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DATA ON THE GEOARCHAEOLOGICAL AND TOPOGRAPHICAL RESEARCH AT PÉCS-JAKAB-HEGY

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Traces of human activity can be observed on Jakab-hegy next to the city of Pécs from the late Bronze Age to the modern period. This utilization stretching over several millennia has also left a mark on the landscape, sometimes clearly and sometimes in less noticeable ways. There are several methods at our disposal from the natural and environmental sciences to understand the archaeological phenomena and structures. The methods of geoarchaeology help explore and map the archeological sites and provide 'depth' data, or, in other words, supply information in relation to vertical extent and stratigraphy.

INTRODUCTION

Jakab-hegy lies in the western range of the Mecsek Mountains, next to the city of Pécs (*Fig. 1*). Research was performed on the area previously.[3] Support from ArchaeoLandscapes Europe within the European Union Culture 2007 program and the Hungarian National Cultural Fund (NKA)[4] provided new impetus for research on the area between 2010 and 2015. Field walks, LiDAR surveys and soil analyses were performed within the area, so as to provide a precise profile of the former landscape use and the horizontal and

Fig. 1: The view of the southern side of Pécs-Jakab-hegy from the Csongor Rock (photograph: Ákos Pető)

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[3] The writings containing results from previous research are listed in the recommended literature.
[4] National Cultural Fund grant identification numbers: 3786/00148, 3786/00188, 3786/158, 3786/00083.

vertical extent of the site. The evaluation and dating of the results is made difficult by the fact that the traces of the individual periods (from nearly one thousand years just in the prehistoric period) are placed upon and next to one another. In the present article, the first results of the geoarchaeological survey performed on certain points of the site will be presented.

The Pécs-Jakab-hegy archaeological site

Research at the end of the 19th century noticed the prehistoric earthworks on Jakab-hegy. In the 1940s, Gyula Török excavated nine tumuli on the mountain.[5] Amongst the prominent finds from tumulus no. 1 was the famous bimetal knife, which clearly dated the collection of the tumuli to the early Iron Age. The next phase of research was the excavation campaign that took place between 1978 and 1996,[6] when the 32 graves from the group of tumuli and the structure of the earthworks were researched and restored under the leadership of Borbála Maráz,[7] as were the medieval Pauline monastery and its surroundings, under the leadership of Gábor Kárpáti.[8] In the 2000s, renewed surveying and conditions stabilization on the monastery were performed under the direction of Gergely Buzás.[9] Following this, in the 2010s, the renewed examination of the site was begun by colleagues from the Janus Pannonius Museum, within the context of the aforementioned research programs.

Archaeological Topography of Pécs-Jakab-hegy – A Summary

The section of Jakab-hegy enclosed by the earthworks is as much as 55 hectares. In the eastern section of the earthworks a citadel-type area (‘acropolis’) can be clearly differentiated, which may have been separated into sections on the interior on the basis of a LiDAR survey.[10] A smaller encircling earthen rampart (20–50 cm tall) enclosing the large earthworks can be seen on the relief map from the LiDAR survey. The collection of tumuli containing about 150 mounds is located on the western side of the earthworks.[11] The excavation of these mounds, situated in several groups, showed that they were erected in the 9th–7th centuries BC, in the early Iron Age. The large earthworks are contemporaneous with at least a part of these. On the basis of the late Bronze Age bronze depot found during excavations, human settlement on the ‘mountain’ can be dated prior to the mounds. The late Bronze Age ceramic fragments that appear in the earthworks also support this theory.[12] The area may have been inhabited all the way to the Roman period;[13] and during

5 Török, Gyula: A Pécs-Jakabhegyi földvár és tumulusok (Earthworks and Tumuli at Pécs-Jakab-hegy). *Archeológiai Értesítő* 77 (1950), 4–7.

6 For a summary, see: Maráz, Borbála: Pécs története a késő bronzkortól a római foglalásig (History of Pécs from the Late Bronze Age to the Roman Conquest). In*: Pécs Monográfia I.*, ed. Visy, Zsolt (Pécs: Pécs Története Alapítvány – Kronosz Kiadó, 2013), 71–73, 76–81.

