The Kakucs-Turján archaeological site was investigated by a Polish-Hungarian-German research team of archaeologists and various specialists. This volume contains the first, preliminary results of their work, giving the reader an insight into the complex history of the Bronze Age settlement and its economic activities as reflected in the multi-layered stratigraphy of the site.
The currently analysed materials from Kakucs-Turján may help to indicate the basic parameters of the development and functioning of the Middle Bronze Age Vatya culture; on the one hand strongly based on local tradition, on the other contextualized within a wider network covering the Carpathian Basin.




In Kommission bei Dr. Rudolf Habelt GmbH

Kakucs-Turján

Mateusz Jaeger, Gabriella Kulcsár, Nicole Taylor, Robert Staniuk (eds.)

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Kakucs-Turján

a Middle Bronze Age multi-layered fortified settlement in Central Hungary

Studien zur Archäologie in Ostmitteleuropa
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Preface from series' editors

The following volume addresses the topic which is intensively covered in the 'Studien zur Archäologie in Ostmitteleuropa/Studia nad Pradziejami Europy Środkowej' series – Bronze Age settlement archaeology, especially the subject of fortified settlements.

The subject of fortified settlements and the various aspects related to their formation and functioning during European Bronze Age was covered in conference proceedings (volumes 5 and 9), a monograph (volume 17), as well as extensive reports on specific sites (the Únětice settlement in Bruszczewo; volumes 2, 6 (1 and 2), 13 and 14).

The following volume summarizes the first stage of Polish-Hungarian-German interdisciplinary research of the Kakucs-Turján settlement located in Central Hungary. Although the settlement was mostly related to Middle Bronze Age Vatya culture, it provided evidence of older, i.e. Early Bronze Age habitation. Excavations provided evidence of a complex stratigraphy related to centuries of habitation. Apart from stratigraphic information the site provided rich amount of archaeological material representing different types of material culture.

The presented volume summarizes the preliminary results of the archaeological and specialist analyses of the excavated archaeological material. It is the opinion of series' editors that it provides valuable input in studies of the dynamics of the communities inhabiting one of the key regions of the European Bronze Age – the middle Danube basin.

Janusz Czebreszuk • Johannes Müller • Sławomir Kadrow

Preface

Multi-layered and fortified settlements are one of the most characteristic features of the Middle Bronze Age in the Carpathian Basin, especially the area of present-day Hungary. The extensive size of such settlements is often a logistical and financial challenges for modern archaeology. Despite the organizational challenges, studying such settlements provides invaluable information regarding the development of local Bronze Age communities.

One way of overcoming challenges related to studying multi-layered fortified settlements is by forming extensive scientific co-operations. The presented volume results from the collaboration of many people. The Polish-Hungarian-Germany scientific project aiming at studying the settlement in Kakucs-Turján was a collaboration of researchers from the Adam Mickiewicz University in Poznań, the Hungarian Academy of Sciences in Budapest and the University of Kiel. The research undertaken between 2013 and 2017 involved both field work and data-processing, which extended beyond the work of archaeologists and included specialists from other fields, students, sometimes simply friends from various institutions in Poland, Hungary and Germany.

Participation of such a large group of people coming from different personal backgrounds and representing different scientific practices and the exchange of experiences and knowledge is one of the main successes of the project. We would like to express our gratitude for all the work and help we received from everyone involved personally or simply supporting us throughout this journey. Special thanks go to the official representatives of the region – István Szalay – the mayor of Kakucs between 2013 and 2014; and Mária Toma Kendéné – the mayor of Kakucs since 2014. It is impossible not to mention the relentless organizational and technical support from István Greman and Pál Kulcsár, whom we would like to say thank you.

The scientific potential of the Kakucs-Turján settlement exceeds our current state of knowledge. We hope to continue our scientific project and work on other documented finds. The results of such works will be published in the upcoming volumes of Studien zur Archäologie in Ostmitteleuropa/Studia nad Pradziejami Europy Środkowej series.

Mateusz Jaeger • Gabriella Kulcsár • Nicole Taylor • Robert Staniuk

CHAPTER 2

Report on the geoarchaeological survey of Kakucs-Turján site

Ákos Pető (Gödöllő), Gábor Serlegi (Budapest), Jakub Niebieszczański (Poznań), Marianna Molnár (Gödöllő), Mateusz Jaeger (Poznań), Gabriella Kulcsár (Budapest), Nicole Taylor (Kiel)

1. Introduction

Settlements of the Middle Bronze Age (2000/1900–1500/1450 B.C.) Vatya culture can be found in areas under various geographical conditions throughout the central part of the Carpathian Basin (e.g. Danube–Tisza Interfluve, Danube valley; Mezőföld Region). These multi-layered fortified settlements and open-air settlements are not only important parts of the cultural heritage of the Carpathian Basin, but are significant elements of the natural heritage, too. The importance of these structures lies within the potential of studying their buried soils and anthropogenic sediments. Data gained by the means of soil scientific methods not only form the basis of environmental historical conclusions, but reveals mosaics of the interaction between ancient human populations and their environment. Settlements in the flat area stretching along the left bank of the Danube Valley bear different horizontal and vertical structures than those of the Mezőföld on the right bank of the Danube. The characteristics of the Mezőföld region settlements' is that those fortified sites are mostly located at the edges of loess ridges. The choice of sites with this topography and terrain may have had a prominent strategic significance as well (e.g. at Perkáta-Forrás-dűlő or Százhalombatta-Földvár). In contrast to this, the sandy alluvial areas of the Danube–Tisza Interfluve offered a different possibility for Early/Middle Bronze Age populations: the dry areas gently rising from the flat landscape were the only 'non-flooded' teritorries providing suitable environmental conditions for the establishment of their settlements.

2. Materials and Methods

2.1. Geographical and geological setting of the site

Kakucs–Turján archaeological site is situated in the central part of the Carpathian Basin, within the Danube–Tisza Interfluve near the settlements of Inárcs, Kakucs and

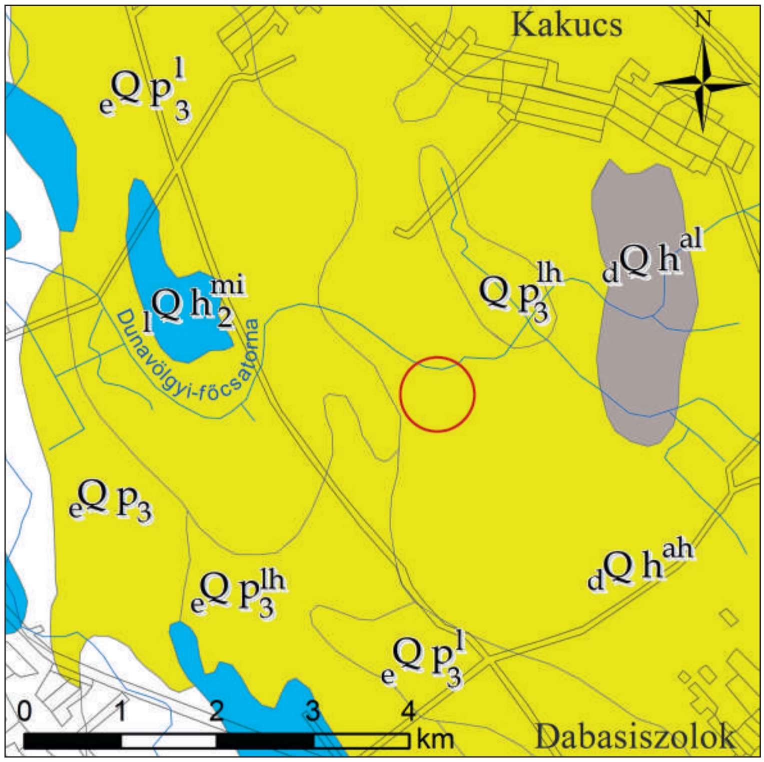


Fig. 1. The geological environment of Kakucs–Turján archaeological site. Legend: eQpl3 – loess; eQplh3 –loessy sand; eQhmi2 – lacustrine silt (lime); dQhah –clayey sand; dQhal – aleurite (re-drawn after Gyalog 2005)

