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NON-DESTRUCTIVE INVESTIGATION OF MEDIEVAL CASTLES AND THEIR ENVIRONMENT IN THE MIDDLE SECTION OF THE KAPOS VALLEY

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The present study introduces the initial stages of an emerging archaeological research programme aimed at a comprehensive investigation of medieval castles and their environment in the middle section of the Kapos Valley. Instead of isolated evaluation, each castle is assessed in the context of the associated estates, settlements, and the historical landscape as a whole in order to reach a more nuanced interpretation. This approach also enables us to analyse the transformation of the region's castle network over time, to model microregional connection networks, among other aspects. In the course of the project, traditional archaeological and historical methodologies – including field survey, archaeological excavation, aerial photography, and the processing of written and cartographic sources – as well as modern investigative and analytical techniques – ground-penetrating radar, magnetometry, LiDAR, photogrammetry, three-dimensional modelling, as well as spatial and geostatistical analysis – are employed to achieve a more detailed and comprehensive understanding of the period and the study area.

Keywords: medieval castles, castle topography, non-destructive archaeological investigation, settlement history, medieval land use, road networks, GIS analysis

The presented project, still in formation, focuses on a region in Southern Transdanubia, along the middle section of the River Kapos, situated in the contact zone of three geographic microregions: the southern part of Outer Somogy, North Zselic, and Völgység. The study area extends to approximately 20 km between Attala and Kurd, following the valley of the Kapos along the present-day county border, with the modern town of Dombóvár at its centre (*Fig. 1*). During the Middle Ages, control over the studied microregion was shared among several castles and monasteries. The dates of foundation of the individual fortifications and the duration of their use remain to be determined. In the cases of Döbrököz, Dombó, and Dáró, their first mentions in 14th-century charters suggest an Árpád Age origin; in the last case, this is supported both by surface finds (Miklós 2007, 235) and by traces of former landscape modifications observed at the site. Among the ceramic finds from Döbrököz, Zsuzsa Miklós identified pieces dating to the 13th century (Miklós 2007, 195); however, the geophysical investigations conducted to date have not revealed any structures predating the regular late medieval ground plan of the castle.

In the case of Dombó, a debate ongoing since the early 1990s concerns whether the ruin area known today as Gólyavár can be identified with the building referred to in the early written sources. Drawing on the so-called report of Mihály Kelcz from 1692, Tibor Koppány argued that the regularly planned castle reconstructed from that description cannot be identical to the structure mentioned in early 14th-century charters. This hypothesis is further supported by Zsuzsa Miklós's excavations at Szigeterdő, where a late Árpád Age tower castle was uncovered along with its associated ditch and rampart system, at a site located less than 1 km from Gólyavár. Zsuzsa Miklós did not exclude the possibility that the early written sources refer to this complex instead; however, she noted that, on the basis of the recovered finds, the fortification was in use from the 13th to the 16th century. Most of the surface pottery finds she collected at Gólyavár date to the 15th–16th centuries. Nonetheless, pieces from the 14th–15th centuries are also present, based

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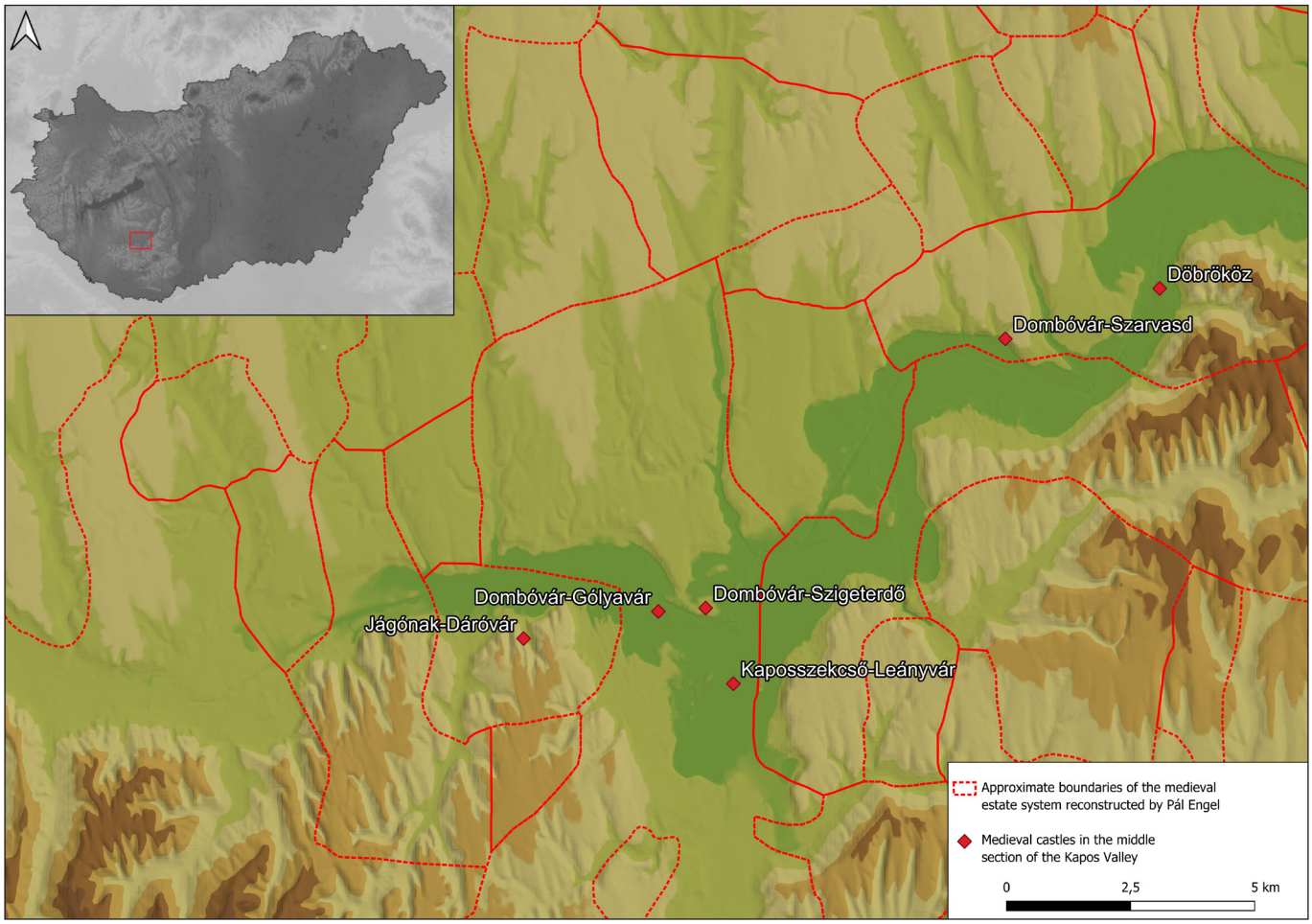