7 Unfortunately only preliminary publications are available on all of this.

8 Kárpáti, Gábor: A jakabhegyi pálos kolostor (The Pauline Monastery at Jakab-hegy). In: *Kővágószőlős*, ed. Füzes, Miklós (Kővágószőlős: Önkormányzat, 2001), 51–60.

9 Buzás, Gergely: A Jakab-hegyi pálos kolostor (The Pauline Monastery at Jakab-hegy). *Várak, templomok, kastélyok* 3 (2007)/4, 8–11.

10 The results of the LiDAR survey have already been published in part: Bertók, Gábor – Gáti, Csilla: *Régi idők – új módszerek* (Old Times – New Methods) (Pécs-Budapest: Archaeolingua Kiadó, 2014), 171; as well as: Gáti, Csilla – Bertók, Gábor: An Iron Age landscape in South-Hungary: New methods with new results. In: *Sensing the Past – Contributions from the ArcLand Conference on Remote Sensing for Archaeology*, ed. A. G. Posluschny (Bonn: Habelt-Verlag, 2015), 44–46. The publication of the further results of the LiDAR survey is presently underway.

11 Estimate based on the LiDAR survey.

12 Maráz, Borbála: Későbronzkori magaslati település Pécs-Jakabhegyen (Előzetes közlemény az 1976–83. évi ásatásokról) (Late Bronze Age Mountain Settlement at Pécs-Jakab-hegy [Preliminary Publication on the Excavations from the Years 1976-83]). *A Janus Pannonius Múzeum Évkönyve* 30–31 (1985–1986), 39–64.

13 Maráz, Borbála: Archäologische Angaben zur mittleren und späten La Tène-Zeit in Südosttransdanubien. *Communicationes Archaeologicae Hungariae* (2008), 65–93.

Fig. 2: Detail of the LIDAR image made of Pécs-Jakab-hegy and its surroundings. Areas dealt with in the text: 1. the large tumulus, 2. the area of smaller tumuli, 3. the large enclosing earthworks, 4. the northern (T03) water catchment area and the dam enclosing it from the north-northwest direction, 5. the ruins of the Pauline monastery, 6. the water catchment area next to the Pauline monastery (T01), 7. the smaller earthworks marking out the "acropolis".

the most recent field walks evidence suggesting use during the Roman period was also found within the earthworks.[14] The earthworks themselves were probably constructed or reinforced in several phases.

According to the written sources, the medieval monastery was built in 1225. It was evident during the excavations that there was an earlier settlement on the mountain prior to this.[15] Connected to the monastery building on the northern side was the monastery garden, which was divided up with bastion-like structures. The monastery was in use all the way up to the 18th century, and during this time it went through several remodellings. In the 19th century, it still received visitors with its standing high walls.

Research Problems

The reconstruction and interpretation of landscape use at *Pécs-Jakab-hegy* is made difficult by the fact that its history covers several millennia (at least 3,000 years). The human occupation and the use of natural resources within this prominent geographical area presumably changed with each period. The human-made (archaeological) features within this landscape can only be dated today through complex examinations.

[14] Bertók, Gábor – Gáti, Csilla: *Régi idők – új módszerek* (Old Times-New Methods) (Pécs-Budapest: Archaeolingua Kiadó, 2014), 171, 123–138.

[15] Kárpáti, Gábor: A jakabhegyi pálos kolostor (The Pauline Monastery on Jakab-hegy). In: *Kővágószőlős*, ed. Füzes, Miklós (Kővágószőlős: Önkormányzat, 2001), 51–60.

The area is now covered in thick vegetation (various forest plant communities[16]), which makes ground surveying, field walks, and even excavation difficult. It is probable that the vegetation cover was less dense during the previous, presumably more intensive use. The present dense forest cover does not fundamentally favor the historic site either; the roots strain and break up the earthworks and mounds, and damage sections of the settlement. Due to the thin layer of humus, in many cases the roots turn up the archaeological features, or even the earthworks. The various elements of the landscape (mounds, earthworks, and settlement) require different research approaches. Another limiting factor is that in many places the surface layer of humus is quite thin, which renders the determination of the possible relationships between the different stratigraphical layers difficult.