Újhartyán. According to the geographical microregions of present day Hungary, the site lies on the border of the Kiskunság Sand Ridge, the Pest alluvial plain and the Pilis-Alpár Sand Ridge. All of the three microregions are characterised by gentle slopes and slightly undulating plains covered by fluvio-aeolian sands (Fig. 1). 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 into the category of moderately warm and warm with a mean annual temperatures of 10.2 to 10.5 °C. The precipitation value alternates between 530–550 mm's annually, upon which the area can be characterised as dry.

Except for the special marshlands of the so called Turjánvidék, which is situated north to the archaeological site, the subjected microregions are characterised by water-shortage and scarce runoff. In accordance with the geology of the microregions the dominant soil types evolved on fluvio-aeolian sand (e.g. loose sandy soils) and loess (e.g. Chernozems).

2.2. Geoarchaeological methods

In order to understand the stratigraphic conditions of the site, a series of shallow geological corings were planned prior to the excavation campaigns (Fig. 2). On the basis of the results of the geophysical survey that covered the entire area of the site the following coring protocol was designed (Pető et al. 2015a):

- exposing the shallow geological cross-section of the site in the north-south and east-west directions;
- understanding the stratigraphic relationships of ditches including both the inner, outer and the cistern-like feature;
- projecting the stratigraphy of the building features found in the central section of the settlement.

The seven shallow geological coring series (cross-sections) comprised of a total of 46 individual corings. The corings were carried out with a hand-operated Eijkelkamp

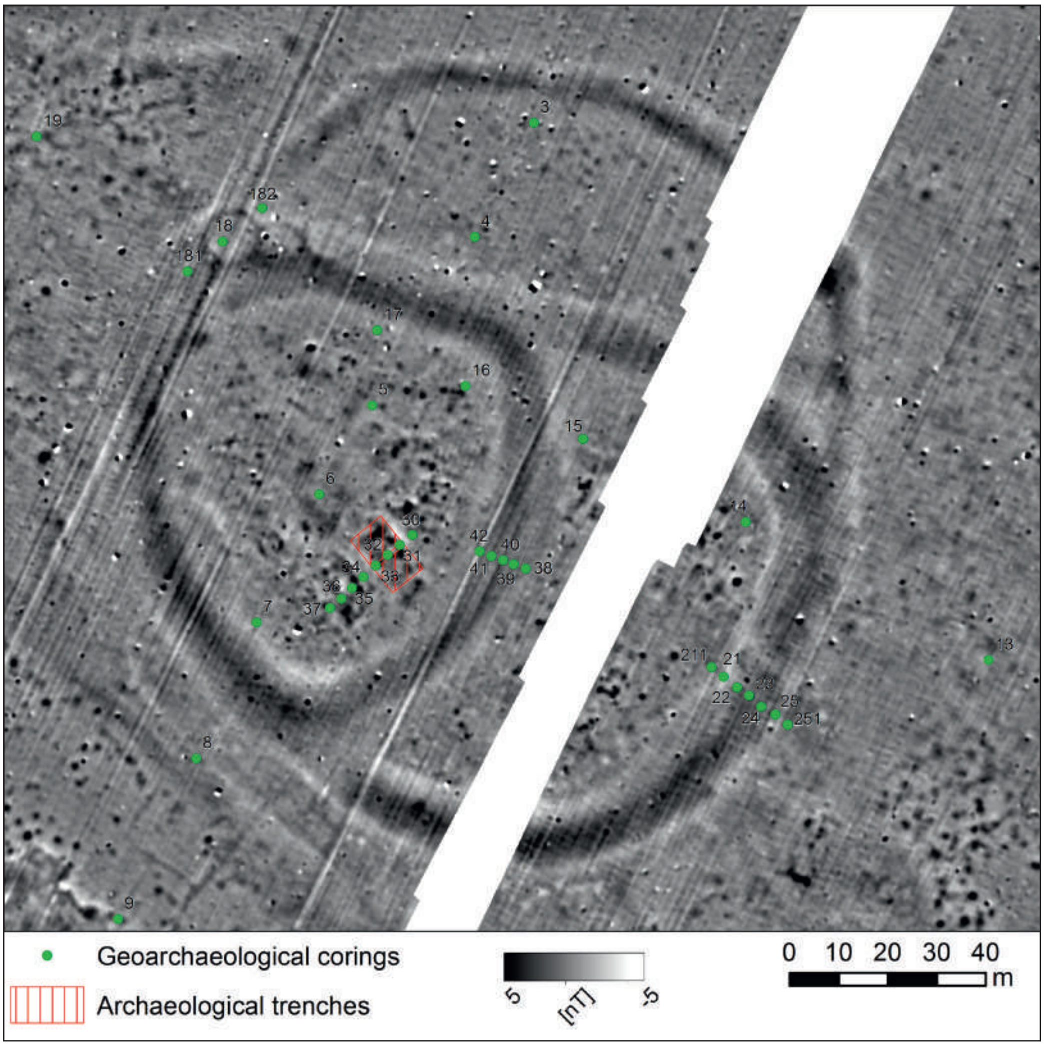


Fig. 2. The magnetometric prospection plan of Kakucs–Turján archaeological site with the location of the excavation area and the position of the shallow geological (geoarchaeological) corings.

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[1] methodology (TIM 1995), which was previously modified and extended in order to be able to describe anthropogenic signs and modification in the soil-sediment environment.

The on-site soil description was carried out based on the following criteria:

- slope/gradient;
- geographic exposure (N, W, S, E);
- vegetation cover;
- colour (based on Munsell Soil Colur Charts 1990);
- texture;
- presence of archaeological phenomenon or particle;
- presence of modern/recent anthropogenic particle or disturbance;
- moisture status;
- carbonate content (with 10% HCl probe: from 0 to +++);
- concretions;
- root intensity;
- compactness;
- structure.

Samples were collected from the main characteristic stratigraphic units. Laboratory analyses consisted of the following:

- humus content [H%] (based on Tyurin's method) (MSZ-08-0452-80)
- total organic carbon content [TOC%] (Loss on Ignition method) (Buzás 1988; Faithfull 2002)
- total phosphorus content [P_{total}] (Murphy, Riley 1962; Füleky 1983)

[1] TIM = Talajvédelmi Információs és Monitoring Rendszer – Methodology of the Soil Information and Monitoring System of Hungary

- pH [H_2O & KCl] (conductometric method) (MSZ-08-0206/2-78)
- salt content [salt%] (conductometric method) (MSZ-08-0206/2-78)
- carbonate content [$CaCO_3$%] (measured with a Scheibler-type calcimeter) (MSZ-21470/51-83)
- texture coefficient [K_A – Arany-type soil texture coefficient] (MSZ-21470/51-83) (for reference values see Tab. 1).

