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The site mapping of Kakucs-Turján by the means of horizontal and vertical proxies: Combining field and basic laboratory methods of geoarchaeology and archaeological prospection

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ABSTRACT

The homogenous cultural identity that emerged during the Middle Bronze Age (2000–1450 cal BC) in the central territory of the Carpathian Basin is identified uniformly as the Vatya culture. The Vatya people created multi-layered tells, open air horizontal, as well as fortified settlements along the western and eastern bank of the Danube river. These archaeological sites are significant elements of both the cultural and natural heritage of the Carpathian Basin. Their significance does not only lie within the possibility to reconstruct the life, society and material culture of Vatya populations, but the buried soils and anthropogenic sediments hold significant information on prehistoric human-environment interactions, and on site formation processes that occurred after the abandonment of the individual settlements. Geophysical prospection methods and field walking helped to locate and identify the tripartite structure of Kakucs-Turján archaeological site within the territory of the Danube–Tisza Interfluve. The settlement was established on the border of different geographical micro-regions and at the conjunction of dissimilar natural geographical environments. The stratigraphy of the site was described by the means of high resolution and focused series of hand auger observations, as well as on the basis of basic soil physical and chemical parameters. The detailed macro-morphological description of the soil core profiles aimed at precisely identifying the soilscape of the site and its vicinity, the stratigraphy of the anthropogenic and natural sediments of the settlement, but also to facilitate our understanding of the site formation process. Data gained by the means of geoarchaeological methods not only form the basis of environmental historical conclusions, but reveals mosaics of the interaction between ancient human populations and their environment.

1. Introduction

1.1. Archaeological background

One of the most distinctive traits of the Middle Bronze Age (MBA; ca. 2000–1450 cal BC) in the central basin of the Danube (and in a broader context across the entire Carpathian Basin) was the dynamic development of fortified settlements (Earle and Kristiansen, 2010; Jaeger, 2016). Some of the settlements functioned uninterruptedly for a number of centuries; as a result, the current thickness of cultural layers ranges from several to over 10 m. As conspicuous elements of the cultural landscape and sites, which yield spectacular finds, fortified settlements drew the attention of researchers quite early. It began with the amateur enthusiasts of antiquity, who were later followed by professional archaeologists (Gogâltan, 2017). The latter half of the 20th century is a period of numerous and intense excavations at a variety of sites in today's Slovakia, Hungary and Romania. Unfortunately, due to the complex structure of the defensive settlements — encompassing monumental (at least in Central European archaeology) elements such as walls or ditches, as well as the aforementioned considerable thickness of cultural layers — archaeological research inevitably involves a range of methodological issues relating to organisation, logistics, and funding; requiring long-term excavation campaigns throughout consecutive seasons. Consequently, in spite of a long history of studies at

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individual sites, examples of comprehensively investigated defensive settlements in the Carpathian Basin are few and far between. The extent to which they have been explored varies: sites range from those merely included in various listings, through settlements, which underwent surface surveys and were documented on altimetric plans, to sites where actual excavations were carried out (Jaeger, 2016).

This is also the case with the area discussed in this paper; namely the region of the central drainage basin of the Danube (Szeverényi and Kulcsár, 2012). Among approximately 40 defensive settlements of the Vatya culture, which predominates in central Hungary, only 14 have been explored by means of excavation (e.g. Poroszlai, 1992, 2000; Kulcsár, 1997, 2002, 2009; Vicze et al., 2005; Vicze, 2011; Reményi, 2012; Jaeger and Kulcsár, 2013; Jaeger, 2016; Kiss and Reményi, 2017). In addition to those, which were excavated, a couple of sites have been inventoried and mapped by implementing geoarchaeological mapping, which is acknowledged as part of the non-invasive technical apparatus (e.g. Százhalombatta–Földvár: Varga, 2000; Perkáta–Forrás-dűlő: Pető et al., 2013; Saláta et al., 2014; Kakucs–Balla-domb, Kakucs–Szélmalom-domb; Dabas–Csárda-puszta; Dömsöd–Leányvár: Pető, unpub; Mende–Leányvár: Sándor, 2011). Nonetheless, it is to be expected that the situation and our state of knowledge will gradually improve. This is due to the fact that a number of projects undertaken in the recent years have been geared towards comprehensive and interdisciplinary investigations (e.g. spanning the relationship between human and natural environment) of particular defensive settlements of the Vatya culture (Gogâltan, 2017; Earle and Kristiansen, 2010). This paper illustrates partial results of investigations conducted by a Polish-Hungarian-German team at the settlement of Kakucs-Turján and in its micro-region (Jaeger et al., 2018a, 2018b) (Fig. 1).

Within the line of investigations at Kakucs-Turján the magnetometry (horizontal aspects) and geoarchaeological mapping (vertical aspects) was followed by excavation campaigns. The excavation work focused on the exploration of a remnant structure located within the nucleus of the site. The magnetometry showed to have been relatively well-preserved (see Niebieszczański et al., 2019 in this volume). The feature, interpreted as the remains of a building was investigated with the opening of two trenches separated with the baulk (treated as trench No. 3.), and documented separately, using digital means (photography, photogrammetry, micro-planigraphy) and descriptive (i.e. stratigraphic) methods. Results of the excavations are summarised in Jaeger, 2016; Jaeger et al., 2018a, 2018b.

Accomplishing the excavations in 2017 provided in-depth documentation of Bronze Age settlement remains present in both trenches. The excavation of the area revealed several main occupation phases: possible Early Bronze Age habitation phase indicated by the presence of a handful of Makó sherds, intensive habitation phase consisting of Early Bronze Age pits (up to 1.5 m deep and containing ceramics of the Nagyrév (Kulcs phase) and Kisapostag styles), followed by Middle Bronze Age house structure related to Vatya ceramic style. The youngest occupations phase is related to late Middle Bronze Age (Koszider period). This stratigraphic sequence suggests that we are dealing with various phases of the site (see Table 1 for the simplified chronology of the subjected area).

1.2. The role of non-invasive methods in detecting and describing Kakucs-Turján archaeological site

Kakucs-Turján was identified following aerial reconnaissance performed by a pair of Hungarian archaeologists, Zoltán Czajlik and Zsuzsa Miklós (Kulcsár et al., 2014). The first non-invasive surveys followed in 2011; the survey was carried out using a fluxgate magnetometer (Bartington Grad 601-1), covering a total area of 1 ha, divided into 20 × 20 m plots. Individual traverses were spaced at a distance of 1 m; measurements were taken at 0.25 m intervals. The objective of the survey was to ascertain whether the bi-partite division of the settlement, discernible on Google Earth satellite imagery, was indeed to be found there. The survey revealed the presence of the third, hitherto unknown, section of the site (Fig. 2). The subsequent step, prior to undertaking excavations, was performing yet another magnetometric survey. The aim of the repeated survey was to provide the original map of magnetic anomalies with further details. Results of the second, verifying archaeological prospection survey is described in detail in Niebieszczański et al. (2019) in this volume.

The obtained image of magnetic anomalies over an area of 110.000 m^2 yielded information about the preserved elements of internal structures, the settlement defences, and its immediate vicinity (Fig. 2). The most significant outcome of the second magnetometric prospection was that it confirmed the complex structural arrangement of the site; lines of fortification divide the settlement into three parts. The survey revealed different types and intensities of magnetic anomalies for each of the sections (Fig. 2). In the first, the survey provided evidence of fairly well-preserved remnants of buildings. In the second, there are numerous single-point anomalies, which do not combine into any evident larger structures (which may in part be due to the contemporary dirt road, whose construction destroyed the underlying layers). The last part of the site did not show a significant number of anomalies, whilst the few registered ones do not form any larger patterns. Such a magnetic image offered grounds to adopt a thesis presuming a functional inner division of the settlement into a residential part, a utility and economic part (crafts, storage/warehousing, supply of building material), and a kraal or area where animals could have been grazed or penned. This interpretation of the magnetometric findings is now being verified by ongoing archaeological research.

Data from the magnetometry survey at Kakucs-Turján provided a basis on which further research was planned with respect to the scope and type of work to be carried out. In view of the sheer acreage and the degree of structural complexity we decided to conduct excavations in selected, isolated locations (e.g. Kulcsár et al., 2014) but prior to those actions geoarchaeological mapping, as well as soil and sediment sampling was performed throughout the site (Fig. 2). In this sense, the geoarchaeoloigcal mapping of the site complemented the ‘horizontal’ knowledge gained through the magnetometry with vertical data.

In the light of the above mentioned, this paper aims to give a summary on the geoarchaeological survey and analysis conducted prior to the excavation campaigns at the MBA site of Kakucs-Turján. Since the dwelling area, which is located in the centre part (or nucleus) of Kakucs-Turján is discussed in detail in Niebieszczański et al. (2019; in this volume) this paper will focus on the geoarchaeological properties of the site in general and its boundary features. In the course of the archaeological prospection, excavation and geoarchaeological works of Kakucs-Turján several papers dealing with the first results have been published in Hungarian, Polish and English throughout the last couple of years (Kovács et al., 2017; Niebieszczański et al., 2018; Pető et al., 2015a, 2015b, 2016, 2018). Our current aim is to sum up the results gained through the archaeological prospection analyses (see Niebieszczański et al., 2019; in this volume) and the geoarchaeological studies of the site.