Fig. 1 Location of medieval fortifications within the study area (by Adrián Berta, Ákos Ekrik, Bianka Gina Kovács)

on which Zsuzsa Miklós raised the possibility of earlier use of the area. In the early 2010s, Géza Szabó suggested that Gólyavár may have had Árpád Age antecedents; however, despite the finds he presented, his argumentation has not been found convincing (for a review of the related literature, see Berta 2018, 215–219 and 252–253). Archaeological excavations conducted since 2014 have not revealed any architectural features predating the regular, planned rectangular building. The results of the most recent geophysical investigations have once again raised the possibility that another structure may have existed at the site, and that it was earlier or possibly coeval with the currently known fortification or some of its elements. Clarifying this question is one of the principal objectives of forthcoming fieldwork in the research plan.

The tower castle of Szigeterdő and Dáró appear to have been abandoned in the first half or middle of the 16th century (Miklós 2007, 190, 238), while Dombó and Döbrököz were converted into Turkish fortresses after 1546. The latter were destroyed in the early 18th century, following the end of Ottoman rule.

No written sources are known to mention two of the fortifications, Dombóvár–Szarvasd and Kaposszekcső–Leányvár. The former was discovered by István Torma, who tentatively dated it to the Árpád Age. Zsuzsa Miklós did not recover any artefacts from either the central part of the site or its immediate surroundings (Miklós 2007, 180). Most recently, a metal-detector survey led by András K. Németh brought to light metal finds from the Ottoman period, indicating post-medieval use of the site and, in the absence of other finds, raising the possibility that it was established relatively lately. As for Kaposszekcső–Leányvár, Zsuzsa Miklós dated the finds recovered during a field survey to the 13th–14th centuries (Miklós 2007, 244–246). According to an 18th-century testimony, the former fortification known as Sziget vár, located in the floodplain of Széki-víz, had served as a refuge for local Hungarians during Ottoman and Serbian military campaigns. The walls of Leányvár were still standing at the time, and the surrounding defensive ditch was also deep (Máté 2013, 53).

EARLIER CASTLE-TOPOGRAPHICAL STUDIES AND RESEARCH IN THE STUDY AREA

Castle-topographical works have traditionally focused exclusively on the fortifications and built structures themselves, as well as their setting. This approach resulted in the publication of such fundamental works as the volumes of the series *Magyarország várainak topográfiája* [*The Topography of Castles in Hungary*], initiated by the Castrum Bene Association and organised according to the present-day county system. The editors of the series strived for uniformity and have collected, and still continue to collect, all castle-like structures of archaeological date in the selected areas (for an overview of the research history and the volumes published to date, see Feld & Terei 2017, 151–154). The works of the Institute of Archaeology at ELTE RCH (the former Institute of Archaeology of the Hungarian Academy of Sciences; hereafter reffered to as the Institute) approach the subject from different perspectives. In her volume on Tolna County, Zsuzsa Miklós presented individual castles, including not only their location, research history, and ownership history, but also descriptions of field surveys, excavations, and geodetic surveys, together with cartographic and survey materials, floor plans and aerial photographs. In addition, she provided a brief presentation and dating of the finds recovered at each site, as well as the location of nearby contemporary settlements (Miklós 2007). This approach was complemented in the more recent volume on the medieval and Ottoman period castles of Pest County through overviews (Kovács 2022).

The present project builds on the aforementioned study by Zsuzsa Miklós, as well as the results of archaeological excavations at the castle at Dombó, conducted since 2014. In addition to the traditional and non-destructive investigation of the fortification's remains, this project also attends to the broader setting of the site. The work of András K. Németh serves as another important starting point. Among other topics, he examined the medieval churches of Tolna County in his PhD dissertation, compiling relevant historical data and toponymic material and subsequently localising the majority of the destroyed churches and villages through field surveys (K. Németh 2015a).