The soil horizons and layers within the individual profiles were coded with the combination of letters and numbers. Individual coring profiles were compiled based on the on-site description as follows:

The *y* axis of the shallow geological profiles were compiled based on the absolute height of the corings) and the individual profile descriptions (e.g. relative depth of the layers). Shallow geological cross-sections are displayed based on the EOV Projection System of Hungary (Unified National Projection). The distance between the corings are displayed on the *x* axis. The intensity of the anthropogenic disturbance was assessed on a semi-quantitative scale and displayed on the individual core profiles with red (daub) and black (charcoal) visual signs. The following codes were used to denominate the identified layers:

Table 1. Value ranges for the Arany-type soil texture coefficient.

Soil texture	Arany-type coefficient value ranges [K_A]
coarse sand (cs)	< 25
sand (s)	25–30
sandy loam (sl)	30–37
loam/silt (l)	37–42
clayey loam (cl)	42–50
clay (c)	50–60
heavy clay (hc)	> 60

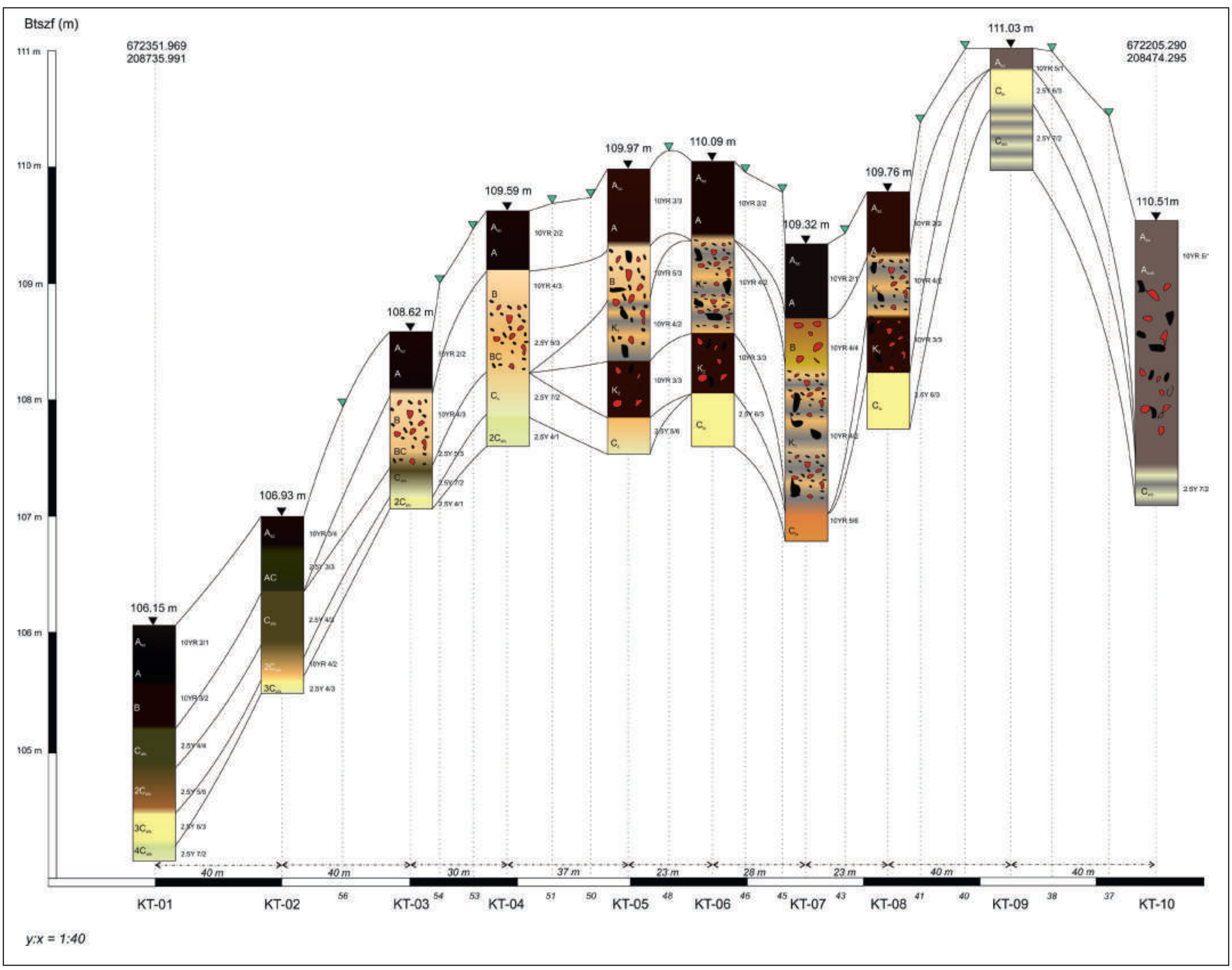
A	uppermost humic horizon of the modern soil profile
A_{sz} or A_p	ploughed layer of the A horizon
B	transition horizon between the uppermost humic horizon (A) and the parent material of the modern soil profile
AC	transition between A and C horizons (part of the natural soil formation process)
BC	transition between B and C horizons (part of the natural soil formation process)
C	parent material
C_{als}	alluvial sandy parent material
C_s	sand parent material (fluvio-aeolian origin)
C_{ls}	loessy-sand parent material
$C_{coll/als}$	alluvial sandy parent material with the signs of post-depositional colluvial effects
C_{coll}	sand or loessy-sand parent material with the signs of colluvial mass movements
K_1	cultural deposit (layer): grayish-yellowish brown in matrix with the presence of anthropogenic inclusions (e.g. daub/charcoal/ceramic fragments/stone fragments etc.)
K_2	cultural deposit (layer): dark brown in matrix with moderate amount of anthropogenic inclusions
K_{inf}	cultural deposit(infill of artificially deepened structures (ditch, well/cistern – e.g. KT-18)

3. Results and discussion

3.1. The description of the coring profiles of the north-south and east-west cross-sections

In order to examine the soilscape of Kakucs–Turján archaeological site two coring series were designed. Both the north-south (Fig. 3; KT 01–10; Pető et al. 2015a) and east-west cross-sections (Fig. 4; KT 11–20; Pető et al. 2015a) incorporated coring points beyond the physical (cf. circular ditches observed on the archaeological prospection of the site) boundaries of the settlement. The coring points were set at equal (40m) intervals and avoided the features (e.g. pits), since the goal was not to survey the individual features, but instead to understand the site's basic stratigraphy. 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 corings taken there. Archaeological phenomena were not indicated in these areas. On the basis of our current knowledge it is possible to state that the settlement could not or did not extend to these areas. Remnants of daub and charcoal were found in several profiles (at depth intervals between 55–100 cm below the ground level) in the northern part of the site. These foreign, anthropogenic particles are probably ex situ and were redposited. The central section of the site is located at the highest point of the examined micro-environment. In the central section of the site there are sand and loessy-sand deposits upon the lower flood plain filled with fluvial layers. This forms a natural,

Fig. 3. The north-south geoarchaeological cross-section of Kakucs-Turján archaeological site (after Pető et al. 2015a).