1.3. Geographical setting of Kakucs-Turján

The settlement lies in the central part of the Carpathian Basin, within the Danube–Tisza Interfluve, within a triangle formed by the modern settlements of Inárcs, Kakucs and Újhartyán. This area is a border region of the following geographical microregions of Hungary: 1) Pest Alluvial Plain, 2) Csepel Plain, 3) Pilis-Alpár Sand Ridge, 4) Kiskunság Sand Ridge (Fig. 1). All of the three microregions are characterised by gently sloping and slightly undulating plains covered by fluvio-aeolian sands (Dövényi, 2010). The monotony of these plains are interrupted by the mosaics of loess derivates and former meanders, filled up with alluvial sediments, however their occurrence is sporadic. The climate of the region falls in to the category of moderately warm and warm with a mean annual temperature of 10.2 to 10.5 °C. The

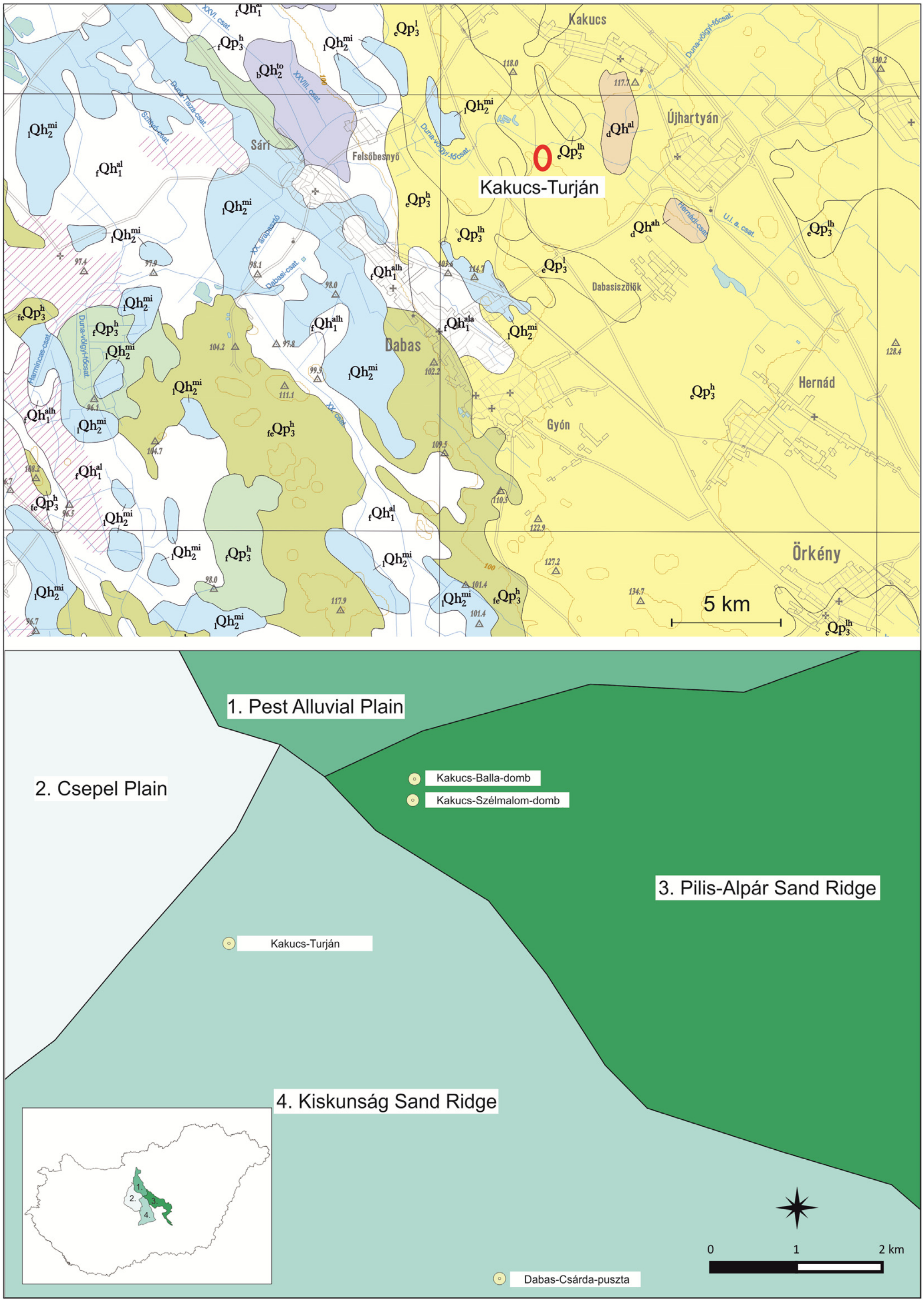

Fig. 1. Geological (above) and geographical (below) setting of Kakucs-Turján archaeological site. Geographical microregions and neighbouring sites of the Vatya culture mentioned in the text in the close vicinity of Kakucs-Turján are displayed on the lower map. Legend: $_{e}Qp_3^{l}$ – loess; $_{e}Qp_3^{lh}$ –loessy sand; $_{e}Qh_2^{mi}$ – lacustrine silt (lime); $_{d}Qh^{ah}$ –clayey sand; $_{d}Qh^{al}$ – aleurite.
(Re-drawn after Gyalog (2005))

precipitation value alternates between 530 and 550 mm-s annually, upon which the area can be characterised as dry. The marshlands of the so called Turjánvidék borders the site from the north, however due to the special geological setting on the Danube–Tisza Interfluve the micro-region of Kakucs-Turján can be characterised by water-shortage and by scarce runoff. In accordance with the geology of the wider environment the dominant soil types of the site evolved on the fluvio-aeolian sand (e.g. loose sandy soils) and loess (e.g. Chernozems) (Marosi and Somogyi, 1990). The site is located on an aeolian dune composed of mixture of sand and loess sediments (Fig. 1).

Table 1
Early and Middle Bronze Age chronology of the inner region of the Carpathian Basin (compiled after P Fischl et al., 2015).

Date (cal BC)	Central Europe	Hungary	Danube River region/central part of the Carpathian Basin
1500/1450	RB B	MBA3	Vatya
	RB A2	MBA 2	
		MBA 1	
2000/1900	RB A1	EBA 3	Late Nagyrév
2200/2100			Kisapostag
2300/2200	RB A0	EBA 2	Bell Beaker
2500/2400	Eneolithic		Late Makó
			Proto and Early Nagyrév
		EBA 1	Makó

2. Materials and methods

2.1. Archaeological prospection methods

The archaeological prospection was carried out by the means of a motorised fluxgate gradiometer (Sensys GmbH) equipped with 8 sensors (type FGM650B). Each of the sensors had two probes spaced at 650 mm, measuring range of ± 10.000 nT with an accuracy of 0.1 nT. The sensors were arrayed at a distance of 250 mm. The raster of the output image ranged from 8 cm to 10 cm. The measurements were recorded in real time using compatible a GNSS RTK receiver (DLMGPS software). The Magneto® ARCH 1.00–03 and TerraSurveyor 3.0.22.1 software were employed to filter data and generate the map of magnetic anomalies.

2.2. Geoarchaeological methods

In order to map the stratigraphic conditions of the site, a series of hand-operated gouge auger observations (soil core sampling) were planned prior to the excavation campaigns. On the basis of the archaeological prospection survey the following protocol was designed (Pető et al., 2015a) (Fig. 2):

- Cross-section of the site and its surroundings in a north-south and east-west directions,
- Cross-sections of the ditch-like anomalies bordering the settlement.

The five cross-sections comprised of a total of 35 pcs of individual gouge auger observations (Fig. 2). The observations and sampling were carried out with a hand-operated Eijkelkamp gauge auger (l = 100 cm; d = 2.5 cm) and an Edelman auger (d = 7 cm). The on-site soil description method followed the principles of both the Hungarian Soil Classification System (Stefanovits, 1963), and the TIM methodology (TIM, 1995), which was previously modified and extended in order to be able to describe anthropogenic signs and modification of the soil-sediment environment. The on-site soil description was carried out based on the following criteria: 1) slope/gradient; 2) geographic exposure (N, W, S, E); 3) vegetation cover; 4) colour (based on Munsell Soil Colour Charts, 1990); 5) texture; 6) presence of archaeological phenomenon or particle (artefacts); 7) presence of modern/recent anthropogenic particles or disturbance; 8) moisture status; 9) carbonate content (with 10% HCl probe: from 0 to + + +); 10) concretions; 11) root intensity; 12) compactness; 13) structure.

In order to characterise the 'cultural soilscape' (Wells, 2006) of both the territory and the wider surroundings of Kakucs-Turján, basic soil chemical and physical soil parameters were measured on a selected set of samples. These imply the following analysis types: humus content [H %] (based on Tyurin's method) (MSZ-08-0452-80, 1980); total organic carbon content [TOC%] (Loss on Ignition method) (Buzás, 1988; Faithfull, 2002); total phosphorus content [P_{total}] (Murphy and Riley, 1962 and Füleky, 1983); pH [H_2O & KCl] (conductometric method) (MSZ-08-0206/2-78, 1978); salt content [salt%] (conductometric method) (MSZ-08-0206/2-78, 1978); carbonate content [$CaCO_3$%] (measured with a Scheibler-type calcimeter) (MSZ-21470/51-83, 1983); texture coefficient [K_A - Arany-type soil texture coefficient] (MSZ-21470/51-83, 1983).

Anthropogenic sediments hold the 'memory' of the once existed settlement and the activities that took place within the form of various physical and chemical parameters of the soil (and anthropogenicaly modified sediments). However, the usefulness of geoarchaeological data in the interpretation of human-induced or disturbed surfaces and vertical features can only be evaluated if the geological and pedological background of the site is known (Terry et al., 2004). To satisfy the aforementioned criteria, control soil profiles located outside the territory of the tripartite settlement structure were selected in order to retrieve background data for the comparison of human-induced surfaces (cf. within the tripartite settlement structure) and the background (embedding) environment.

2.3. Visualisation of the results

The soil horizons and layers within the individual profiles were coded with the combination of a letter and number according to the criteria of the Hungarian Soil Classification System (Stefanovits, 1963). Individual coring profiles were compiled based on the on-site description and the GIS values. The *y* axis of the shallow geological profiles were compiled based on the GIS values (absolute height) and the individual profile descriptions (e.g. relative depth of the layers). Shallow geological cross-section are displayed based on the EOV Projection System of Hungary (Unified National Projection). The distance between the cores are displayed on the *x* axis. The intensity of the anthropogenic disturbance was assessed on a semi-quantitative scale and displayed on the individual soil core profiles with red (daub) and black (charcoal) visual signs.

3. Results and discussion

3.1. The horizontal structure of the site

When interpreting the results of geophysical prospection (Fig. 2), substantial emphasis was placed on geographical information systems, which offer extensive data display and processing capabilities. In the case of Kakucs-Turján, the map of magnetic anomalies was processed to isolate raster cell value ranges (expressed in nT), which corresponded to anticipated or preliminarily-identified structures, such as remnants of daub walls. This way, following extraction of raster cells with a specified attribute range, and subsequent conversion to polygonal vectors, an objectivised layout of anomalies was obtained (see Fig. 2. in Niebieszczański et al., 2019, in this volume). This procedure also made it possible to eliminate the misleading array of anomalies resulting from ploughing, due to which the original analysis was not as efficient as it might have been and revealed only a part of the existing features. The intensity of anomalies within a pre-defined, reclassified and generalised raster cell was another factor which underwent scrutiny and selection. The first visualisation of geophysical results demonstrated the actual size of the settlement and revealed its tripartite structure (Fig. 2). This was a major development, as the initial analysis of aerial photography and satellite imagery suggested only a bipartite division; the third, eastern section was not, as noted previously, visible based on the vegetation indices.

