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Revealing the internal organization of a Middle Bronze Age fortified settlement in *Kakucs-Turján* through geoarchaeological means: Magnetometric survey and sedimentological verification of a housing structure

J. Niebieszczański[a,*], M. Jaeger[b], Á. Pető[c], I. Hildebrandt–Radke[d], G. Kulcsár[e], R. Staniuk[f], N. Taylor[f], J. Czebreszuk[a]

[a] *Institute of Archaeology, Faculty of Historical Studies, Adam Mickiewicz University in Poznań, Umultowska 89D str., 61-614 Poznań, Poland*
[b] *Institute of European Culture, Adam Mickiewicz University in Poznań, Kostrzewskiego 5-7 str., 62-200 Gniezno, Poland*
[c] *Institute of Nature Conservation and Landscape Management, Szent István University, Páter Károly 1 str., 2100 Gödöllő, Hungary*
[d] *Department of Quaternary Geology and Palaeogeography, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University in Poznań, Krygowskiego 10, 61-680 Poznań, Poland*
[e] *Research Center for Humanities, Institute of Archaeology, Hungarian Academy of Sciences, Tóth Kálmán 4 str., H-1097 Budapest, Hungary*
[f] *Graduate School "Human Development in Landscapes", Institut für Ur- und Frühgeschichte Christian-Albrechts University in Kiel, Johanna-Mestorf str. 2-6, 24118 Kiel, Germany*

A R T I C L E I N F O

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A B S T R A C T

Kakucs – Turján is a multi – layered fortified settlement from the Middle Bronze Age located in Central Hungary. The site was subjected to a non – invasive prospection using the magnetometry method. The magnetic anomalies provided insight into the horizontal plan of the site, revealing a tri-partite structure encircled and divided internally by ditches. In one of the so-defined zones, an agglomeration of a house – like anomalies were detected indicating the location of the housing area. One of these features was subjected to archaeological excavations which revealed the remains of two houses built on top of each other (tell – like deposition). In addition to excavations, sedimentological and geochemical sampling provided data on the functional aspects of the house. The spatial distribution of chemical elements and grain – size parameters showed that the house witnessed heavy anthropogenic activity. The distribution of phosphorous, copper and zinc indicated that a large part of activities could have taken place outside of the house, in the area where a suspected entrance was registered during the excavations. Geoarchaeological analysis at Kakucs – Turján thus resulted in a delimitation of the site's internal organization and a clarification of one of the house's chronology and functionality.

1. Introduction

The Middle Bronze Age (MBA) fortified and multilayered site of Kakucs-Turján is located in the Middle Danube Basin in Central Hungary (Fig. 1). In this region, such sites are comprised of several specific characteristics. First of all, their long duration of occupation should be emphasized. Most of these sites had already emerged by the end of the 3rd millennium BCE, when they are predominantly associated with Nagyrév pottery (Bóna, 1975:31ff.; David, 1998:232–233; Reményi, 1992). According to the present state of knowledge, at this stage of development the sites had an open character and lacked any defensive structures (Jaeger, 2016: 84; Marková and Ilon, 2013: 820). In light of excavated examples, the next stage of multi-layered site development is related to pottery stylistics of the Vatya culture. The settlements showing this cultural affiliation were fortified by massive constructions, among which walls and/or ditches were the most common, sometimes combined with additional structures like palisades (Jaeger, 2016: 84–87). The development and occupation of the multi-layered sites ended in the middle of the 2nd millennium BCE, during the Koszider horizon (Fischl and Reményi, 2013: 734; Jaeger, 2016:92).

* Corresponding author.
E-mail addresses: jakubniebieszczanski@gmail.com (J. Niebieszczański), jaeger@amu.edu.pl (M. Jaeger), peto.Akos@mkk.szie.hu (Á. Pető), hilde@amu.edu.pl (I. Hildebrandt–Radke), kulcsar.gabriella@btk.mta.hu (G. Kulcsár), rstaniuk@gshdl.uni-kiel.de (R. Staniuk), nicole.taylor@ufg.uni-kiel.de (N. Taylor), jancze@amu.edu.pl (J. Czebreszuk).

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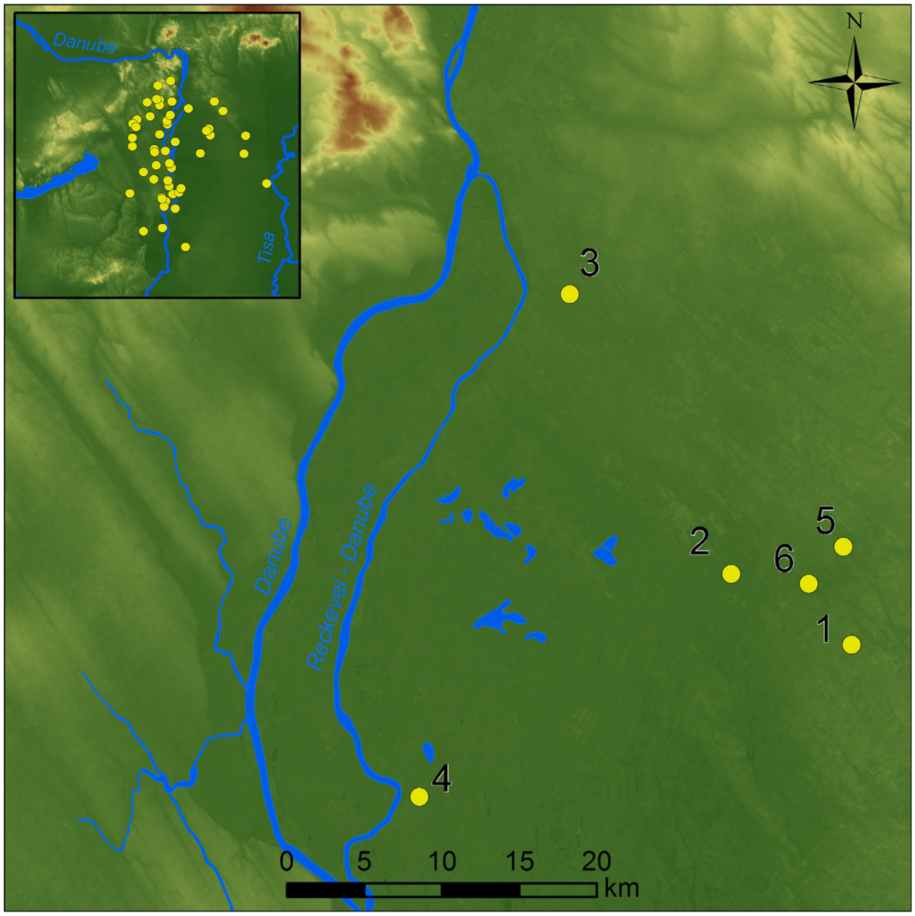

Fig. 1. Vatya multi-layered and fortified settlements (upper left corner) and microregion of Kakucs: 1 – Dabas – Dabasi szőlők; 2 – Dabas – Sári/Bugyi; 3 – Soroksár – Várhegy; 4 – Dőmsőd - Leányvár; 5 – Kakucs-Balla-domb; 6 – Kakucs - Turján.

