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Abbreviations

ATH	<i>Archaeological Topography of Hungary</i>
DEM	<i>Digital Elevation Model</i>
ELTE	<i>Eötvös Loránd University, Budapest, Hungary</i>
GIS	<i>Geographic Information Systems</i>
GPR	<i>Ground Penetrating Radar</i>
HLC	<i>Historic Landscape Characterization</i>
LBI ArchPro	<i>Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology, Vienna, Austria</i>
Lidar	<i>Light detection and ranging</i>
LRG	<i>Landscape Research Group</i>
RGZM	<i>Römisch-Germanisches Zentralmuseum, Mainz, Germany</i>
ZAMG	<i>Zentralanstalt für Meteorologie und Geodynamik, Vienna, Austria</i>

Abstract

This thesis deals with GIS-based landscape archaeological analysis based on the integrated interpretation of geophysical prospection data and various types of archaeological and historical data. From a historical viewpoint, the aim of the research was to visualize the inner dynamics of central places in context with their surrounding landscape. To achieve this goal archaeological material from the early complex of Visegrád in Hungary and its surroundings, the medieval settlement network of the Pilis region was analyzed. This thesis presents further the methodological elements of data acquisition and processing, and the integrated interpretation of the data on different scales of the archaeological landscapes: on the landscape scale, on site scale, and on intra-site scale. On intra-site scale, geophysical prospection data and its analysis serve as a core for the research. In that, the stratigraphical information of GPR (ground penetrating radar) data is discussed in detail. On the scale of archaeological landscapes, historical maps, historical sources and present-day topographical maps serve as data layers for a more complex understanding. As a conclusion, a historical evaluation, the potential for the use of prospection data in landscape archaeology and the value of a GIS-based approach in an integrated archaeological analysis are all summarized.

Zusammenfassung

Die vorliegende Doktorarbeit befasst sich mit der GIS-basierten landschaftsarchäologischen Analyse mittels der integrierten Interpretation von Daten sowohl aus geophysikalischer Prospektion als auch aus Archäologie und Geschichte. Inhaltlich war das Ziel der Untersuchung, die innere dynamische Entwicklung und Veränderung von Zentralorten unter Berücksichtigung der sie umgebenden Landschaft an einem praktischen Beispiel zu visualisieren. Dazu wurde das frühe königliche Zentrum und dessen Umgebung in Visegrád an der Donau nördlich von Budapest ausgewählt, das zusammen mit dem mittelalterliche Siedlungsnetz im Pilis-Gebirge dargestellt wird. Ausführlich behandelt werden die Methodik der Datensammlung und -verarbeitung sowie auch der Prozess der integrierten Interpretation auf den verschiedenen Ebenen der archäologischen Landschaft – der Landschaft, der archäologischen Fundstellen und der Befundobjekte (intrasite scale). Auf der Ebene der Befundobjekte bilden die Georadar-Daten das Herzstück der Forschung. Auf der Ebene der archäologischen Landschaft sind es die Landkarten, schriftlichen Quellen und die heutigen topografischen Karten, welche die Basis für ein komplexes Verständnis bilden. So kommt die vorliegende Doktorarbeit zu neuen Einblicken in die Geschichte und Archäologie des Untersuchungsgebiets. Darüber hinaus konnte gezeigt werden, wie Prospektionsdaten in der Landschaftsarchäologie nutzbar gemacht werden können und zeigt - letztendlich - auch das Potential und die praktische Bedeutung Geografischer Informationssysteme in der integrierten archäologischen Analyse.

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I. Introduction

In the last decades in the field of archaeology, data acquisition methods and interpretation techniques have developed and changed in many ways. Acquisition methods now provide various datasets on every scale, from intra-site to landscape level. As the extent and contents of these datasets vary from one site or one data acquisition method to another, a combined interpretation of various data needs a flexible system in which one can zoom in and out dynamically between the layers. This needs a system in which a scale can be dynamically changed according to the data availability, or the research questions. GIS - Geographic Information Systems - provide an excellent possibility to achieve this goal, as these systems were developed to model the real world with geographical determinations and to handle several layers of thematic data.

Similarly to many other disciplines, archaeologists exploit more frequently the benefits of GIS in their research. Even though the results of a GIS-based analysis are impressive in many ways, these methods have their own limits that may affect the archaeological interpretation process misleadingly. In the present research, I used various methods on different scales of archaeological information in order to explore the benefits, and to highlight the possible difficulties of a GIS-based analysis.

I tested different analysis methods on various case study areas. The selection of these areas was based on the data sets provided to me by the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) and on my previous research and my general archaeological interest. My interest in and previous knowledge in the (early) Middle Ages led me to evaluate the results of the GIS-based analyses, by posing and answering archaeological and historical research questions.

The case study area I present in this thesis is the 10-11th century centre of Visegrád in Hungary, and its surroundings the Pilis region. Excavations revealed here different elements of an early centre, while in the Pilis area field surveys identified the settlement network which developed in the Middle Ages.

The case study area invokes historical questions to discuss in the present thesis too. Visegrád is considered to have been a place of special importance at a certain period; it offers an outstanding possibility to study the question of early centres and early urbanization. This question can be studied on site scale, where the inner structure of settlements and settlement parts are studied along with the feature types. On the landscape scale the question of urbanization can be studied from settlement hierarchy and settlement distribution. Furthermore, studying the site on a timeline from its birth until its decline enlightens the dynamic processes within its landscape.

In my research I followed a spatial approach. The digital spatial platform I developed let me analyse the site and its surroundings from a spatial viewpoint. This platform offers me the possibility for comparison, but it has its own risks too. The platform enables the joining of data together on

different scales and visualizes them in various ways. These visualizations provide a background for interpretation, in which one has to keep in mind the availability and the reliability of the original datasets. In my research I listed and evaluated the different datasets and also underlined their values and their weaknesses. As a result the digital spatial platform enabled me to create a large number of maps, which creates the basis for my interpretation. I included more than 70 illustrations in this thesis - almost all of which are derived directly from the compiled dataset.

I.1 Data availability

On landscape scale the present day topography creates the base onto which different types of datasets were added in both cases. From the Pilis region, archaeological sites were digitized from the published volumes of the *Archaeological Topography of Hungary* series. On intra-site scale geophysical prospection measurements provide the core on which I built up the interpretations. From Visegrád, geophysical data is available as a result of the co-operation of the University of Vienna, the Zentralanstalt für Meteorologie und Geodynamik (ZAMG), the Römisch-Germanisches Zentralmuseum (RGZM) and the Eötvös Loránd University in Hungary (ELTE). Even though the measurement covered here only a limited area, the results were impressive and later were tested by excavation. The comparison of the GPR data and the excavation results gave me the possibility to verify my interpretations and to reveal the inner stratigraphy of the site.

I.2 Methodological discussion

The first step of my research was to create GIS projects where the various data can be joined together at all scales, to conduct GIS-based analyses on the datasets. After the compilation of the project's layers within the GIS environment, I followed two main methodological approaches. On the site-level I conducted spatial queries to reveal spatial patterns based on the location of sites within their landscape. On intra-site level, however, GPR data needed more elaborate analysis methods, and therefore I divided the interpretation process into two main parts. First, I performed manual feature selection and tested different 3-dimensional visualization methods. As a result I traced anomalies which I considered as subsurface archaeological features. As a next step, I gave archaeological determinations to the anomalies and conducted spatial queries on them. Furthermore, I gave functional determinations to the features if possible. In the interpretation process I dealt with stratigraphic sequences, and therefore included excavation data as comparative material to the projects. Here my aim was to find connecting links or features within the excavation material and the GPR datasets, which helped me in the chronological or stratigraphical determination of the interpreted features. Both the inner stratigraphical ordering on the intra-site level, and the chronological divisions of the sites, helped me to examine the dynamic processes of the study areas.

I.3 Approach and structure

As my research was based on the evaluation of the GIS-based analysis, I needed to find a common conceptual platform on which the archaeological and the GIS-based concepts could be physically joined together. Therefore I considered the case study area as an archaeological landscape. I understood an archaeological landscape as an area where features developed as a result of the acts and needs of the people of the period studied. As elements of the archaeological landscape, I considered all of the features (paths, ditches, ramparts, mounds etc.) which can be identified with landscape archaeological methods. Within my research I studied the relations between the features of the archaeological landscape and the present topography.

This thesis is divided into seven chapters. Following the introduction I discuss the question of early urbanization in Chapter 2 which is followed by the presentation of the concept of archaeological landscapes and its features. In Chapter 4 I present in detail the methodological questions and the general methodological issues I followed in the data interpretation. Here I only present the main data types without the detailed information of site-specific data. Following the methodological discussions, chapter 5 (Visegrád & Pilis region) is meant to give a detailed historical presentation of the case study area, along with the archaeological interpretation of the different datasets. I also included here the presentation of the site specific data.

Chapter 6 is meant for presenting the evaluation of the results, while chapter 7 presents the conclusion of the thesis.

II. Urbanization in the early Middle Ages

The selection of the case study area raises the question of early central places and early urbanization. Visegrád was studied previously from spatial viewpoint questioning its urban characteristics. Therefore I found it useful to review the development of these concepts. I do not aim to give a comprehensive historiography here but only list those concepts which are in connection with the spatiality sites and help me to link the historical research with the interpretation results from the GIS-based datasets.

II.1 Urban settlements

Most researchers agree that after the fall of the Roman Empire in early medieval Europe town formation followed three main phenomena. In Italy and along the Mediterranean Sea the former Roman towns lived further with an almost continuous habitation. In the area of the Roman provinces the former towns were still in use but the population cannot be considered as continuous. The areas outside the former Roman Empire witnessed the rise of newly founded towns. In these areas merchants and craftsmen settled around ecclesiastical or secular centres. (Wickham 2001) It is however still debated that which types of settlements can be considered as towns, or on what scale can the level of urban development be measured.

The research on medieval urbanization has long been dominated by the work of the Belgian historian, Henry Pirenne (1862-1935). His books, *Medieval Cities*¹ and *Mohammed and Charlemagne*², determined the core of historical debate in the first half of the 20th century. His main concept was that Roman towns remained flourishing at the same economic level until the Arab Invasion. (McCormick 2014, p. 7.) He also stressed that it was only around the 10-11th centuries when new towns, *wics*, emerged; founded by merchants who were engaged in long distance trade. (Verhulst 1994, p. 362.) In the 1970-ies Edith Ennen analysed the early town forms, using textual material. The author determined three zones in which she studied the question of urbanization: the non-Romanised areas in the North, the strongly Romanised area in Italy, and the less intensively Romanised areas. (Clarke & Simms 1985a, p. xxiii.) She discussed thoroughly the question of the *wics*, the markets and also the legal and topographical issues of urban development. She interpreted the *wics* as 'mushroom cities'; settlements that emerged and declined rapidly as they did not have deep roots. (Ennen 1979, p. 45.) Following the work of Pirenne and Ennen both historians and archaeologists listed a variety of terms to describe towns or urban settlements. A starting point in the determination of these settlements was the understanding of the terms of the written sources

¹ Pirenne, H. (1925), *Medieval Cities: Their Origins and the Revival of Trade*, New York, N. Y.: Doubleday & Company.

² Pirenne, H. (1965), *Mohammed and Charlemagne*, Cleveland: The World Publishing Company.

from the contemporaneous Latin writers. According to the observations of J. Wachter six different terms corresponds to urban in meaning in the Latin terminology (Clarke & Simms 1985b, p. 676.):

- *civitas*
- *colonia*
- *municipium*
- *oppidum*
- *urbs*
- *vicus*

From these terms *civitas/castrum* and *vicus* were already in use in the Merovingian times. *Civitas* had the meaning of town, or fortified episcopal town while *castrum* was used for fortified locations. The term *vicus* was used to denote unfortified settlement structures. *Vicus* or *wics* were considered further as the trading settlements of permanent population without chartered rights but also without the meaning of a rural settlement. (Ennen 1979, p. 40.; Reyerson 1989, p. 313.) As a result of the difficulties in the conceptual determinations of the early medieval towns, the concept of proto-towns or the proto-urban settlements was introduced to the research. These types of settlements consist of a stronghold, an ecclesiastical feature, a market place and a settlement of craft-workers or merchants. Clark and Simms proposed the following grouping of these proto-towns (Clarke & Simms 1985b, p. 687.):

1. Trading settlement
2. Stronghold settlement / Burgwallsiedlung
3. Cult settlement
4. Market settlement

Trading settlements are considered as points of exchange. They are consisting of a hilltop fortification and a wic settlement. Stronghold settlements consist of a stronghold of the chief and his warriors and a suburbium, its settlement. Cult settlements consist of an episcopal church or a monastery and the attached suburbium. Later developed types are the market settlements which only emerged around the 12th century. It should be noted that the study of early urbanization still lacks an important element, which is the explicit and unambiguous explanations of the terms. Therefore it is still a future task to determine a clear-cut terminology for these early urban settlement types. (Müller-Wille 2010, p. 382)³

Another fundamental point in the research of the early urban settlements is the determination of the level of urbanization and the central functions. A comprehensive categorization of the central functions was presented by Dietrich Denecke. In studying the urban settlements the author realized

³ with an extensive list of the variety of terms

that due to the large variety of settlement types it is problematic to create a comprehensive list of functions without over-categorization. Denecke instead suggested studying the spatial organization of the settlements within a larger area and those dynamic processes which can be captured through time. He implied that the development of places is strictly connected to their environment and it is dependent on the settlement system around them. (Denecke 1975, p. 41.)