Analysis of the entire output image from the archaeological (magnetometric) prospection, generated using various spectrums to obtain graphic rendering of raster attributes, made it possible to distinguish three major types of registered anomalies, which may be interpreted as resulting from the presence of particular archaeological features. The first type, comprising elongated features with a rectangular outline, up to 1 m wide and varying in length, are interpreted as remnants of wall

Fig. 2. Points of the geoarchaeological mapping of the ditch system (above) and of the broader environment (below) of Kakucs-Turján.

or their foundations. Another type includes large features with elevated magnetic values, elongated in shape and up to 15 m wide, which surround and divide the interior of the settlement, interpreted as trenches (ditches) filled with sediment. The last distinguished type comprise of three circular anomalies, with distinctly marked boundaries and a diameter of about 5 m, whose only instance was detected in the northern part of the settlement. It is highly likely that these anomalies signal the presence of a feature, which was a water tank, probably with a retaining function (see Fig. 2. in Niebieszczański et al., 2019, in this volume).

The map of anomalies also revealed elongated structures with elevated sediment magnetism, which at the initial stage was interpreted to have resulted from their being filled with biogenic and diluvial material. During the analysis of results of the magnetometric survey on a large scale, the anomalies seem to form a compact and uninterrupted network, but a closer examination demonstrated gaps between individual components. The conjecture that these had once been trenches/ditches was to be verified by means of geoarchaeological observations, followed by laboratory analyses of the collected samples. The tests confirmed the anthropogenic nature of the elongated, trench-like hollows, which were filled with biogenic sediments.

3.2. The main stratigraphical units of Kakucs-Turján archaeological site

The geoarchaeological mapping of Kakucs-Turján provided detailed information both on the level of the individual soil profiles, and also with regard to the geological cross-sections. In order to understand the stratigraphy and the taphonomy of the site, the description of the main stratigraphical units, such as soil horizons, soil layers and anthropogenic layers should be described based on a soil morphological basis. In addition to the main stratigraphical units – described in the followings –, local and minor – in many cases significant – differences do exist on the level of the individual profiles. These peculiarities are emphasised in the description and analysis of the geoarchaeological cross-sections in the following subchapters. The most important macro-morphological trait of the main stratigraphical units of the site and its soilscape are summarised in Table 2.

Since the soilscape of the site is diverse, and both higher elevation sand dunes, and lower situated paleochannels are located in the close vicinity of the settlement, the parent material varies on broader scale. The central part (nucleus) of the site is located on a higher elevation dune, which consist of a mixture of fluvio-aeolian deposit of loess and sand (C_{ls}) ($_{e}Qp_{3}^{lh}$). Fluvio-aeolian sand material (C_s) ($_{e}Qp_{3}^{h}$) can be found throughout the periphery of the site, but it also occurs as thinner lenses in the deeper section of the central area. The lower surfaces, which were mainly influenced by periodical flooding of the once existed water courses evidence different layers of alluvial sediments (C_{als}) ($_{d}Qh^{al}$) (Table 2). These type of sediments, which show minor morphological variability throughout the studied area also occur in the bottom of the ditches, whilst parent material layers indicating the signs of mass movement also occur (C_{coll}) (Table 2).

A human-induced layer coded as K_2 is situated above the parent material in all cases within the nucleus of the site. Tangible anthropogenic material was observed in more profiles, however the signs of soil disturbance was a general key trait of this stratigraphic unit (Table 2). As discussed and emphasised earlier (Pető et al., 2015a, 2015b, 2016, 2018), the K_2 layer is thought to be the remains of the paleohumus horizon on which level the inhabitation of the site may have occurred during the EBA/MBA period. Based on its condition, this layer can be less or more intensively disturbed. In the light of these observation it can be anticipated that the occupation of the site appeared on this level, however the living process of the inhabitant diversely disturbed the paleohumus horizon and this disturbance also resulted in the mixing of anthropogenic particles (e.g. daub, charcoal, stone, bone etc.) with and into the matrix of this layer.

The K_1 anthropogenic sediment layer is situated above K_2 and beyond the modern soil cover. In most cases the transition between the natural soil cover and this anthropogenic sediment is gradual in colour and in texture, however the occurrence of anthropogenic particles and disturbance defines the boundary between the culturally affected and the natural formations. K_1 is multicoloured and its colours vary on a broad scale depending on the type and density of anthropogenic material. Typically, daub and charcoal fragments appear in this layer, however their relative density varies (Table 2). This layer is situated between the relative depths of 60 and 160 cm-s. In general, and as discussed previously (Pető et al., 2015a, 2015b, 2016, 2018), the K_1

Table 2
Main stratigraphical units identified in the soil core samples taken at Kakucs-Turján mögött archaeological site.

Denomination of the soil/sediment horizon/ layer	Colour (in general)	Macro-morphological description and observations
A_p layer	10YR 2/2 or 10YR 3/3	Ploughed layer of A-horizon Sandy texture, contains moderate amount of carbonates; Lightly compacted due to the effects of soil tillage; Granular structure Neither anthropogenic particles, nor modern anthropogenic contamination present
A horizon	10YR 2/2 or 10YR 3/3	Humic horizon; Sandy texture; Moderate amount of carbonates; Granular structure; Sporadic appearance of anthropogenic particles
B horizon	10YR 3/3 to 10YR 5/6	Transition horizon between the uppermost humic horizon and parent material; Sandy texture; High carbonate content
K_1 layer	Multicoloured; matrix: 10YR 4/2	Anthropogenic layer Sandy loam texture; Moderate amount of carbonates; Appearance of anthropogenic particles (daub and charcoal)
K_2 layer	10YR 4/4	Transition (anthropogenic) layer; Sandy loam texture; Moderate amount of carbonates; Sporadic appearance of anthropogenic particles
K_{inf}	Multicoloured; matrix: 2.5Y 4/1	Cultural deposit infill of artificially deepened structures
Types of slightly different parent materials detected		
C_{ls}	2.5Y 6/3	Kakucs-Turján central part (nucleus); Loessy sand ($_{e}Qp_{3}^{lh}$); Sandy silt texture; loose sediment; high carbonate content
C_s	2.5Y 7/3	Kakucs-Turján periphery and wider surroundings; Fluvio-aeolian sand ($_{e}Qp_{3}^{h}$); Sand texture; loose sediment; high carbonate content
C_{als}	Multicoloured: 2.5Y 4/3–5/6	Depressions, lower surfaces and bottom of ditch features; Alluvial parent material ($_{d}Qh^{al}$); Loam/silt texture; loose sediment; high carbonate content
C_{coll}	Multicoloured: 2.5Y 5/3–6/6	Sand and or loessy-sand parent material with the signs of colluvial mass movements; high carbonate content

layer is thought to be the complex of the rubble layer and the debris that accumulated during the inhabitation of the site. In this context the variance in the relative density of the anthropogenic material is acceptable, since the homogenous distribution of these material types cannot be imagined within such human-induced contexts.

The culturally affiliated anthropogenic sediments are covered with a modern soil. The relative depth of the A horizon varies between 45 and 60 cm-s. Anthropogenic particles with archaeological/cultural affiliation could have only been observed in a few cases (e.g. small and strongly weathered particles of daub). These are acknowledged as deriving from the cultural layers beyond the modern soil cover. In many cases a transition B horizon could also be identified. The territory of the settlement is an arable field for long decades (Bedekovich, 2015), and this can also be detected in the soil. The depth of the ploughed layer (A_p) is uniformly 30 cm throughout the entire site (Table 2).

3.3. The vertical structure of the site and its soilscape

3.3.1. Control (background) soil profiles

Soil profiles KT11 and KT19 were chosen as control (or background) profiles, because they are located outside the boundaries (outer ditch) of the site, they represent the general environment and do not bear any signs of anthropogenic impact. Both profiles were identified as Chernozem soil evolved on sandy parent material, which is the fluvio-aeolian sand ($_{e}Qp_3^{h}$) and sand dominated loess ($_{e}Qp_3^{lh}$) of the wider environment in the Kiskunság Sand Ridge geographical microregion. The uppermost brownish black (10YR 2/2) soil horizon (A) of the profile was sandy textured in both cases ($K_{A\ KT11}$ = 28; $K_{A\ KT19}$ = 26) (Table 3). The TOC content of the A horizons was high compared to the lower horizons and sediment layers (TOC% KT11 = 3.0; TOC% KT19 = 2.6) (Figs. 3 and 4), whilst it is considered moderately calcic based on the $CaCO_3$ content (Table 3). The B horizons of the profiles showed high lime accumulation ($CaCO_3\%_{\ KT11}$ = 14.00%; $CaCO_3\%_{\ KT19}$ = 20.00%), whilst the TOC% content drops down to less than half compared to the humic A horizon (Table 3). Due to the presence of carbonates both profile show a balanced pH in the slightly alkaline value range (Figs. 3 and 4), and an extremely low P_{total} content with a vertical decrease from the upper soil horizon towards the parent material (Figs. 3 and 4).

3.3.2. Geological cross-sections

The coring points of the north-south (Fig. 5) and east-west running geological cross-sections (Fig. 6) were set at an equal 40 m interval and consciously avoided features distinctly visible on the prospection map (e.g. pits). The area to the north and northwest that was formerly prone to flooding was clearly delineated on the basis of the fluvial layers of sediments observed in the cores taken there (KT01, KT02; Fig. 5). Neither archaeological phenomena, nor anthropogenic fragments were detected in these soil profiles. On the basis of our current knowledge it is possible to state that the settlement could not or did not extend to these territories (see also arguments by Niebieszczański et al., 2019, in this volume). Remnants of daub and charcoal were found in several profiles (at depth intervals between 55 and 100 cm) in the northern half of the site (KT03, KT04; Fig. 5). These anthropogenic particles indicate the possible level of human settlement. The central part (nucleus) of the site, which is represented by soil profiles KT05 to KT07, is located at the highest point of the examined micro-environment (Figs. 5 and 6). The nucleus of Kakucs-Turján is located on sediment deposits built up of sandy loess and sand material. This deposition forms a natural ridge in the landscape, emerging from the lower flood plain filled with fluvial layers. The surface of the nucleus is over 109 m m.a.B.S.l. This island-like geomorphological feature, which slightly rises above its environment was most probably more than ideal for occupation purposes during the Early/Middle Bronze Age. Below the modern soil cover of the site an anthropogenic deposit (indicated by the code K_1) occurs. This deposition clearly contains large amounts of daub debris, ceramic remains, ashy micro-layers and particles of charcoal. Below the K_1 cultural layer another formation (K_2) could be observed that was altered through human impact and activity. On the basis of the observations of the soil core profiles, this anthropogenic impact is also detected in the area to the south outside the ditches (KT08), and at the same time an eroded soil cover appears (KT09) on the top of the sand ridge neighbouring the site to the south (Fig. 5). In the depression, represented by KT10, between the two sand dunes allochthonous sediment (ex situ), most likely washed here from a higher elevation, was observed. This contained anthropogenic particles (remains of ceramics, daub, charcoal and ash) in particularly large amounts.