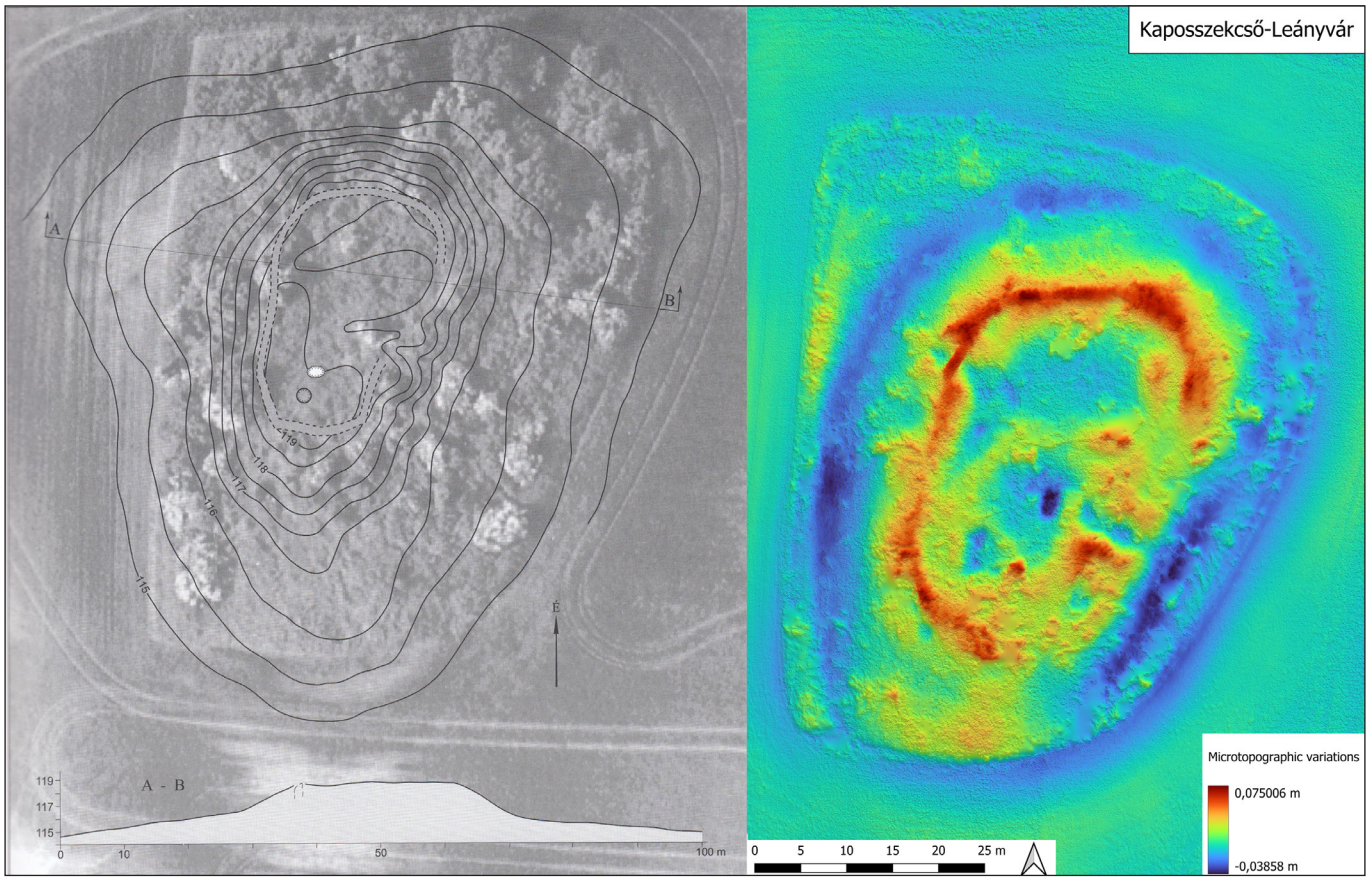

Fig. 2. Kaposszekcső–Leányvár. A, contour survey by Zsuzsa Miklós; b, LiDAR detail. Shades of red: high (elevations); shades of blue: low (depressions) (surveyed by DoubeRingWings Ltd, processed by Ákos Ekrik)

Fig. 3. Kaposszekcső-Leányvár. Aerial photograph (by Zsuzsa Miklós)

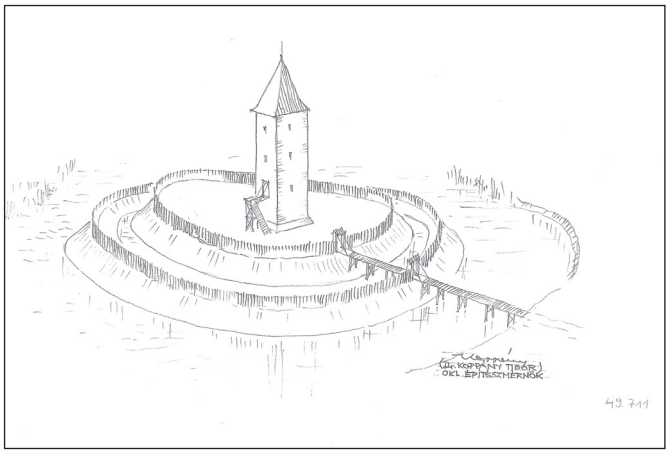

Fig. 4. Dombóvár-Szigeterdő, reconstruction (graphics by Tibor Koppány)

One of the key steps in the study of medieval castles and the associated estates is the collection of related historical sources. These can, in certain cases, make it possible to determine the date of construction of a fortification, as well as the boundaries of the related estate and the circumstances of its destruction, and contribute to reconstructing of the former appearance of the building. A good example is Dombóvár–Gólyavár, whose condition was described in detail by Mihály Kelcz in 1692 (Szőke 1983).

As noted above, field survey was an important component of the synergic approach adopted by Zsuzsa Miklós. She and her colleagues created individual contour maps of each site using traditional geodetic methods and recorded wall remains. With topographical conditions understood in detail, they could interpret certain features, such as the enclosing wall of the castle at Kaposszekcső–Leányvár (*Fig. 2a*).

Another key element of Zsuzsa Miklós's research method was archaeological aerial photography, which makes it possible to examine castles and their surroundings as a complex unit, and helps clarify specific details; for example, at Kaposszekcső–Leányvár, where the ditch surrounding the fortification appeared on the aerial photograph as a darker band in the surrounding terrain (Miklós 2007, 246) (*Fig. 3*).

