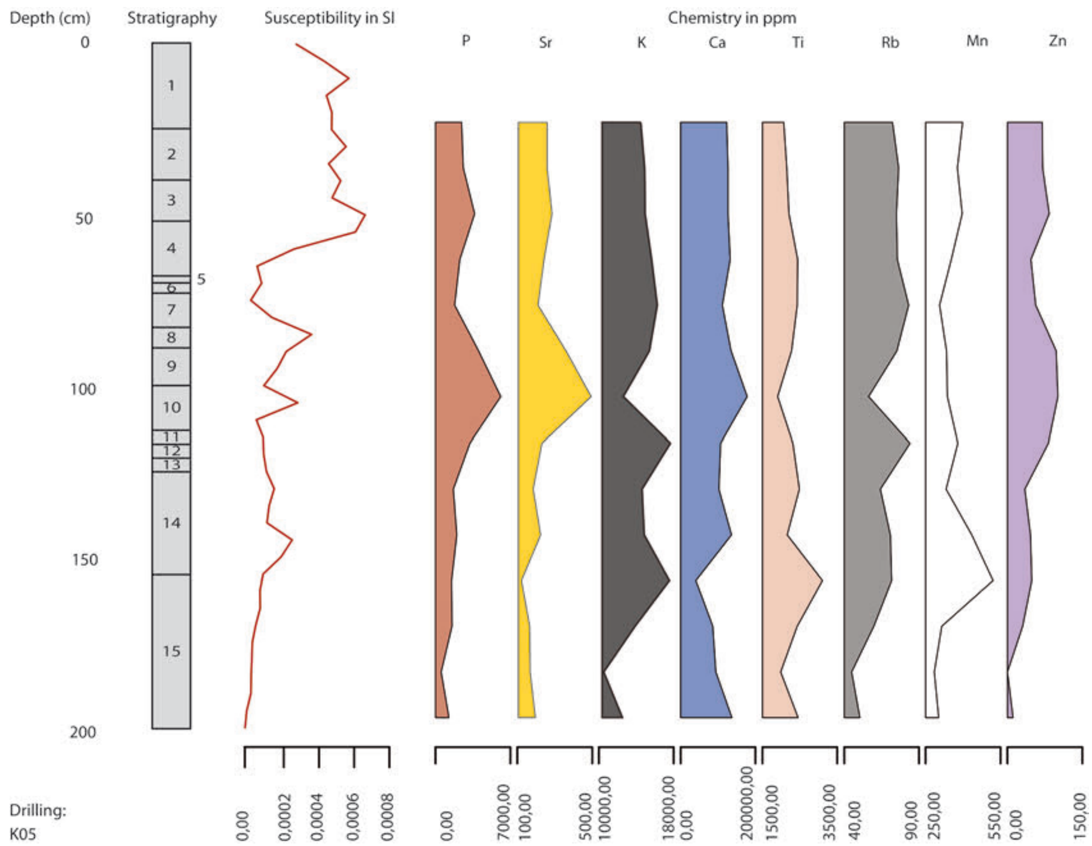

Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P Sr K Ca Ti Rb Mn Zn
0
50
100
1 2 3 4 5 6 7 8
Drilling:
G13
0 0,002 0,004
0,00 2000,00 100,00 350,00 8000,00 17000,00 90000,00 180000,00 1800,00 2600,00 30,00 90,00 200,00 500,00 0,00 70,00
Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P Sr K Ca Ti Rb Mn Zn
0
50
100
1 2 3 4 5 6 7
Drilling:
G14
0,0001 0,0003 0,0005 0,0007
0,00 1500,00 150,00 350,00 15000,00 20000,00 90000,00 170000,00 1500,00 3000,00 60,00 110,00 300,00 700,00 50,00 100,00
Susceptibility in SI
Chemistry in ppm
P Sr K Ca Ti Rb Mn Zn
0
50
100
1 2 3 4 5 6 7 8
Drilling:
G16
0,00 0,0002 0,0004 0,0006
0,00 2000,00 150,00 350,00 14000,00 21000,00 90000,00 180000,00 0,00 3000,00 50,00 110,00 300,00 800,00 30,00 100,00