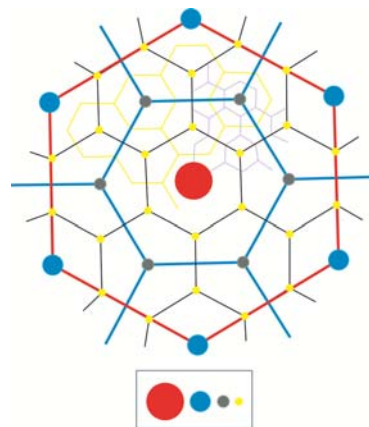
A third approach was based on the study of the economic relationships within Europe after the fall of the Roman Empire. In this question one of the most notable scholars is Richard Hodges. In the first edition of his book, *Dark Age Economics (DAE)* published in 1982, the author studied the economics between 600-1000 AD along which he analysed the trading systems and the trading settlements of Europe. He determined two groups of the emporia, the trading settlements: the Type A and the Type B emporia. (Hodges 1989, p. 51-52.) He called Type A emporia those places which developed around fairs, while type B emporia those which have planned streets and dwellings. For his analysis the author quoted many Scandinavian sites, including Birka, which he considered as a type B emporium.

Both his results and approaches are reflected in many scholarly studies since the publication of *DAE* challenging his findings in many ways. The main concern against his approach was that his study missed the evaluation of the rural sites and the role of the Church. In 2010 the author published a completely new edition of *DAE* in which he proposed answers to these challenges. He analysed the main causes why a settlement developed at a given point into a specific character. He stated that rural sites were also part of the economy even if prestige goods lack from the material there. He also underlined that regional variabilities should be considered within the settlements and the land-use. (Hodges 2012, p. 50-51.) The author concluded that all the different emporia had its own story, and even though they acted as nodes in a network, they were rather 'experiments of urbanization' and they were mostly limited to the demand of the elite. (Hodges 2012, p. 114-115.)

In the case of the present research the location of early settlements are also of importance, as Visegrád is a river-based settlement. Even though coastal trading sites are subjects of investigations since long, the study of river-based urban settlements and their role in trade is not dominating in the research. According to Frans Theuws it is feasible that the development of the early towns which were based near rivers was not connected only to the long-distance trade but also to their hinterland. (Theuws 2012) The importance of the Danube in the urban development of the Pilis region was most recently summarized by Katalin Szende, who also underlined the importance of those places where the long-distance routes crossed the river. (Szende 2015, p. 146-152.)

II.2 Central places

As both the terminology and the determination of the level of urbanization are problematic to define, another concept entered the research, which is the central place theory. Central places have relative significance to their surroundings with or without urban functions. It should be noted that towns can be considered as central places but central places not necessarily mean towns in historical times. (Brüggler 2010, p. 14.) The theory of central places was first introduced to geographical research by Walter Christaller in 1933. (Christaller 1933) In his book the author analysed the early 20th century functions of towns and settlements in order to determine their importance within various communities.⁴ The main point in his approach was that he studied the functionality of settlements based on their relative importance to the surroundings instead of considering them as political or economic units. He also determined hierarchy between central places based on their importance to the surroundings, calling them central places of higher or lower order. (Christaller 1966, p. 18.) According to the author the *economic distance* is an important criterion in measuring the relative importance of a place. The *economic distance* is the element which is composed from the time and cost needed to transport goods from the place of production to the place of consumption. Based on the law of the economic distance, he analysed the topography of central places as well, demonstrating that in the surrounding of a greater place a network of smaller places is situated which build up the complementary region or the periphery of a central place.



1. A central place and the network of places in its complementary region, according to Christaller.

Christaller studied further the central places based on their location, in connection with, as he called it, the *traffic principle*. According to this principle sites are located to those preferred locations where the transportation of goods can be managed. (Christaller 1966, p. 76.) From an economic

⁴ 'We shall therefore speak of central places. Place is also more correct in a concrete sense, because in our consideration we deal neither with settlement units, nor political communities, nor economic units. Thus place includes as far into the surrounding settlements as the inhabitants of those settlements exercise urban or, as we should now say, central professions. The place may be larger or smaller than the settlement unit or community.' (Christaller 1966, p.17.)

point of view Christaller highlighted that not only the production of goods was crucial in a network of places but the offering and the rendering of services too, as a market place emerges either where the costumers come to collect the service, otherwise the products should be transported directly to the costumers' residence. (Christaller 1966, p. 20.) He also recognized that the network of central places should be considered as a dynamic system. The author underlined that all the factors which give places further importance are under continuous change. Therefore the dynamic processes should also be under analysis. (Christaller 1966, p. 90.)

The central place theory became fundamental in location theory of geographical research. (Brush & Baskin 1966) In the further research however weak points of the theory were also discussed. Even though it was aimed for structured regional planning, it only dealt with a homogeneous plain therefore it was not possible to use or accept it generally. The theory lacked another aspect as well, namely it did not deal with interregional territories which are defined by central places of equal size. (Böventer 1969, p. 121-122.)

In the classification of archaeological sites within a landscape, the central place theory of Christaller has been used and re-interpreted in a number of cases. (Collis 1986) The concept was introduced to the archaeological research in the 1970's and - after the English translation of Christaller's book - it was quickly adapted to the New Archaeology. A problematic methodological issue was in Christaller's theory that it only studied the horizontal organization of sites, in a homogenous plain. (Haselgrove 1986, p. 9.) Archaeologists also underlined that not only the central places but also their agglomerations are important to understand. Besides the central places of a given area various other types of settlements create the settlement network as parts of the social organization. Their economic relationship can be two folded, as in a larger territory, a central place can influence or even force its impact onto its hinterland, or, it attracts the hinterland for trade and draws in material from the surroundings. (Rivers et al. 2013, p.2.) As village life is rather poorly documented it is problematic to reconstruct the whole settlement structure even though farmsteads or hamlets are important settlement elements. According to the suggestion of Boháčová dynamics in the hinterland can be detected based on functional determination and detailed chronological classification of the settlements. (Boháčová 2008) This should not be solely based on archaeological evidence, but on other types of data, like historical sources, topography, or toponomastic research.

The research history of the Central Place Theory in archaeology has been summarized and challenged most recently by Oliver Nakoinz (Nakoinz 2010). Beside the use of the theory within GIS he also studied the question of territories. He presented that with the use of mathematical models ideal territories can be reconstructed, while in the reconstruction of real territories different other factors, like topographic features should also be included. He suggested visualizing the density of settlements of a territory with relief or isolines. He also added that it is a task for social archaeology to determine hierarchy levels within the sites and classifying them into ordinate and sub-ordinate places. (Nakoinz 2010, p. 255-256.)

II.3 Central places and urban development in the Hungarian research

In Hungary the research on early urbanization processes was initiated by Erik Fügedi who studied the medieval town formations using both written sources and archaeological material. He identified two different types of settlements: the castle with suburbium and the towns which were developed from smaller settlement units, located close to each other. Along his research Fügedi also realized that those towns which developed in the 11-12th centuries followed the urban tradition of Western Europe. He explained this phenomenon with the migration of Western European people to the less populated Hungarian Kingdom. (Fügedi 1981, p. 320-334.; Kubinyi 2000, p. 120.)

As a methodological tool, the central place theory is not used widely in the Hungarian archaeological research. It was András Kubinyi who, almost solely, used Christaller's method in his analyses on late medieval urban development. He assumed that besides the chartered towns or royal towns a certain number of the so-called market towns (*oppida*) can be considered as a part of the town-network of the late middle ages. This assumption challenged the previous historical approach, the main part of which lied on the acceptance of towns according to legal system determination. Kubinyi also assumed the existence of a market region around these settlements. Kubinyi developed a system in which he grouped the central settlements to 7 categories. The categories were determined by using a scoring system. In his system he granted 60 points as a maximum out of the 10 criteria. He studied the existence/number of the following features: (Kubinyi 1999, p. 502-503.)

1. Residence, manor
2. Places of authentication - *Loca credibilia*
3. Fiscal or monetary center
4. Ecclesiastical administration
5. Ecclesiastical institutions
6. Number of students enrolled to foreign universities
7. Number of craftsmen's or traders' guild
8. Road crosses - how many of the other central places can be directly reached
9. Market
10. Legal status

From a spatial point of view Kubinyi found out that the location of the late medieval settlements based on the system of 2-4-6-8 Hungarian miles. (A Hungarian mile is app. 8 km.) This location of places coincides well with the term *rasta* used for the 2-Hungarian-miles length which stems from the german *Rast*, a resting place. The above listed criteria of Kubinyi were meant to study the late town formations and the results were highly based on written sources. Studying the early urbanization, however, requires different methodology.

The question of early urbanization was most recently summarized by József Laszlovszky and Katalin Szende (Laszlovszky & Szende 2014). In their work the authors grouped the urban type settlements into four different categories (Laszlovszky 1995, p. 313.):

- Towns nearby a royal residence
- Centres of long-distance trade and craftsmen
- Weekly market places
- Foundation towns

In the present thesis I consider Visegrád as an early centre. As the central place theory is not widespread in Hungarian research, especially in connection with the early town formations, I do not denote Visegrád as a central place. It is however an aim of the present thesis to test its criteria on Visegrád too. I did not conduct my research solely on the site itself but I took into consideration its connection to the surrounding landscape. I fulfilled this task using those methodological points of landscape archaeology which I present in the next chapter.

III. Archaeological landscapes and their research

'understanding central place functions, the places where they were carried out and relationship with various types of estates should be one of the prime roles of the researcher interested in the dynamic processes in society in the Middle Ages.' (Michael Aston)

The above mentioned quotation⁵ of Michael Aston is still fundamental in the research of dynamic processes of medieval times. As it was presented in the previous chapter central place research mainly puts its emphasis on the ranking of different features within places. These values are then compared to the same functions of other sites. This comparison can be further supplemented with the thorough study of the man-made landscape elements which appear in the hinterland of sites or those natural landscape elements in which the society operates. In the present chapter I discuss the question of landscape research and the concept of archaeological landscapes.

III.1 Landscape studies and historical geography

The different approaches in landscape studies resulted in various definitions for the term 'landscape' as well as many different explanations for its meaning. In general, all the landscape approaches or landscape concepts were aimed to understand the spatial patterning in the landscape. The term itself stems from the Dutch word *landschap*, with a meaning of bordered and organized territory. (Antrop 2013, p. 12.) Landscape therefore does not reflect solely to the natural land but also to its organization which refers to humans who made imprints on areas. These imprints reveal also their cultural identity. From a geographical point of view, the landscape is a combination of the natural and physical properties of an area representing the cultural characteristics of the people living there.