To explore this collection of problems, a series of investigations were launched that make use of numerous methods from the natural and environmental sciences. Alongside the site detection (*see* LiDAR survey) methods, a series of preliminary geoarchaeological and soil cores were performed. The results of this are reported in the present publication.

Introduction to the Landscape Geography of Pécs-Jakab-hegy

In landscape geography terms, the site is located in the Mecsek Mountains microregion within the greater Trans-Danubian Hill region. The site is on the southern border of the Mecsek Mountains, and Jakab-hegy (592 m) is to the north of the towns of Kővágószőlős and Pécs. The microregion is made up of ranges classified as low and intermediate mountains; a series of lifted fault blocks run east-west in its western section (the Western Mecsek Mountains).[17] The *Pécs-Jakab-hegy* archaeological site is on the so-called Jakab-hegy Sandstone Formation ($^{j}T_{1}$), or rather on its base conglomerate ($^{j}T_{1}^{kg}$).[18] The soil cover of the Mecsek Mountains microregion is dominated by brown forest soils. The most common soil types are *Luvisols* developed on Tertiary sediments and highly acidic non-podzolic brown forest soil. The soil type characteristic of carbonate-rich parent materials are *Rendzinas*, and the shallow surface soil on the eroded material of silicate-rich sandstones are *Rankers*.[19]

THE OBJECTIVE AND METHODOLOGY OF THE GEOARCHAEOLOGICAL SURVEY

To gain a detailed understanding of the site's stratigraphical relationships, the location of the series of corings were selected on the basis of the LiDAR survey:

- the *H1–JH6* section aimed at intersecting two small burial mounds in the northwestern group of tumuli;
- the *T1-01* and *T1-02* coring locations were at the basin situated to the east of the Pauline monastery; the *T2-01* and *T2-02* coring locations were at the southeastern tip of the earthworks, at the basin found at the so-called acropolis area; and the *T3-01* and *T3-02* coring locations were in the basin situated to the north of the Pauline monastery.

[16] The potential natural forest plant communities of the Mecsek-hegység microregion belong to the so-called Pécs floral district (Sopianicum) of the Western Balkan floral province. These communities are: European smoketree karst shrub forests (Querco pubescenti–Continetum), pubescent and sessile oak forests (Querco pubescenti–petraeae), (Illyrian-type) common hornbeam and sessile oak forest (Querco petraeae Carpinetum mecsekense), and (Illyrian-type) Mecsek beech forest (Fagetum silvaticae mecsekense).

[17] Marosi, Sándor – Somogyi, Sándor (eds): *Magyarország Kistájainak Katasztere (Inventory of Hungarian Micro-Regions)* (Budapest: Magyar Tudományos Akadémia, Földrajztudományi Kutató Intézet, 1990).

[18] Gyalog, László (ed.): *Magyarázó Magyarország fedett földtani térképéhez (az egységek rövid leírása) (Explanation of the Geological Map Covering Hungary [Brief Descriptions of the Units]). 1:100.000*. (Budapest: Magyar Állami Földtani Intézet, 2005), 189.

[19] Marosi, Sándor – Somogyi, Sándor (ed.): *Magyarország Kistájainak Katasztere (Inventory of Hungarian Micro-Regions)* (Budapest: Magyar Tudományos Akadémia, Földrajztudományi Kutató Intézet, 1990); Hoyk, Edit: A Nyugat-Mecsek növényzetének értékelése optimalizációs térkép alapján (Evaluation of the Flora of the Western Mecsek Mountains on the Basis of an Optimization Map). *Földrajzi Konferencia* (Szeged, 2001), 1–8; Stefanovits Pál – Filep György – Füleky György: *Talajtan* (Budapest: Mezőgazda Kiadó, 1999).

The soil analysis and shallow geological coring at the determined points were performed with a hand-powered *Eijkelkamp* bore equipped with a gouge auger. In every case, the cores were sunk to the level of the parent material characteristic of the area or to the level of solid rock bedding.[20] Laboratory soil analysis and so-called flotation remains analyses[21] were performed on the soil and sediment samples collected during the coring.