She also regularly conducted field surveys and on-site inspections; however, some sites were inaccessible. For example, at Dombóvár–Szarvasd, dense vegetation had overgrown the area to such an extent that no finds were visible on the surface (Miklós 2007, 181).

Among the castles of the study area, the first to be excavated was Döbrököz, where Ernő Kammerer opened trenches in 1890 (K. Németh 2022). Modern excavations were carried out at Dombóvár–Szigeterdő (*Fig. 4*) and Dombóvár–Gólyavár. The former was fully excavated by Zsuzsa Miklós as part of a planned research programme between 1998 and 2000, while fieldwork at the latter has not yet been completed (Miklós 2007, 181; Berta 2018). Previously, architectural surveys and partial conservation works were carried out at Dombóvár–Gólyavár and at the castle of Döbrököz, where standing wall remains have also survived (Gere & Miklós 2011; Gere & Miklós 2006).

RESEARCH STRUCTURE AND APPLIED METHODOLOGY

In the course of this research, individual castles are not examined as isolated units, as they operated in close connection with the former castle estates and the surrounding historical and archaeological landscape, the understanding and reconstruction of which are essential for a complex interpretation. To this end, a methodological model has been developed, which allows the medieval castle to be assessed together with its *dominium* through the application of various methods (*Fig. 5*). Most data are recorded in, and analysed within, a GIS-based system. The application of this methodological framework enables a complex approach that represents an advance on the traditional perspective of castle topography.

An important aspect of this research is the collection and re-evaluation of historical data on castle estates, which simultaneously allows for the delimitation of the study area. In addition to written sources, the processing

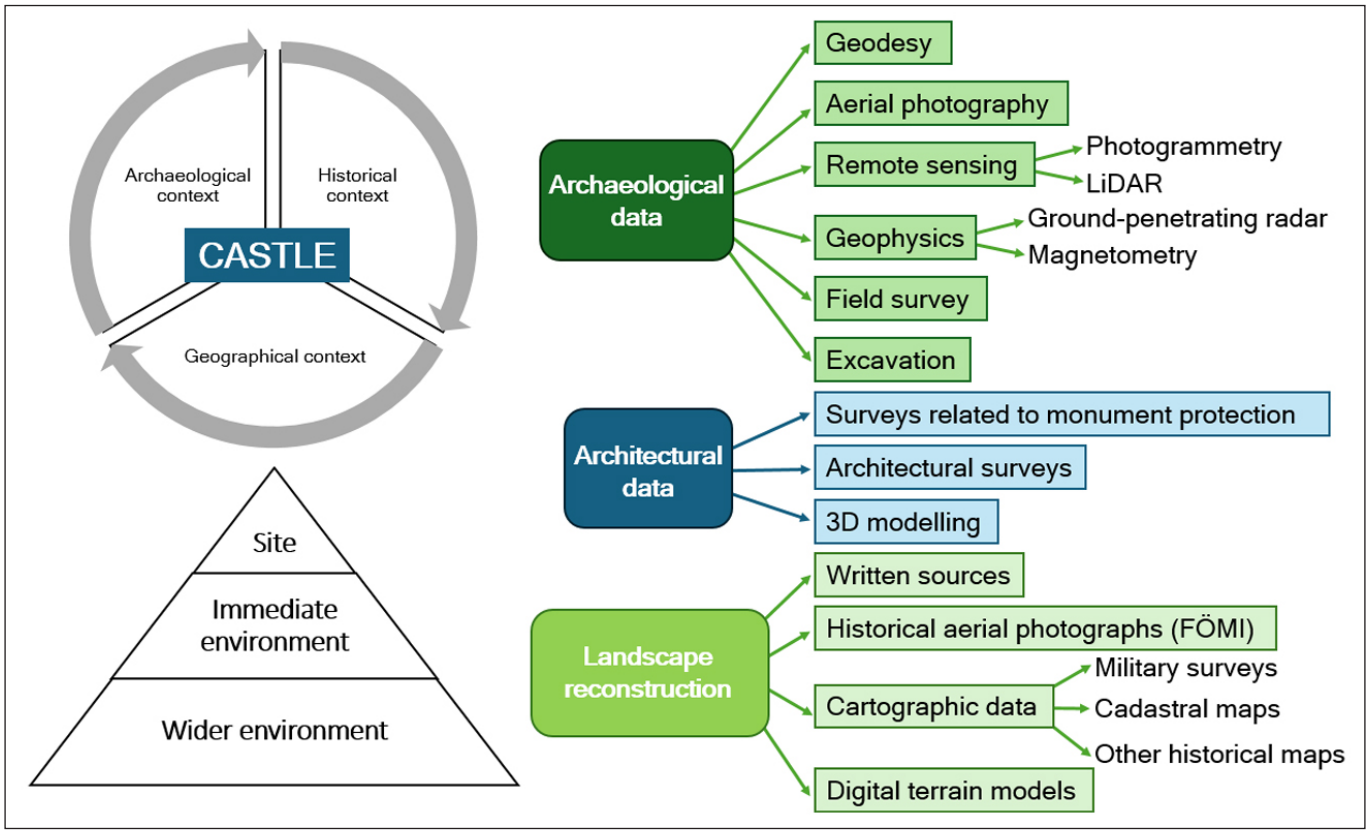

Fig. 5. Structure of the project (graphics by Adrián Berta, Ákos Ekrik, Bianka Gina Kovács)

of cartographic data – including military surveys, cadastral maps, and other historical maps – is also essential. The National Registry of Archaeological Sites serves as an excellent starting point for the systematic investigation of archaeological sites located in the vicinity of castles. At an early stage, its data allowed areas – typically medieval monasteries, churches, and settlements – to be selected for investigation using various non-destructive methods. In striving for completeness, the results also serve to revise the NRAS and expand it with new sites.