First observations on landscapes dealt with the physical description of areas. After the First World War the use of aerial photography gave a new shift to landscape research as these photos provided a wider and more complex view of larger regions. As a discipline, landscape research, begun to develop in the second half of the 20th century when a *cultural turn* took place in the humanities as well as in the field of geography. This theoretical turn resulted in an approach which enhances that the present state of our environment is a result of continuous human decisions and culture is connected to the environment in many ways. (Howard et al. 2013, p. 1.) In the systematic landscape research an important step was the establishment of the *Landscape Research Group* (LRG) in 1967 promoting studies on the sustainability of the natural and cultural landscapes involving also archaeologists as

⁵ Aston 1986, p. 74.

members.⁶ Since 1968 the LRG coordinates the publication of the *Landscape Research Journal*. In 2000, it was the European Landscape Convention⁷ which prescribed that the landscape should be thoroughly studied and systematically protected. At present 38 of the member states of the Council of Europe ratified and two states signed the Convention already which -- beside the environmental issues -- also underlines the importance of the cultural aspects of the landscape. It also states that the landscape is a “*basic component of the European natural and cultural heritage*”.⁸ In the question of the historical elements of landscapes the Convention invokes the European Convention on the Protection of Archaeological Heritage (Valletta, 16. January 1992.)⁹ This latter text does not use the term 'landscape' itself, but includes it to the group of archaeological heritage elements as “*history of mankind and the related environment*”.¹⁰

Until recently different approaches developed within landscape studies. Historical geography is aimed to study the development within the landscape through time. For that historical maps and literary texts are used the latter of which contains textual representations of landscapes. Written sources can highlight the important features along which one can navigate while literary texts show traditional views of the landscape, presenting 'good or bad' features within it. These texts can also include imaginary descriptions, and features which are hard to identify in the physical world. Charters and boundary descriptions contain more specific information on landscape elements of a given area. These can help in the historical research even though they provide mainly bits and pieces of information, and therefore very sporadic and hard to identify on land. It was W.G. Hoskins who, in his historical research, introduced a structured methodology to reveal the history of a landscape. In his book, *Making of the English Landscape* (1955) Hoskins presented the dynamics of landscape changes through time within the English countryside. For that he used topographical, toponomastic, historical and archaeological data. Using various source materials he listed the detectable changes of landscapes which can be connected to former human activities. He also listed different site-types which developed or disappeared within the landscape, like the different villages, towns and field boundaries or the re-positions of roads which he connected with changing field boundaries. (Hoskins 1955) The Millennium witnessed the emergence of multidisciplinary approaches in landscape history. From 2000's in the UK, a new approach evolved, the *Historic Landscape Characterisation* (HLC). Within the HLC different character types are assigned to areas based on morphology and determination. Beside the differentiation of built environment, these groups also contain data on landscape elements and land cover. (Clark et al. 2003, p.3.) HLC aims to describe the landscape from a historical point of view and provides a reconstructed topographical background to archaeological sites.

⁶ <http://www.landscaperesearch.org/> last accessed: 2020-10-27.

⁷ <http://conventions.coe.int/Treaty/EN/Treaties/Html/176.htm> last accessed: 2020-10-27.

⁸ <http://conventions.coe.int/Treaty/EN/Treaties/Html/176.htm> last accessed: 2020-10-27.. (Preamble)

⁹ <http://conventions.coe.int/Treaty/EN/Treaties/Html/143.htm> last accessed: 2020-10-27.

¹⁰ <http://conventions.coe.int/Treaty/EN/Treaties/Html/143.htm> last accessed: 2020-10-27. (Article 1.1.i)

III.2 Landscape archaeology

It was a geographer, O.G.S Crawford, who, after the Second World War, initiated the making and use of aerial photographs within archaeology and stated that the landscape is a result of continuous change and development. Crawford saw the landscape as a palimpsest, into which the continuous human activities subsequently wrote and rewrote their traces which recognition gave a new shift to archaeological research.¹¹ (Crawford 1953, p. 51.) In the 1970-1980's the cultural turn contributed to the birth of systematic landscape archaeology too, which studies the dynamics and changes of a landscape along a longer period. For the historians, written documents and maps provide the main sources of information, but landscape archaeological research is based on the detection and the spatio-temporal analysis of the material remains of human activity, like field boundaries, earth works, cemeteries, settlements or traces that can be connected to religions or believes; administration; crafts or industry, animal husbandry. One of the starting points in practical landscape archaeology was the publication of handbook by Michael Aston and Trevor Rowley in 1974. Their work, *Landscape Archaeology*, was meant to be a manual of the techniques in which the authors presented how the different elements of the landscape can be recognized and documented. They also underlined that even though the landscape is under continuous change it is still possible to trace the earlier states of its elements. (Aston & Rowley 1974, p. 11-15.) The authors listed the most useful methods in landscape archaeology, which are still in use nowadays: beside the aerial images, field walking surveys provides data of larger areas. These can be supplemented with analytical methods and results from natural sciences supporting the reconstruction of historical land cover and vegetation.¹² Local history, i.e. local documents, place names as well as oral history, the memories and knowledge of the local people helps further in the analysis. Dating of landscape elements can be more problematic but excavations and collections of surface finds, like pottery or other datable finds can help to determine the chronology of features. (Aston 1985)

At present landscape archaeological research is dominated by the development of large scale archaeological prospection methods: Lidar measurements and geophysical prospection methods gain more ground beside field surveys. Lidar (light detection and ranging) technique uses airborne laser measurements to collect 3-dimensional point-clouds from the present surface. The end result of the measurement is a digital terrain model which represents the present day land cover. In case of

¹¹ 'The surface of England is a palimpsest, a document that has been written on and erased over and over again; and it is the business of the field archaeologist to decipher it. The features concerned are of course the roads and field boundaries, the woods the farms and other habitations, and all the other products of human labour: these are the letters and words inscribed on the land. But it is not easy to read them because, whereas the vellum document was seldom wiped clean more than once or twice, the land has been subjected to continual change throughout the ages.' Crawford, O.G.S. *Archaeology in the Field*. London: Phoenix House Ltd, 1953.

¹² Detailed presentation on the various scientific dating methods was given by Richard G. Roberts and Zenobia Jacobs, *Dating in Landscape Archaeology*. In *Handbook of Landscape Archaeology* ed. Bruno David, Julian Thomas, 347-364. Walnut Creek, CA: Left Coast Press Inc, 2008.

landscapes with low vegetation even small height differences can be detected on the resulting models. On datasets from forested areas it is possible to eliminate the present vegetation with post-processing methods and the surface elements hidden under the forest can be detected more easily. (Jones 2010, p. 1-3.) While Lidar provides information on the surface, geophysical prospection methods are used to detect subsurface archaeological features. Handheld and motorized measurements are conducted to map contrasting electrical and/or magnetic properties of the near surface subsoil to locate anomalies indicating subsurface archaeological features. (Everett 2013, p. 12.)

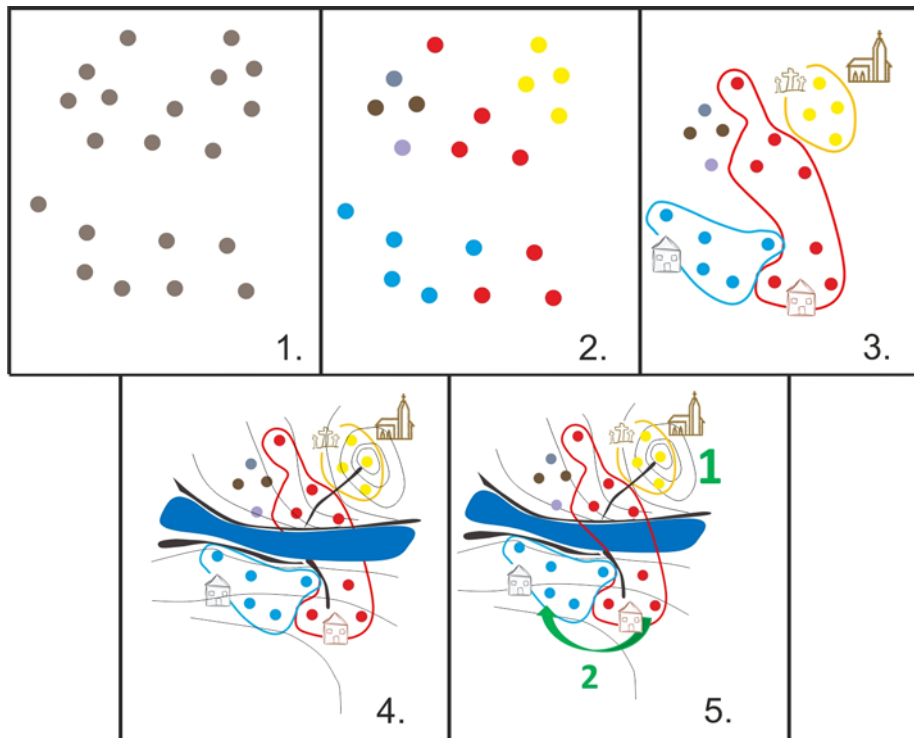
As a result of the latest technological developments landscape archaeology is now under revolution. Remote sensing data and large scale geophysical surveys produce large amounts of data from complete landscapes. Consequently, our understanding of the past societies can be challenged in many ways.

III.3 Concept of archaeological landscapes

III.3.1 Scales of archaeological information

Archaeological data - independently from its source - has its own three-dimensional space. In a bottom-up approach the starting points are the archaeological remains, like the artefacts or the single features unearthed by archaeological excavations. The second layer consists of functional or chronological groups of artefacts/features or both resulting from *intra-site analysis*. As in the present thesis I am not analysing directly artefacts, only features, under the term *intra-site analysis* I understand the study of the features as elements within one site. As a preconception I consider sites as confined geographical areas where a group of archaeological remains or artefacts can be continuously detected from various historical periods. In the present thesis I used the term '*complex*' in connection with both of the case study areas to denote a special group of sites. I used this term as in both cases the above mentioned meaning of a 'site' refer to multiple coherent parts of a whole complex, like a settlement with an adjoining cemetery. In my approach I consider them as coherent parts of a larger system where their complex itself has its own geographical limits. The uppermost scale of archaeological research is the *large-scale analysis* where several sites can be compared to each other based on different factors. It is possible to build up this comparison on site- or on intra-site data. In both cases properties of elements (features, elements, site-types, etc.) can be compared to each other spatially or chronologically. In a landscape-based approach the archaeological remains are studied in connection with their environment. On each and every scale it is possible to supplement archaeological features with landscape elements. These elements can be natural elements in which a 'site' operates (i.e. river banks, hill slopes) or man-made elements, which are the results of the habitants' activities (i.e. ditches or dikes). The complex understanding of the features on different scales together with their landscape helps to understand the inner dynamics of an area.

A different approach was suggested by Martin Millet, a classical archaeologist, in his mind-blowing talk at the Computer Application in Archaeology Conference 2015. There he suggested a top-down approach where he considered the landscape as a basis which determines how the society lives there and how it is able to be transformed according to economic needs. This approach views the landscape as the origin for the development of social structures instead of taking the already known sites as points around which the natural and the man-made structures should be studied.



2. Scales and elements of archaeological information. (1) Artifacts/elements; (2) Grouping of artifacts/elements into a site; (3) Grouping of sites according to chronology and type; (4) Landscape elements; (5) Dynamic changes within the archaeological landscape.

III.3.2 Archaeological landscapes

In the present thesis I use the concept ‘*archaeological landscape*’ describing areas in which man-made landscape elements can be detected along with natural landscape elements and archaeological remains. I distinguish archaeological landscapes from the present landscape as I consider them to have an *initial state* at the beginning of the study period from which it is transformed naturally or artificially. In that I partly follow the notion of archaeological landscapes determined by Rossignol & Wandsnider 1992 who stated that “*the distribution of archaeological artifacts and features relative to elements of the landscape (and not merely the spatial relationships among artifacts and features) provide insight into social and economic organizations in the past.*” (Rossignol & Wandsnider 1992, p. viii.) Similarly to the above presented scales in archaeology, an archaeological landscape is also built up from different layers. On intra-site level earthworks, ditches, mounds (etc.) can be considered as elements, while on site level I understand those elements which are in connection with further sites (i.e. communication lines). Consequently elements of an archaeological landscape can be detected on similar scales with archaeological remains. Large scale prospection methods provide complex views of archaeological landscapes offering information both from sites and from their surroundings.

IV. GIS-based data analysis

Using the above presented theoretical framework I conducted my analysis in a GIS environment. In the present chapter I describe the methodological background on which the analyses were conducted and the interpretation of the data was achieved. The historical and archaeological evaluation of the datasets is presented in the following chapter of the present thesis.

IV.1 A spatial approach

In my research I followed a spatial and temporal approach. In a spatial approach a key feature is to analyse data from a geographic point of view. Here, all the data needs to be connected to a common spatial platform, i.e. a common projection system or a common map. A late 19th century example of the use of spatial analysis comes from Dr. John Snow who analysed the 1854 cholera outbreak in London. His hypothesis was that the cholera was transmitted through drinking water therefore he mapped the location of the water pumps and the location of the cases. With this spatial analysis, using Thiessen-polygons, he identified the pump from which the water stemmed and with which he could prove his hypothesis. (Haggett 2006, p. 732-733.) Theoretical backgrounds of the spatial approach were initiated by Waldo R. Tobler. According to Tobler's first law (TFL) of geography 'everything is related to everything else, but near things are more related than distant things'. (Tobler 1970, p. 236.) This law provides a fundamental basis in spatial studies.

Besides the development within the spatial statistical methods, the 1970's witnessed the first steps of the use of computer aided analyses too. Developments within the computer aided spatial statistics and the digital cartography led to the birth of the discipline of Geomatics or Geoinformatics in the 1980's. This discipline addressed questions to the problem of dealing and manipulating of spatial information and led to the development of GIS (Geographic Information System) applications.