PRELIMINARY RESULTS OF THE GEOARCHAEOLOGICAL SURVEY

Results of the Mapping of the Burial Mounds

The examined features were located about 500 meters to the north of the overhang falling off to the south of Jakab-hegy.[22] We opened a soil profile in an area not affected by the tumuli and took samples from its genetic soil horizons so that it would be possible to characterize the soil as precisely as possible in the small area examined. The profile representing this area is encoded as JHSz[23] (*Table 1*). On the basis of the results, it can be stated that the area is covered with quite shallow surface soil, strongly acidic with poor water and presumably poor nutrient content, which can be defined as *Ranker* soil formed on so-called sandstone debris.

Table 1: Baseline laboratory data from the soil profile encoded JHSz opened at the Pécs-Jakab-hegy archaeological site

Soil horizon	Sample code	Depth [cm]	Parameters				
			Humus %	pH (H_2O)	$CaCO_3$%	Total salt %	K_A*
A_O	JHSz/1	0–5	> 8.0	5.44	0.0	<0.02	73
AC	JHSz/2	5–20	1.69	4.85	0.0	<0.02	39
C	-	-	-	-	-	-	-

* Arany-type soil texture coefficient

The strongly acidic pH level is the joint result of the non-carbonate (silicate) bedrock, the powerful leaching due to the high annual precipitation levels, and micro-organisms breaking down the plant litter creating biological agents that promote acidification. This process can speed up the decay of carbonate-containing archaeological elements (e.g. bone materials), which affects the site's general taphonomic characteristics.

Mounds that seemed undamaged during the inspection of the site prior to planning the geoarchaeological research were chosen for sampling. On the basis of the documentation from the earlier research, stone

[20] Due to the conditions of the archaeological stratigraphy of the site as well as the structures of the features examined, in many cases it was not the natural level of dense rock that was the lowest point of the core, but instead a man-made dense rock level.

[21] The archaeobotanical expert Dr. Árpád Kenéz performed the flotation remains analysis. Here we would like to thank him for his assistance.

[22] The mounds are found in a plateau-like area with patches of scrub-brush and oak forest, but on the mountain side sloping to the north Illyrian-type hornbeam and oak, and then Illyrian-type beech (Mecsek beech) habitats appear and alternate with one another.

[23] The tripartite soil section (A_O–AC–C) was opened to a depth of 25 cm. The uppermost humic A-horizon appeared to a depth of 5 cm. Its color was a slightly reddish deep brown (7.5YR 4/6). On the basis of the results of laboratory measurements and observations at the site, the upper soil had a high clay content (K_A = 73). Plant remains within the litter that had not broken down were still visible in the so-called moder type humus cover. The humus content of the upper soil was extremely high (H%> 8,00). The pH level of the unstructured, loose A_O-horizon was strongly acidic (pH 5.44). The soil made from the debris of the Jakab-hegy Sandstone Formation ($^jT_1$) at the AC-horizon differentiated gradually in color but sharply in texture from the humus upper soil. Its color varies between light brown (7.5YR 6/4) and pink (7.5YR 7/4). The proportion of coarse structural parts increases with depth in the AC-horizon, which showed the physical characteristics of loam. The humus content of the layer is moderate (H%= 1.96), and as a sign of its full leaching, it does not contain any calcium carbonate. In contrast to the A_O-horizon, anthropogenic particles with archaeological affiliation were observed in this genetic soil horizon. Ceramic fragments were removed from the profile at a depth of 14–15 cm, and in addition small patches of wattle-and-daub debris could be observed (cf. the data from *Table 1*).