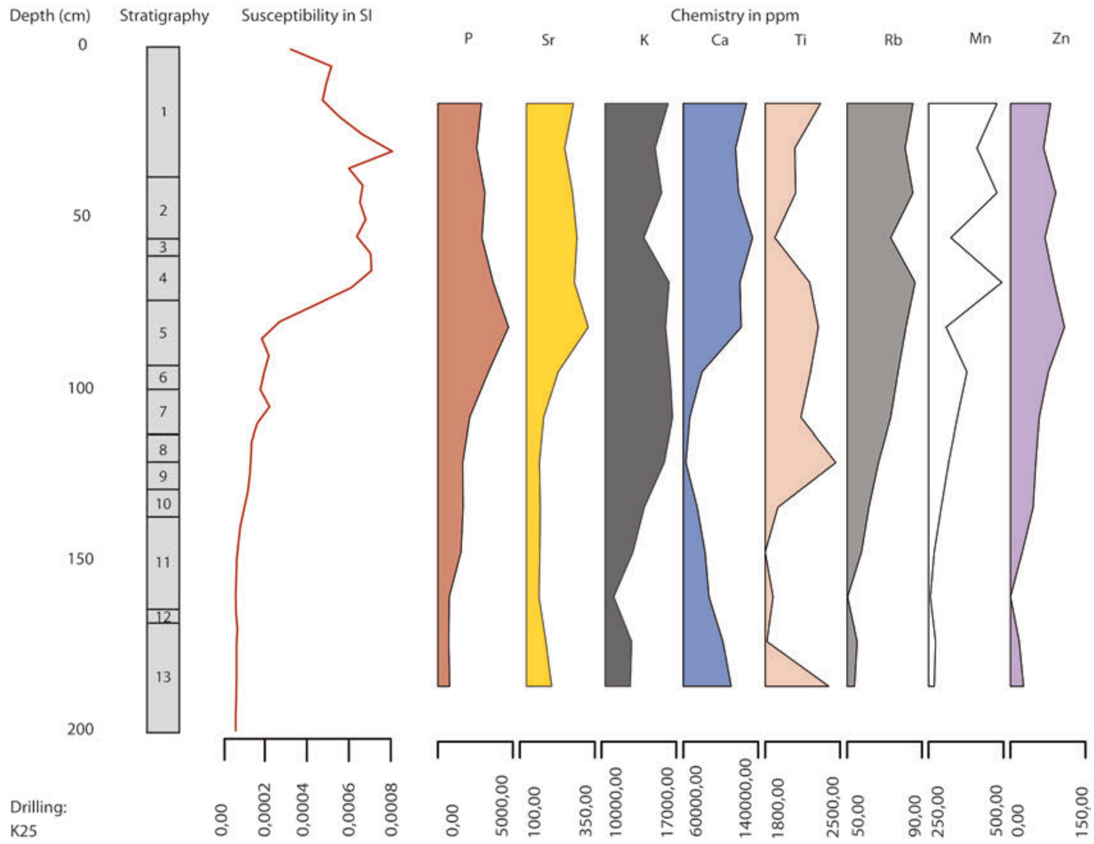


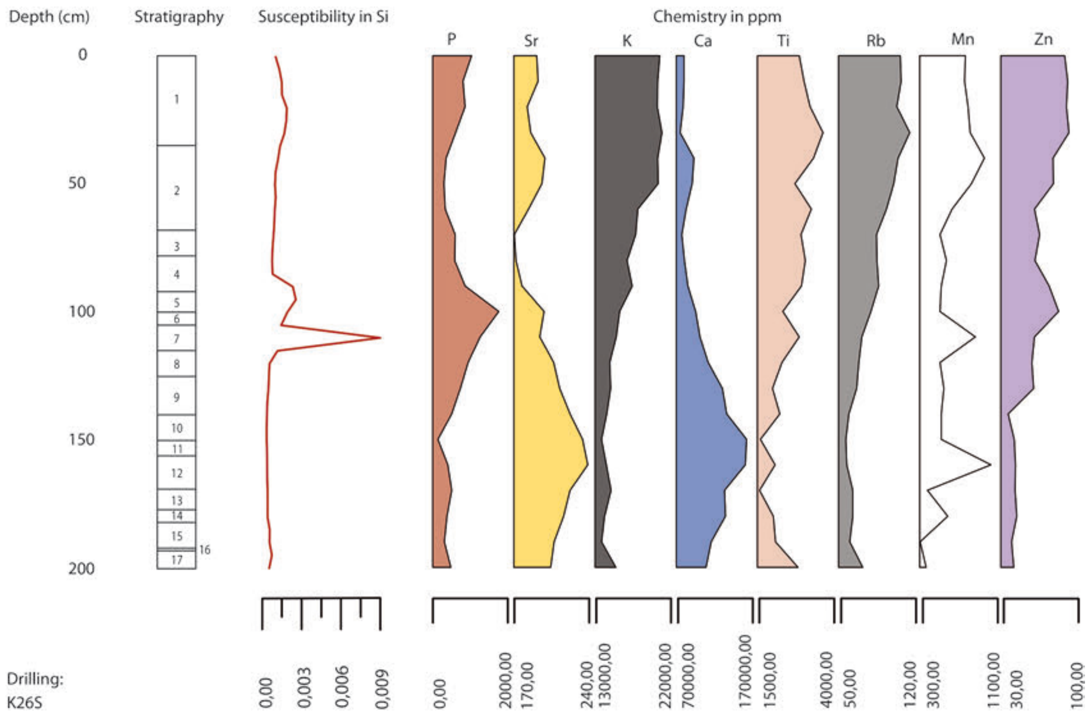
Appendix 2. Fajsz-Kovácshalom. Magnetic susceptibility and multi-element chemical analysis of Cores K02, K04, K05, K25, K26S, K37, K52, K57, K66.