IV.1.1 GIS – Geographic Information Systems and archaeology

The meaning and general content of GIS is determined by the ISO/TC 211 standard for Geographic information/Geomatics.¹³ According to this standard a geographic information system is an *'information system dealing with information concerning phenomena associated with location relative to the Earth'*¹⁴. Generally a GIS system is based on geographical data and GIS applications. The main attribute of geographic data is that it has *'data with implicit or explicit reference to a location relative to the Earth'*. Three main types of geographical data exist for modelling the real world, which are the point, polyline and polygon type of datasets. In GIS, these data types are stored

¹³ <http://www.isotc211.org/> (last accessed 2020-10-29)

¹⁴ ISO 19101-1:2014, 4.1.20 <https://www.iso.org/obp/ui/#iso:std:iso:19101:-1:ed-1:v1:en> (last accessed 2020-10-29)

with accurate geographic locations two-, or three-dimensionally. As a fourth variable, time-information can also be managed within GIS systems. In GIS applications datasets are used as layers on which spatial queries can be managed. Spatial queries are aimed to reveal the spatial relationships between the elements. Simple queries can be done on features from single layers but complex queries can also be managed on multiple layers involving different mathematical methods. Analysis of 3D surfaces creates a large group of spatial analyses too, involving the study of aspect and slope of an area or visibility properties between points.

As GIS is under an on-going development it is still a task to explore the possible use of its solutions within archaeological research. In the 1970's the technique found its way quickly to the archaeological reasoning. In 1973 researchers at Birmingham University organised the first 'Computer Applications and Quantitative Methods' (CAA) conference to present research methods and results involving spatial statistical tools.¹⁵ Since then this yearly held conference is one of the main fora of the latest developments in computer applications in archaeology. In the last few decades digital data acquisition techniques became more prevalent in archaeology which also resulted in the use of geographic information systems (GIS). Furthermore, paper-based archived archaeological data is more and more frequently transformed to digital information and added to these systems. In archaeological reasoning GIS analysis methods are chosen according to the research questions and data availability. Presenting links between the different layers within one single system is quite rare however. As technically GIS has no limits in storing and analysing data from different scales it is possible to join the different archaeological layers together. It is therefore a task of the present thesis to introduce methodological issues on joining various archaeological datasets within one single system to model the archaeological landscape and its elements more clearly.

IV.1.2 Temporal modelling and visualization

Beside the understanding of the datasets on a horizontal plane another aspect should be also studied within an archaeological interpretation; which is the fourth dimension, the time, as a variable. With the help of GIS it is possible to model the *historical world* spatially with the same methods that are used for modelling the real world. As GIS has its origin in cartography, it is well prepared with mapping tools to visualize cartographic information. But adding a fourth, a temporal dimension is still problematic in these systems. Traditional archaeological analysis deals with space and time as two separate, but still coherent variables. According to the archaeological methodology the chronology of each feature should be precisely determined. Furthermore, in archaeology, time information can be managed on all the scales. On the scale of artefacts, typology can be of use. On the site scale, from where excavation data is also available the analysis of stratigraphical sequences is prevailing in the results. For that the Harris-matrix is an optimal solution as it stores the relative

¹⁵ <http://caa-international.org/about/history/> (last accessed 2020-10-29)

position of the features with their stratigraphic relations. (Harris 1989) On landscape scale time series of spatial patterning and the study of co-existing features are predominant. In GIS systems developed for archaeological interpretation probability techniques are used to deal with the uncertainty of chronological determination. (Langran 1992, Green 2011) From temporal point of view, however, another aspect is worth to observe: the functional changes of a feature along a longer time period. These functional changes, which are originated from the continuous use of a given feature can also be recorded and should also be marked as an attribute within a GIS system. In GIS systems it is often said that modelling of time information can be managed only in a so-called frozen way and modelling tools are still not fully sufficient for storing detailed information on movement or change. The frozen temporality of the features stems from the way how temporal models are embedded into the systems. As the most common way, timestamps are stored into the database, to build up the model from discrete temporal layers. If spatial information is combined with temporal data, movement of a feature, or changing of an attribute can be analysed. These models however give a discrete character to the process, because of the way how the changes are stored. As they are stored on layer basis, the result of the modelling process will create versions of the original features. Modelling the continuity instead of versioning in these models however, still needs more development in GIS methodology.

Instead of modelling, visualizing tools for temporal information can be rather successfully used for chronological interpretation. These tools are for example the timeline, time maps or multimedia maps. In the present thesis the expression *temporal modelling* refers rather to the method how a data model is built up, and how temporal data is stored in the database; while *visualization* refers to methods how the temporal aspects of spatial data could be displayed and used for interpretation with those mapping and data management tools that are already built into most of the GIS systems.¹⁶

¹⁶ As the present thesis is to be submitted in a printed format it has only limited possibilities for the visual representations of the results. Most probably with the future spread of the interactive books there will be more elaborate possibilities to illustrate and dynamically visualize temporal changes.

IV.2 Data types

The main groups of the used data types of this research are the following:

On landscape scale:

1. Base maps (Hungary)
 - a. Administrative units
 - b. Present day topography
 - c. Land Cover
 - d. Elevation model
2. Field survey data (Pilis region)

On site scale:

3. Excavation data (Visegrád)
4. Textual sources (Visegrád)
5. Geophysical prospection data
 - a. Ground penetrating radar data (Visegrád)
 - b. Magnetic data (Visegrád)
6. Remote sensing data
 - a. Aerial photography (Visegrád)
 - b. Digital elevation models (Visegrád, Pilis region)
7. Historical maps (Visegrád)

(1) Base maps: I collected topographical data on the present land use and topography from various, freely available sources. Country boundaries, waterways and the location of main places were downloaded from OpenStreetMap.¹⁷ The OpenStreetMap project offers and distributes free geospatial data from the entire world. These datasets contain manually recorded track datasets collected by volunteers. The data can be directly imported to ArcGIS environment using shape files in WGS84 coordinate system. Administrative units were further downloaded from DIVA-GIS where one can find collections of freely available spatial datasets for the whole world.¹⁸ DIVA-GIS provide a collection of data from different sources, like the Database of Global Administrative Areas¹⁹, the Digital Chart of the World (last updated in 1992) and also SRTM datasets on 30 seconds resolution. All the data is provided in WGS84 projection system. To understand the present land use, I also included the Corine LandCover 50 database.²⁰ The CORINE program is aimed to gather, store and distribute data on the environment, including geographical information on the location of the natural areas, flora

¹⁷ <http://www.openstreetmap.org/> and <http://download.geofabrik.de/europe.html> (last accessed 2020-10-29)

¹⁸ <http://www.diva-gis.org/gdata> (last accessed 2020-10-29)

¹⁹ <http://www.gadm.org/> <http://www.gadm.org/> (last accessed 2020-10-29)

²⁰ <http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-4> (last accessed 2020-10-29)

and fauna, soils and other features of the environment. One of the end results of the program was the creation of a GIS system providing information on the EC Member States' environment. The program is operated by the European Environment Agency and provides an inventory of 44 classes of the present landuse. Data is collected from Earth observations satellites (SPOT and Landsat) and maps are generated to 1:100000 scale. (CLC 1995, p. 18.) Soil maps are available from the National Soil Maps project (EUDASM)²¹, through the European Council's European Soil Data Centre (ESDAC). 3D elevation models are generated based on SRTM data. The SRTM (Shuttle Radar Topography Mission) is operated by NASA since 2000 when the first Space Shuttle Endeavour was launched into space aiming to collect topographic elevation data with radar measurements.²²

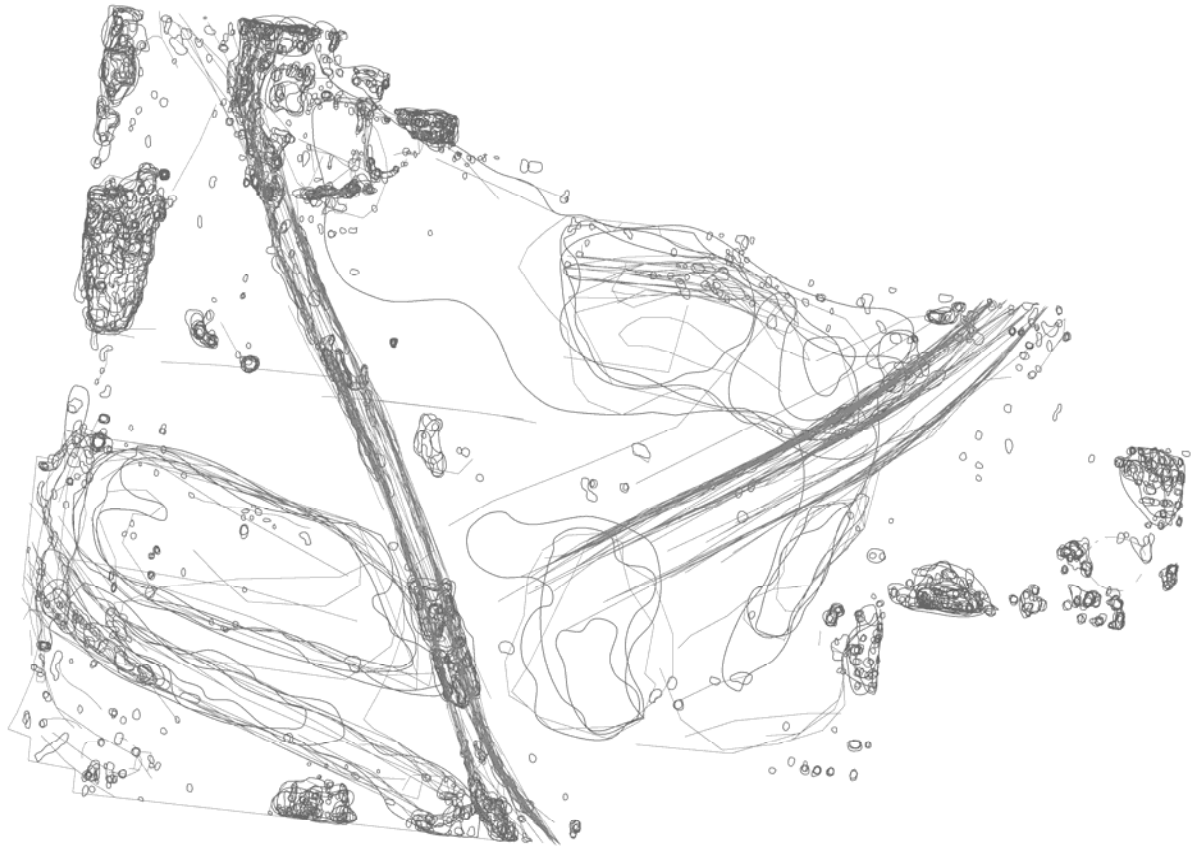
- (2) **Field survey data:** On landscape scale archaeological site information came from a nation-wide site catalogue. For the Pilis region I used the published volumes of the Archaeological Topography of Hungary.
- (3) **Excavation data:** Excavation data was available from Visegrád. Excavation data is stored in a geodatabase with feature identification numbers (*SID*) and elevation data if available. Information on the time of collection and on the excavators was also stored in the database.
- (4) **Textual sources:** I also included data based on textual sources into my analysis as the list of places of the Pilis region mentioned in medieval charters is available as printed publication.
- (5) **Geophysical prospection data**
 - a) **Ground penetrating radar data:** The main part of the research is based on data from non-invasive remote sensing methods. The core of the interpretation is based on ground penetrating radar data which was available for the fortified area of Visegrád.
 - b) **Magnetic data:** Magnetic measurement data was also available and was used along with the GPR data interpretation in the case of Visegrád.
- (6) **Remote sensing data:**
 - a) **Historic aerial photographs:** I used archive aerial photos in the study of the micro-topography of Visegrád. I downloaded the appropriate aerials from the online collection of the former Institute of Geodesy, Cartography and Remote Sensing, today Lechner Nonprofit Kft in Hungary²³. The Institute published almost 160.000 scanned aerial images from all over Hungary from the period of 1959-2007 as georeferenced tiff images. I used these images both in the georeferencing and in the interpretation process.
 - b) **Digital Elevation models:** Digital surface models were used to visualize the overall topography. In the case of Visegrád, contour lines were digitized and transformed to a 3D model.

²¹ <http://esdac.jrc.ec.europa.eu/resource-type/national-soil-maps-eudasm> (last accessed 2020-10-29)

²² <http://www2.jpl.nasa.gov/srtm/mission.htm> (last accessed 2020-10-29)

²³ <https://www.fentrol.hu/en/introduction> (last accessed 2020-10-29)

(7) Historical maps: In For Visegrád and the Pilis region archive maps were used to understand the settlement system and communication routes within the area.