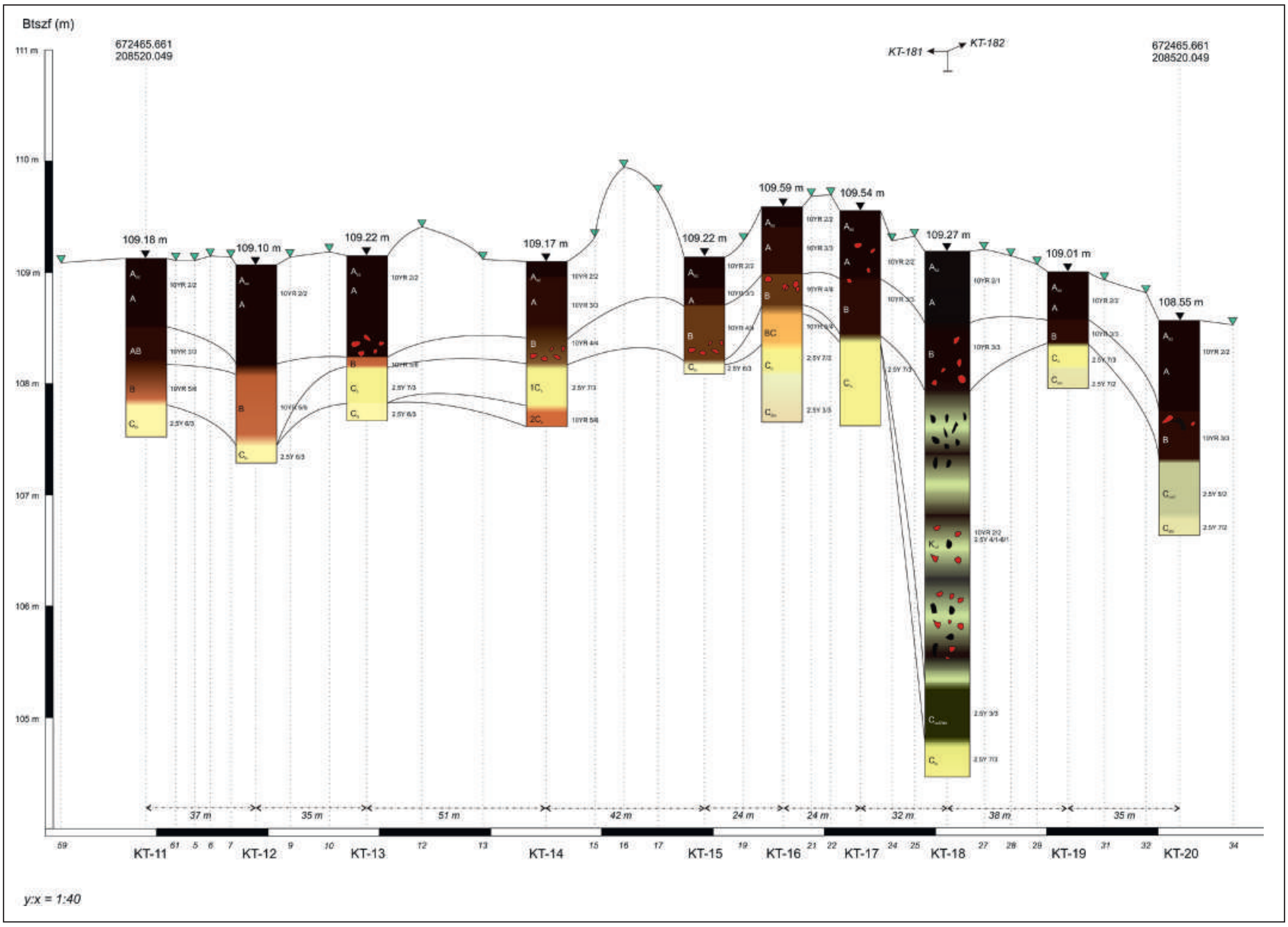


Fig. 4. The east-west geoarchaeological cross-section of Kakucs-Turján archaeological site (after Pető et al. 2015a).

island-like ridge in the landscape, which was most probably optimal for occupation purposes during the Early/Middle Bronze Age. A well-marked change appears in the central area of the site: the particles indicating anthropogenic impact can be observed even on the surface, and their intensity increases from a depth of 50 cm below the ground level. Below the modern soil cover of the site it was not the parent material that appeared, but a layer of anthropogenic deposits (cultural layer) indicated by the code K_1. 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 also developed through human activity, or was altered through its impact. On the basis of the corings, this anthropogenic impact is also detected in the area to the south of ditches, and at the same time an eroded soil cover appears on the sandy ridge neighboring the site to the south. In the depression between the two sand dunes a transported *(ex situ)* sedimentation most likely washed here from a higher elevation was observed, which contained anthropogenic particles (remains of ceramics, daub, charcoal and ash) in particularly large amounts.

Based on the observations of the corings taken to the east of the outer ditch encircling the site and the laboratory data currently available – in particular the total phosphorus content measured in the samples taken from here – it seems that the former human activity in this area was not too intensive (Table 2). While the eastern section of the settlement between the two ditches shows some anthropogenic impact, the unified cultural layer indicated by the K_1 designation observed in the central section was not detected. This may be related to the fact that this area was (also?) less intensively utilized during its occupation in the Bronze Age. Another interesting observation was that the sampling locations near the northern inner ditch in the central section also showed very little anthropogenic impact. On the basis of this, the occupation probably had a less

Table 2. Soil chemical and physical data of representative layers taken at coring point KT-11 and KT-19 at Kakucs–Turján archaeological site (data from Pető et al. 2015a).

Horizon/ Layer	Sample depth	TOC%	H%	P_{total}	$CaCO_3$%	pH [H_2O]	pH [KCl]	Salt%	K_A
	[cm]			ppm					
KT-11									
A_p	0–25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
A	25–60	3.0	1.7	276	5	7.6	7.2	0.01	28
AB	60–90	1.9	1.1	237	11	8.0	7.5	0.01	28
B	90–120	1.2	0.7	265	14	8.1	7.5	0.01	26
C_{ls}	120–16	0.3	0.2	295	26	8.4	7.9	0.01	31
KT-19									
A_p	0–25	2.6	1.5	374	10	7.9	7.3	0.01	26
A	25–40	2.0	1.2	321	13	7.9	7.5	0.01	26
B	40–60	1.2	0.7	236	20	8.0	7.8	0.01	24
C_s	60–80	0.7	0.4	180	30	8.2	7.7	0.01	30
C_{als}	80–100	0.4	0.2	161	22	8.4	7.7	0.01	37

intensive impact on this northern half of the central section. However, in the case of the interior of the central section and the sections indicated in the area of the buildings, the cultural layer that can be separated from the natural soil formations appears clearly. Foreign materials (e.g. daub fragments) indicating human occupation and disruption were also found in the corings of the northern section, but their quantity did not come close to that detected in those performed in the central area of the site. The western sampling locations outside the ditches outlined the lower, formerly flooded areas of the site's local environment.