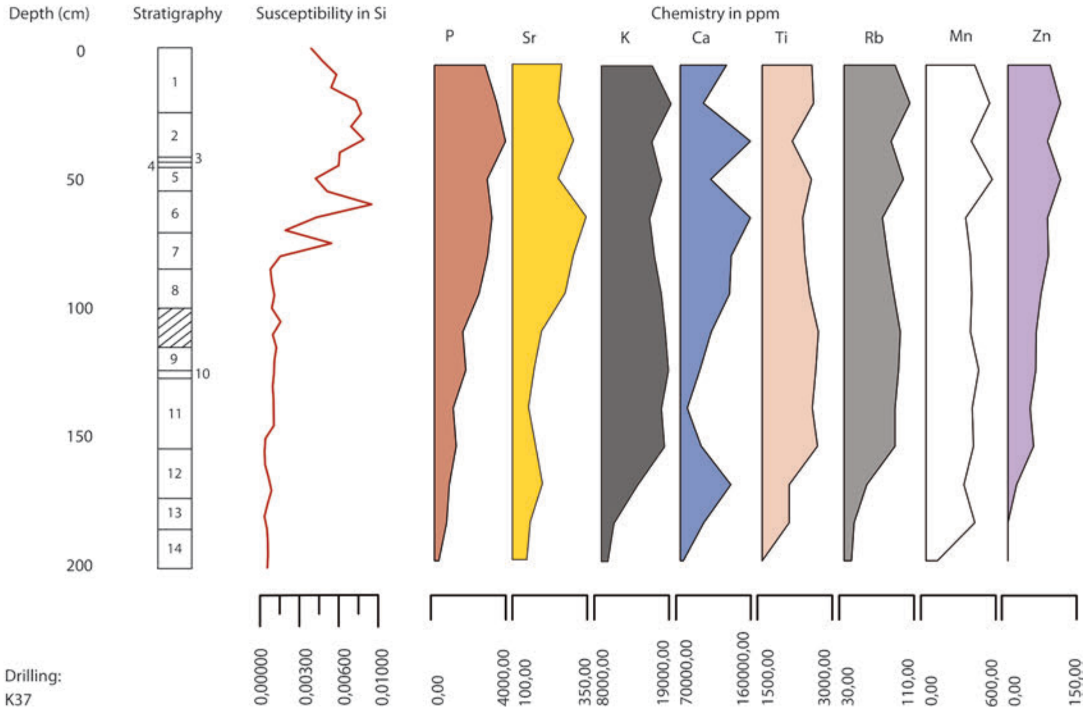


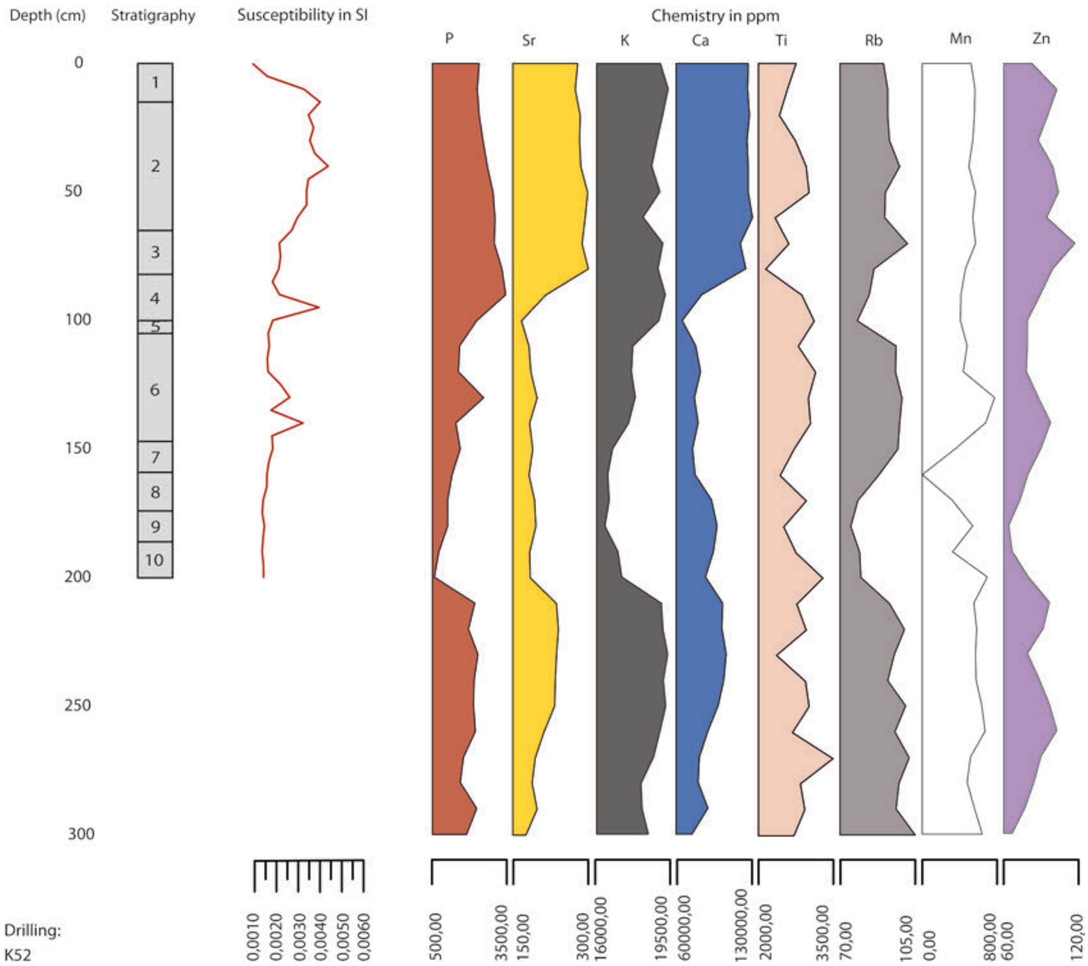

Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
250
300
Drilling:
K02
0,0010
0,0015
0,0020
0,0025
0,0030
0,0035
0,00
2000,00
100,00
250,00
9000,00
17000,00
0,00
200000,00
0,00
5000,00
30,00
90,00
0,00
700,00
0,00
70,00