chambers were created in the central region of the Iron Age tumuli found here.[24] The burial was bordered by at least a ring of stones, but there are known examples where this was combined with a packing of stones covering the entire burial area,[25] which in certain cases (possibly) came about through the placing of not just one layer, but several layers of rocks upon one another.[26] In addition to reconstructing the burial ritual, understanding these phenomena is also important from the aspect of performing the soil bores, since no matter whether it is natural or man-made – that is laid stone material – it is impossible to bore through with a hand-operated gouge auger. Besides all of this, the manifestation of this solid rock contains important information. In the depictions of the cross sections of the mounds excavated by Borbála Maráz, it is clear that in many cases either no or only an insignificant amount of eroded soil material covered the central tomb.[27] These observations are consistently supported by the soil cores performed on the small tumuli and on the large mound. The solid rock, which with one exception was detected quite close to the surface in the cases of the coring performed on the small tumuli, may have been the packing of stones covering the mound. This is also supported by the fact that in many cases the bore was not stopped by conglomerated eroded sandstone, but by clearly dense stone blocks. The JH4 bore site was an interesting exception, where – most likely due to finding a gap in the rock by chance – the core was sunk below the presumed level of the stone packing and possibly into the central tomb. The existence of the anthropogenic layer (cultural layer) was detected here, which clearly showed that at this level – within the context of the technology provided by a soil gouge augre – an anthropogenic in-mixture suggesting burning was observed (ash and bits of charcoal) *(Fig. 3)*. According to descriptions, the funeral pyre was built in the center of the stone circle as part of the burial.[28]

On the basis of the examinations, it can be hypothesized that the parent material below the soil cover on the stone packing of the tumuli is not a natural formation, but man-made.[29] In contrast with the idea that soil was put on the stones of the mound after they were packed, we find the spontaneous accumulation of soil more likely, since it is hard to imagine that they would have placed topsoil, which was very shallow in this area, on top of the packed stones. In addition, quick erosion would have washed away this raw topsoil created at burial that would have had no structure and dried out.

The flotation remains analysis performed on the JHSz profile samples showed two extremely interesting remains. The existence of the (carbonized) fish bone found in the 0–5 cm layer, that is the A_O -horizon, is difficult to explain in this area. Naturally, it may be a one-time, chance occurrence, but it may indicate some activity related to former human use of the area.[30] A more tangible phenomenon is that in the sample from the depth of 5–20 cm, blackberry seeds (*Rubus* sp.) were found. All traces of these archaeobotanical finds underline that the remains are of archaeological age, in other words, they were carbonized. The presence of this species draws attention to the fact that in earlier times a more open blanket of vegetation (e.g. an open pasture forest, clearing, etc.) might have characterized the area of the Iron Age tumuli.

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[24] E.g. Maráz, Borbála: Zur Frühhallstattzeit in Süd-Pannonien. *Janus Pannonius Múzeum Évkönyve* 23 (1978), 145–164: table I, 157.

[25] E.g. Maráz, Borbála: Zur Frühhallstattzeit in Süd-Pannonien. *Janus Pannonius Múzeum Évkönyve* 23 (1978), 145–164: table V:1, 161.

[26] E.g. Maráz, Borbála: Zur Frühhallstattzeit in Süd-Pannonien. *Janus Pannonius Múzeum Évkönyve* 23 (1978), 145–164: table III:2, 159.

[27] E.g. Maráz: Előzetes jelentés az 1976–77. évi ásatásokról (Preliminary Report on the Excavations of 1976–77). *Archaeológiai Értesítő* 106 (1979)/1, 82–93.: Fig. 12, 86.

[28] Naturally, it is not possible to conclude a clear parallel between descriptions in the literature and the results of the coring based on one example, but in any case it is an interesting coincidence that a core sunk into the central region of a small tumulus turned up an accumulation of anthropogenic deposits containing traces suggesting burning.

[29] A very distant parallel is provided by the characteristics of the formation of the recent soil cover developing on the surface of kurgans (burial mounds) of the Great Hungarian Plain, since here as well the soil cover developed over a man-made parent material.

[30] It is an interesting parallel that in the course of conducting geoarchaeological survey on the middle Bronze Age fortified settlement at Perkáta-Forrás-dűlő, fish bones were found at a high, dry location (unpublished data). However, it is true that natural streams are much closer to the earthworks there than is the case of Pécs-Jakab-hegy.