The east-west running geological cross-sections (from KT11 to KT20) display a less undulating surface (section) within the landscape of the settlement (Fig. 6). Part of the cross-section that covers the south-eastern area outside the visible boundaries of the site shows uniform and monotone soil properties (KT11 to KT13). Based on the observations of the soil core profiles taken to the east of the encircling outer ditch it seems that the former human activity in this area was not as intensive. This is also underlined by the laboratory data of KT11 control profile, especially if we consider the extremely low concentration of total phosphorous within the samples collected from KT11 (Table 3; Fig. 3). With regard to the research done on the phosphorous content of Hungarian soils (Füleky, 1973, 1983, 2007), it can be anticipated that areas with a total phosphorous value below 1000 ppm are not considered as human-induced territories. The east-west cross-section intersects the eastern compartment (KT14; KT15) and the northern boundary of the nucleus (KT16; KT18) of the settlement (Fig. 2). Although the soil core profiles deepened in the eastern compartment (KT14; KT15) display some anthropogenic impact in the form of sporadically distributed daub and charcoal fragments in the B horizon, the unified cultural layer (K_1) typical for the nucleus of the site could not be detected. The differences in the stratigraphy and the amount of human activity related anthropogenic particles may be in relation to the lower and less intensive and different type of utilisation of the eastern

Table 3
Basic soil parameters of KT11 and KT19 control (background) soil profiles (data from Pető et al. 2015a and 2018).

Soil profile	Soil horizon/layer	Colour	Depth	TOC%	H%	P_{total} (mk/kg)	$CaCO_3$%	pH [H_2O]	pH [KCl]	Salt%	K_A	
											Value	Evaluation
KT11	A_p	10YR 2/2	0–25	–	–	–	–	–	–	–	–	–
	A	10YR 2/2	25–60	3.0	1.7	276	5	7.6	7.2	0.01	28	Sand
	AB	10YR 3/3	60–90	1.9	1.1	237	11	8.0	7.5	0.01	28	Sand
	B	10YR 5/6	90–120	1.2	0.7	265	14	8.1	7.5	0.01	26	Sand
	C_{ls}	2.5Y 6/3	120–160	0.3	0.2	295	26	8.4	7.9	0.01	31	Sandy silt
KT19	A_p	10YR 2/2	0–25	2.6	1.5	374	10	7.9	7.3	0.01	26	Sand
	A	10YR 2/2	25–40	2.0	1.2	321	13	7.9	7.5	0.01	26	Sand
	B	10YR 3/3	40–60	1.2	0.7	236	20	8.0	7.8	0.01	24	Sand
	C_s	2.5Y 7/3	60–80	0.7	0.4	180	30	8.2	7.7	0.01	30	Sandy silt
	C_{als}	2.5Y 7/2	80–100	0.4	0.2	161	22	8.4	7.7	0.01	37	Silt

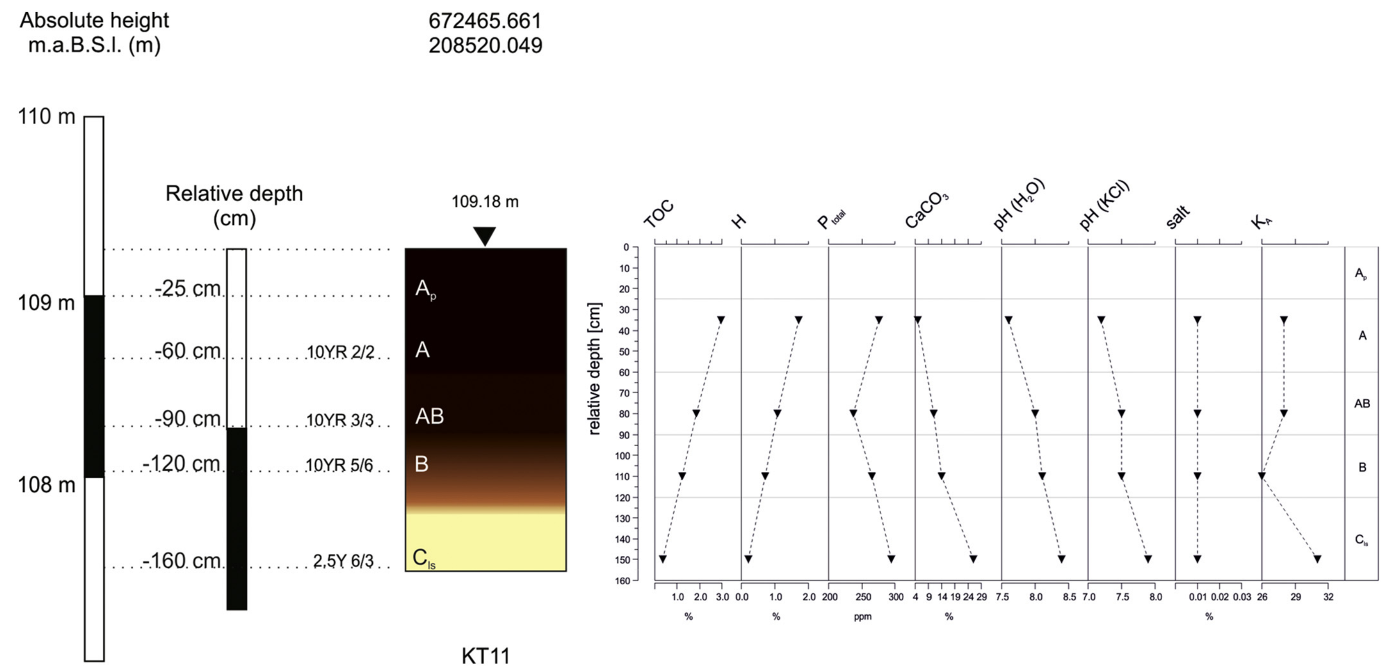

Fig. 3. Detailed stratigraphy and the vertical distribution of laboratory data of KT11 control (background) soil profile.

compartment during the occupation of the settlement. A very similar situation can be described in soil core profiles KT16 and KT17, which are located within the nucleus but extremely close to the inner ditch that forms the northern boundary of this central area. Based on the macro-morphological observations these two profiles also indicate a lower intensity impact on this northern half of the central section. Thus, in the interior of the nucleus the K_1 anthropogenic deposition (cultural layer) can be clearly and undoubtedly separated from the natural soil formations. Foreign materials (e.g. daub fragments) indicating human occupation and disruption were also found in the cores of the northern section, but their quantity did not come close to that detected in those performed in the interior area of the nucleus. The western sampling locations outside the ditches outlined the lower, formerly flooded areas of the site's local geographical environment (e.g. KT20; Fig. 6).

3.4. Ditch-like features

3.4.1. The outer ditch

The geological cross-section consists of seven profiles ranging from KT211 to KT251 (Fig. 7) and its aim was to provide a detailed view of the cross-section of this ditch part. The uppermost metre is homogenous and represents the modern, Chernozem-like soil cover of the archaeological site with similar soil physical and chemical properties, as well as macro-morphological traits same to those of the control profiles used in this study (KT11 and KT19: Table 3; Figs. 3 and 4).

The infill sediment of the ditch (K_{inf}) is present in various thickness

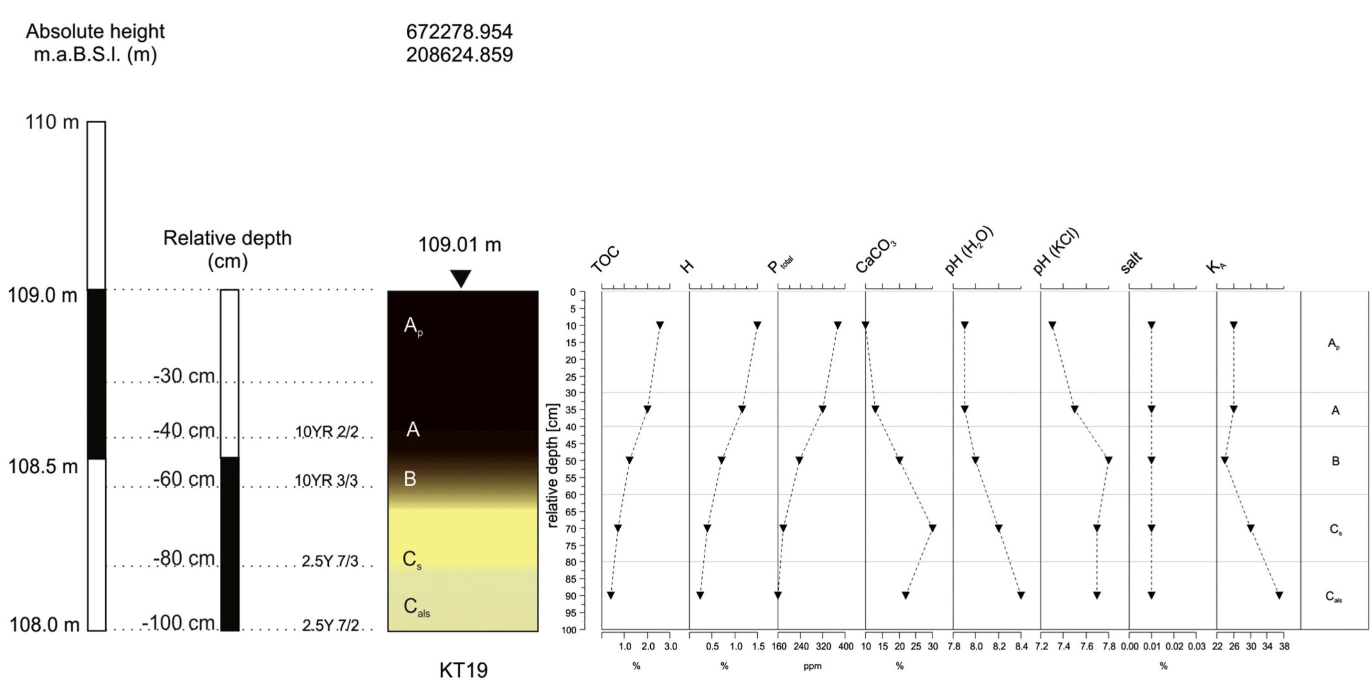

Fig. 4. Detailed stratigraphy and the vertical distribution of laboratory data of KT19 control (background) soil profile.