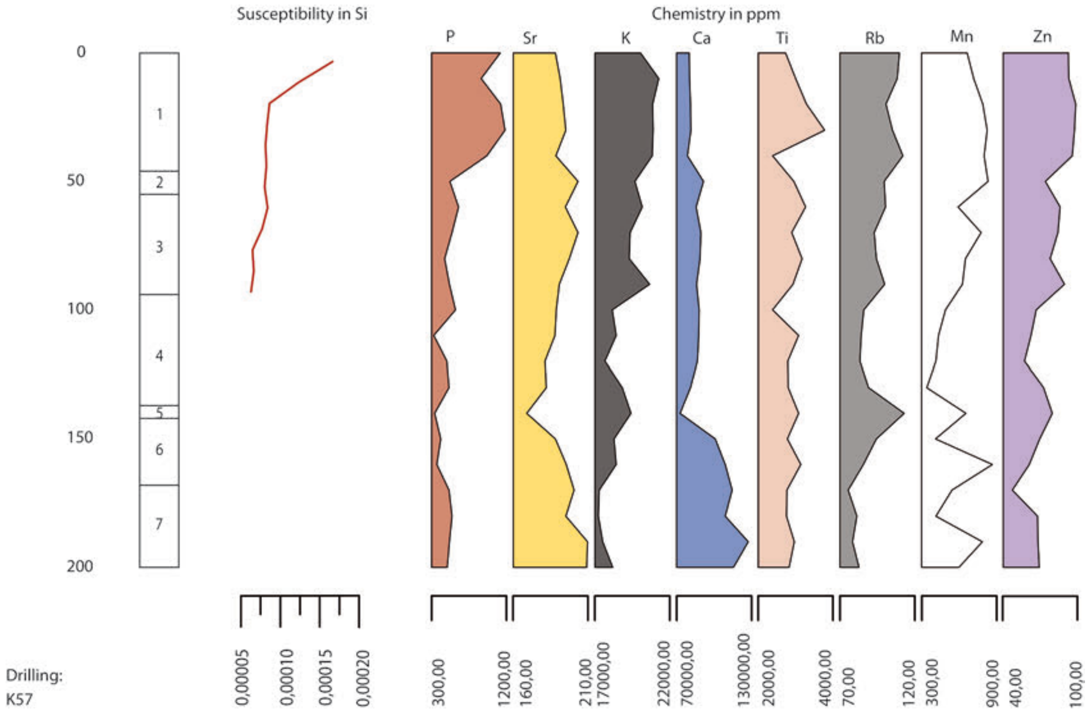

Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
Drilling:
K05
0,00
0,0002
0,0004
0,0006
0,0008
0,00
7000,00
100,00
500,00
10000,00
18000,00
0,00
200000,00
1500,00
3500,00
40,00
90,00
250,00
550,00
0,00
150,00