The detailed macro-morphological description of K_1 and K_2 units is given below in the following sub-chapter.

3.2. The description of the corings deepened within the dwelling area

In the central area of the site two series of corings were implemented passing through two Bronze Age buildings (KT-30–37, Fig. 5; Pető et al. 2015a). In the series of corings the individual sampling locations were at 2.5 meter intervals. In general the stratigraphy of these corings are as follows: the buildings are covered by the modern soil formation of the archaeological site, which consist of a ploughed humic A-horizon. Directly below the modern soil cover an unified anthropogenic deposition designated as the cultural layer K_1 was formed. Below the K_1 cultural layer there is a layer characterized by a typically darker K_2, which is followed by the parent material of the site (C_{ls}).

The detailed description of the identified soil horizon, cultural layers/stratigraphic units are given in the followings:

A_p layer: The ploughed layer of the A horizon is dark brown (10YR 3/3), its texture can be defined as sandy loam, contains moderate amount of carbonates (++); it is slightly compacted due to the effects of soil tillage; its structure is granular. Nor anthropogenic particles with archaeological/cultural affiliation, neither modern anthropogenic contamination was observed in this layer. The depth of this layer is uniformly 30 cm below ground level.

A horizon: The part of the A horizon, which is untouched by soil tillage works

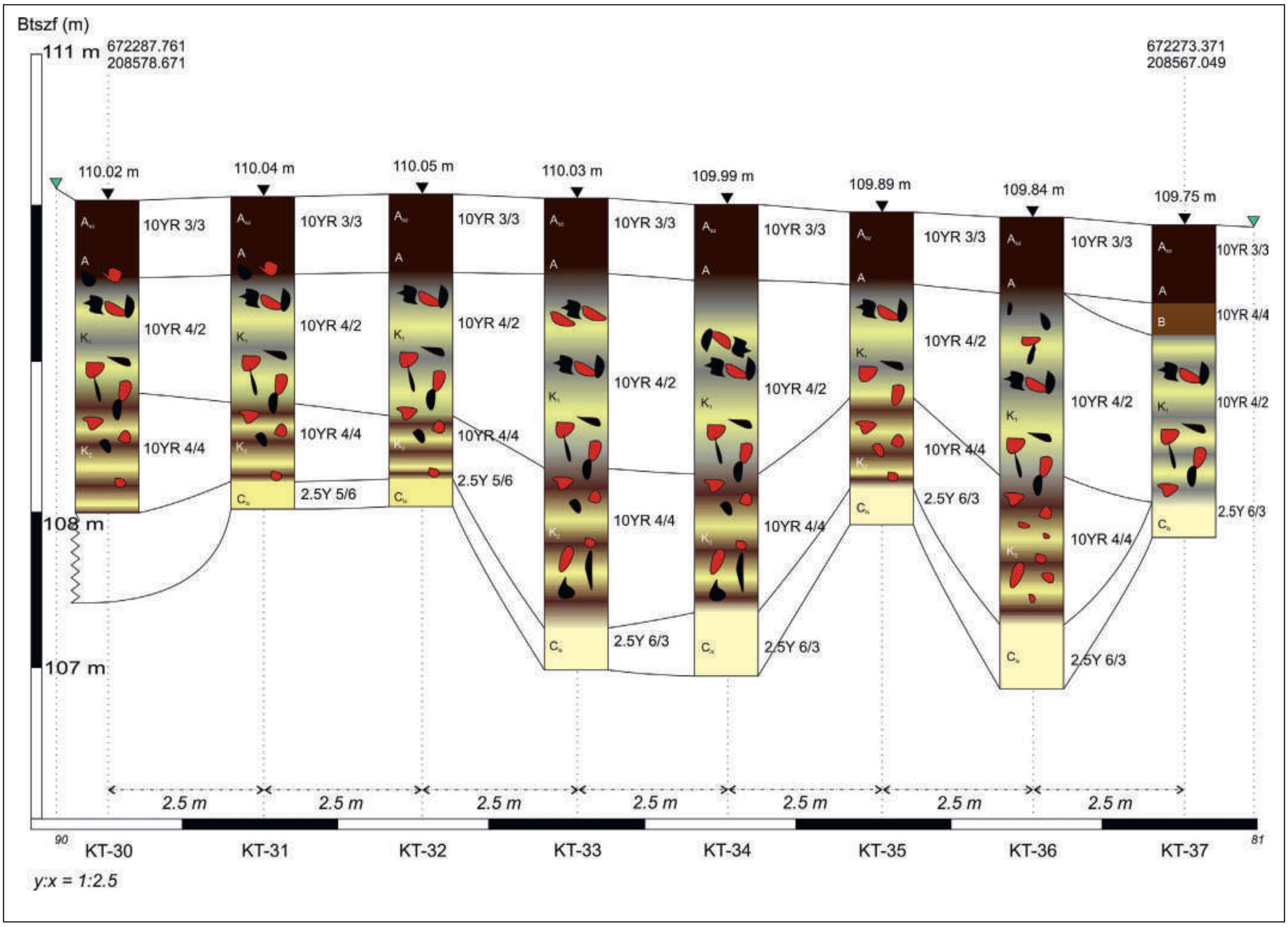


Fig. 5. The geoarchaeological cross-section of the inner ditch of Kakucs–Turján archaeological site (after Pető et al. 2016).

show similar properties. Dark brown colour (10YR 3/3), sandy loam texture, moderate amount of carbonates (++), less compaction and granular structure. The relative depth of this horizon varies between 45 to 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 humic soil cover.

K_1 layer: This anthropogenic layer is situated beyond the modern soil cover and in most of the cases the transition between the natural soil cover and this layer is gradual in colour and in texture, however the occurrence of anthropogenic particles and disturbance defines the boundary between the culturally affected and natural formations. The matrix of K_1 is grayish yellow (10YR 4/2), however the layer is multicoloured and its colour varies on a broad scale depending on the type and density of anthropogenic material that is located at the coring point. Its texture is sandy loam, containing low or moderate amount of carbonates (from 0 to ++). Typically daub and charcoal fragments appear in this layer, however their relative density varies. This layer is situated between the relative depths of 60 and 160 cm-s, its thickness varies, but no extreme observations were recorded. In general, and as discussed previously (Pető et al. 2015a; Pető et al. 2015b), the K_1 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 cannot be imagined within such human-induced contexts.

K_2 layer: This anthropogenic layer is situated beyond K_1 within the central part of the site. This layer is brown (10YR 4/4) in colour, however depending on the intensity of anthropogenic effects its colour might vary; its texture is sandy loam, con-

tains low or moderate amount of carbonates (from 0 to ++). Tangible anthropogenic material was observed in more profiles, however the signs of soil disturbance was a general key trait of this layer. As discussed earlier, the K_2 layer is thought to be the remain of the paleo humus horizon on which the inhabitation of the site 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 original humus horizon and this disturbance also resulted in mixing anthropogenic particles (e.g. daub, charcoal, stone, bone etc.) in the matrix of this soil material.

Parent material: The parent material within the dwelling area, which is the highest altitude surface of the site is dominantly loessy sand (C_{ls}), which is a dull yellow (2.5Y 6/3), sandy loam textured, loose sediment, which does not contain any anthropogenic material.