Within the project, surface features are examined partly through remote sensing methods such as 3D photogrammetry and UAV LiDAR, and partly through traditional field survey. For the non-destructive detection and mapping of subsurface features within areas of archaeological relevance, geophysical methods – magnetometry and ground-penetrating radar – were applied. Excavation is the method that allows for the most comprehensive understanding of the internal structure and chronology of any archaeological site; however, due to the considerable time, labour, and financial investment it requires and the inherently limited scope of any single exposure, it cannot serve as a standalone method in landscape-based castle research, however important it may be. In the following section, the investigations completed to date are briefly presented according to these criteria.

Photogrammetric documentation has been extensively employed throughout the project. The principle underlying this method is that a large number of overlapping images are taken of the area or object under examination, from which an algorithm – using mathematical formulas to replicate natural stereo vision – generates a three-dimensional model. For site prospection, the area is surveyed by UAV, enabling the cost-effective production of a terrain model and spatial documentation. At Dombóvár–Gólyavár and the castle of Döbrököz, highly accurate models have also been produced of the standing wall remains. This technology enables the effective analysis of otherwise difficult-to-access parts and less visible details. During the excavation at Dombóvár–Gólyavár, a photogrammetric 3D model was produced for each unearthed feature, enabling the digital documentation of the excavation process. Some selected finds, particularly stone carvings, are also recorded using this method, which facilitates detailed analysis and potential digital reconstruction at a later stage of the research.

Drawing on the experience gained at Dombó, drone-based laser scanning (UAV LiDAR) proved to be the most efficient method of surveying the surrounding castles, except for the fully excavated Szigeterdő. This method not only facilitates microtopographic surveys but also enables the precise and streamlined planning of further fieldwork at individual ruin sites. By means of digital elevation models (DEM) generated from LiDAR data with the vegetation filtered out, it has become possible to identify the buried walls and the extent of the former castle ditch at Kaposszekcső–Leányvár, as well as to document traces of sand-mining from the 19th and 20th centuries (*Fig. 2b*).

Since 2018, non-destructive investigations have been conducted within the area of the castle at Dombó and its immediate surroundings, with the scope of research extending beyond the ruin field to include the entire former island. The latter area has been surveyed on multiple occasions using UAV photogrammetry; however, due to the dense tree and shrub vegetation covering the surface, the resulting data proved to be of limited use for its micromorphological analysis. To deal with this issue, a geodetic survey was first carried out within the area using GNSS-RTK and total station (TS) systems, which yielded a low-density point cloud. A joint assessment of these data and other archaeological and geophysical findings enabled us to identify an area enclosed by an earthen rampart system west of the former castle, which may have functioned as an advanced outwork or a *suburbium.* The UAV LiDAR survey proved to be the most suitable method for refining these results, confirming the outcomes of the geodetic survey and providing a clear and coherent representation of areas that would otherwise have been inaccessible due to the dense vegetation. Furthermore, it revealed the extent of some of the destruction caused in the north-eastern part of the site by a sand quarry established in the 1980s.

The systematic surface find collection survey of the study area plays a crucial role in the identification of former castle estates. In this respect, the long-term research objectives include surveying all accessible territory associated with the castle domains using a unified methodology. During the survey, finds are collected along parallel, north-south oriented lines with a 20 m spacing. Findspots are recorded using a handheld GPS device, and finds are packed in 20 m sections, thus creating a 20 × 20 m collection grid. Each participant uses two GPS devices: one to record the distribution of finds and the survey track, and the other to record scattered bricks and stones, although these are not collected during the survey. Site conditions are classified using nine different land cover categories, five accessibility categories, and four visibility categories. During the field survey, finds are collected from all archaeological periods, which may subsequently provide valuable data on past hydrological changes. After securing a grant to fund the project, the first surface find collection surveys were carried out in the area of Döbrököz. As a result, several previously unknown sites were identified, and the spatial extent of a number of already recorded sites was specified (*Fig. 6*).

Magnetometer surveys have been carried out in the immediate surroundings of the castles at Dombó and Döbrököz. In both cases, the aim was to investigate the presence and extent of medieval and/or early modern settlements beneath the castles. In the former case, although historical data – at least for the post-Ottoman period – confirm the existence of a settlement adjacent to the castle, and although the geodetic and LiDAR investigations have likewise supported this conclusion, the potentially buried features were not detectable due to the remanent magnetisation originating from the significant quantity of demolition debris, particularly fired bricks, spread out over the area. The magnetometer survey of the unbuilt areas surrounding the castle of Döbrököz did not reveal any features indicating the presence of a medieval or a later settlement in the immediate vicinity of the former fortification either.