Fig. 3: The section of the core taken at the JH4 bore representing an anthropogenic layer in the depth of 20-40 cm (photograph: Ákos Pető)

Geoarchaeological Survey Performed in the Catchment Basin Areas

The second objective of the present examination was to drill cores into areas that, on the basis of their current natural conditions, are considered to be possible water catchment basins, situated on the top of the mountains. Following the surveying of the topographical and runoff conditions, it was found that these areas are in natural basins and collect the surface runoff waters from a significant portion of the earthworks *(Fig. 4)*. The catchment basin indicated with the T1 and T2 codes even held water at the time of the on-site investigation.31 In the case of T1, there was a topsoil which could be characterized as not yet decayed organic material similar to peat formation, below which was the red sandstone or gray silt characteristic of Jakab-hegy *(Fig. 4)*. The strongly acidic pH in this case may represent an obstacle to the classic formation of humus, so the annual input of organic materials can only decay slowly, or only partially transform into humus. This phenomenon is less marked in the case of T2, where the topsoil shows signs of humus formation. This is conspicuous in part from its weak structure and the much lower accumulation of undecayed plant matter. At the same time, it must be pointed out that in this case quite low, extremely acidic pH levels were measured, which could hinder soil formation as well *(Table 2)*.

[31] In the case of T1 the surface cover was tall sedge shore vegetation paired with individual softwood trees (e.g. willows). In the case of T2 gradually closing forest and in part a basin trough covered in weed species.

Fig. 4: The high sedge shore vegetation at the top of Pécs-Jakab-hegy from the water catchment basin (encoded as T1 in the text), and the profile of the T1-02 core sample (photographs: Máté Szabó and Ákos Pető)

Table 2: Baseline laboratory data on the soil and deposit samples collected from the cores bored into one of the water catchment areas (T1-02) at the Pécs-Jakab-hegy archaeological site

Soil horizon	Sample code	Depth [cm]	Parameters				
			Humus %	pH (H2O)	$CaCO_3$%	Total salt %	K_A*
A_o	T1-02/1	0–15	> 8.0	5.91	0.0	<0.02	81
C1	T1-02/2	50-60	0.47	6.40	0.0	<0.02	< 25

* Arany-type soil texture coefficient

The T3 catchment basin presented an entirely differing profile. The almost entirely forested area does not hold back water at present. While the T1 and T2 catchment areas are natural basins without an outflow, in the case of T3 the northern side of the basin is made up of an asymmetrical formation reminiscent of a parabolic dune similar to a man-made dam. An opening, a 'cut-through' can be seen in this. The stratigraphic relationships of the T3 basin also show *colluvial* effects; that is, the appearance of accumulated soil material washed in from the south could be observed. This *colluvial* material is covered by a recent humus-rich A level. Ceramic fragments, charcoal, and accumulations of daub appeared at the depth of 30–100 cm in the basin (*Fig. 5*). On the basis of the observed and reconstructed surface development process in the area, it is difficult to imagine in a profile theoretically used as a water catchment area that anthropogenic deposits

would have accumulated to a depth of nearly 70 cm. So, it is more likely that – at least in part – inflow and soil erosion from the southern side can be assumed. This phenomenon takes the hypothetical reconstruction in the direction of an open soil surface or opening forest plant communities differing from the present surface cover.

CONCLUSION

In conclusion it can be stated that the data obtained from the geoarchaeological survey support the previous practical observation that only a minimal layer of humus can be counted on in the area of the Pécs-Jakab-hegy archaeological site. Not only does the general, quite acidic soil in the area not favor humus formation, but it also breaks down the man-made objects in the soil (ceramics, metals) to a great extent and hinders their survival. In the case of the mounds it seems that the area once had much scantier vegetation and the earthen mound covering the piles of rock probably developed as the result of natural deposits and soil formation. In the course of future research on the mountain, the proceeding steps must be planned while taking this information into account. The examinations begun now (LiDAR, geoarchaeology/soil analysis) only provide a starting point for the later research plan aimed at landscape use and a precise topography.

Fig. 5: The profile of one of the cores bored into the T3 water catchment area, and the ceramic fragments appearing in the core sample (upper right); soil material slightly mixed up with anthropogenic particles (lower right) (photograph: Ákos Pető)

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