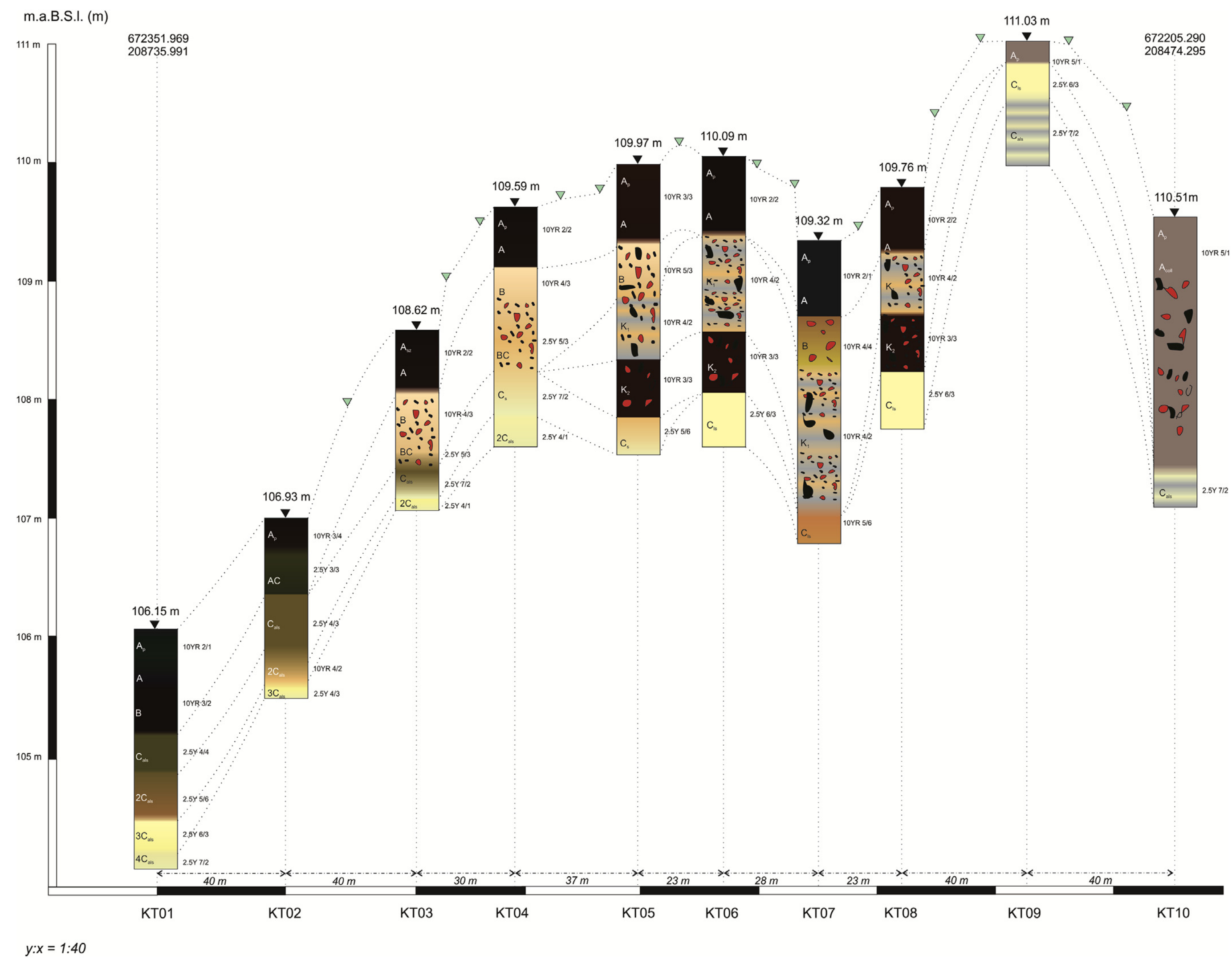

Fig. 5. The north-south geoarchaeological cross-section of Kakucs-Turján archaeological site.
(Used and amended after Pető et al. 2015a and 2018)

throughout the cross-section (Fig. 7). K_{inf} was not identified at KT211 and KT251, which supposes that the mapping reached the border slope of the ditch. The K_{inf} shows its thickest facies at KT21 and KT24 and draws up a clear V-like pattern indicating that the original ditch was excavated to a V-shape. The colour of the K_{inf} varies between brownish black (10YR 2/2) and yellowish gray (2.5Y 4/1–6/1), and consisted of two types of sub-layers. Very fine laminations were identified within this sediment, which underlines the gradual refill of the ditch across a longer time period. The alternation of darker, more humic, and brighter, sandy fractions point to cyclic redeposition of sediment materials with different origin. Besides these laminations, thicker, turbated and mixed-up blocks of clays and silty sediments also occur within the K_{inf}. These laminations and the bigger flecks of clayey blocks all represent a stage of the ditch development. Based on these observations, it is difficult to determine whether the ditch was always filled with water or if it only held water periodically. The fine lamination points to a sedimentation process that took place in a standing, still water environment, but in opposition to that, the thicker and turbated parts point to "terrestrial" sedimentation processes. Samples from each representative layer were taken at from core profile KT21 (Table 4). Values for the ploughed layer (A_p; 0–20 cm) and the A-horizon (20–150 cm) are in accordance with control profiles and show a Chernozem-like soil developed on a sandy parent material. In this regard, any difference to the other parts of the site cannot be stated. It is interesting to note that the results of the K_{inf} in general do not represent a high organic matter input (TOC% K_{inf} = 1.4). All organic matter indicators, such as the TOC%, P_{total} and H%, show low values, and draw up a gradually decreasing trend in their vertical distribution throughout the KT21 profile (Fig. 8). This absolute concentrations and the distribution of these indicators mean that material high in organic residues, such as settlement waste or dung, was not deposited here, moreover the ditch might have been kept clean. There are only two parameters, which have a peak in the vertical curve (Fig. 8). The carbonate content ($CaCO_3$%) shows a maximum value in K_{inf} at 24.0%, whilst the texture coefficient rises up to 37 (Table 4). The entire ditch was cut in a greyish yellow (2.5Y 7/2) sediment ($1C_{als}$), which – according to the on-site observations of the soil core profiles – showed signs of stagnant water. Manganese and iron flecks (cf. gley) and even smaller concretions could have been observed in this layer, which served as the bedding for the ditch. Based upon these observations, it can be imagined that this sediment acted both as a ground water filter and a periodically water resistant bedrock for the ditch. This is how the somewhat controversial texture coefficient of the sample taken from this layer can be explained (K_A $1C_{als}$ = 31; Table 4). The texture coefficient value indicates here sandy silt instead of pure silt or clay, what one would expect. Since the K_{inf} layer, situated above the $1C_{als}$ layer gave a higher texture coefficient value, it might be considered in this case that the water retention level was approximately on the boundary

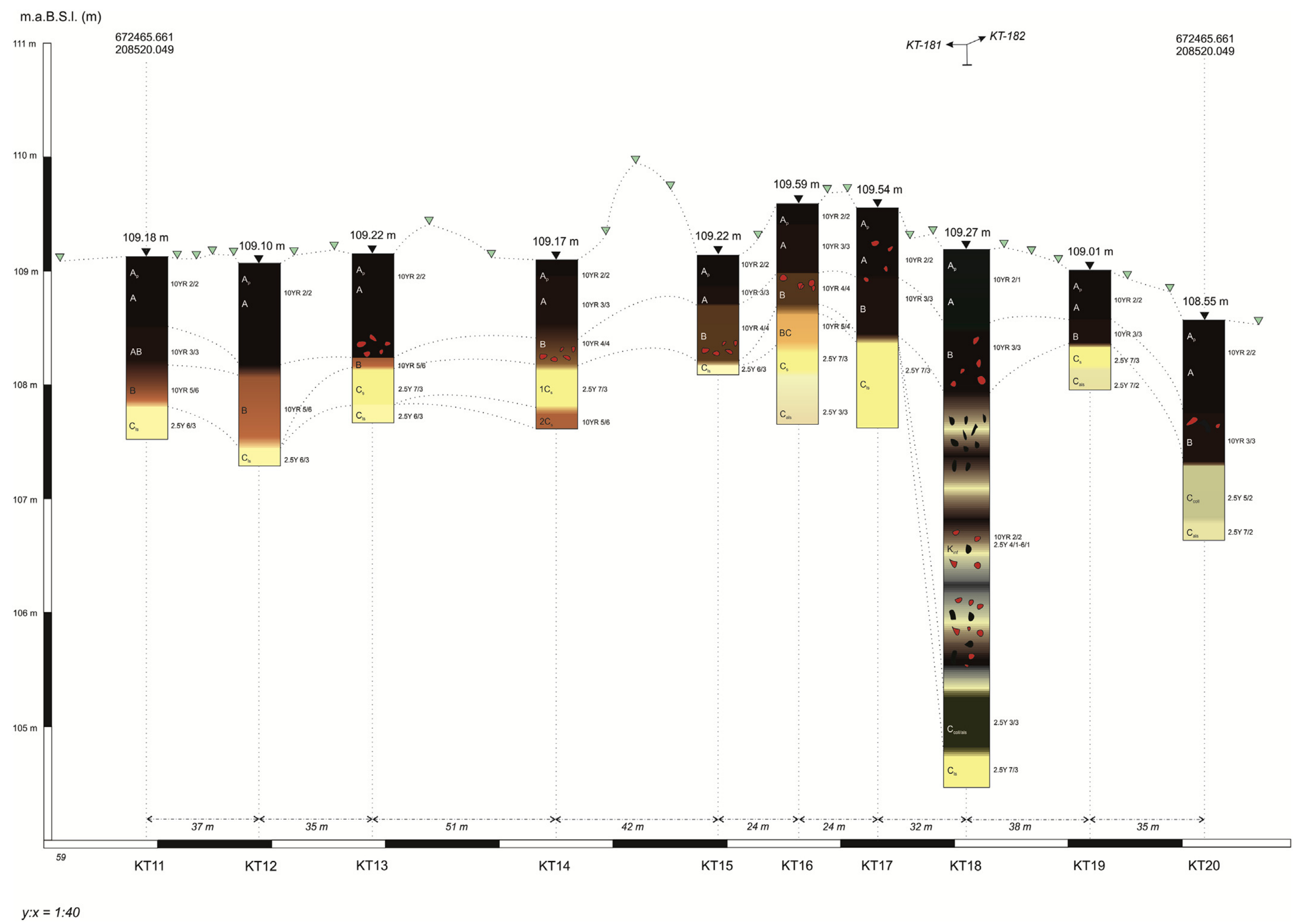

Fig. 6. The east-west geoarchaeological cross-section of Kakucs-Turján archaeological site. (Used after used and amended after Pető et al. 2015a and 2018)

of these two stratigraphic units (Fig. 8). The lower layer – situated around 106.0–106.5 m.a.B.S.l. – acted as a filter, which channelled ground water below the entire site filling up the ditch. In this sense the higher coefficient value of the K_{inf} is only a secondary value, which derives from the later infill material of the ditch itself, and it cannot be considered naturally, but as a result of post-depository processes.