In result of the continuous, multi-century history of occupation these sites have complex vertical and horizontal stratigraphy which provokes interpretational difficulties. This raises the question of the optimal method for exploring such settlements and recognizing their spatial organization.

Full-scale archaeological excavations of the multilayered sites are relatively rare in the discussed region, mainly because these Bronze Age settlements extend over multiple hectares and contain several meters of stratigraphy. Because of this, there are a growing number of investigations applying non-invasive methods to study the inner organization of fortified settlements in the Carpathian Mountains and Basin (i.e. Gauss et al., 2013; Kienlin et al., 2018; Sava and Gogâltan, 2017). Some of the most effective methods for obtaining information about the horizontal stratigraphy as well as for preliminarily evaluating the complexity of such sites are geophysical methods, among which magnetometry is the most common.

In 2012 a geophysical prospection was conducted at the fortified settlement Kakucs-Turján. This research spanned 11 ha in total, covering an area selected on the basis of the satellite imagery (c.f. Szeverényi and Kulcsár, 2012: 330). The latter suggested the presence of a system of ditches encompassing and dividing in two an area of 1.4 ha (Szeverényi and Kulcsár, 2012: 329–330). The magnetometry prospection was planned to reconstruct the course of the suspected ditch enclosures. The survey revealed additional ditch-like structures as well as evidence of the remains of buildings inside one of the settlement's parts (Fig. 2). After the preliminary evaluation of the magnetic picture it was clear that the site in Kakucs-Turján extended over an area of at least 2.2 ha which was enclosed by an outer ditch system (see Niebieszczański et al., 2018). Therefore, the acquired horizontal plan of this site presented a tri-partite settlement organization (zones A, B and C) (Fig. 2). In zone A, a high portion of anomalies suggested the presence of a concentration of dwellings. Zone C included a scant number of possible anthropogenic objects, while zone B is thought not to have been settled, but to have only been used as a grazing area or kraal.

In the scope of revealing the habitation history at the site and the settlement processes, the most important result of the magnetometry study was the detection of more than a dozen building outlines in the western part of the site (zone A). One such feature was excavated over four seasons (2013–2016) (Jaeger, 2018b; Jaeger et al., 2018a, b). During the excavations it was decided to include sedimentological and geochemical analyses in order to reveal lithological differentiation within and outside of the housing structure. The main aim of the archaeological research conducted in the area of the well preserved house was to determine the stratigraphy and chronology of the structure. Furthermore, it was planned to collect materials reflecting particular activities that could have taken place in the inhabited area of the site. In this context sedimentological and geochemical indicators were used as important additional source of information.

In light of the collected data, the site was settled at the end of the 3rd millennium BCE and abandoned at the end of the first half of the 2nd millennium BCE (Table 1). Similar settlement sequences are known from many other sites in the Middle Danube Basin, including settlements located in the closest vicinity of Kakucs-Turján (e.g. Kakucs-Balla-domb: Jaeger and Kulcsár, 2013).

In the scope of the abundant archaeological material as well as chrono-stratigraphical data, a sampling of sediments was performed in order to conduct sedimentological and geochemical analyses. Their aim

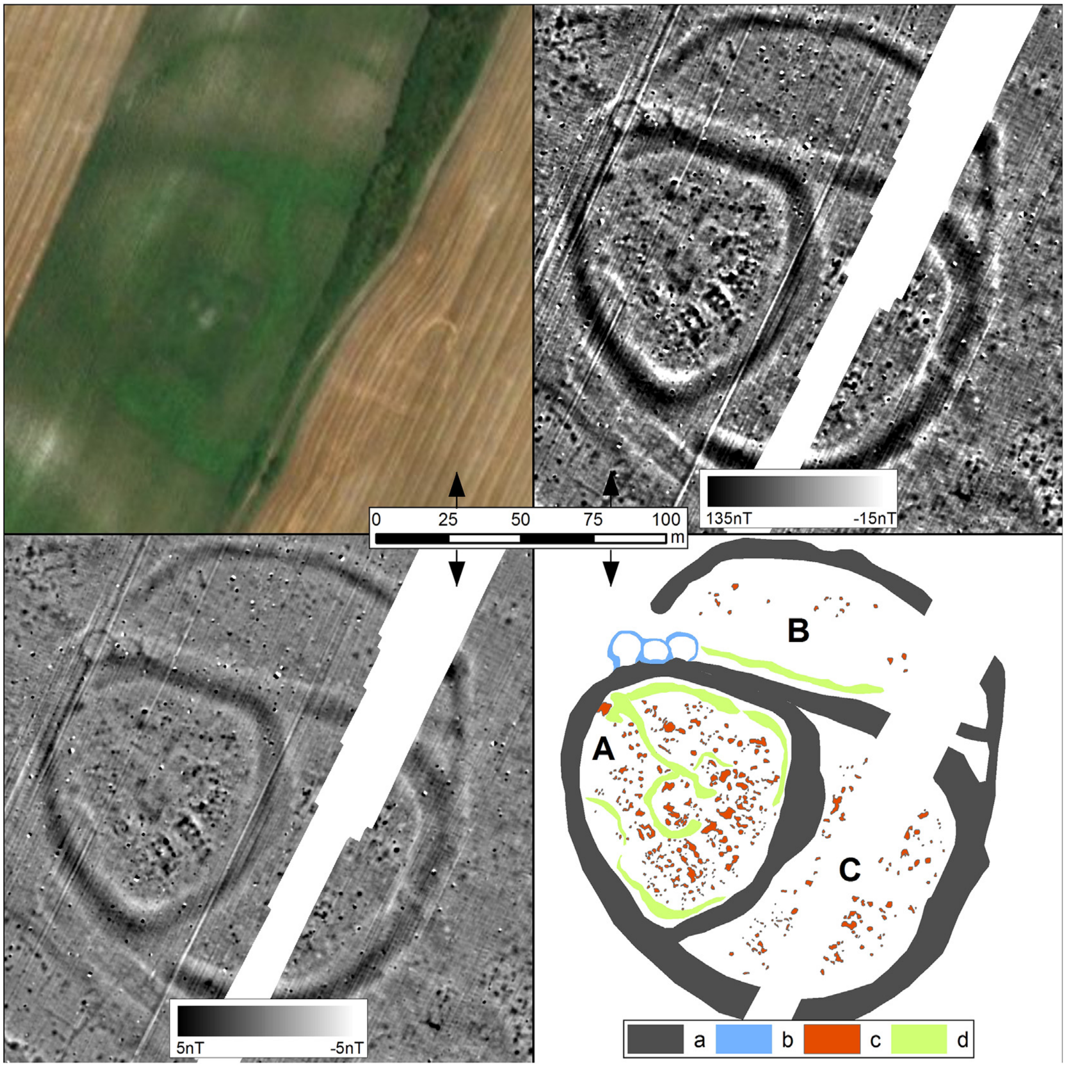

Fig. 2. Kakucs – Turján fortified settlement. Non – invasive research and interpretation. Upper left corner: Satellite imagery (ArcGIS basemap: World Imagery); Upper right corner: Magnetometry results with a minimum – maximum range of nT values; Lower left corner: Magnetometry results with values cut to +5 to −5 nT; Lower right corner: Interpretation of magnetic anomalies (a – ditch – like structures; b – well – like structures; c – buildings outlines; d – suspected pathways; A, B, C – zones of the fortified settlement divided by ditch system).