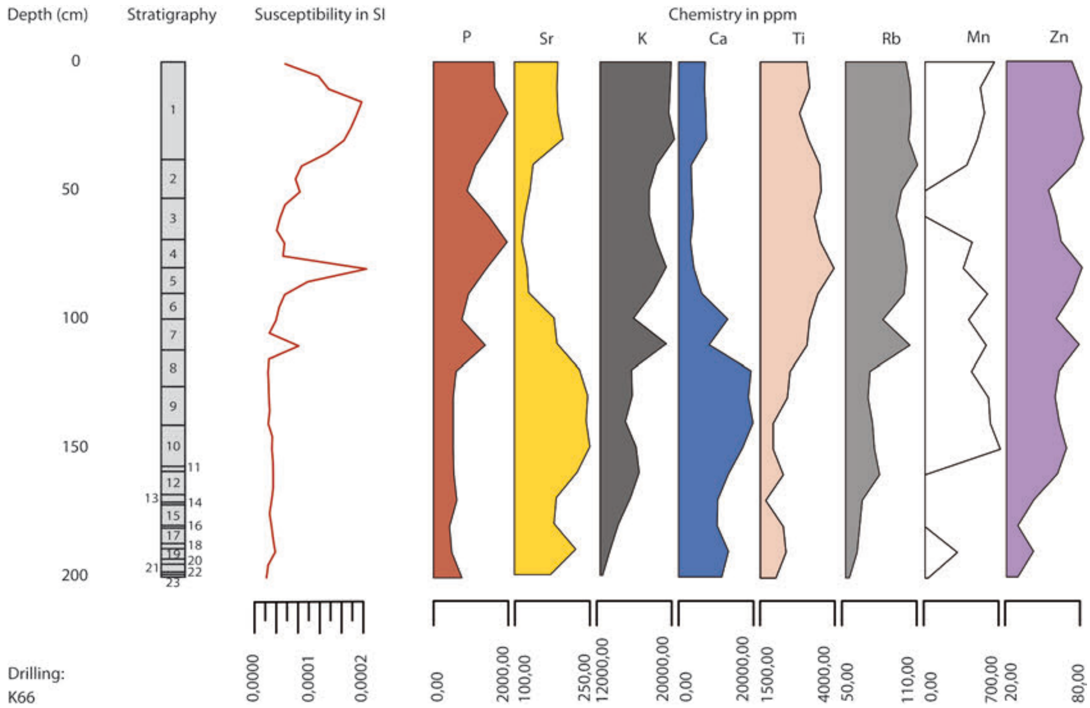

Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
1
2
3
4
5
6
7
8
9
10
11
12
13
0,00
0,0002
0,0004
0,0006
0,0008
0,00
5000,00
100,00
350,00
10000,00
17000,00
60000,00
140000,00
1800,00
2500,00
50,00
90,00
250,00
500,00
0,00
150,00
Drilling:
K25


Depth (cm)
Stratigraphy
Susceptibility in Si
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
0,00
0,003
0,006
0,009
0,00
2000,00
170,00
240,00
13000,00
22000,00
70000,00
170000,00
1500,00
4000,00
50,00
120,00
300,00
1100,00
30,00
100,00
Drilling:
K26S


Depth (cm)
Stratigraphy
Susceptibility in Si
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Drilling:
K37
0,00000
0,00300
0,00600
0,01000
0,00
4000,00
100,00
350,00
8000,00
19000,00
70000,00
160000,00
1500,00
3000,00
30,00
110,00
0,00
600,00
0,00
150,00


Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
250
300
1
2
3
4
5
6
7
8
9
10
Drilling:
K52
0,0010
0,0020
0,0030
0,0040
0,0050
0,0060
500,00
3500,00
150,00
300,00
16000,00
19500,00
60000,00
130000,00
2000,00
3500,00
70,00
105,00
0,00
800,00
60,00
120,00


Susceptibility in Si
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
1
2
3
4
5
6
7
Drilling:
K57
0,00005
0,00010
0,00015
0,00020
300,00
1200,00
160,00
210,00
17000,00
22000,00
70000,00
130000,00
2000,00
4000,00
70,00
120,00
300,00
900,00
40,00
100,00


Depth (cm)
Stratigraphy
Susceptibility in SI
Chemistry in ppm
P
Sr
K
Ca
Ti
Rb
Mn
Zn
0
50
100
150
200
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Drilling:
K66
0,0000
0,0001
0,0002
0,00
2000,00
100,00
250,00
12000,00
20000,00
0,00
20000,00
1500,00
4000,00
50,00
110,00
0,00
700,00
20,00
80,00

Abstract: Windows onto the landscape: Prospections on the prehistoric sites at Alsónyék, Fajsz-Kovácshalom, Fajsz-Garadomb, and Tolna-Mözs in the Sárköz region

The investigated geographic area is a key region in the cultural exchange and communication network between the northern Balkans and Central Europe, occupying a position of special interest in Neolithic studies. The region known as the Sárköz, located along the Danube in southern Hungary, was the scene of major archaeological excavations in the past two decades, both on the eastern, Kalocsa side of the Danube (at Fajsz) and on the western side, in the Tolna Sárköz region. Here some of the authors partook in several excavations ahead of the planned motorway track. One of these was undertaken at the exceptionally large site of Alsónyék. The investigation of the Neolithic sites in the Sárköz region provided a good opportunity to invite the work team for non-invasive landscape surveys of the Römisch-Germanische Kommission (RGK) to the region in order to clarify the human impact on the unexcavated parts of the settlements. Since 2011, and especially after 2013, collaboration between the partners became closer and the intensive non-invasive survey work eventually became much more than just geomagnetic prospection. Topographic data were compared with borehole sampling and soil chemistry, while multi-element chemical analysis was supplemented with magnetic susceptibility measurements of the cores. Thus, a series of important new data can be compared and interpreted together with information based on the excavations. The present study offers an overview of the entire range of non-invasive research in the Sárköz region.