3.4.2. The inner ditch

The geoarchaeological characteristics of the inner ditch surrounding the almost round nucleus of the settlement was investigated through five soil profiles located at a 2 m interval from each other (KT38 to KT42; Fig. 9). On the basis of the geological cross-section it was possible to reconstruct the deepest point of the ditch at a 300–350 cm relative depth. The morphological features identified in the undisturbed core samples suggest the presence of stagnant water, and the fine laminated structure detected in several locations indicates gradual sedimentation. Based on the observation results, it is anticipated that there might have been different periods of ditch infill, but it is hard to determine whether all of these occurred after the site was abandoned or during its lifetime. Based solely upon the cores we cannot define signs of conscious ditch clearing. The laminations might have occurred whilst the site was occupied, but might also represent periods of sediment accumulation after site abandonment. From a geoarchaeological point of view, the different types of morphological features (fine laminations vs. bigger blocks of humic material) refer to different sedimentation periods, linked to different ditch conditions. In particular, fine laminations might develop if the ditch is filled with water, whilst the bigger blocks of soil matter may have entered the ditch during times that it experienced drier conditions. It must be stressed, however, that these hypotheses are based on the results of macro-morphological analysis/observations of the profiles.

The careful and thorough analysis of the geophysical image does demonstrate that at a certain point the structure of the anomaly is interrupted. For this reason, one should exercise caution in interpreting trench-like features as a continuous ditch system. It is nevertheless possible that individual ditch sections functioned independently, as separate structures. As an addition to that, we have found that the rubble layer of the settlement (K_1 and K_2) can be found on top of the infill of the inner ditch (KT38 to KT42; Fig. 9) and is missing from the top of the outer ditch. This might point to the fact that the tripartite organisation of the settlement is a result of its expansion, and represents a development in time. Two hypotheses can be based on this. Firstly, that the settlement expanded over the inner ditch with time, and in this case the inner ditch was partly filled during the life of the settlement. The second option is related to the taphonomy of the site. After the site was abandoned, the rubble (destruction) layer (K_1) eroded and was re-deposited on a wider area than it was originally distributed. However, the absence of K_1 in other parts of the site seem to contradict this latter assumption.

The immediate neighbourhood of the ditches is interesting as well, as the latter features are accompanied by strips of ground, approximately 7 m wide, located on the inner side of the settlement, which the geophysical image shows to be devoid of magnetic anomalies. The soil profiles and analyses of the samples demonstrated that these areas are

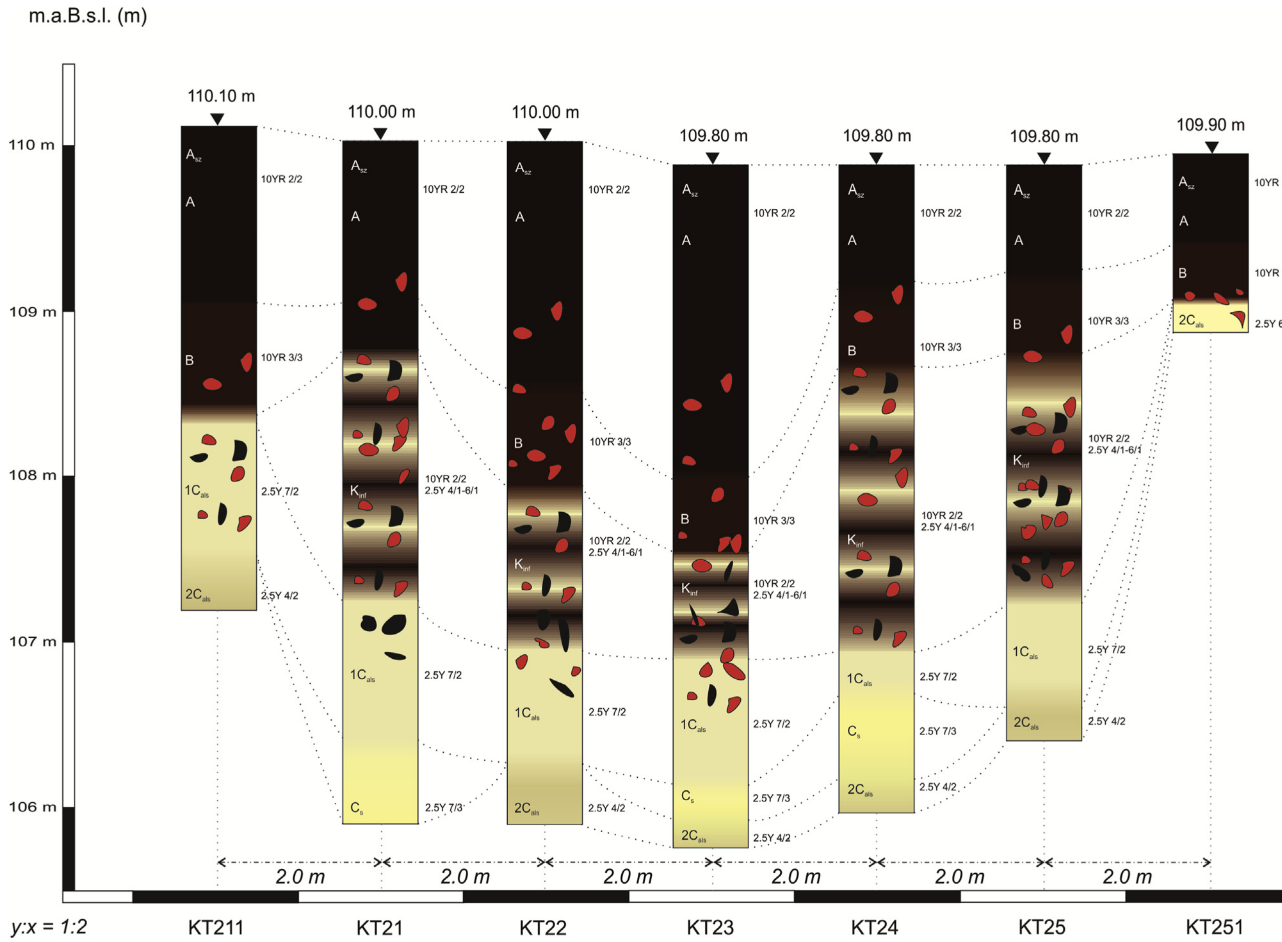

Fig. 7. The geoarchaeological cross-section of the outer ditch of Kakucs-Turján archaeological site.
(Used after used and amended after Pető et al. 2016 and 2018)

Table 4
Basic soil parameters of KT18; KT21 and KT39 soil core profiles (data from Pető et al. 2016 and 2018).

Soil profile	Soil horizon/layer	Colour	Depth	TOC%	H%	P_{total} (mk/kg)	$CaCO_3$%	pH [H_2O]	pH [KCl]	Salt%	K_A	
											Value	Evaluation
KT18	A_p	10YR 2/1	0–25	–	–	–	–	–	–	–	–	–
	A	10YR 2/1	25–60	3.1	1.8	324	7	7.8	7.3	0.01	26	Sand
	B	10YR 3/3	60–100	3.0	1.7	1230	22	8.2	7.8	0.01	36	Sandy silt
	K_{inf}	Multicoloured; matrix: 2.5Y 4/1	100–420	4.0	2.3	468	24	8.3	7.9	0.02	47	Clayey silt
	$C_{coll/als}$	2.5Y 3/3	420–450	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	–
	C_{als}	2.5Y 7/2	450–470	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	*n.a.*	–
KT21	A_p	10YR 2/2	0–20	3.8	2.2	506	7	7.7	7.2	0.01	31	Sandy silt
	A	10YR 2/2	20–150	2.8	1.6	419	6	7.8	7.3	0.02	33	Sandy silt
	K_{inf}	Multicoloured; matrix: 2.5Y 4/1	150–270	1.4	0.8	295	19	8.6	8.1	0.02	37	Silt
	$1C_{als}$	2.5Y 7/2	270–350	1.1	0.7	241	13	8.5	8.0	0.03	31	Sandy silt
	C_s	2.5Y 7/3	350–400	–	–	–	–	–	–	–	–	–
KT39	A_p	10YR 2/2	0–30	–	–	–	–	–	–	–	–	–
	A	10YR 2/2	30–60	3.7	2.2	323	10	7.9	7.5	0.01	32	Sandy silt
	B	10YR 3/3	60–100	4.0	2.3	383	15	8.0	7.7	0.01	32	Sandy silt
	K_1	10YR 4/2	100–200	2.0	1.1	236	16	8.3	7.6	0.01	29	Sand
	$1K_{inf}$	Multicoloured; matrix: 2.5Y 4/1	200–300	2.8	1.6	1234	19	8.6	8.0	0.02	42	(Clayey) silt
	C_{als}	2.5Y 7/2	300–370	2.3	1.3	403	17	8.6	8.1	0.03	41	Silt
	C_s	2.5Y 7/3	370–400	–	–	–	–	–	–	–	–	

anthropogenic in terms of genetic and sedimentological factors. KT42 falls within this range (Fig. 2). The morphological features of this core profile gives a transition between the signs we have observed in the case of the ditches and the signs of the central part of the site. The stratigraphy of this profile (KT42) is quite complex (Fig. 9). Below the modern soil, layers similar to the ditch infill sediment types occurred. We identified three slightly different layers: $1K_{inf}$, $2K_{inf}$, $3K_{inf}$.