During the examination of the buildings situated parallel to one another, an essentially identical stratigraphy was found, although differences in thickness could be observed. At certain points the K2 cultural layer below the K_1 thickens significantly and shows a specific, visible stratification. In some places the lowest points of the anthropogenic K_1 and K_2 cultural layers is close to 3 meters below the surface (see KT-33 and KT-34 on Fig. 5). This is more than 1 meter deeper than the same levels in the neighbouring two core samples sunk into what was also presumed to be the interiors of the buildings (Fig. 5). The sub-stratigraphy of these coring points were found to be similar.

K_1 showed the following stratigraphy:

- 50–80 cm: brown, sandy textured natural soil formation;
- 80–100 cm: pale brown, homogenous layer;
- 100–160 cm: disturbed layer with high amount of daub fragments and varied in colour;

K_2 showed the following stratigraphy:

- 160–220 cm: anthropogenic sediment with daub fragments, charcoal remains and humus lenses;
- 220–250 cm: yellowish sandy layer;
- 250–280 cm: brownish yellow layer showing parallel carbonate concretion due to alternating vertical water movements, such as periodical leaching and infiltration.

3.3. The description of the ditch structures

The outer ditch: A shallow geological coring series was designed to map the stratigraphy, depth and geological properties of the outer ditch. A coring series consisting of seven coring points (KT-211–251, Fig. 6; Pető et al. 2016) aimed at providing a detailed view of the cross-section of this ditch part.

The uppermost soil cover is homogenous and represents the modern, Chernozem-like soil cover of the archaeological site. No significant differences were found between the morphological features of the recent soil cover above the ditch and the soil cover of the entire site in general (Pető et al. 2016).

The infill sediment of the ditch (K_{inf}) is present in differing thickness throughout the cross-section (Fig. 6). K_{inf} was not identified at KT-211 and KT-251, which means that the coring series reached the border of the ditch. The K_{inf} shows its thickest facies at KT-21 and KT-24 and draws up a V-like pattern indicating the original ditch shape.

The colour of the K_{inf} varied 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 underline the gradual refill of the ditch across a longer time period. The alternation of darker, more humic, and brighter, sandy fractions point to cyclic refill with different materials. Besides these laminations, thicker, turbated and mixed-up blocks of clays and silty sediments also occur within the K_{inf}. These laminations

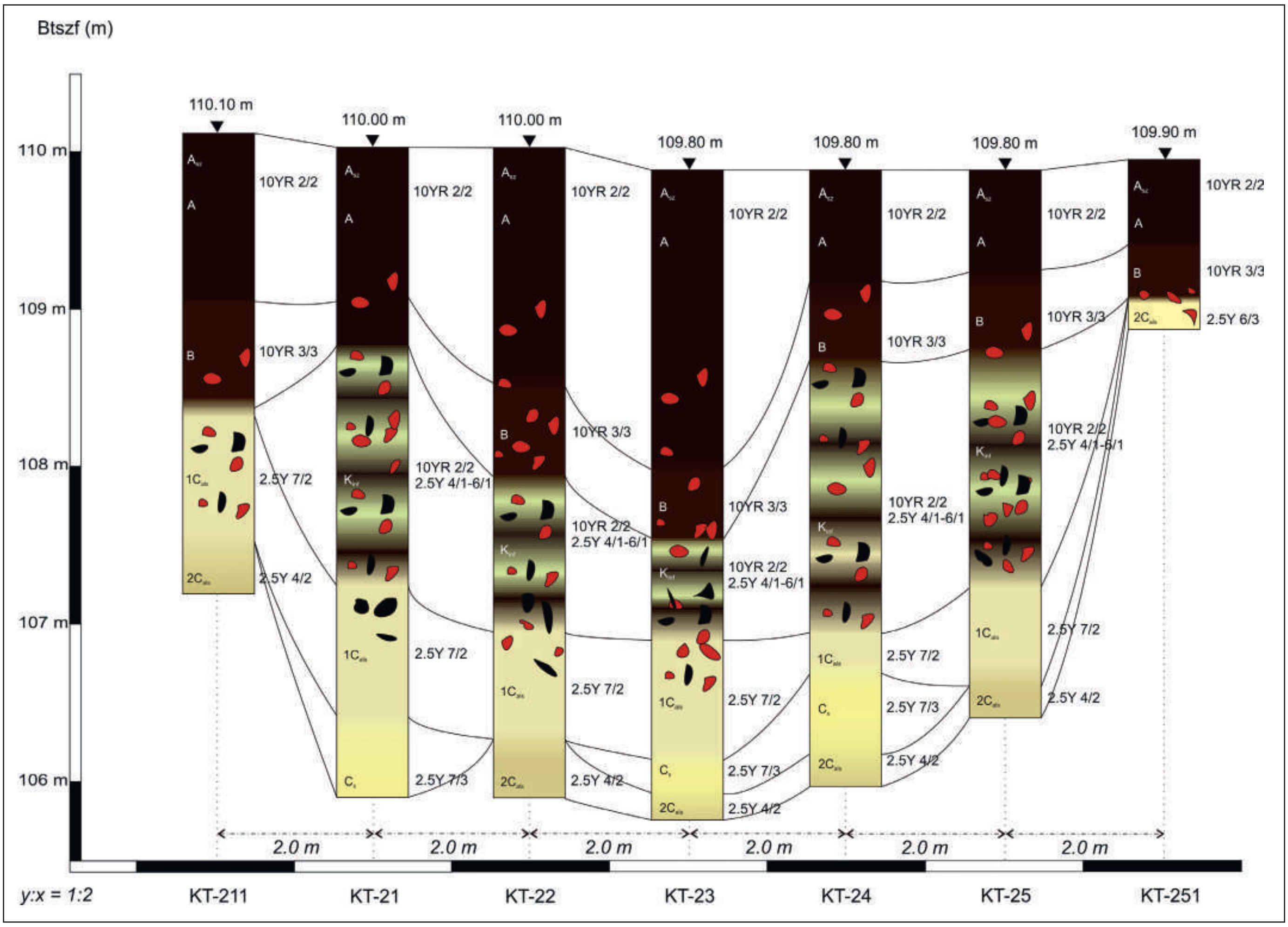


Fig. 6. The geoarchaeological cross-section of the outer ditch of Kakucs–Turján archaeological site (after Pető et al. 2016).

and the bigger flecks of clayey blocks all represent a stage of the ditch development. Based on these observations, it is difficult the 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.

Samples from each representative layer were taken at coring point KT-21 (Table 3). Values for the ploughed layer (A_p; 0–20 cm) and the A-horizon (20–150 cm) are in accordance with Chernozem-like soils 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. All organic matter indicators, such as

Table 3. Soil chemical and physical data of representative layers taken at coring point KT-21 within the outer ditch of the Kakucs–Turján archaeological site (data from Pető et al. 2016).