Table 1
Phasing of the Kakucs-Turján settlement, duration of dated phases, general chronology of the Hungarian Bronze Age and the absolute dating of particular periods (after Jaeger et al., 2018a, b).

Kakucs phases	Absolute duration (sigma1)	Hungarian Bronze Age Periods	Hungarian Bronze Age Periods cal BC
Kakucs 1	NA	EBA 1–2	2600–2200/2100
Kakucs 2	NA	EBA 3	2200/2100–2000/1900
Kakucs 3	NA	EBA 3/MBA 1	2000/1900
Kakucs 4	NA		
Kakucs 5	NA	MBA 1	
Kakucs 6	1871/1778–1866/1769 BCE		
Kakucs 7	1865/1762–1865/1751 BCE		
Kakucs 8	1863/1746–1862/1742 BCE	MBA 2	2000/1900–1500/1450
Kakucs 9	1861/1736–1862/1728 BCE		
Kakucs 10	1860/1680–1859/1692 BCE	MBA 3	
Kakucs 11	2860/1680–1859/1660 BCE		
Kakucs 12	NA	Iron Age–Sarmatian Period	NA

was to reveal the sedimentary environment associated with the using of the housing structure in the discussed period and also support the functional interpretation of the dwelling.

2. Materials and methods

2.1. Magnetometry prospection

The first step of research was to uncover the inner structure of Kakucs-Turján and its complexity, which was primary evaluated based on aerial imagery (Szeverényi and Kulcsár, 2012). Thus, a magnetometry survey was conducted over nearly 11 ha using eight vertical fluxgate sensors (FGM650B), each containing two probes separated by 0.65 m, attached to a vehicle-towed GPR carrier (Mitsubishi L200). The interval between sensors was set to 0.25 m, therefore the resolution of the obtained image is a 0.125 m raster grid. Each measurement was fixed by a Trimble RTK GPS using the KGOFOMI GNSS service. The prospection was cunducted by Gábor Márkus.

The first visualization and filtering of the image was done in Terra Surveyor, Magneto ARCH 1.00–03 and Golden Surfer 11.6.1159, while the data processing of the magnetic plans was conducted in ArcGIS 10.1.

2.2. Excavations

In order to verify the specific features visible in the magnetic picture, a set of drillings was conducted in- and outside of the recognized settlement. Despite its aim to obtain the vertical stratigraphy of the site (see Pető et al., 2018), the excavations were focused strictly on uncovering the housing structure and establishing its chronology (Jaeger, 2018a). To that end, three trenches were opened in the central part of the site where a house-like type of anomaly was visible on the magnetic plan. The first trench (No.1) was started in 2013 and completed in 2016. It measured 7 × 8 m and its longer axis was oriented northwest – southeast. In 2014, a second trench was opened (No.2), extending trench 1 to the south-east. The trenches were separated by a 0.5 m wide baulk which was excavated in 2016 as a distinct unit (trench No.3).

Investigations in all three trenches followed the same methodology and relied on the same measurement techniques and documentation models. Excavation was carried out by means of trowels using the "plastic" technique, where particular horizontal plans constituted successive levels of exposed layers. Artificial layers with a set thickness of ca. 15 cm were removed only in the highest levels, until clearly discernible concentrations of daub—indicative of the remnants of the building—appeared at a depth of approximately 40–45 cm b.g.l.

The collected artifacts were divided into two categories: mass finds and special finds. The first category comprises mainly fragments of pottery which possess no diagnostic traits in terms of morphology and ornamentation. These were gathered separately from individual square metres in each level. The category of special finds included all ornamented sherds as well as fragments of bases, rims, and other distinctive parts of vessels. Apart from pottery, this second category also included metal artifacts, bone, flint and stone tools, characteristic fragments of daub with imprints of wooden structural elements, and other special finds. All of the registered finds were associated with geodetic coordinates and could thus be transferred into the ArcGIS spatial database.

2.3. Sedimentological and geochemical analyses

During the excavations a set of 248 soil samples were obtained from trench No.1 at a depth of 0.5–0.6 m b.g.l. in order to recognize the spatial distribution of geochemical compounds and sedimentological parameters. Each sample weighed approximately 0.5 kg and both cultural and "less anthropogenic" deposits were collected. The sampling targeted the same cultural layer (stratigraphic unit), in order not to mix up the different possible phases of the occupation, but to create a baseline data set as homogenous as possible (for detailed stratigraphy see Pető et al., 2018 and also Pető et al. in this volume).

To analyze the sedimentological parameters of the excavated level, the larger grain sizes were first separated by sieving (2000 μm mesh). Laser diffraction using a Malvern MasterSizer Hydro 2000 allowed the determination of fractional percentage and other grain-size parameters. The obtained grain-size distribution was calculated based on the Folk & Ward method (Folk and Ward, 1957) in the phi scale in Gradistat 5.11. The acquired parameters were: the median (Mz), standard deviation (SD), skewness (Sk) and kurtosis (Kg).

The basic geochemical analysis consisted of estimating the $CaCO_3$ and organic matter content. Both amounts were evaluated using the loss-on-ignition method (Heiri et al., 2001); for carbonates the calcination lasted for 2 h at 950 °C, while the organic matter was heated for 4 h at 550 °C. To determine the phosphate concentration, the colometric method with ammonium molybdate was used (Spychalski et al., 2016). Other elements (Zn, Mn, Fe and Cu) were extracted in *aquaregia* based on the ISO 11466 (1995) norm and subsequently filtered into measuring flasks (100 ml). The exact estimation of ppm values was obtained using the ASA method (emission mass spectrometry in acetylene flame).

3. Results and discussion

3.1. Magnetometry plan and interpretation of anomalies

A first view of the magnetic imagery reveals an amoeba-like, tripartite settlement outlined and divided by passes with high magnetic properties (Fig. 2). The analysis of this data using different raster representation techniques and operating the min-max range allows the detection of a variety of anomalies which can be attached to three functional categories or types. The main visible arrangement of anomalies is the concentric system of passes. Their course encircles the settlement as well as divides it internally. A second recorded type of magnetism is related to three circular structures located in the northwestern margins of the site. Several hundred other anomalies of different shapes and irregular arrangements are also visible.

Ditch-like structures – The passes with higher magnetic properties were interpreted as ditches or moats (Fig. 2). Although at first glance these anomalies appear continuous, a closer look at the junctions between the supposed ditches shows discontinuity. The mean width of this type of anomaly is approx. 10 m; however, it varies throughout their course. As was mentioned earlier, these lines internally divide the settlement into three parts (Fig. 2).

Verification of these features was conducted by coring (see Pető et al., 2015, 2013, 2018). Examination of the cores suggested that these passes are linear concavities filled with biogenic deposits with traces of laminations, indicating the presence of water environment. Their depth reached up to 4 m (Pető et al., 2018: 33–39).