3. Results of the manual feature selection on Visegrád

IV.3 GIS-based processing methods

I performed data analysis within ArcGIS software environment.²⁴ The aim of using GIS in this research was to join all kinds of data together in a spatial order and illustrate features with 3D coordinates. The data collected represents different scales of information. In order to model the various elements of an archaeological landscape a required prerequisite is a previous knowledge on the elements, namely, archaeological data to be available on every scale of the analysis. Within my database I used polygon, polyline and point type features. My attribute data was usually stored first in Excel sheets which were later converted to geodatabase tables. I also used generalization on different polygon type layers, which helped me in the cartographic visualisations on larger scale. For the two case study areas I used two different projection systems. My selection of the projection system was based on the projection of the original datasets. For the Hungarian case study area I chose the Hungarian Projection system EOVI - HD72.

I used the GIS projects to visualize the data layer by layer and to combine the different datasets with each other using spatial queries and spatial analysis methods. The result was two folded: on one hand different maps were created, displaying the results in two dimensions. On the other hand multimedia files were also created which are useful for displaying the results dynamically in three dimensions. Along with the data processing I conducted spatial queries on my database using different tools from the ArcGIS toolbox. My aim in the analyses was to display spatial trends within the data.

IV.3.1 GPR data processing and analysis

The core part of the present research is based on the interpretation of high resolution ground penetrating radar (GPR) data. GPR instruments transmit radar signals into the ground on various frequencies. GPR data acquisition methods for archaeological use are now under revolution. In contrast to the previous use of single channel geophysical surveys the newest technical and methodological developments introduced multi-channel GPR systems. One of the first tests of a 16-channel 400 MHz MALÅ Imaging Radar Array (MIRA) became available in 2008 and was tested on Birka, Sweden. During this survey an 8 cm cross-line and 4 cm in-line spacing was achieved with a velocity of 10-15 km/h. Parallel swaths were measured up to 170 m in length, covering in total 3 ha of measured areas, only in 5 days. This test proved both the speed and accuracy of these newly developed motorized systems. (Trinks et al. 2010.) This arrangement only led measurement in one direction, the measurement was triggered by an odometer attached to the wheels of the motorized lawn mover. The position of the measurement was recorded with a total station and an RTK GPS.

The next step in the development of the motorized systems was led to conduct the measurements in every direction. In parallel to that data processing methods were further tested to

²⁴ The software was provided by the University of Vienna.

make processing the large amount of data possible. In 2010 the LBI ArchPro purchased a 16-channel 400 MHz MIRA system, which was mounted in front of a Kubota BX2350 tractor. Furthermore a Sensors and Software SPIDAR system with 6 500 MHz Pulse Ekko Pro antennae was also purchased and used with a quad-bike, with 25 cm cross-line channel spacing. This later system lets 30 km/h survey speed, resulting up to 8 ha measured area per day. The latest results led to rolling turns as well and continuous operation for up to 30 minutes at a time. This approach led the LBI ArchPro and its partners to prospect 1482 hectares around different parts of Europe until 2016. A methodological challenge rose with the high speed data acquisition however, namely the survey needs to be positioned. To solve this, as a new development, LBI ArchPro uses time-triggering instead of odometer triggering. In that time stamps are recorded in Pulse-per-second (PPS) markers, recorded by a GPS receiver which is attached to the GPR system. Furthermore RTK-GNSS receiver record the position of the GNSS antenna mounted on the GPR system. The positioning data is stored together with the GPR data, furthermore it is used for real time navigation on the measured field. During data processing, GPR data position is corrected with GPS positioning using the PPS markers. At present an in-house developed software, LoggerVis is used for measurements.

The large amount of data needs special methods to process as well. The new solutions need to have quality control and geo-referenced high-quality images therefore LBI ArchPro developed a new software solution. The data processing includes correcting data positioning (using time-triggering using PPS markers), channel balancing (aligning the recorded GPR channels), adaptive time-zero adjustments (exact time-zero of each time series), background removal (removing the reflections of the vehicle), frequency filtering (band-pass filtering of the lower and upper cut-off frequencies), migration and depth-slice computation.

Depth-slices are the standard outputs of the GPR measurements. These are 2D grey-scale images representing the reflecting energy of a certain depth range. The depth-slices are stored as georeferenced images. Further image processing tasks are used on these images. Stripes and anomalies caused most probably by recent, agricultural activities are filtered out from the data. (Trinks et al. 2018) Archaeological interpretation of the depth-slices can be done in GIS environment manually or semi-automatically. Manual interpretation consists of redrawing and attributing the anomalies, which can also be extruded to a certain height, resulting in a 3D visualization of the data. Depth-slices can be visualized with scrolling through the slices, like an animation. This method highlights more easily the 3D shape and behaviour of the features. Semi-automation algorithms help to classify the data into features based on the automated identification of shape, orientation or other characteristics.

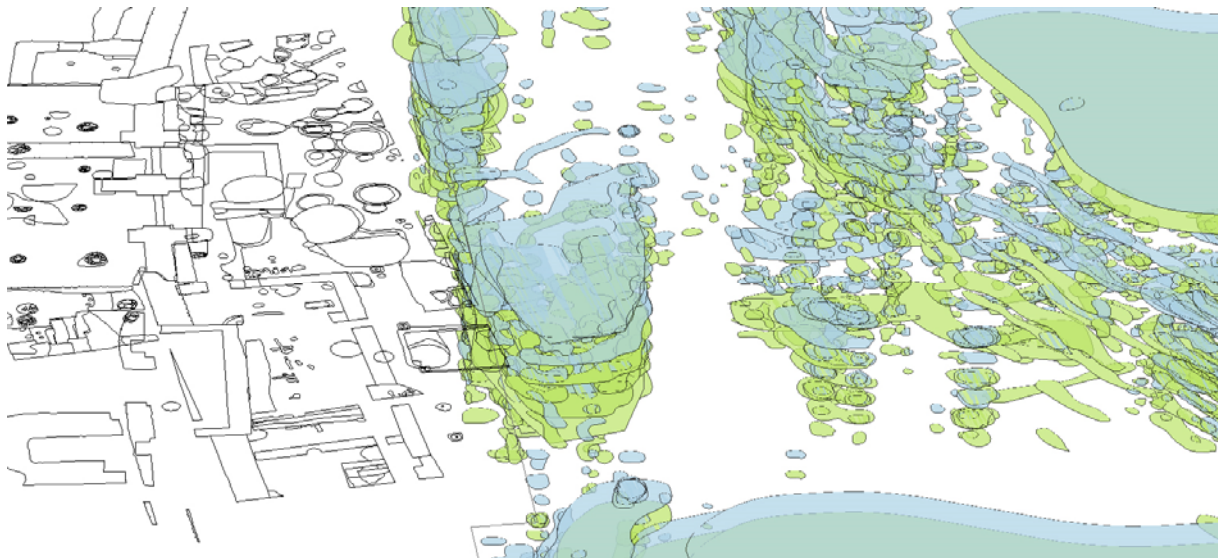
In my research I added depth-slices as raster files to the GIS projects. Next I created vector datasets from the raster images in two steps. The first step was to classify the anomalies visible in the depth-slices corresponding to natural or archaeological subsurface features. The aim here was to make a reduction of data to get a more insights to these datasets which are otherwise too complex.

In this thesis I call this process *manual feature selection*. (Fig. 3.) Then, as a next step, I interpreted these as archaeological features.

As a first step of the manual feature selection, anomalies, identified on depth slices were digitized and stored into a geodatabase. Each feature had its depth information added into the database using only one feature class, in which I embedded all the data.

In the interpretation I also used a method based on Raster mosaics. Raster mosaics are used in ArcGIS to see several raster images into one, single mosaicked image.²⁵ The ArchaeoAnalyst© Tool developed by the LBI ArchPro enabled me to change dynamically the number of images used for the mosaic. In this method I also included 'depth from' and 'depth to' values into the database to store on which depth I traced the anomaly.

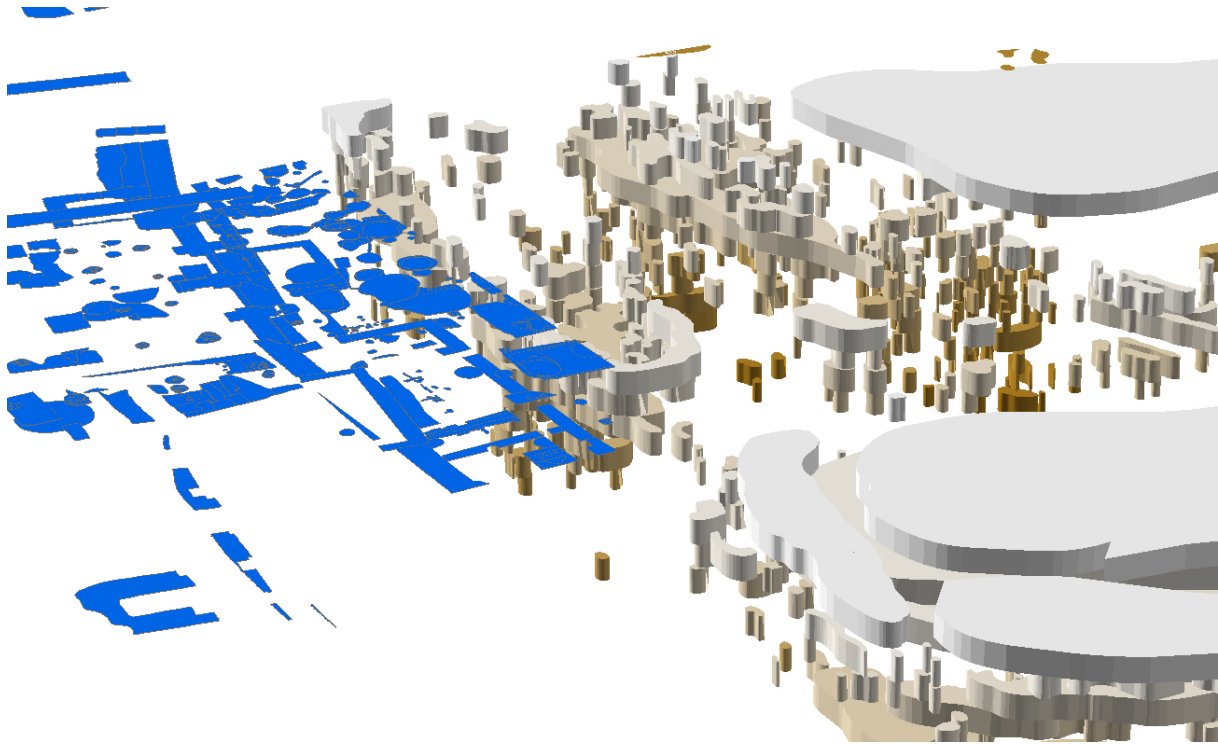
Datasets resulted from the manual feature selection was analysed using 3D visualization. I tested two ways of 3D visualization to study the stratigraphical sequences of the features and to understand the inner chronology of the site. The main difference between the methods is that in the first case, features were visualized two-dimensionally, using only their horizontal location (*Method No1.*). In the other method however, their volumetric dimensions were also represented in the three-dimensional space (*Method No2.*). The aim of *Method No1.* was to show the features layer-by-layer. As I included into the database a *depth-from* and a *depth-to* information along with the manual feature selection I was able to separate a 'starting' and an 'end' level for every feature. To visualize this in ArcGIS ArcScene application, I doubled the layer which contained the feature and I set the Base Heights (Layer Properties dialog box/Base heights tab) to show them at the same time both depths.



4. Visualization method No.1.- doubled layers

²⁵ <https://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/what-is-a-mosaic-dataset.htm>
last accessed 2020-10-29

In *Method No2*. I used three-dimensional, volumetric models from features based on their *depth-from* and *depth-to* information. Here I extruded the features according to the formula $[[depth_from] - [depth_to]]$ applied by *adding to the base height* and set the Base Height to $(- depth\ from)$.