Horizon/ Layer	Sample depth	TOC%	H%	P_{total}	$CaCO_3$%	pH [H_2O]	pH [KCl]	Salt%	K_A
	[cm]			ppm					
A_p	0–20	3.8	2.2	506	7	7.7	7.2	0.01	31
A	20–150	2.8	1.6	419	6	7.8	7.3	0.02	33
K_{inf}	150–270	1.4	0.8	295	19	8.6	8.1	0.02	37
$1C_{als}$	270–350	1.1	0.7	241	13	8.5	8.0	0.03	31
C_s	350–400	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

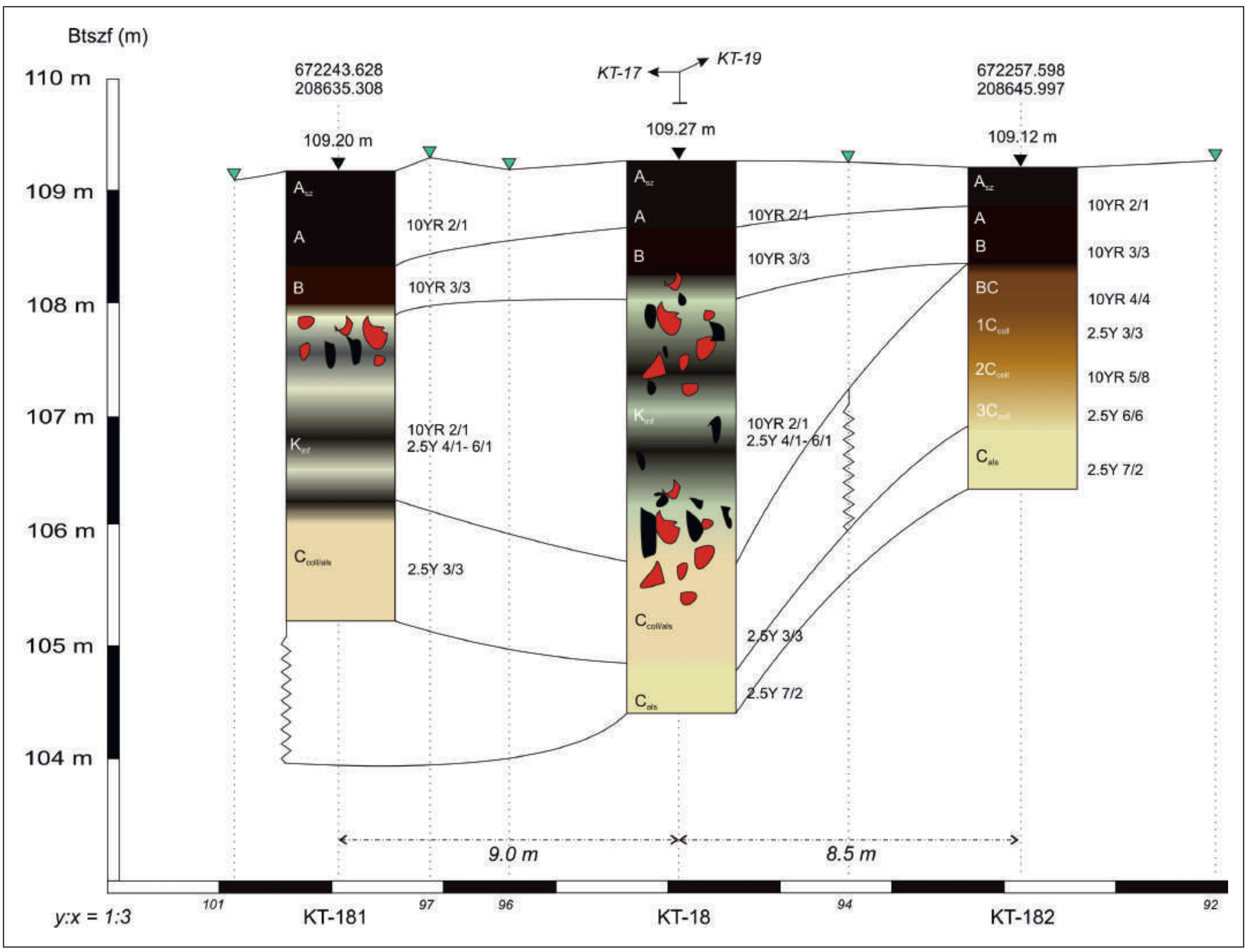
the TOC%, P_{total} and H%, show quite low values (Table 3), which might refer to the fact that settlement waste was not deposited in the ditch. In other words, the ditch was kept "clean".

The entire ditch was cut in a greyish yellow (2.5Y 7/2) sediment, which – according to the on-site observations – 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 as a water resistant, or at least periodically water resistant, bedrock for the ditch. This is somewhat controversial in light of the value of the texture coefficient (K_A = 31; Table 3) of this layer, because that value indicates sandy loam instead of a hard clay. It must be stressed, however, that a finer clay fraction, which might serve the aims of water retention within such sediments, cannot be seen in or measured by the K_A coefficient.

The cistern-like 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. Its nature was examined by means of a dense network of drillings, which exposed the subsurface structure of the sediments making up the feature (see Niebieszczański et al. *Geoarchaeological and non-invasive investigations of the site and its surroundings*: Figs 6, 12; in this volume). Coring point KT-18 was positioned in the very middle of this anomaly to map the depth of this possible cistern or retention tank feature. Similar to the other coring points, the uppermost 1 meter 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. The following stratigraphy could be observed (after Pető et al. 2016) (Fig. 7):

- 100–130 cm: dark brown (10YR 3/3), crumbly structured, clayey silt, high

Fig. 7. The geoarchaeological cross-section of the round-shaped archaeological feature at Kakucs–Turján archaeological site (after Pető et al. 2016).



concentrations of charcoal fragments;

- 130–180 cm: pale brown/yellowish gray (2.5Y 4/1), homogenous matrix, clayey silt;
- 180–260 cm: yellowish gray (2.5Y 6/1), sand, few daub and charcoal fragments;
- 260–300 cm: dark brown (10YR 3/3), humic, high intensity of charcoal, fine laminations composed of grey and yellowish coarse sand;
- 300–320 cm: dark brown (10YR 3/3), homogenous matrix; clayey silt, daub and charcoal;
- 320–340 cm: pale brown/yellowish grey (2.5Y 4/1), homogenous matrix; sand, daub and charcoal;
- 340–370 cm: dark brown (10YR 3/3), homogenous matrix; clayey silt, daub and charcoal;
- 370–420 cm: yellowish gray (2.5Y 6/1), loose sand, only few anthropogenic particles (daub, charcoal), humic inclusions.

As it is shown by the detailed description above, 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 the layer series also refer to sedimentation in standing water (Fig. 8). The refill process of this feature most probably occurred in separate steps; this is what the easily separable layers refer to.

A sample taken for the representation of the entire layer shows a clay texture (K_A = 47), and high organic matter input within this layer (TOC% = 4.0). Within the anthropogenic indicators, only the total phosphorus content gave a low value (P_{total} = 468 ppm) (Table 4). This combination – similar to the case of the ditches – might refer to the fact that no waste material was deposited here. The high TOC% and H% values might come from the erosion of the surface soil material. The embedding sedi-

Fig. 8. A detail of the K_{inf} with laminations in the core profile deepened within the round-shaped, cistern-like feature (coring point: KT-18 at 260–300 cm relative depth).

Table 4. Soil chemical and physical data of representative layers taken at coring point KT-18 within the outer ditch of the Kakucs–Turján archaeological site (data from Pető et al. 2016).