Ground-penetrating radar (GPR) surveys were conducted at four sites in the region, three castles and a monastery. At the castle site of Dombó, geophysical surveys, complemented by the results of traditional excavation, made it possible to reconstruct the complete ground plan of the former fortification, enabling us to create a new architectural reconstruction. The survey provided further data on the system of ditches and ramparts surrounding the castle. In the immediate surroundings of the tower castle of Szigeterdő, the GPR survey did not reveal any buried archaeological remains. At the ruins of Döbrököz, the survey was planned based on a DEM with a 10 cm/pixel resolution, generated from LiDAR data. Predefined tracks were laid out with consideration to the positions of the walls and trees at the site, the terrain of which exhibits elevation

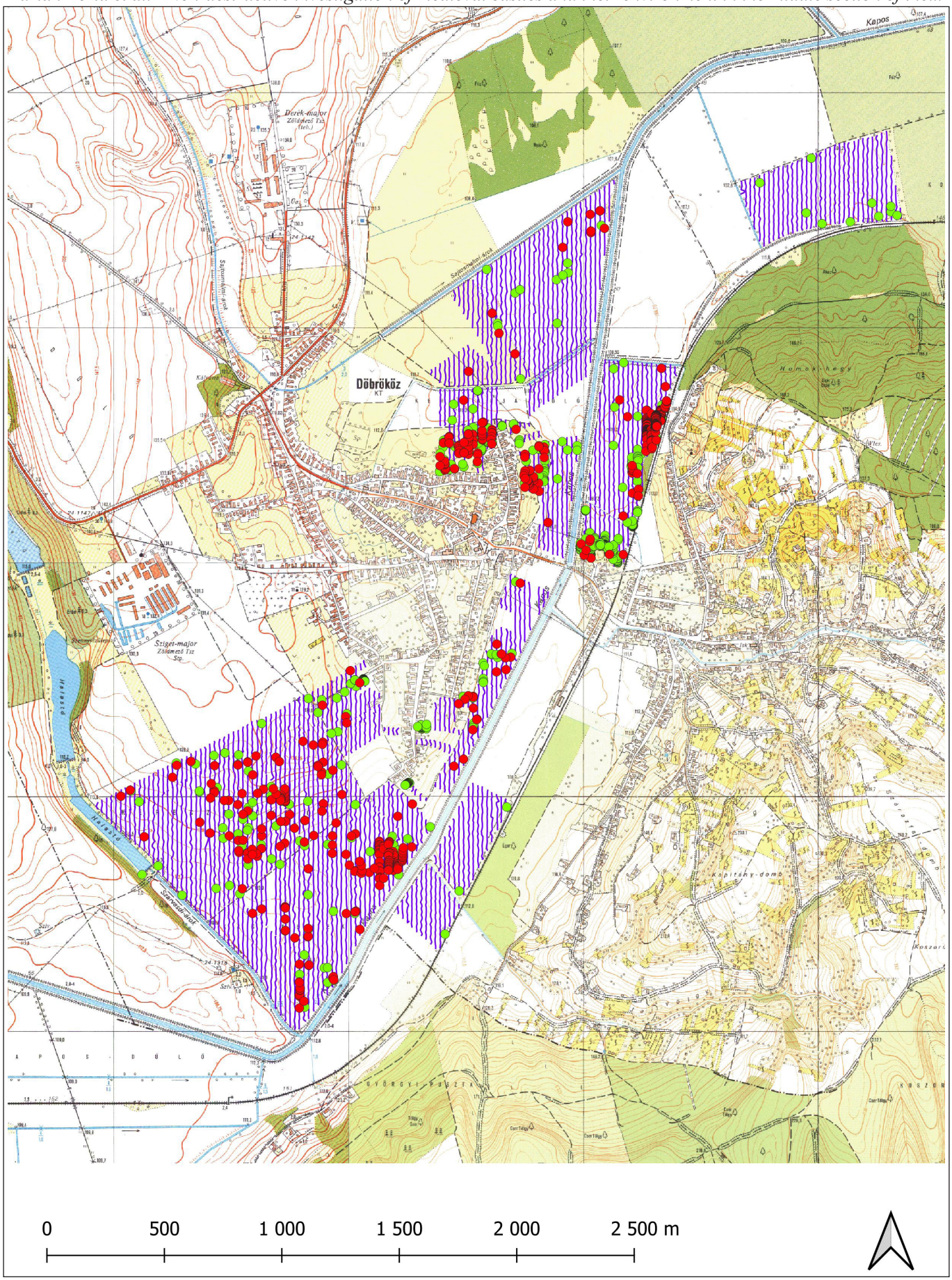

Fig. 6. Areas surveyed during the first field campaign (2024) in the territory of Döbrököz. Red: pottery, green: bricks (by Adrián Berta, Ákos Ekrik, Bianka Gina Kovács)