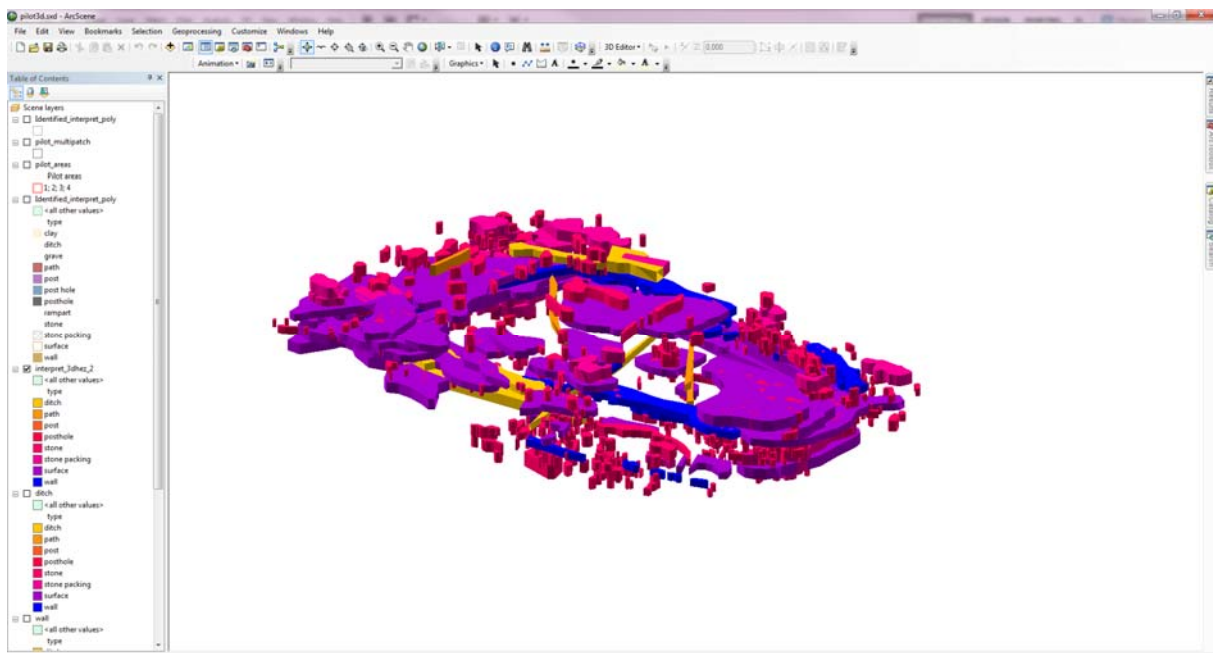
5. Features extruded according to the *depth-from - depth-to* information

This method helped me to visualize the overlapping features, or those which are connected within each other. Furthermore it let me the possibility to create '*pseudo*' cross-sections.

As traditional archaeological reasoning involves horizontal plan and vertical sections I found it useful to generate cross-sections from the dataset. I am using the expression *pseudo*- in connection with these cross-sections to differentiate them from the cross-sections created at excavations. Here pseudo-cross-sections are only generated digitally. These cannot be directly made in ArcScene application on extruded features therefore I needed to export 3D models and process them with different software. I used SketchUp for that, as in this 3D modelling software cross-sections can be flexibly created. There are several ways to export models from ArcScene into SketchUp even though the number of features and vertices and the computing capacities highly determines the methods that can be used. The first and foremost problem is that ArcScene (in version 10.2) only exports 3D models directly in VRML (*.wrl) format. VRML – Virtual Reality Modeling Language is a file format representing 3D vector graphics.²⁶ SketchUp however does not import *.wrl files directly, but many different formats, like 3ds from 3DMax, or Collada (*.dae) files. The latter, Collada (Collaborative Design Activity) is also a 3D file format for interchange data between 3D application with the help of

²⁶ <http://www.web3d.org/x3d-vrml-most-widely-used-3d-formats> last accessed 2020-10-29

open standard XML schema.²⁷ It is also possible to export Collada from ArcScene, via ArcToolbox. In the exporting process I followed the methodology published by M. Tenney. According to this process the ArcGIS features should be first turned to Multipatch features as this geometry type is used to represent the boundaries of 3D features with the help of 3D rings and surfaces. Multipatch features can be created after the extrusion of features using *3DAnalyst Tools / Conversion/ Layer3D to feature Class*. (Tenney 2012)

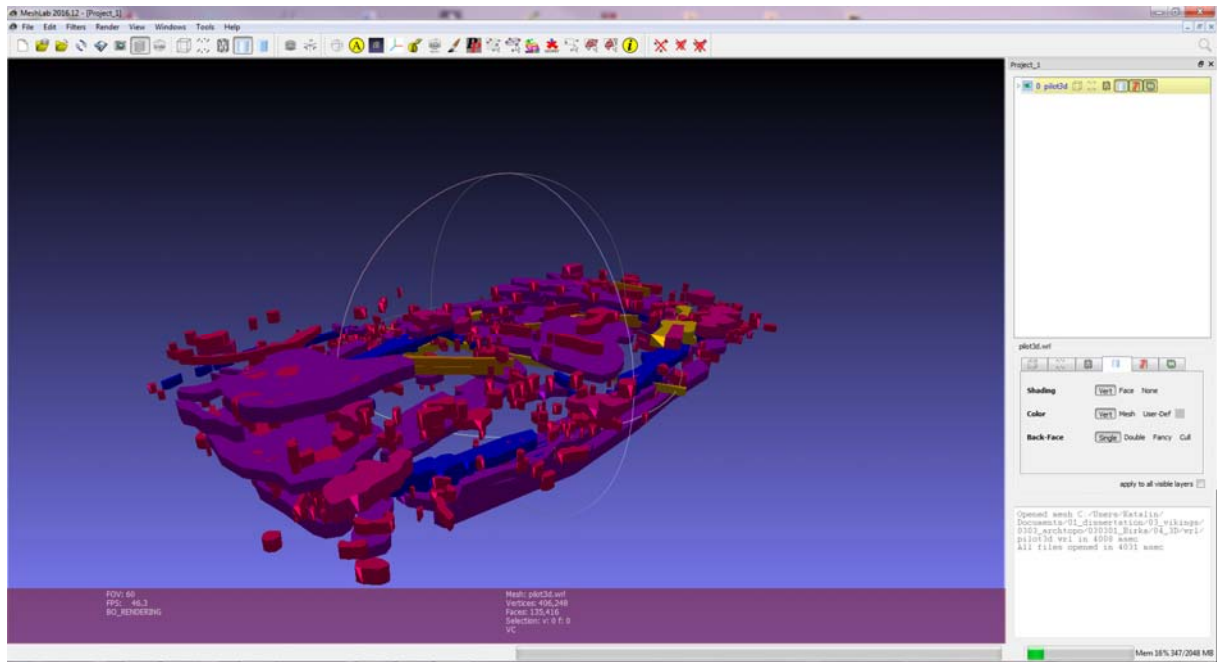


6. Extruded and color coded features turned into Multipatch feature type.

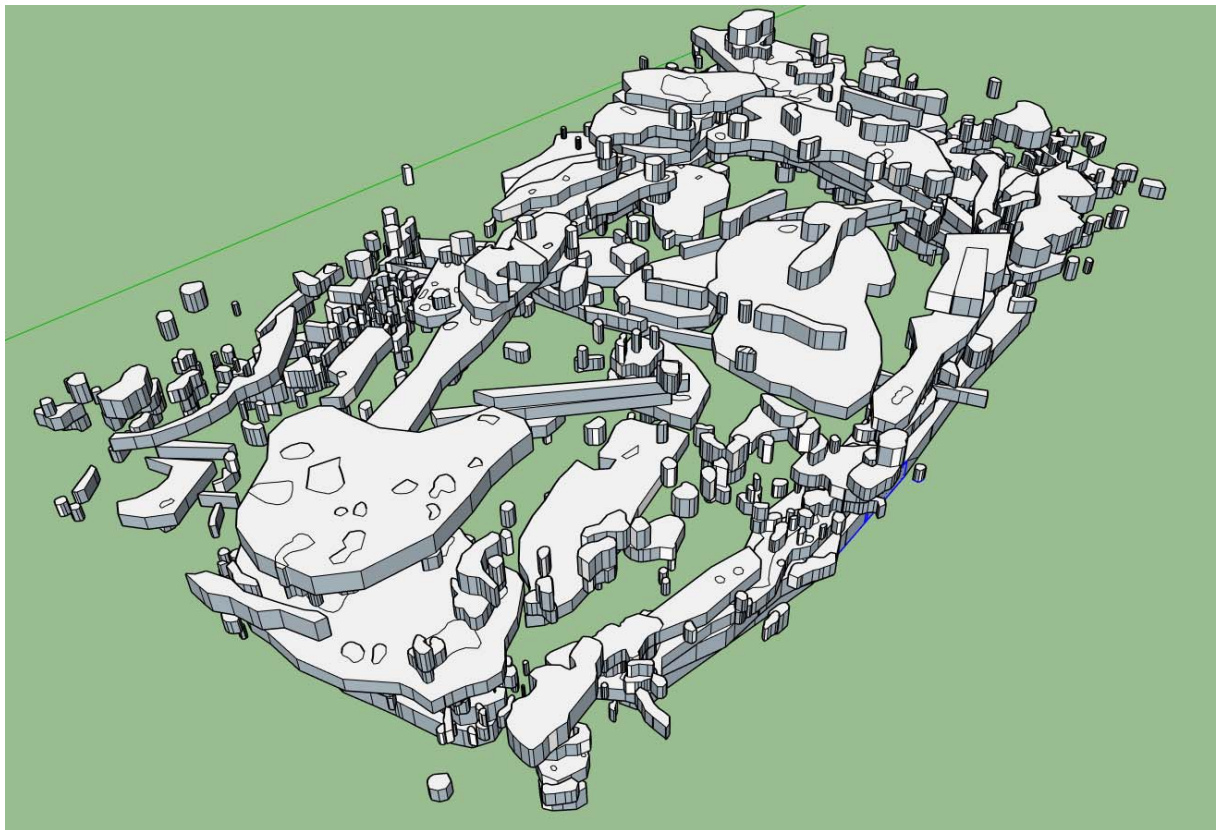
The resulting feature class should be as a next step converted into Collada format with the help of *ArcToolbox/Conversion tools/To Collada/Multipatch to Collada*.²⁸ Even though the conversion worked well on my datasets the end result was unfortunately not sufficient enough for my research aims. The problem was that my dataset contained too many vertices and SketchUp could not import the resulting file. As I needed to find another solution I included another step to the process using MeshLab software. I exported vrml files directly from ArcScene using *Files/Export Scene /3D command*. The resulting *.vrl file was then imported into MeshLab with *File/Import Mesh*. In Meshlab also the colouring of the different layers was preserved. From Meshlab I exported new Collada files but these ones worked well in SketchUp.

²⁷ <https://www.khronos.org/collada/> last accessed 2020-10-29

²⁸ <http://gmvc.cast.uark.edu/modeling/software-visualization/sketchup/workflow-sketchup/arcscene-to-sketchup-to-arcscene/> last accessed 2020-10-29

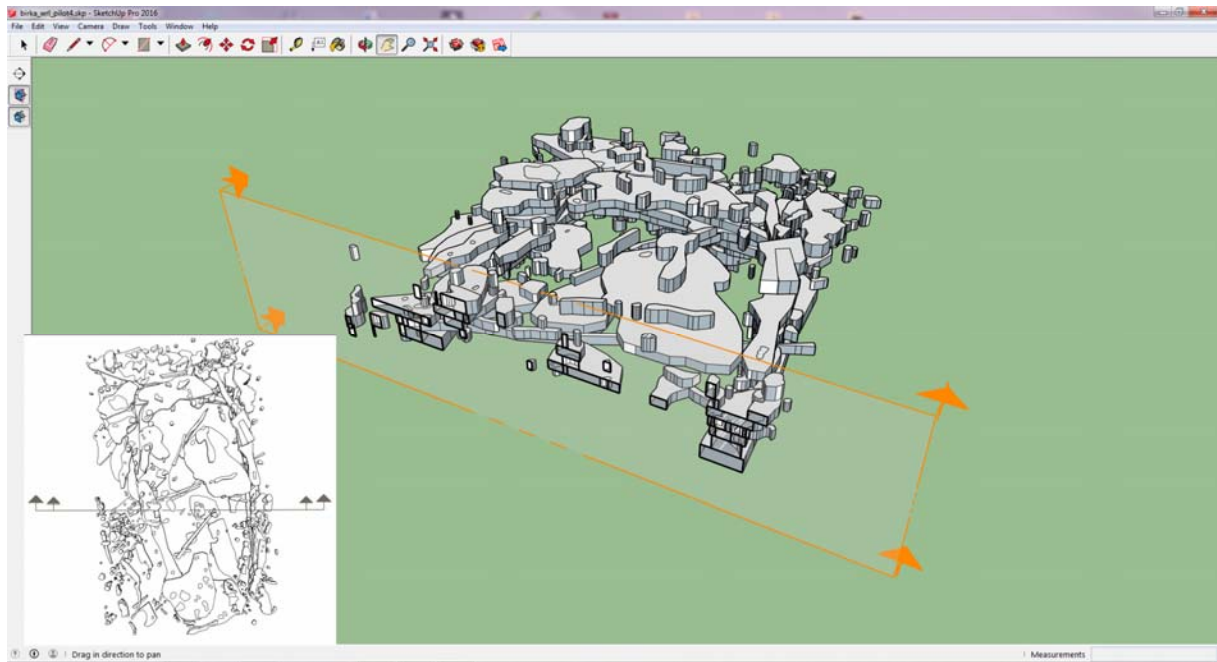


7. Features imported to MeshLab in *.vrl format.

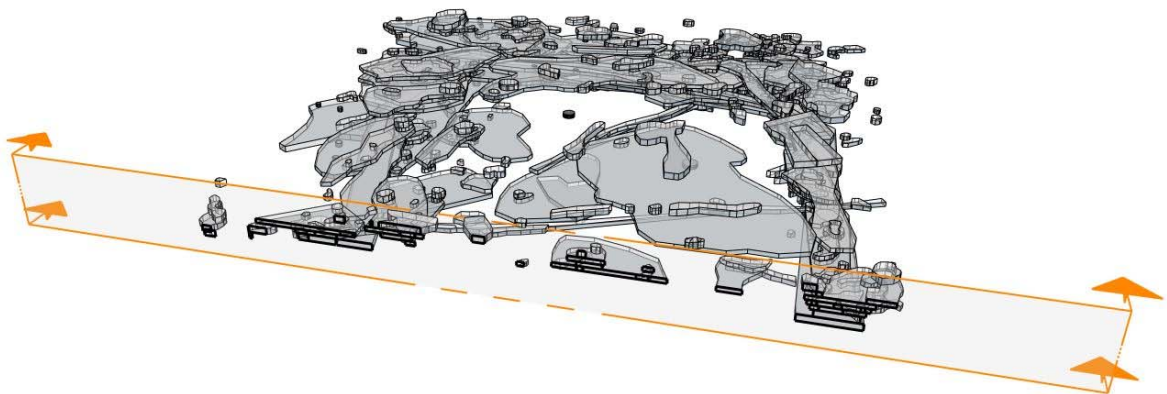


8. Features imported to SketchUP in *.dae format, without color coding.

In SketchUP it is possible to create cross-sections at any part of the model using the *Section Plan tool*.