Zusammenfassung: Fenster in die Landschaft: Prospektionen auf den prähistorischen Fundplätzen Alsónyék, Fajsz-Kovácshalom, Fajsz-Garadomb und Tolna-Mözs in der Sárköz Region

Der untersuchte geographische Raum ist eine Schlüsselregion für den Kulturaustausch und die Kommunikationsnetzwerke im nördlichen Balkan und Mitteleuropa und erfährt eine besondere Aufmerksamkeit in der Erforschung des Neolithikums. Die als Sárköz bekannte Region, die an der Donau im südlichen Ungarn liegt, war in den vergangenen beiden Jahrzehnten Schauplatz wichtiger archäologischer Ausgrabungen, sowohl in der Kalocsa-Region auf der Ostseite der Donau (Fajsz) als auch auf der Westseite, in der Tolna Sárköz-Region. Hier nahmen einige der Autor*innen an mehreren Ausgrabungen im Vorfeld eines geplanten Autobahnbaus teil. Eine dieser Ausgrabungen fand auf dem ungewöhnlich großen Fundplatz von Alsónyék statt. Die Untersuchung neolithischer Fundplätze in der Sárköz-Region bot eine gute Gelegenheit zur Einladung des Teams für nicht-invasive Landschaftssurveys der Römisch-Germanischen Kommission (RGK), um den menschlichen Einfluss auf die nicht ausgegrabenen Bereiche der Siedlung zu klären. Seit 2011 und insbesondere nach 2013 wurde die Zusammenarbeit zwischen den Partnern enger und aus den nicht-invasiven Surveys wurde weit mehr als nur eine geomagnetische Prospektion. Es wurden topographische Daten mit Daten aus Bohrungen und Bodenchemie verglichen und chemische Multielementanalysen wurden um magnetische Suszeptibilitätsmessungen an den Bohrkernen ergänzt. So kann eine Reihe wichtiger neuer Daten miteinander verglichen und in der Zusammenschau mit den aus den Ausgrabungen gewonnenen Informationen interpretiert werden. Der vorliegende Beitrag bietet eine Übersicht über die gesamte Breite der nicht-invasiven Untersuchungen in der Sárköz-Region.

Absztrakt: Ablak a tájra: Alsónyék, Fajsz-Kovácshalom, Fajsz-Garadomb és Tolna-Mözs újkőkori lelőhelyek roncsolásmentes vizsgálata a Sárköz-vidéken

A Sárköz, amely az Észak-Balkán és Közép-Európa közötti kapcsolati háló fő ütőere volt, különös jelentőséget kapott az újkőkori régészeti kutatásban. A régió a Duna dél-magyarországi szakaszán a folyó mindkét partja mentén fontos régészeti feltárások színhelye volt az elmúlt két évtizedben. Ilyen a keleti, kalocsai oldalon fekvő Fajsz és a nyugati, Tolnai Sárköz területén fekvő lelőhelyek, közöttük a kivételes nagyságú alsónyéki intenzív telep és temető. A Sárközben folyó régészeti kutatások során kapcsolódott a munkába a frankfurti Römisch-Germanische Kommission (RGK) roncsolásmentes vizsgálatokra specializálódott csapata. 2011-től kezdve, de még intenzívebben 2013 óta, mióta személyes szakmai kötelék is egybefűzi a résztvevőket, a geomágneses prospekciót messze meghaladóan szélessé vált a vizsgálati módszerek skálája. A topográfiai adatok összevetve a fúrásokból nyert mintákkal, azok kémiai elemzésével ugyanúgy fontos elemei a vizsgálatnak, mint a minták szedimentológiai és mágneses szuszceptibilitás-mérése. Ez a számos új módszer az ásatásokból nyert adatokkal összevetve kiváló lehetőség az adatok összességének együttes kiértékelésére. A Sárközben végzett non-invazív régészeti kutatások összefoglalója a jelen tanulmány.

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References of figures:
Figs 1, 5: © RGK. – *Figs 2, 25, 37, 57*: MAPIRE (© Österreichisches Staatsarchiv, https://mapire.eu/en/). – *Fig. 3*: Photo: K. Winkelmann. – *Fig. 4*: Photo: K. Rassmann. – *Figs 6–24, 26–36, 39–56*: K. Rassmann. – *Fig. 38*: Osztás et al. 2016a, 11 fig. 3. – *Fig. 58*: after Bánffy et al. 2016, 289 fig. 4. – *Fig. 59*: Bánffy et al. 2016, 287 fig. 1. – *Tabs 1–3:* K. Rassmann, M. Podgorelec, graphics K. Ruppel (RGK). – *Appendices 1–2:* K. Rassmann.