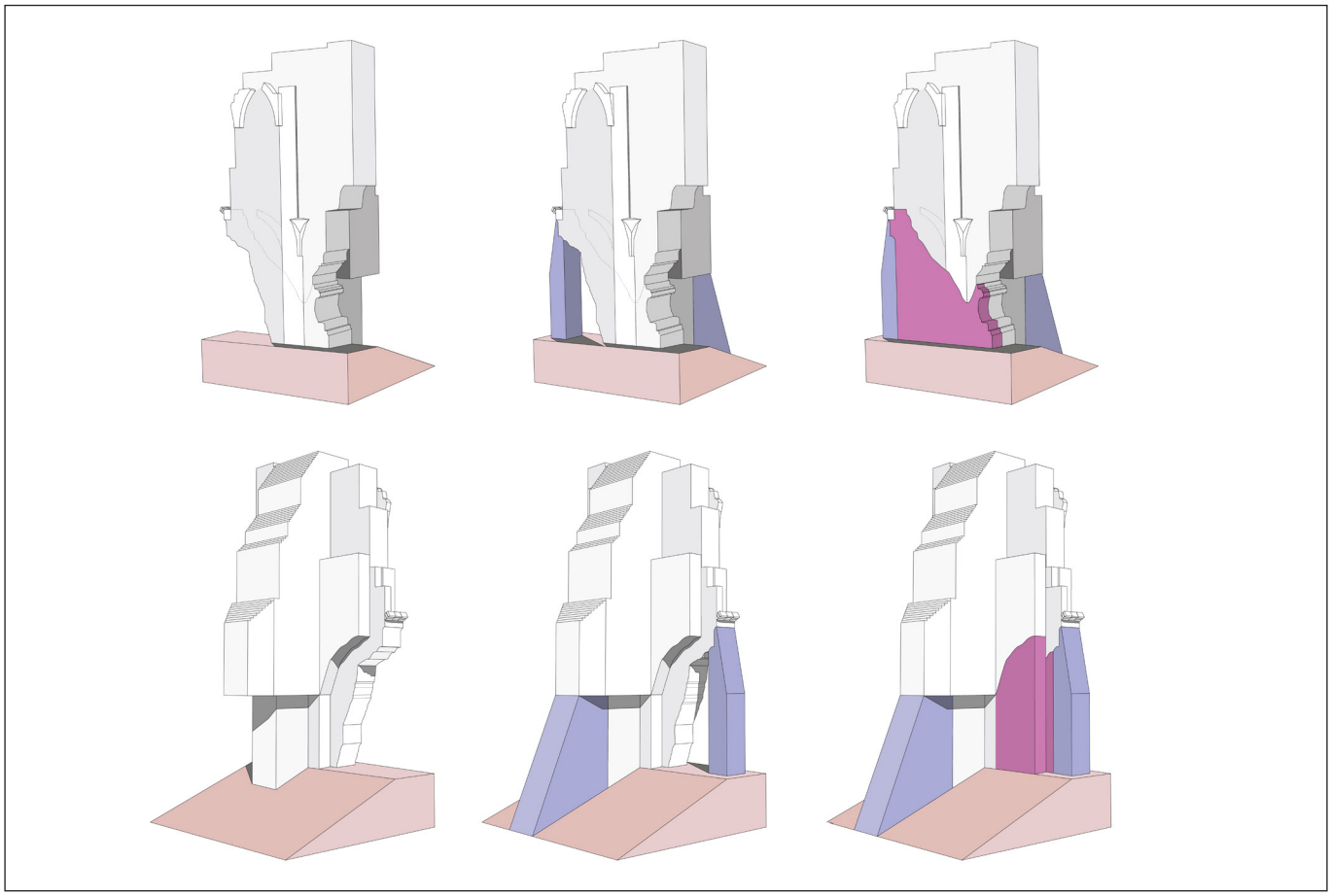

Fig. 7. Three-dimensional model of the south-western wall stump of the castle of Döbrököz. Conservation interventions are marked in colour (graphics by Nóra Mészáros)

differences up to 7–8 m, and the entire area was surveyed as a single unit. The standing walls of the castle have been preserved to a relatively great height below the modern surface; therefore, the entire ground plan of the castle could be mapped. The investigation of the middle section of the Kapos Valley also encompassed a GPR survey at the former Cistercian monastery of Ábrahám, associated with the Majos family of Dáró, located in the Tüske district within the built-in area of present-day Dombóvár (Berta, Ekrik & Kovács 2024).

New archaeological excavation could be conducted only at the castle of Dombó, where research has yielded numerous significant results over the past ten years (see, for instance, Berta 2018). Comprehensive architectural survey and modelling at the ruins of the castles of Dombó and Döbrököz, where wall remains are also visible on the surface, have been largely completed. A digital model was created of the architectural elements exposed during recent and previous excavations at Dombó, and a new theoretical reconstruction of the former building was built on the basis of these and of written sources. In the case of Döbrököz, a three-dimensional model was created of the standing wall remains (*Fig. 7*).

ANALYSIS OF THE HISTORICAL LANDSCAPE

Beyond the investigation of architectural and structural remains and their immediate surroundings, an important objective of the present project is to situate them in a broader historical and geographical setting.

The investigations focused on multiple scales, and the terrain models employed vary in resolution accordingly. DEMs with a 10 × 10 m resolution were used on a microregional level. This model incorporated data from the DDM10 model of Hungary[4] and digitised contour lines. It enables the examination of former

[4] https://lechnerkozpont.hu/oldal/magassagi-adatok (Last accessed: 15. 01. 2026.)