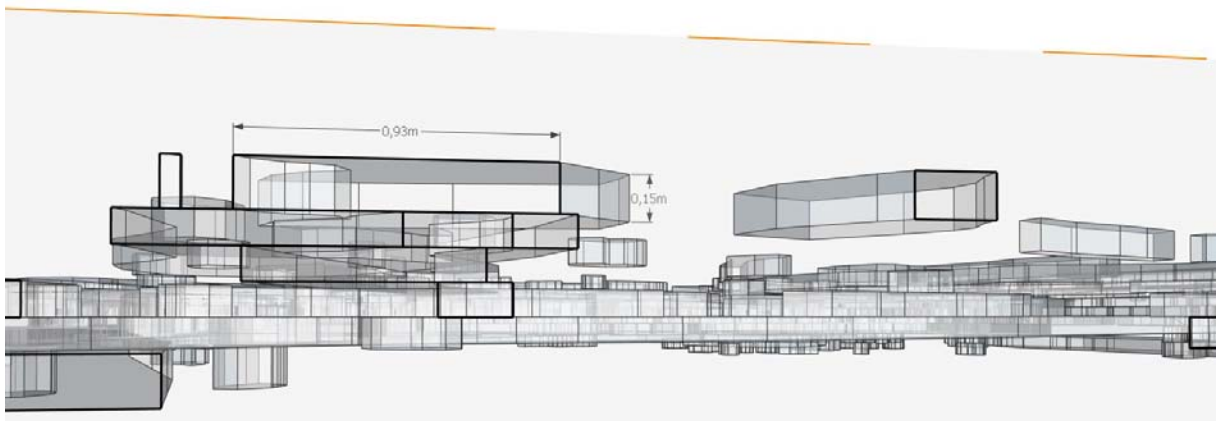


9. Sectioning the model.



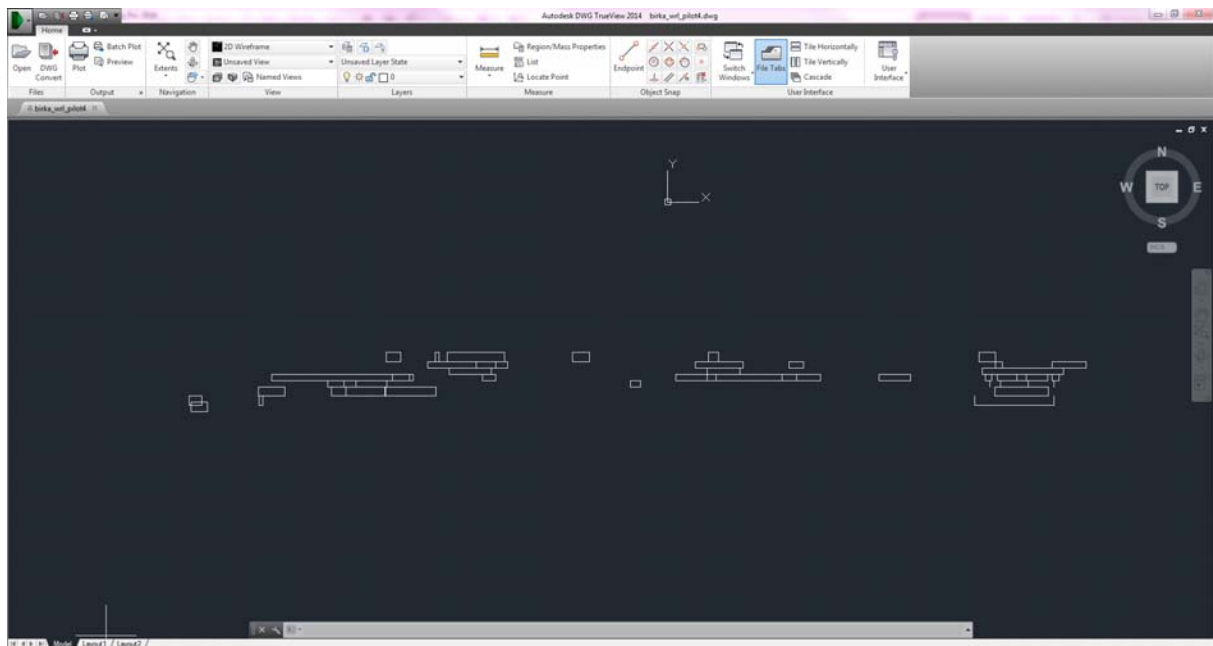
10. Location of the section can be directly changed within the model.

On the section plans it is further possible to measure the extent of the features vertically.



11. Direct measurements within the model.

The section drawings can as a next step exported to CAD applications in .dwg file format.



12. Example of a pseudo-cross section, imported to CAD.

IV.3.2 Data classification and interpretation

Data classification and interpretation was meant to turn the result of the spatial analyses into archaeological/historical information on the question of the dynamic development of the early centres. For the interpreted data I created a stand-alone dataset within my database with further feature classes.

As GPR data provided the core for the interpretation, I used both the 2D and 3D representations of the data. In my GIS database I created a different layer on which I grouped those anomalies which I understood as being a part of a common feature. In that sense I followed a traditional archaeological analysis even though the source material was not the analysis of the artefacts or the excavated features but the detected anomalies. As a next step I classified the features and gave an archaeological interpretation based on published archaeological material. This interpretation meant mainly the type or functional determination of the feature (i.e. building / dwelling; path / ditch; wall). Another issue in my research was to compare excavation material with the GPR measurements. As at Visegrád excavations followed and tested the previous results of GPR and magnetic measurements, I was able to compare the depth information of the layers and the extent of the features outside boundaries of the excavated trenches.

I created further maps and illustrations based on various layers of the database which I included into the text. I used these illustrations in two ways. In some cases the spatial queries resulted in a map which was not used further. In many cases however the resulting maps were further used in the evaluation process as comparative materials or bases for further spatial queries.

V. The archaeological landscape of the Pilis region (Hungary) in the Middle Ages

In the following chapter I present in detail the different datasets of the Pilis region and Visegrád. Here I present the geographical surroundings, the topography and the source material. In the case of Visegrád, I also present in detail the elements of the archaeological landscape and I discuss in detail the archaeological interpretation of the datasets involved.

V.1 Introduction

As a case study area of my PhD research I studied the archaeological landscape and the elements of an early Arpadian age centre from Visegrád, Hungary. Visegrád as a county and a county seat was mentioned in one of the earliest charters of the Kingdom in 1009. Being most probably a county centre from the earliest days of the Hungarian Kingdom, the Visegrád complex consisted of several archaeological landscape elements. The core of the complex was a late Roman fortification which was rebuilt in most probably the 9th-10th century. Both excavations and geophysical measurements were conducted within the inner area of this fortification. In the present chapter I summarize the results of the previous excavations and I give an interpretation of the GPR datasets from the site and I present briefly other elements of the Visegrád-complex too. Even though the concept of central places is rarely used in Hungarian research I consider this site as a central place and I analyse how the different elements of the site fit into this preconception.

Visegrád is situated to the Danube bend at the foot of the Pilis-Visegrádi Mountains. Its surrounding, the Pilis forest, was continuously a royal property in the centre of the *medium regni*, the middle part of the country. Systematic field survey revealed a large number of archaeological sites in the close vicinity of the royal forest. To understand the role of the Visegrád complex within its surroundings I analyse the sites from the area. Even though the exact dating of the abandonment of the early complex is not known, a probable sign for that is the erection of a new castle, the Upper castle around 1250. This, in connection with the lack of high medieval finds from the early complex lets me to close my investigation with the end of the 13th century. In the present chapter I discuss briefly the early history of the Hungarian Kingdom too. Then I give an overview on the present day topography of the Pilis region. The core of this chapter is the presentation of the Visegrád complex which is followed by a discussion on the archaeological sites from the Pilis region from which I discuss here in detail only the site specific datasets. Consequently I present more thoroughly those methodological issues which are relevant for the site specific data. Considering the Pilis region as an archaeological landscape I present its elements on a larger scale. As a conclusion I evaluate the Visegrád complex in connection with the Pilis region.

V.2 Time frame

The starting point of my analysis in the present chapter is the Hungarian Conquest period (around 896) and the time of the state formation at turn of the 10-11th century. The latter was strongly connected to the spread of the Christian faith, and the country-wide Christianization process in the Hungarian Kingdom. I conducted my research on the Arpadian period sites of the study area (c.1000-1301). The period was named after the Grand prince Árpád (896-907) who headed the Hungarian tribes along the Conquest period. His descendants inherited the ruling power until 1301. In c. 970 Grand Prince Géza, had himself baptized with the help of the Holy Roman Empire. His son Vajk, (later Stephen I. (997-1038)) became the first Christian king of the Magyars. The royal authority of the *Arpads* rested on the newly erected or renovated castles. The *medium regni*, the triangle of the royal towns of Esztergom – Székesfehérvár – Buda, was the most densely populated area of the Kingdom with the most prominent castles of the country. (Benkő 2015, p. 12.)

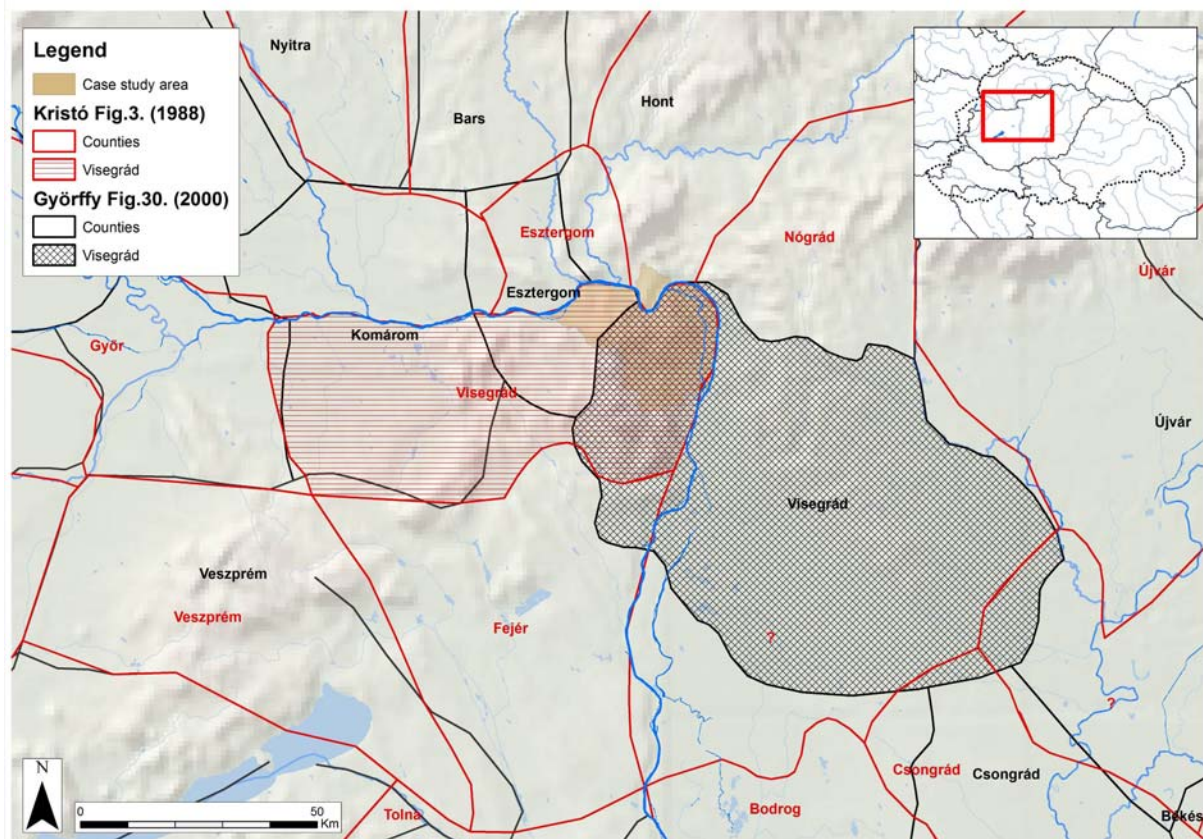
The Pilis area, lying in the hearth of the *medium regni* played a crucial role as a royal centre and hunting domain. In the forested areas of the Pilis a dense network of royal residences developed from the eleventh century. In that period the sovereign did not have a permanent seat or capital, but the court was travelling between the royal mansions. (Szabó 2005) The royal residences were in several cases turned later to monasteries. Besides the royal properties a well-developed system of settlements was detected in the Pilis region.