In addition to the linear features with high magnetic properties, a system of low magnetic linear features was recorded as well. These structures run parallel and are directly adjacent to both the outer and inner ditch systems. At this stage an interpretation of their actual form is not possible as they could represent the halo of the higher magnetic values of the ditch (c.f. Müller-Scheeßel et al., 2016: 86), the remains of pathways, or perhaps defensive ramparts.

Well-like anomalies – In the northwestern part of the site, three circular anomalies were detected, each measuring approx. 12 m in diameter (Fig. 2). The outlines of these anomalies have higher magnetic values, their inner parts are characterized by insignificantly higher magnetism. The coring performed on these features suggests the presence of concave structures several meters deep (Pető et al., 2018: 35–37). The fill of these hollows was formed of partially laminated biogenic deposits; therefore, it is hypothesized that they served some hydrological function – possibly as a well or for water retention (Pető et al., 2018: 36). The last interpretation is supported by the location of

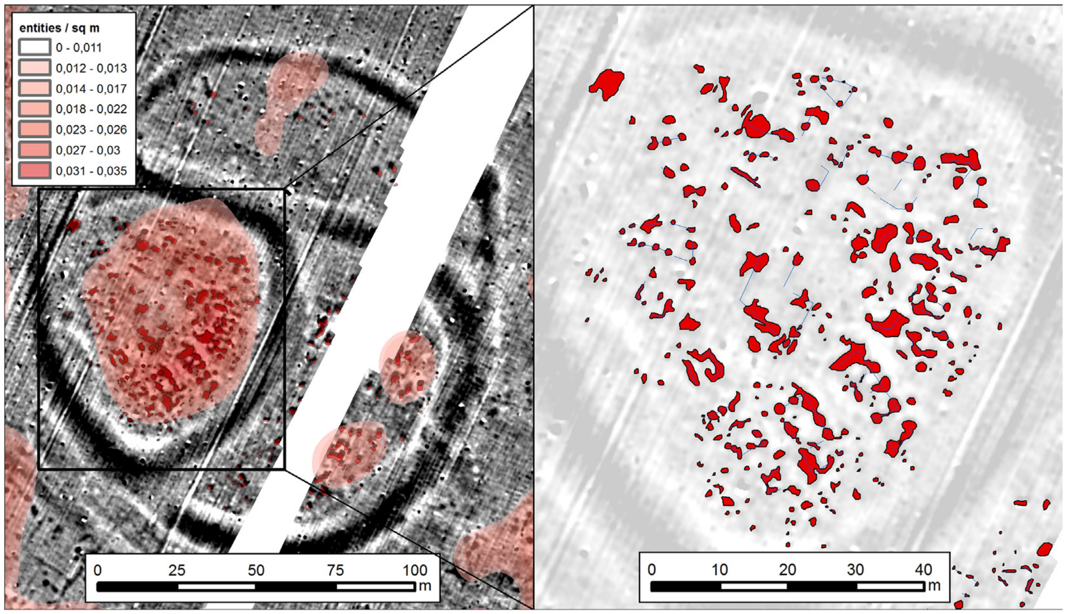

Fig. 3. Spatial analysis of magnetometry results. Left: *Kernel Density* analysis in ArcGIS (20 m radius, cell size 0.1 m) of house – like type of anomalies (2 nT values); Right: House – like type of anomalies distribution in zone A of the settlement.

these features within the ditch system.

Other types of anomalies – On the magnetic plan there are hundreds of elongated anomalies with higher magnetic properties which could indicate the presence of archaeological features such as pits, daub concentrations, or postholes (Fig. 2). The variety of shapes provoked further analytical steps for distinguishing the most relevant arrangements, among which the most important for stratigraphic and functional interpretation are the house-like types of anomalies.

3.2. House-like anomalies – distribution and patterns

In order to detect the highest density of the supposed housing structures, a *Kernel Density* tool was used in ArcGIS 10.1. Based on the most representative feature located in zone A of the settlement, it was decided to search for anomalies characterized by a magnetic signature of 2 nT. The raster was therefore converted to a shapefile using the *Reclassify* tool to extract the aforementioned values and then subjected to a spatial analysis of density. Due to the high variability of the magnetic values and diversified sizes of particular anomalies, the analysis was focused only on those whose area exceeded $0.4\ m^2$. Using this threshold, insignificant anomalies were omitted from the estimation and the analysis was restricted to objects of considerable sizes which might represent wall-like features. As a result of the *Kernel Density* analysis, it was possible to detect the highest concentration of house-like anomalies in zone A of the settlement, while it was observed that the zones B and C lacked or had an insignificant number of such features (Fig. 3).

Another focus point of the spatial distribution analysis was the wall-like structures. For this purpose, values between −5 to 5 nT were extracted and transformed into a shapefile. Each polygonal feature was given a symmetry line along its longer axis to understand the layout of the house. In total, 101 line features were registered, forming 16 housing structures. The distribution of these features shows a somewhat regular arrangement (Fig. 3). Especially in the southeastern part of zone A of the settlement, the house-like structures are grouped in a row of 3 objects oriented with their longer side along a southeast – northwest axis. Their approximate sizes are 10 × 4 m. To the northwest, in the central part of zone A, a larger rectangular structure of 10 × 10 m was recorded, which could indicate the presence of a central building. In the western part of zone A, the anomalies were highly concentrated but do not match any regular arrangement. This could indicate several phases of occupation superimposed on each other in a non-regular plan. A more dispersed concentration of anomalies was recorded in the northern part of this zone.

3.3. Excavations of a house-like anomaly

Verification of a house-like type of anomaly was conducted by excavations (Fig. 4). It was decided to investigate the most well-preserved housing feature visible on the magnetic map (Fig. 4). The excavations and analysis of the archaeological material proved that this type of anomaly corresponds to the wattle and daub walls.

The stratigraphy documented in the trenches presents two stages of settlement development (Table 1). It appears that this particular place bears traces of two houses (re)constructed in the same place within a relatively short period (phases Kakucs 5 – Kakucs 9) (Jaeger et al., 2018a, b). In light of available sources, these structures are a typical housing forms for the MBA in the region. The walls were made of a wooden construction enforced and covered by daub. The floors were created using hardened clay. Both buildings had a hearth and a fireplace, while the older structure was associated also with a specific feature (No. KEX 13-15: 12134) located outside of the house, close to its wall. This feature consisted of an ideally circular pit, filled with a considerable amount of ashes and charcoals. The top of this feature was covered by a coarse ceramic bowl, which was in turn originally covered by a thick clay plate with numerous perforations (the sherds of this plate were found inside the coarse bowl). The amount and quality of macroremains suggests that it could have served as a small-scale processing structure (Jaeger et al., 2018b; Filatova et al., 2018). The reconstructed set of ceramic vessels, osteological remains, deposits of grains, fragments of burnt pie and the assemblage of tools (i.a. spindle whorls, bone needles, small bronze chisel), indicate that the household area witnessed activities related to production, food preparation, consumption, and storage of crops (Jaeger et al., 2018a, b).