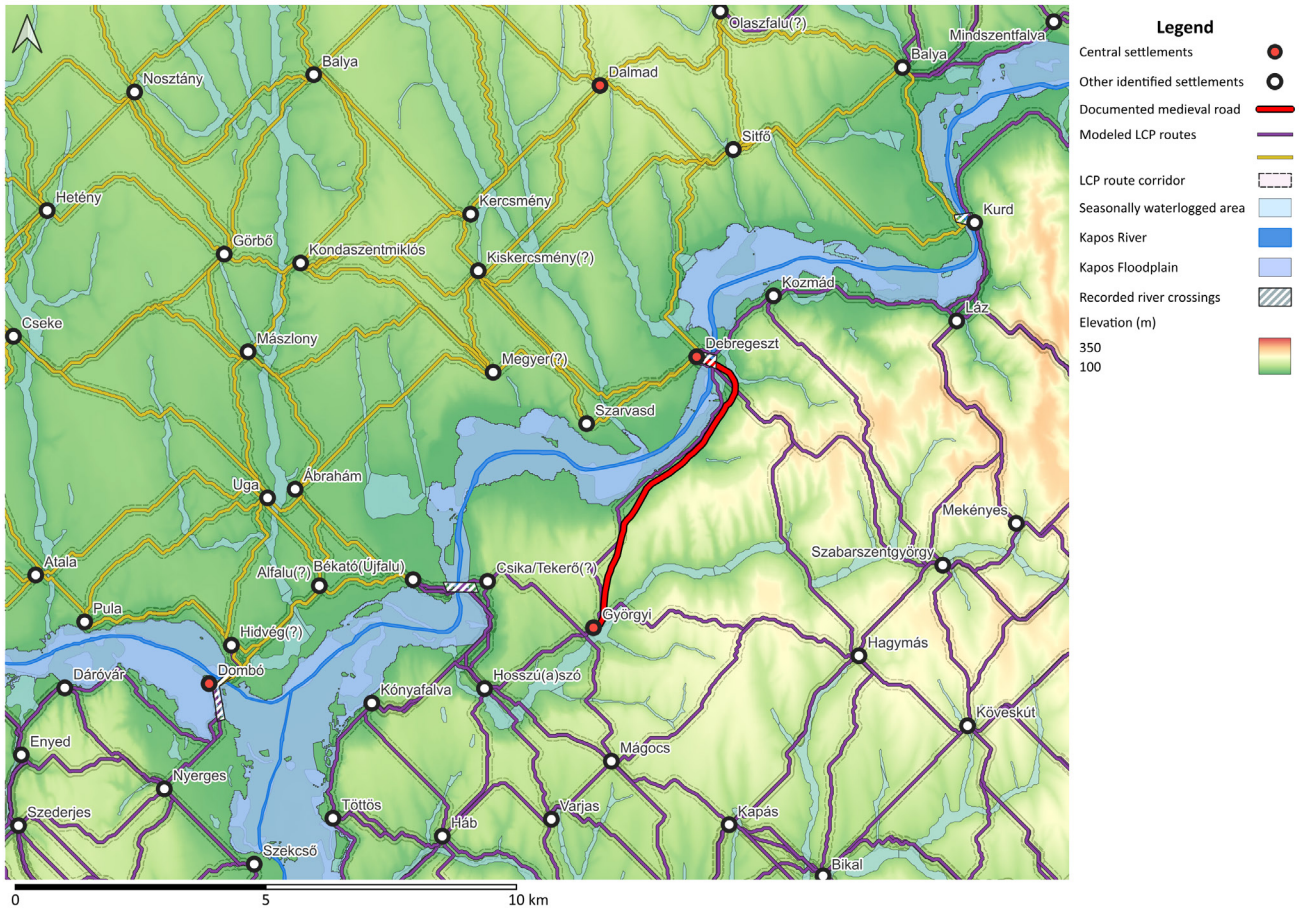

Fig. 8. Tentative reconstruction of the road network in the study area at the end of the Middle Ages (by Péter Ódor)

hydrographic conditions, the presumed road network, and, in some cases, the system of estate boundaries. For individual sites, models of considerably higher resolution, derived from photogrammetry and LiDAR surveys, are used; their 10×10 cm resolution enables a detailed analysis of microtopographical features.

The road network that had developed in Tolna County by the 16th century underwent significant changes during the Ottoman period and the subsequent decades. However, only a small proportion of earlier connections – some of which still exist today – can be identified through a joint utilisation of landscape archaeological methods, historical sources, and modern maps. Nevertheless, geographical conditions, the characteristics of roads, and the localisation of deserted settlements (K. Németh 2015b) made it possible to reconstruct former routes through spatial analysis. The most commonly applied method is Least Cost Path (LCP) analysis, which identifies the most economical route between two points with cost factors defined by the geographical environment or the physical quantities characterising movement. A comprehensive LCP analysis conducted within the area of late medieval Tolna County successfully re-identified medieval routes connecting settlements, belonging to the lower level of the road hierarchy, while also highlighting the limitations of the method in diverse environments and over longer distances. In addition, it yielded a comprehensive reconstruction of the road sections between settlements, and demonstrated its potential for visualising social and economic networks (Ódor 2024) (*Fig. 8*).

SUMMARY

The research questions of the present enterprise arise at three different scales, across various spatial and theoretical-hierarchical levels. Consistent with the castle topography research traditions of the Archaeological Institute, which have become well established today, research focused on individual castles aims primarily

to conduct the most comprehensive possible survey of the remains and to learn about the ruined buildings and their immediate surroundings. Compared to earlier approaches, the innovation lies in the widespread use of non-destructive survey methods and modern architectural and geodetic techniques, which reveal details and relationships within a site that could not be identified by traditional means. Over the past two years, investigations of this kind have been initiated at all six castle sites.

From a methodological perspective, an intermediate level is represented by the transformation of the network of Árpád Age forts, each of which was a centre of power of the respective region, during the 14th–15th centuries, followed by another profound transformation in the Late Middle Ages due to the Ottoman conquest. Key foci are the origin and abandonment of castles, continuity, and possible relocation. This intermediate scale also encompasses the mapping of the immediate physiographical environment of the individual castles, the castle estates partially covered by the study area, their settlement networks, and the associated architectural remains, in accordance with the renewed methodology and approach of the MRT (Archaeological Topography of Hungary). The first complex systematic field surveys have been launched in the territory of Döbrököz, while geophysical surveys were conducted at Ábrahám and Szigeterdő.[5]

The third level is the microregional scale, which focuses on the relationships and settlements of neighbouring centres and their hinterlands and of various smaller and larger areas of different ownership and legal status wedged between them, the associated settlements, and the formation and transformation of the anthropogenic landscape, with particular emphasis on the analysis and understanding of the spatial patterns these processes generated. This involves the production of an environmental model encompassing a hydrographic map, settlement and road networks, and changes in land use. Preparatory work for this has already begun; the initial phase includes the development of GIS databases and the completion of certain (preliminary) sub-analyses.

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[5] Similar investigations have been conducted in the former Csókakő Castle estate within the framework of the VAART project (*Castles, settlement system, material culture, 1300–1700 – Complex micro-regional research on the history, landscape history, and archaeology of Transdanubia*) since 2023. While former research in the area represented a sound basis (Bocsi 2007; Hatházi 2010, 117–119, 123–125), work within the frame of this new project was designed in accordance with the novel methodology (see, e.g., Bocsi et al. 2023; Mesterházy 2025).

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