Horizon/ Layer	Sample depth	TOC%	H%	P_{total}	$CaCO_3$%	pH [H_2O]	pH [KCl]	Salt%	K_A
	[cm]			ppm					
A_p	0–25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
A	25–60	3.1	1.8	324	7	7.8	7.3	0.01	26
B	60–100	3.0	1.7	1230	22	8.2	7.8	0.01	36
K_{inf}	100–420	4.0	2.3	468	24	8.3	7.9	0.02	47
$C_{coll/als}$	420–450	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
C_{als}	450–470	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

ment of this feature shows similar morphological traits (especially gley marks in the form of manganese and iron flecks) as the sediment embedding in the ditches did.

In summary, we might conclude that the feature is a man-made hollow with a distinct boundary, 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.

The inner ditch: The geoarchaeological characteristics of the inner ditch surrounding the nearly round nucleus of the site was investigated through five corings (KT-38–42; see Niebieszczański et al. *Geoarchaeological and non-invasive investigations of the site and its surroundings*: Fig. 12; in this volume) (Fig. 9; Pető et al. 2016). Similarly to the outer ditch, the individual sampling locations were placed in two meter interval. On the basis of the corings it was possible to reconstruct the deepest point of the ditch at 300–350 cm relative depth (Table 5).

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 preliminary results, it is anticipated that there might have been

Table 5. Soil chemical and physical data of representative layers taken at coring point KT-39 within the inner ditch of the Kakucs–Turján archaeological site (data from Pető et al. 2016).

Horizon/ Layer	Sample depth	TOC%	H%	P_{total}	$CaCO_3$%	pH [H_2O]	pH [KCl]	Salt%	K_A
	[cm]			ppm					
A_p	0–30	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
A	30–60	3.7	2.2	323	10	7.9	7.5	0.01	32
B	60–100	4.0	2.3	383	15	8.0	7.7	0.01	32
K_1	100–200	2.2	1.1	236	16	8.3	7.6	0.01	29
$1K_{inf}$	200–300	2.8	1.6	1234	19	8.6	8.0	0.02	42
C_{als}	300–370	2.3	1.3	403	17	8.6	8.1	0.03	41
C_s	370–400	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a

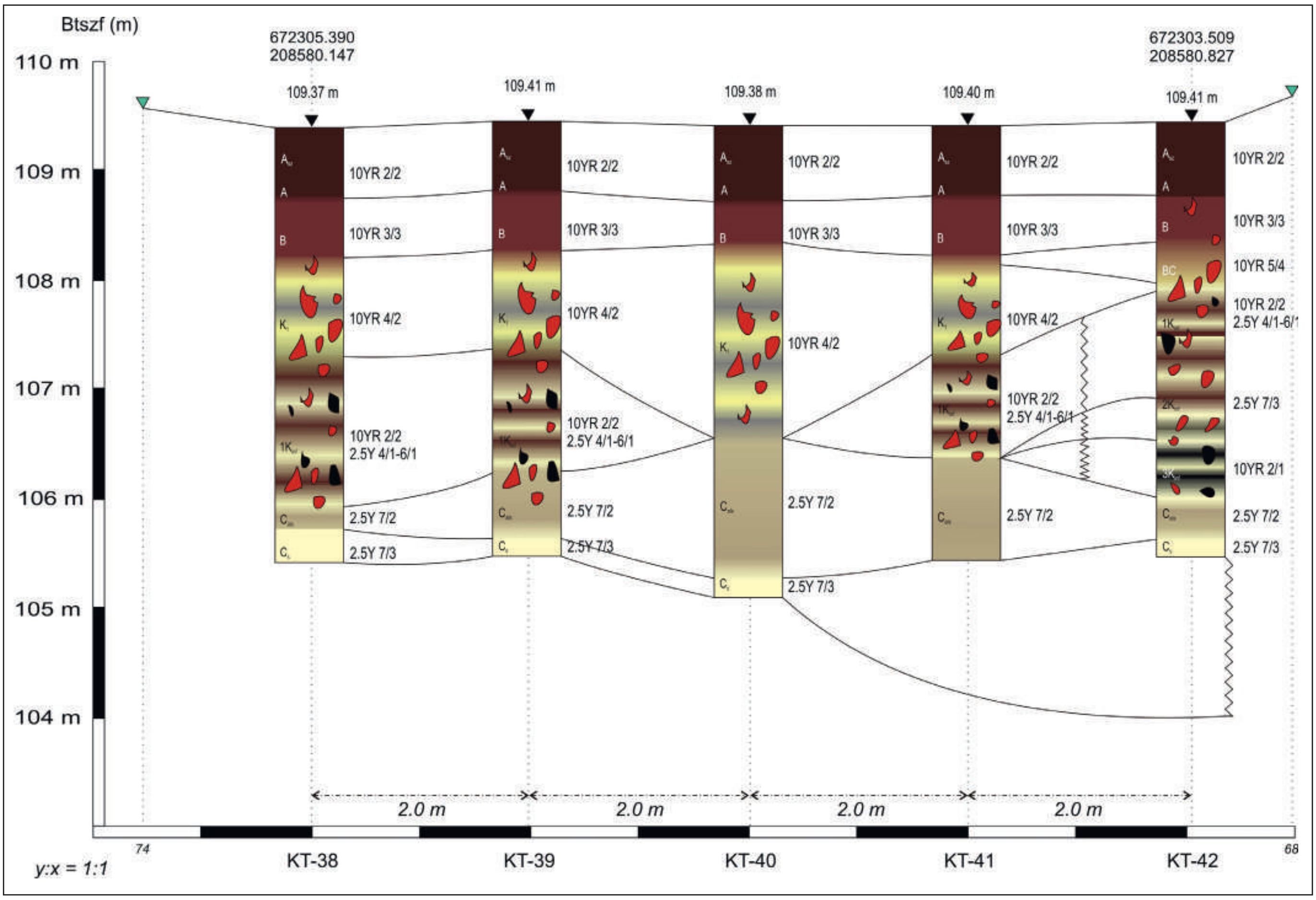


Fig. 9. The geoarchaeological cross-section of the dwelling area (buildings) located in the centre part of Kakucs-Turján archaeological site (after Pető et al. 2015a).

different periods of ditch refill, but it is hard to determine whether all of these occurred after the site was abandoned or during the life of the settlement. Based solely upon the corings, we cannot define signs of conscious ditch clearing. The laminations might have occurred while the site was occupied, but might also represent refill periods 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, while the bigger blocks of soil matter could 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 macromorphological analysis/observations of the corings.

It has to be stressed that a 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; *see description earlier in the text*) can be found on top of the infill of the inner ditch (KT-38 to KT-42; 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.

The immediate neighbourhood of the ditches is interesting as well, as the latter features are accompanied by strips of ground, approximately 7 meters wide, located on the inner side of the settlement, which the geophysical image shows to be devoid of magnetic anomalies. Geoarchaeological corings and analyses of samples demonstrated that these areas are anthropogenic in terms of genetic and sedimentological factors. Coring point KT-42 falls within this range (Fig. 2). The morphological features of this coring give 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 core is complex. Below the modern soil profile, 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 150 cm thick layer (situated between 170–280 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 between 280–320 cm relative depth). All three layers can be identified as ditch infills, although this coring 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 KT-42 represents the slope of the ditch.

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