3.4. Sedimentological and geochemical analysis of samples from trench 1

The recovered archaeological material suggest settlement processes which occurred over a relatively short period of time. The excavated plana showed two housing structures with a considerable amount of

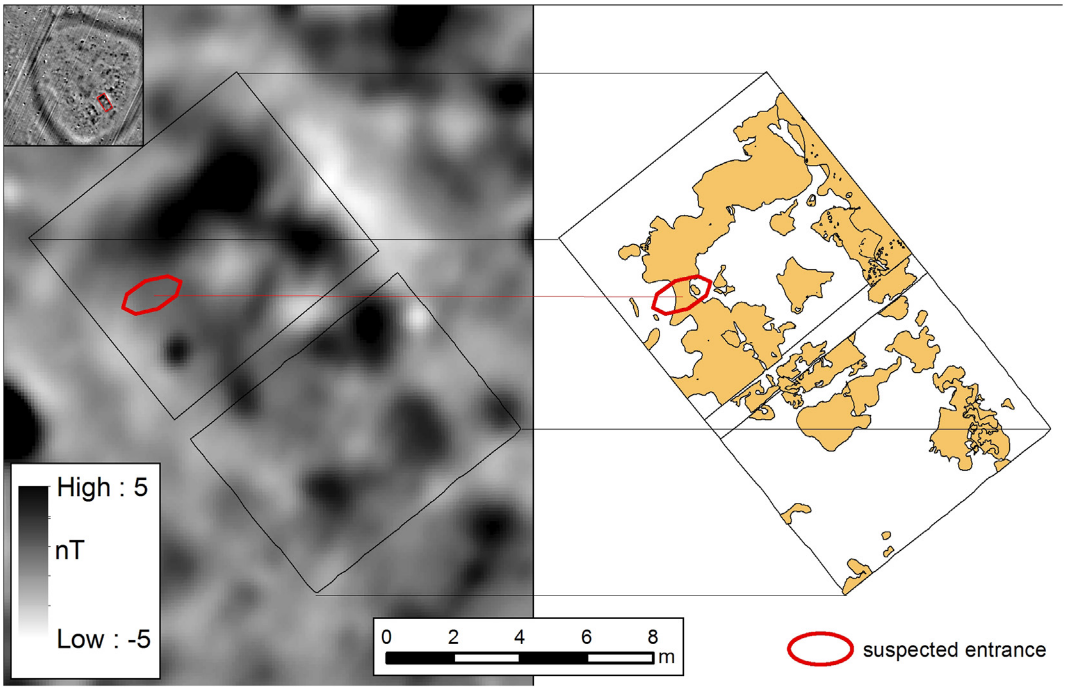

Fig. 4. Correlation of the magnetic anomalies with the archaeological excavations of a Middle Bronze Age house. Right part of the figure presents the layers most representable for the excavated hut (Yellowish spots represent the daub layers).

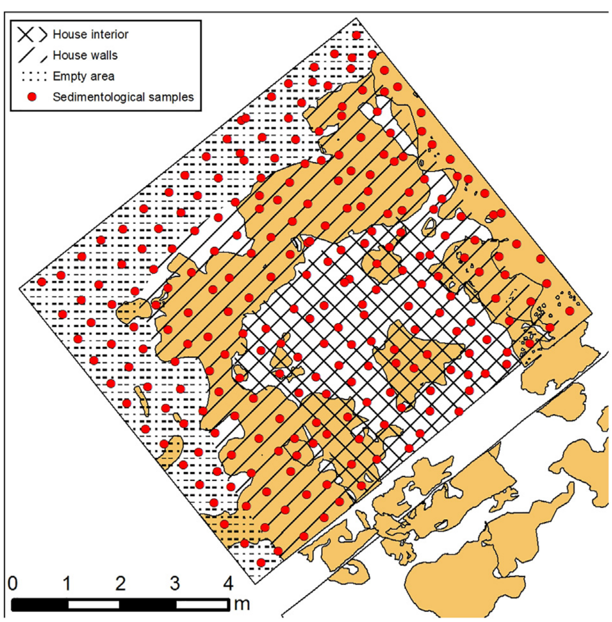

Fig. 5. Location of sedimentological samples and division of the zones within the trench 1. Yellowish spots marks the layers of daub related to the walls and floor.

empty space in the western part of the trench. The small number of finds and archaeological features in this area of the trench allowed the definition and investigation of differences between a house structure and its immediate surroundings. However, the spatial distribution of archaeological features indicated the presence of a gap in the settlement processes recorded in the western part of the trench, there was an opportunity to search for other parameters which could indicate the human activity in the area outside the house.

Therefore, at a resolution of approx. 4 samples per square meter, a total of 248 sediment samples from both within and outside of the defined household area in trench 1 were collected for analysis (Fig. 5). Regarding both the sedimentological and geochemical data it is crucial to keep in mind that the samples were obtained from a single level between 50 and 60 cm b.g.l. Therefore, the results of the analyses must be considered as the record of settlement processes within this stratigraphic unit. On the other hand, the multilayered and tell-like stratigraphy of the excavated area suggests that this 10 cm layer must be considered not as the result of a single activity, but an accumulation of processes.

Sedimentological differences of the three zones inside the trench (house – walls – empty zone) are expressed most clearly in the distribution of the sorting (SD), skewness (Sk) and kurtosis (Kz) (Fig. 6). The SD indicates that the most poorly sorted material was abundant in the area outside of the house and thus shows correlation with the planigraphy. However, the overall sorting of the sediment was poor within the entire trench; considering the anthropogenic character of the study area, this does not seem to be driven by natural factors. Like the SD, the Kz shows a difference in values within and outside of the house. Inside the house, the Kz vary between 1.14 and 1.41 phi, suggesting a pulsating sedimentary environment. The area outside of the house is associated with lower values below 1.14, but not reaching lesser than 1 phi. This indicates that the area adjacent to the house was also characterized by unstable sedimentary processes, though to a lesser degree. The distribution of the Sk parameter shows a slight rise to the east from −0.03 to 0.09 phi. This may be associated with the presence of features such as walls or floors which were constructed of finer sediments.

The mean grain size oscillates between 5.5 and 6 phi within the trench, therefore the main component of the sediments may be described as fine silts. A noticeable concentration of finer sediments is visible in the northern part of the trench where the kiln was located (Fig. 6). A similar spot with finer grain-sizes was registered in the southwestern part of the excavation area, directly adjacent to the house.