The sediment type encoded as $1K_{inf}$ is the same as the one we described for the outer ditch section. Below that, $2K_{inf}$ is a 110 cm thick layer (situated between 170 and 280 cm relative depth), which is light yellow (2.5Y 7/3), and has slightly laminated sediment, which is followed by a black (anthropogenic?) layer encoded as $3K_{inf}$ (situated

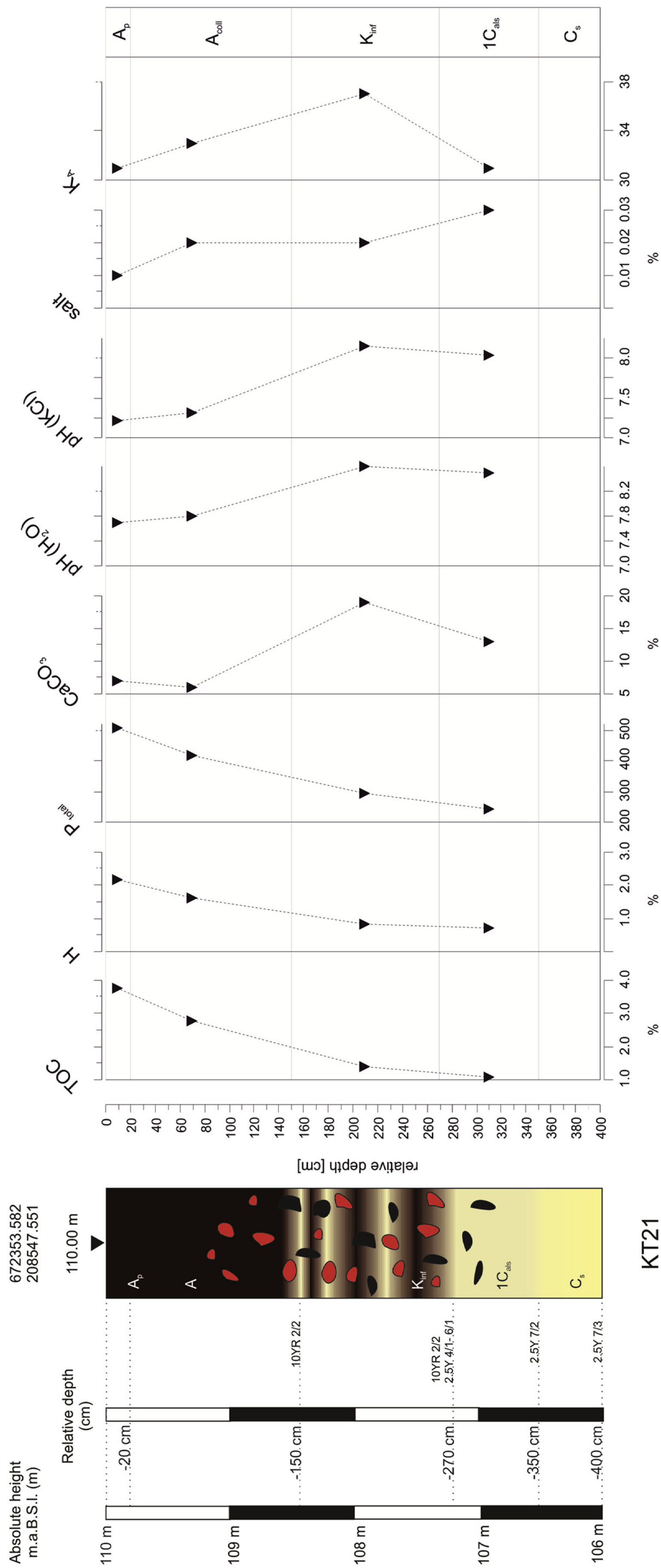

Fig. 8. Detailed stratigraphy and the vertical distribution of laboratory data of KT21 core profile (outer ditch section).

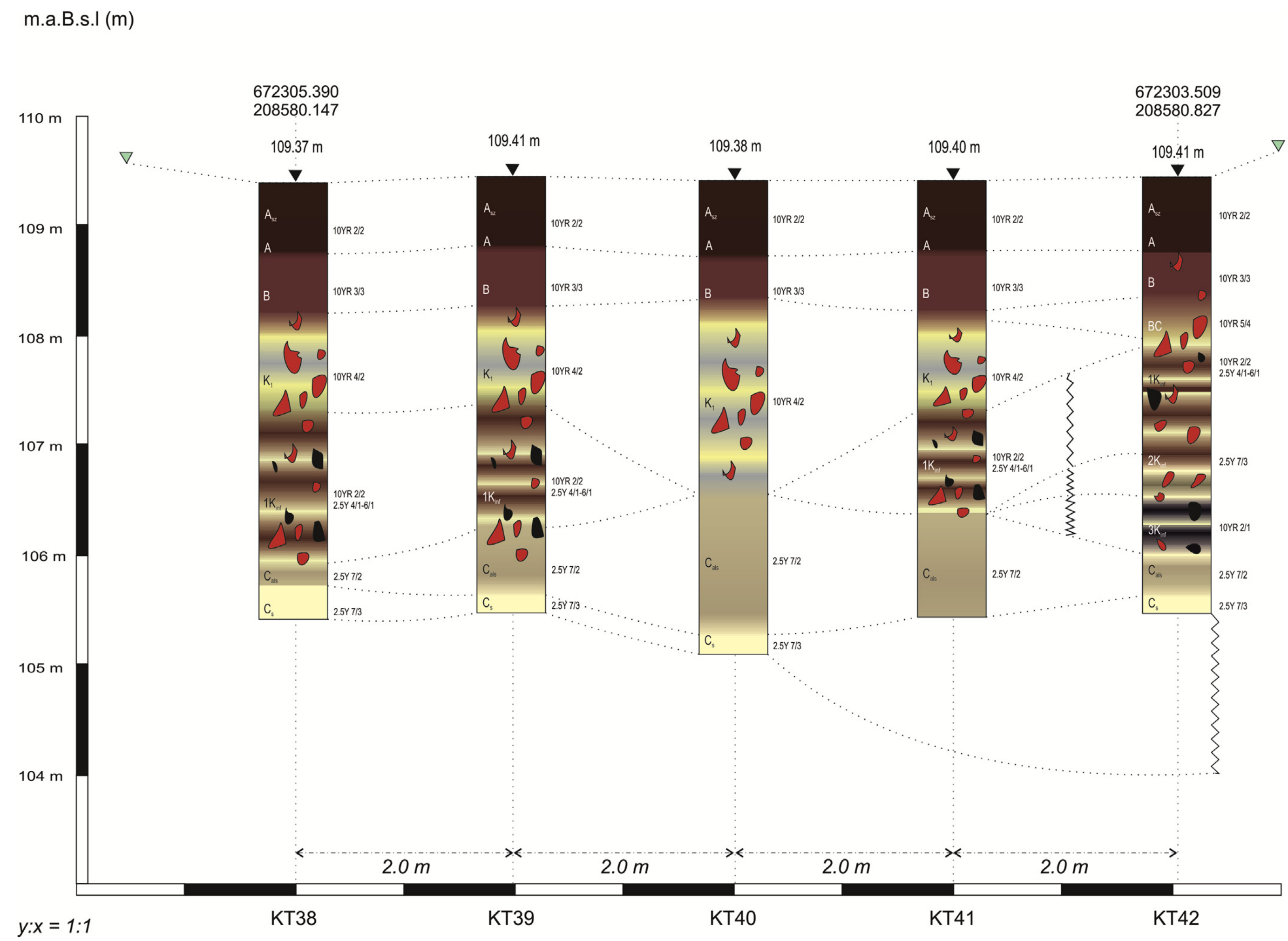

Fig. 9. The geoarchaeological cross-section of the inner ditch of Kakucs-Turján archaeological site.
(Used after used and amended after Pető et al. 2016 and 2018).

between 280 and 320 cm relative depth). All three layers can be identified as ditch infills, although this core represents a transition between the ditch and the central part of the settlement. Thus, these layers do not show well-defined laminations and show more intensive disturbance, which can be related to the fact that KT42 represents the slope of the ditch.

Core profile KT39 was chosen to represent the cross-section of the inner ditch. Samples collected from each layer were subjected to basic laboratory measurements (Table 4). Both the soil physical and chemical values are similar to those measured in KT21 and the background soil profiles; the only exception is the $1K_{inf}$ layer. Although the macromorphological traits of this layer is similar to that observed in the core profile of the outer ditch (K_{inf} at KT21 to KT25), an increased total phosphorus content (P_{total} $1K_{inf}$ = 1234 ppm) could have been detected here (Fig. 10). Not only does the P_{total} value give a high organic matter in-put indication in this depth, but so does the total organic carbon (TOC% $1K_{inf}$ = 2.81) and the humus content (H% $1K_{inf}$ = 1.63%) (Table 4). A similar situation could have been detected in profile KT18, which represent the circular feature of the ditch system (see description in the next subchapter). It is interesting to note that high organic material in-put values could have only been detected in those parts of the site (inner ditch and circular feature), which are situated in the close vicinity of the settlements nucleus, where both K_2 and K_1 are present. The nucleus of the settlement is considered to be a more intensive territory in terms of local activity, whilst the periphery does not show the signs of intense areal activity.

3.4.3. The circular feature

In the northern section of the site, the survey detected a circular anomaly measuring approximately 12 m in diameter and distinguished by markedly elevated magnetic values (Fig. 2). Its nature was examined by means of a dense network of soil core profiles, which exposed the subsurface structure of the sediments making up the feature (see also Fig. 2. in Niebieszczański et al., 2019, in this volume). Soil profile KT18 was positioned in the very middle of this anomaly to map the depth of this feature. Similar to the other profiles, the uppermost 1 m consisted of the modern soil cover. Below that, we identified a 320 cm thick infill of sediment layer series (K_{inf}), situated in 100–420 cm relative depth (Fig. 11; Table 5). Laboratory data of the sample taken from this layer compared to the general soil conditions of the site, showed higher organic matter input. Both the humus (H% = 3.98%) and the total organic carbon content (TOC% = 2,31) (Table 4) can be considered high compared to the same parameter values of the control soil profiles (KT11 and KT19). However, their absolute value is not considered to be extremely high, neither within the site (see sedimentological and geochemical data in Niebieszczański et al., 2019, in this volume), nor compared to other Hungarian EBA/MBA sites investigated through similar proxies (e.g. Perkáta–Forrás-dűlő: Pető et al., 2013; Százhalombatta–Földvár: Füleky et al., 2015). Both parameters can be considered here as chemical fingerprints of human activity related to organic matter management (Goldberg and Macphail, 2006; Engelmark and Linderholm, 1996). One of the main factors affecting the amount of TOC content in the soil is the primary organic input that affects the soil