Fractional differentiation also follows the features defined archaeologically (Fig. 7). There is a high concentration of mud (silts and clays combined) where the kiln is located (89–94%). The area within the house exhibits higher percentages of clay, which possibly reflects the remains of the hardened clay floor. On the other hand, one of the highest concentrations of finer sediments is again (as in the Mz) located

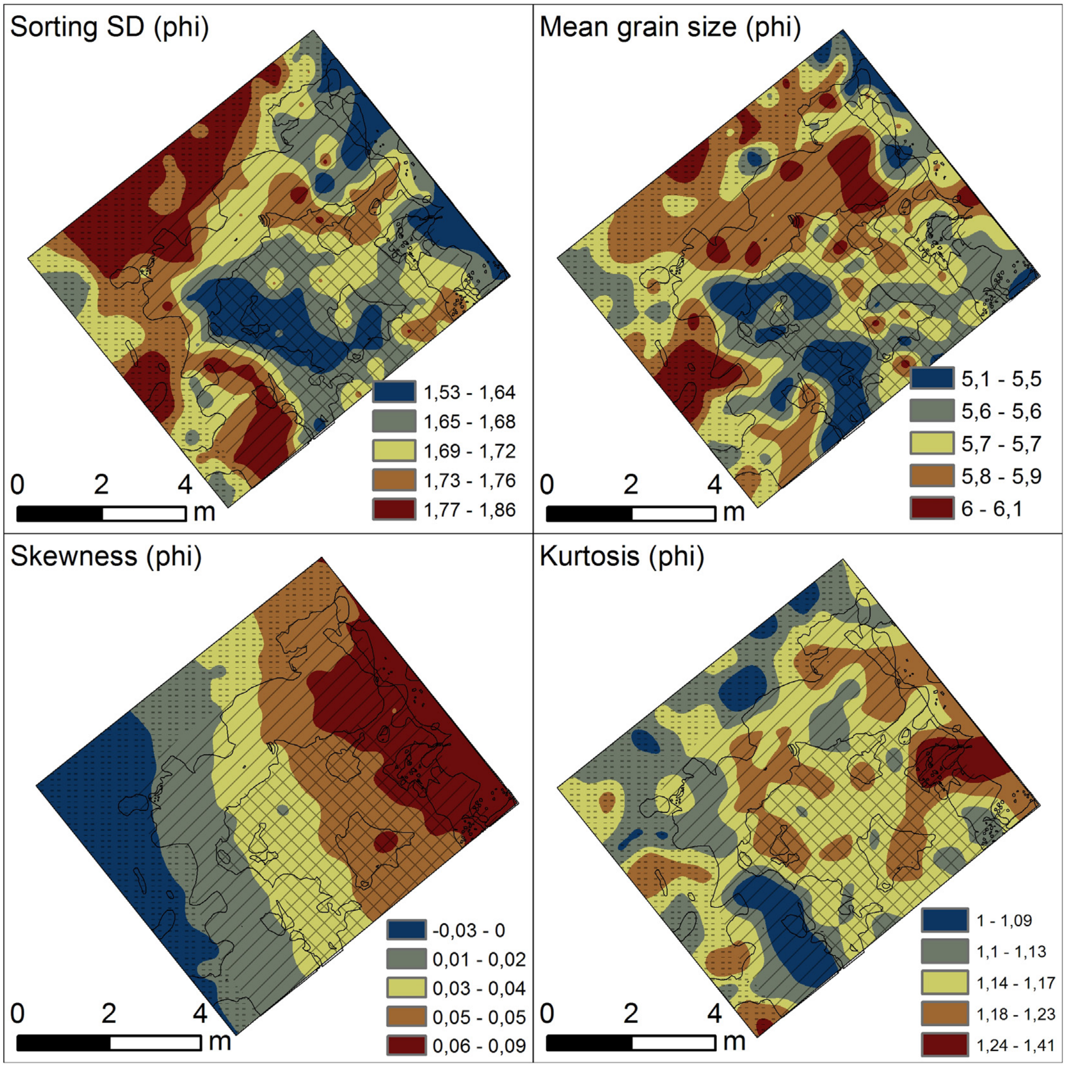

Fig. 6. Sedimentological parameters distribution in trench 1. Zones are represented accordingly to the legend in Fig. 5.

in the western part of the trench, in the area adjacent to the house. The amount of sand varies between 6 and 26%, with the highest values occurring in the area of the house's western wall. This suggests the usage of sand as an admixture to the clays used in construction.

Geochemical analyses were performed on the same set of samples (Figs. 5 and 8). The distribution of geochemical compounds also matches the features defined during excavation (Fig. 8). First of all, the carbonate concentration in the samples seems to follow the division between the house and the open area to the west; in the latter, this compound is nearly absent (up to 1.5%), while in the interior part of the house its value rises to 12% (Fig. 7). The elevated amount of carbonates inside the house is likely connected with the usage of carbonate rich clay.

Contrastingly, the distribution of P seems to be inverted in comparison to the sedimentological characteristics already discussed which show more intense human activity within the house. The values of P inside the house vary between 180 and 2000 ppm, while for the western part of the trench they are between 2000 and 4300 ppm. According to the research of Füleky (1973) in the last two decades, the background concentration of total P content within Hungarian soils does not significantly exceed 1000 ppm, therefore values above that are usually considered geoarchaeological markers of possible human influence on soils and sediments. One the one hand, the mean amount of P within the trench indicates a strong anthropogenic influence on the sediments (c.f. Fidvár by Vráble; Gauss et al., 2013, Perkáta–Forrás-dűlő, Pető et al., 2015); but, on the other, it is striking that the highest concentration of P is situated outside the house. However, it is imaginable that materials that produce the highest P geochemical finger print – such as dung or animal wool – could have been periodically or continuously deposited and stored next to the building and not within the living area.

The element reflecting the distribution of archaeologically recognized features most directly is Fe. The range of measured concentrations of this element is between 11,074–16,550 ppm, with the highest values attributed to the exact course of the walls. This association could be explained by the specific composition of the clays used to construct the walls which originally could have contained a large amount of Fe.

Mn, which is an indicator of the efficiency of the weathering processes, was registered in the highest amounts (up to 419 ppm) in the same area as the maximum concentration of P. The lowest levels of Mn oscillated around 251 ppm and were located in the north-central part of the house's interior.

Similar patterns of distribution to that of Fe and P were documented for Zn and Cu. The concentrations of these elements ranged from 31 to 48 ppm for Zn and 11 to 24 ppm for Cu. The highest concentrations were registered in the western area, directly adjacent to the house.

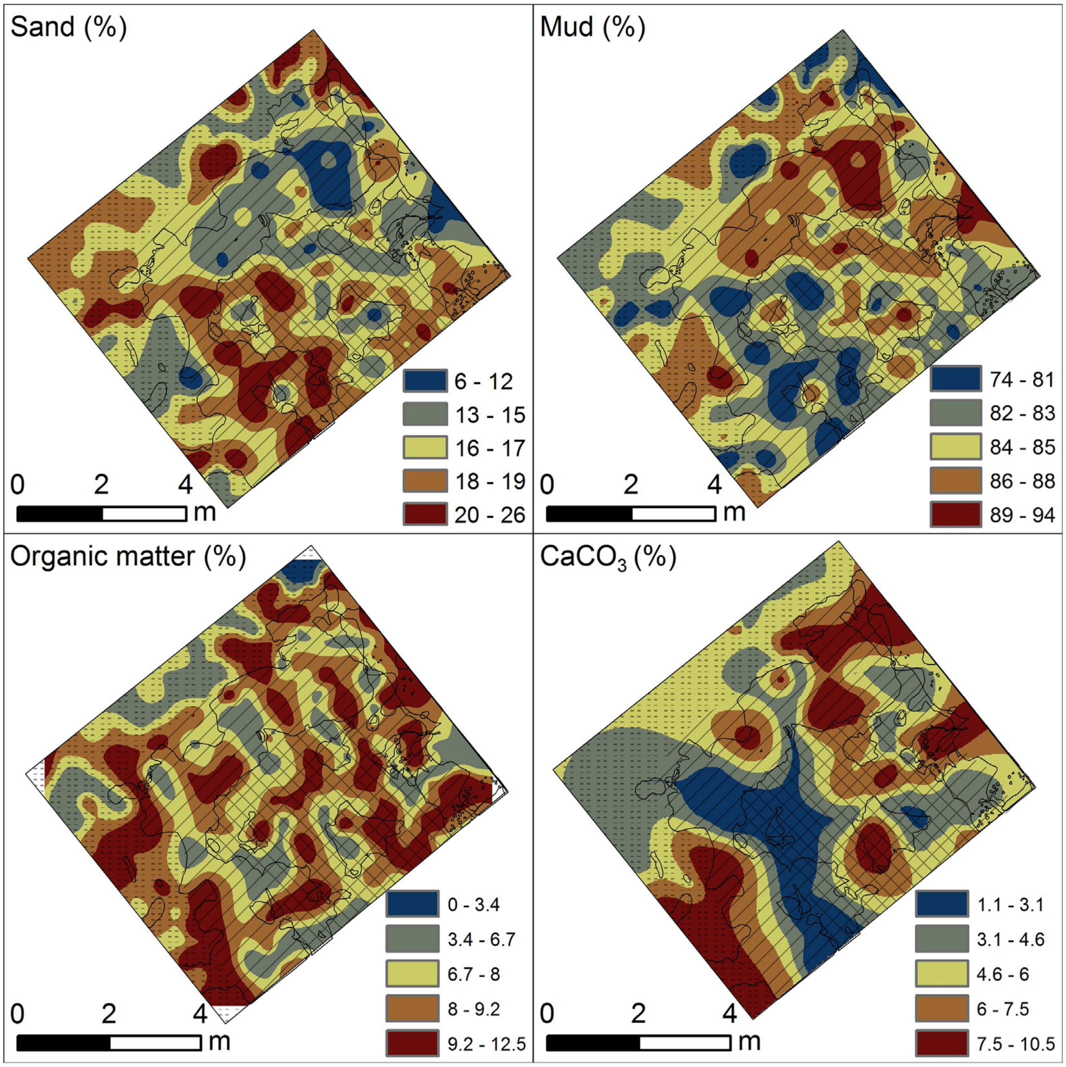

Fig. 7. Distribution of fractional share, organic matter and calcium carbonates in trench 1. Zones are represented accordingly to the legend in Fig. 5.

3.5. Interpretation of sedimentological and geochemical analysis in light of the archaeological excavation and magnetometry survey

The acquired results of the analyses of the sediments are strongly connected to the data recovered from archaeological excavations (Fig. 9). First of all, it seems that the entire area of the trench was characterized by an unstable sedimentary environment. However, the values of Sk, Kz and SD varied, suggesting that the most anthropogenic part is the house. The differentiation in the proportion of sand and mud fractions resulted from the presence of daub structures.

While the $CaCO_3$ and OM concentrations were not the most indicative in terms of spatial distribution, the chemical elements provided more relevant archaeological interpretations. The location of the highest concentrations of P, Zn, Cu, and Mn in the western section of the trench adjacent to the house deserves further consideration (Fig. 9). Here, it is worthwhile to compare the results with the magnetometry plan. In the same area where the high values were recorded, the geophysical plan shows an interruption in the course of the anomaly related to the wall structure (Fig. 4). Moreover, the archaeological excavation revealed that this particular place should be treated as the entrance to both of the stratigraphically distinguished houses. The presence of a high concentration of P in this spot could indicate that food processing and other activities took place in front of the house, just next to the entrance and the Cu and Zn could be connected to the using or production of bronze objects such as tools. From this perspective, the lack of magnetic anomalies outside those related to the walls is intriguing. Regardless, based on the sedimentological and geochemical analysis, the area outside the house should be treated as an anthropogenic zone where activities also took place. Perhaps the lack of stratigraphically and spatially delimited objects resulted in no traceable anomalies on the magnetic plan. Despite the lack of distinctive objects, this area should be interpreted as an anthropogenic in form of a possible pathway between the houses. Such a situation was documented in another MBA settlement in Central Hungary, namely at Százhalombatta (Poroszlai, 1993: 32).

The anomalies recorded on the magnetometry map mostly reflect the archaeological features interpreted as walls. However, some further features can be traced as well. The best example of such is the kiln, located in the northernmost corner of the house in the exact same place where a high magnetic anomaly was recorded.

3.6. The house area at Kakucs-Turján in light of available regional data

The picture of the internal arrangement for most Vatya MBA settlements is only fragmentary (Jaeger, 2016: 77–83). The complexity of site stratigraphy, which in many cases shows the above mentioned settlement continuity from the Early Bronze Age (EBA), meant only relatively confined areas could be excavated in a timely manner. The same holds true for Kakucs-Turján. However, the combination of excavations with geochemical analyses allowed the collection of some