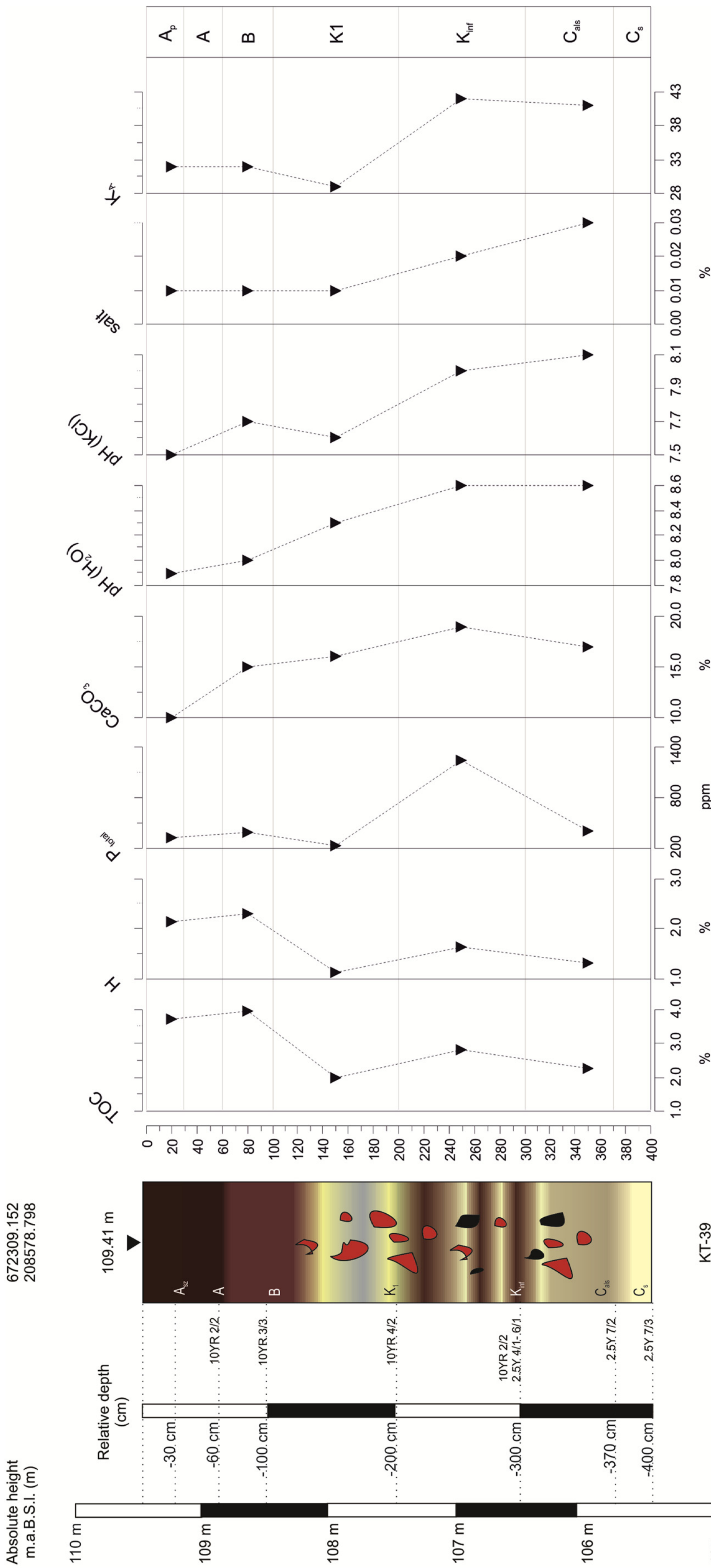

Fig. 10. Detailed stratigraphy and the vertical distribution of laboratory data of KT39 core profile (cistern-like feature).

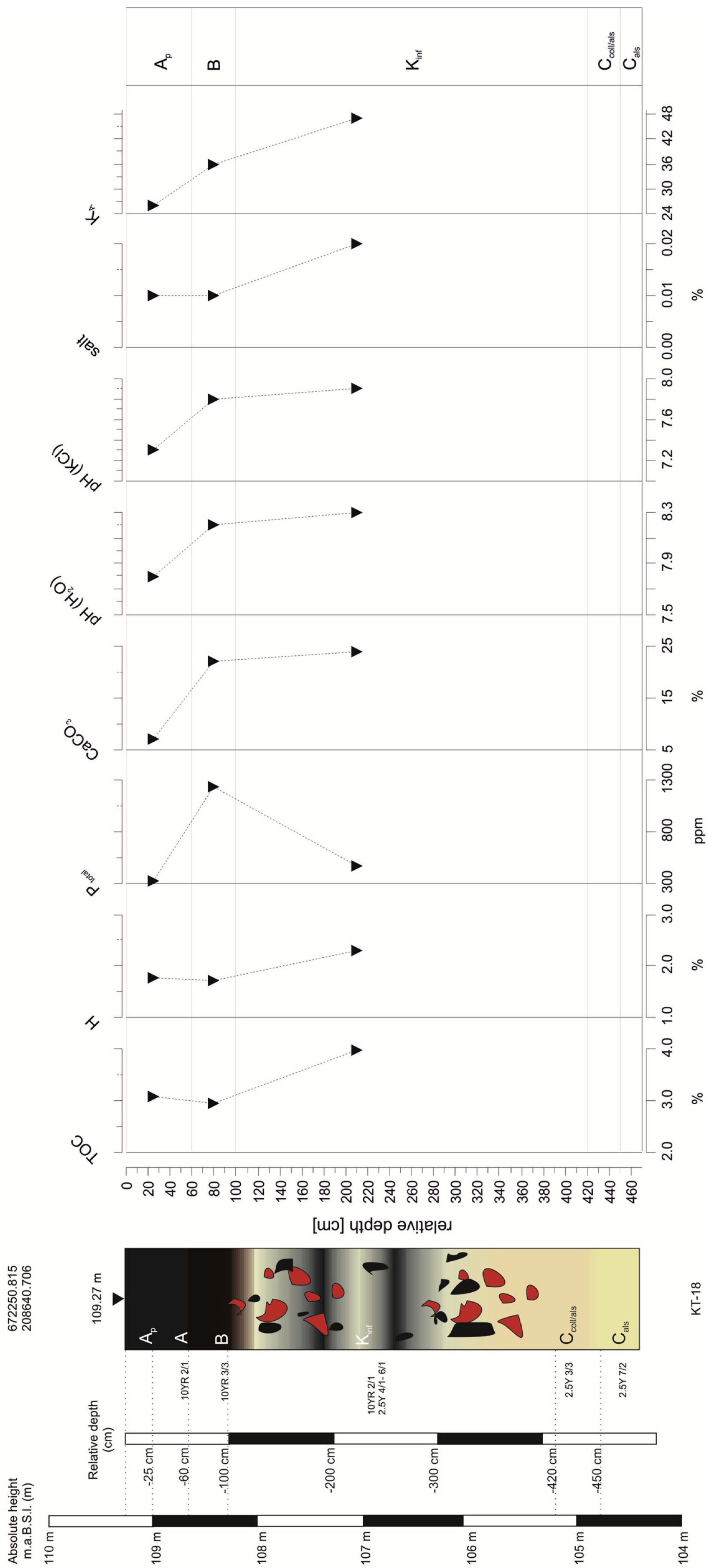

Fig. 11. Detailed stratigraphy and the vertical distribution of laboratory data of KT18 core profile (internal ditch section).

Table 5
Subdivision of layer K_{inf} within the soil core profile KT18.

Relative depth	Colour	Macro-morphological description and observations
100–130	10YR 3/3	Crumbly structured, clayey silt, high concentrations of charcoal fragments
130–180	2.5Y 4/1	Homogenous matrix, clayey silt
180–260	2.5 Y6/1	Sand, few daub and charcoal fragments
260–300	10YR 3/3	Humic, high intensity of charcoal, fine laminations composed of gray and yellowish coarse sand
300–320	10YR 3/3	Homogenous matrix; clayey silt, presence of daub and charcoal
320–340	2.5Y 4/1	Homogenous matrix; sand, daub and charcoal
340–370	10YR 3/3	Homogenous matrix; clayey silt, daub and charcoal
370–420	2.5 Y6/1	Loose sand, only few anthropogenic particles (daub, charcoal), humic inclusions

surface, so that the deposition of materials rich in organic matter will result in an increased TOC content (Grabowski and Linderholm, 2014), or the low value of them in the lack of such depositions. The laboratory results might refer to the fact that no waste material high in organic matter was deposited here, although we cannot exclude some sort of organic matter source in the infill of the circular feature. It cannot be excluded however, that the somewhat higher TOC% and H% values might also come from the erosion of the surface soil material.

It must also be taken into account that a high resolution vertical column sampling could not have been performed. Only the detailed macro-morphological description of thick K_{inf} layer was accomplished. The result of this detailed analysis underlines the possibility of sedimentation in waterlogged environment (Table 5 used and modified after Pető et al., 2016). As it is shown by the detailed description, the K_{inf} shows a certain range of variability in texture, colour, and the intensity of anthropogenic particles. Similar to the examined outer ditch section, the fine laminations observed in this stratigraphic unit also refer to sedimentation in standing water. The infill process of this feature most probably occurred in separate steps; at least this is what the easily separable layers might refer to (Table 5).

Similarly to the outer ditch, this circular feature is also embedded in a sediment material (C_{als}) with alluvial origin, showing the signs of stagnant water. Its macro-morphological traits are similar to that observed below the outer ditch section in profile KT21. The relative depth of the C_{als} layer in the circular feature appears to be the lowest in the case of KT18 profile. It is around 104 m.a.B.S.l., which is lower than the position of the same layers in the examined two ditch sections (KT21 and KT39). This observation further suuports the idea that the circular feature of the settlement may have functioned as a water retention tank and was part of the hydrological system of Kakucs-Turján. Summing up the results of the soil core profile observations and the available laboratory data, the circular feature is most-probably a man-made hollow, and it has a distinct boundary on the magnetic prospection, tentatively interpreted as a kind of retention tank (e.g. a cistern at the junction of the surrounding ditches?). It should be noted that the feature in question is connected with the system of trenches surrounding the settlement. Assuming that water was present in the trenches/ditches, the hollow may have been a kind of facility to create a hydrological depression, thanks to which the ditch would be filled with water from a nearby river or surface waters, and then flow down towards the tank. In contrast, if no watercourse had existed in the proximity of the site, it should be assumed that the hollow functioned as a hydrogeological depression which gathered water from various underground levels. In either case, the tank should be interpreted as a singular, innovative hydrogeological solution whose purpose was to supply and maintain a certain water level in the ditch which surrounded the settlements.

4. Conclusions

The inner structure of the fortified and open-air settlements of the MBA Vatya culture are highly diverse, and it is assumed that these settlements had distinct features both above and beyond ground level when they were inhabited. Due to the effect of intense and long-term and intensive cultivation (Saláta et al., 2014; Bedekovich, 2015) most of the surface features of these sites were destroyed and gradually demolished by erosion (e.g. agrogenic transformation of the soil scape; Lisetskii, 2008; Lisetskii and Rodionova, 2015). Except for a couple

of sites that fall beyond the territory of agricultural production (e.g. higher elevation sites with wood vegetation cover like the 'small castle' of Perkáta–Forrás-dűlő or parts of Százhalombatta–Földvár) most of the MBA Vatya settlements are found on almost flat arable lands. For this reason description and mapping of these sites can only be accomplished if both the horizontal aspects and the vertical components are taken into account.

In the case of Kakucs-Turján the stratigraphy of the site was revealed and described in detail by the means of high-resolution geoarchaeological mapping designed and carried out on the basis of magnetometric plan, and prior to the excavations. The case of Kakucs-Turján showed how the different non-invasive (or minimally invasive) prospection methods can be hierarchically built upon each other. This case study also highlighted the complementary nature of these methods in the detailed mapping and description of an archaeological site in general. As it is also emphasised in the paper of Niebieszczański et al. (2019, in this volume) dealing also with Kakucs-Turján, we also stress the importance of the combination of non-invasive and basic laboratory analysis techniques during the pre-excavation study phase of a site in order to retrieve horizontal and vertical data, which supports decision-making in further excavation planning.

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