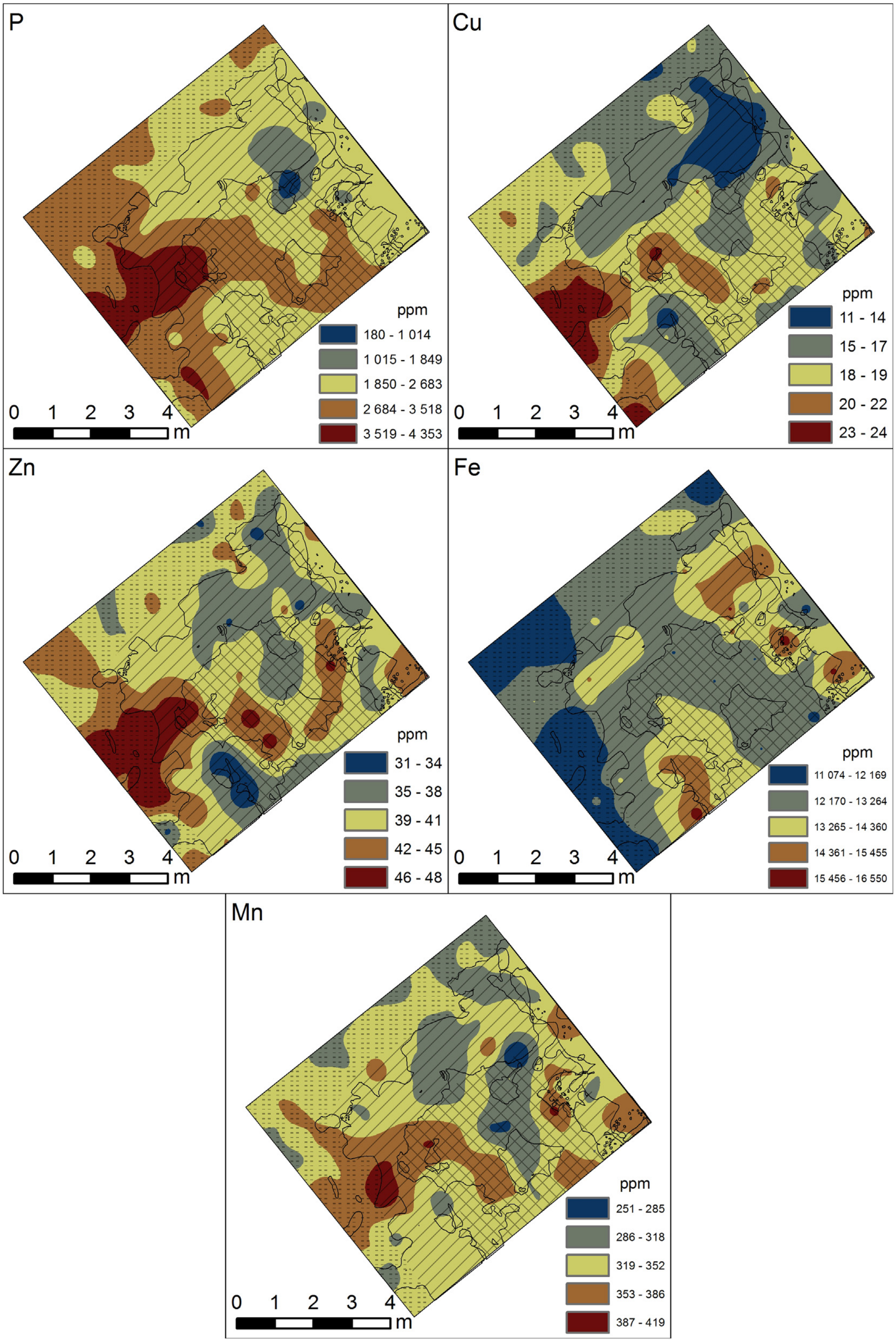

Fig. 8. Distribution of chemical elements in trench 1. Zones are represented accordingly to the legend in Fig. 5.

important information regarding habitation structures.

In light of the information gathered to date, it appears that during the Vatya period of settlement at Kakucs-Turján, the building form did not diverge from the known pattern of the period and region. The houses had a wooden (posts and wattle) structure reinforced with clay (daub). Clay was also used to build floors and some of the internal elements, like e.g. hearths and ovens.

Local settlement tradition is reflected not only in building techniques and materials, but also confirmed by what is observed at many other sites: the reiteration of a settlement sequence (though not continuity), spanning from the EBA until late MBA, i.e. from the late phase of the Nagyrév culture to the Koszider period.

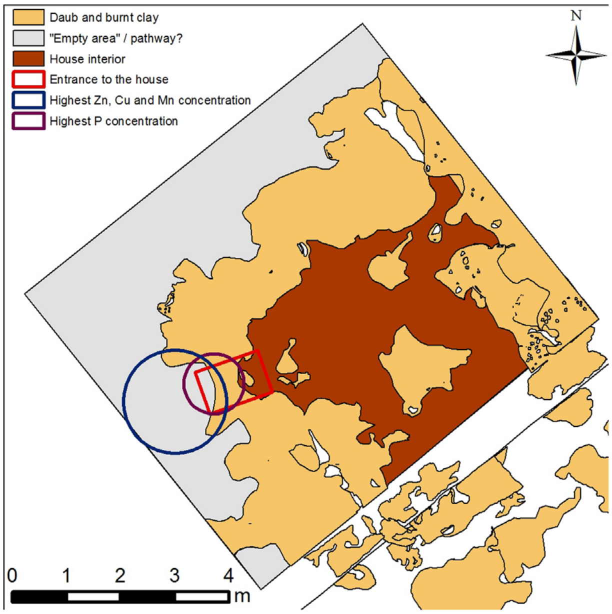

Fig. 9. Results of the sedimentological, geochemical and archaeological research in trench 1. The figure comprise archaeological features and concentration of the most indicative anthropogenic elements (P, Zn, Cu and also Mn).

Available sources suggest that the inner space of Vatya culture settlements was approached in a pragmatic way, with the houses separated by relatively small distances (e.g. Nagykőrös-Földvár, Poroszlai, 1988:33, 36–37, Fig. 9). There also seem to have been certain rules governing the placement of particular utility features, such as ovens and hearths, near the houses (e.g. Alpár-Várdomb, Bóna and Nováki, 1982:115). Moreover, it may be hypothesized that specialized economic activity, such as pottery and metallurgic production, were taking place in defined locations. This may be inferred from the discovery of the clustered pottery kilns in Százhalombatta (Poroszlai, 1996:10) and remnants of a metallurgical workshop in Lovasberény-Mihályvár (Kovács, 1984:226).

In the case of Kakucs-Turján, both Vatya houses contained sets of archaeological material confirming the whole spectrum of economic activities typical for the MBA in the region. The inhabitants used crucial raw materials (metals, amber, obsidian, flint) and worked bones and antler. Indirect sources (spindle whorls) confirm the production of textiles. Moreover, there seems to be local production of pottery. The analyses of the sediment samples shed some light on practices of waste management, as is visible in the high P content concentrated outside the house in the space separating it from the neighboring building. It is very plausible that this space served not only as a path, but also as a place of waste deposition. In addition, the geochemical analysis suggest this part of the area around the house was a place where some specific tasks were performed. A high concentration of Cu and Zn can be explained as a result of long-term use of metal tools in this particular place. Although it is not possible to define the activity more precisely, as there were no features suggesting metalworking (production) in this area, it seems more plausible that the geochemical composition of soil should be rather understood as a result of work with (cutting?) or work on (sharpening?) metal tools.

4. Conclusions

Despite the complicated stratigraphy and vast horizontal expanse of the MBA fortified settlement of Kakucs-Turján, some essential aspects of the housing space were reconstructed using a multidisciplinary methodology. The extensive magnetometry survey provided an overview of the site's horizontal structure. According to the magnetic map, the site was partitioned into three zones, separated internally and enclosed externally by a system of ditches. Within this system of ditches, three well-like structures were also recorded. However, the most important in the terms of the occupation history was the detection of at least 16 house structures in zone A. Excavations of one structure provided insight into the settlement stratigraphy, revealing two houses rebuilt in the same location and thus indicating tell-like practices. Among numerous finds, wattle and daub walls with wooden posts were recorded corresponding to the location of anomalies detected on the magnetic plan. Within the house, a clay hearth and kiln were revealed alongside innumerable artifacts providing evidence of specific activities which could have taken place inside. Sedimentological and geochemical analyses of samples taken from a particular level of the excavation showed spatial differences in the anthropogenic indicators; although the entire area of the archaeological trench was characterized by an unstable sedimentary environment, there were differences between the housing and open spaces. Geochemistry, especially the P content, indicated that waste disposal was concentrated in the area outside the hut, just next to the suspected entrance visible as a discontinuity in the wall. This area served also for other activities involving bronze items, which was evidenced by the high amounts of Cu and Zn.

In conclusion, the combination of archaeological methods with non-invasive techniques and laboratory analysis proved the potential of using a multidisciplinary approach to reveal a site's horizontal expanse and vertical stratigraphy. Moreover, it expanded upon archaeological explanations, using sedimentological and geochemical analyses to obtain knowledge about functional aspects of housing space in Kakucs-Turján.

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