The Visegrád complex is special in a way as it was named in a donation charter, issued by St. Stephen I. (997-1038) in 1009. This donation charter lists four *civitas* – Veszprém, Fejér, Kolon and Visegrád - and puts them under the authority of Bishopric in Veszprém. It is widely accepted in the historical research that the term used in this charter (*civitates ... seu terminis and finibus*) refers to a county as a territory. (Zsoldos 2010, p. 5.) The geographical extent of the counties founded by St. Stephen I. (997-1038) is still a subject of scientific debate. According to Gyula Kristó, the form of the county as a legal entity was Frankish in origin however its content followed the own needs of the Hungarian social organization. According to him the early territorial division was a consequence of the original tribal division while György Györffy connected it to the location of the clans (*gens*). (Kristó 1988, pp. 97-100.) In parallel to the county system, the net of castle districts also developed. It is problematic to determine a geographical division between the two types of organizational units as a county incorporated land from the castle district too. It can be assumed that at the time when the first counties developed the castle district and the county covered the same area. With new foundations, the number of castles grew and a county needed to incorporate more castle districts. This then led to a fragmentation of the lands of a castle district as they could be located to different counties. Consequently a county could enclose lands of castles situated outside the county borders.

The foundation of the ecclesiastical units closely followed the development of the administrative organization. One of the most prominent of the early foundations was that of the St Adalbert Archbishopric of Esztergom in 1001. Besides the archbishopric the area of the Kingdom was divided into ten dioceses headed by bishops. As an inferior level in the ecclesiastical administration a net of

Archdeaconal churches were also founded. These churches were placed to the bailiffs' seats and controlled by deans. The bailiffs and the deans together were meant to guarantee the legal and ecclesiastical regulations determined by St. Stephen I. (997-1038). These orders protected the rights of the freemen and regulated the building process of the *ecclesia baptismalis*, the parish churches. Markets were located also nearby these churches. Following the laws of St Stephen I. (997-1038) the leaders of the early centres ensured the obligatory church visits and the secure trading at the market places. (Závodszy 1904, pp.13-56.; Györffy 2000, p. 186.)

The centre of Visegrád county, mentioned in 1009, was identified with excavations at the fortification on Sibrik-hill, at the area of present-day Visegrád. This charter however raises further questions concerning the county as a geographical and administrative unit. As the dating of the above mentioned charter is generally accepted to 1009 it was concluded that Visegrád can be seen as one of the earliest counties of the Kingdom. As the county later disappeared from the sources both its geographical determination and its decline are subjects of historical debate.



13. Estimated territory of Visegrád county.

According to Györffy the county of Visegrád was located on both sides of the river Danube. On his reconstruction map the county covered an app. 6000 km² large area incorporating the lowland at the present-day Pest county. (Györffy 2000, Fig. 30.) A different picture was suggested by Kristó. According to him, the county of Visegrád extended only to the right side of the river Danube. (Kristó 1988, pp. 251-253.) For the overall county he estimated a rather rectangular area bordered by the

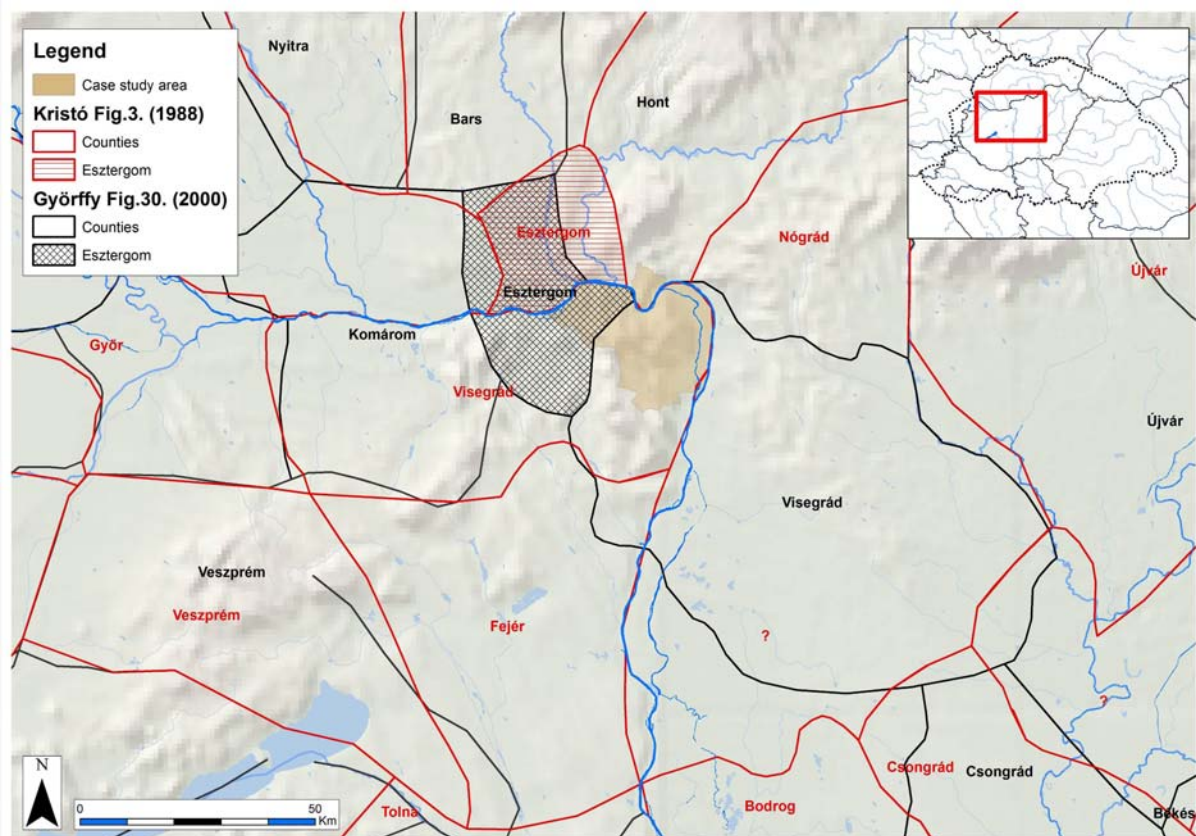
Danube on the north and on the east covering ap. 3300 km² for the time of St Stephen I. (997-1038) (*Fig. 13.*) Recently Attila Zsoldos presented the idea that the early Visegrád county incorporated both sides of the river Danube, and therefore the Danube was not a county or diocese border. (Zsoldos 2001, p. 33.)

Comparing the early county of Visegrád with other counties of the Kingdom scholars observed some peculiarities. As there are a large number of royal properties within the area it is not possible to detect a well-developed castle system here. Furthermore there are a large number of exempt churches - obeyed directly under the bishopric of Esztergom - which might also be explained with royal use. (Tringli 2010, p. 398.) In general these peculiarities suggest that this centre part of the Kingdom was owned by the royal family. (Tringli 2010, p. 406.)

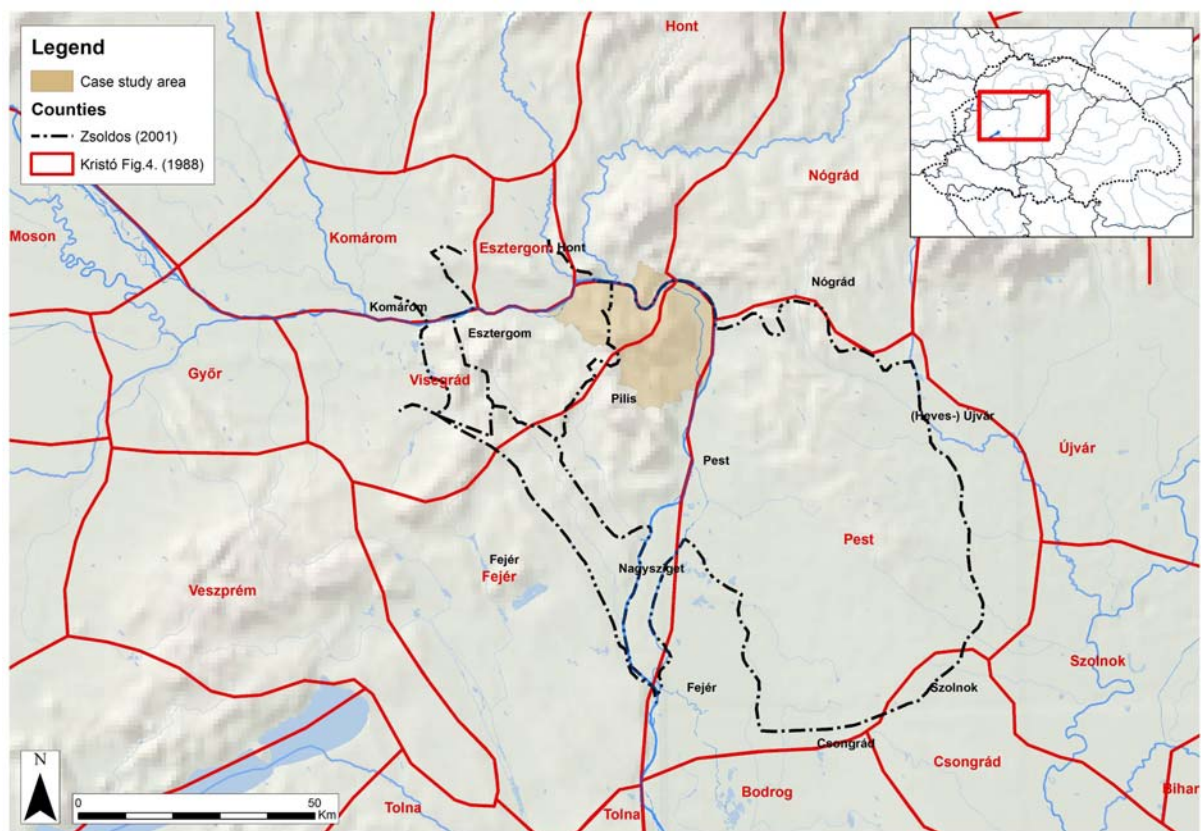
The selected case study area around the Visegrád complex was understood by both Györffy and Kristó as parted between two or three counties. Both researchers agreed that the settlements situated north from the Danube belonged to Hont county. In the question of the area south from the Danube the two researchers had different views. According to Györffy this part of the case study area was parted between Visegrád and Esztergom counties. According to Kristó however it belonged totally to the county of Visegrád. He understood the county of Esztergom instead as a small area county, mainly on the northern side of the Danube. According to Györffy however Esztergom county was located on both side of the Danube.

Esztergom county was named after the royal town of Esztergom. As this town was also located within the present case study area its connection with the Visegrád complex is crucial for the present research. According to Zsoldos, Esztergom can be viewed as an early royal centre and a personal property of the Árpád dynasty until 1018. From that year onwards another town, Fehérvár in county Fejér, became the royal 'capital', which most probably resulted in a change in the status of Esztergom too. The first bailiff from Esztergom is only known from 1079. This appearance of the bailiff in Esztergom may refer to the fact that the bailiff moved here from Visegrád sometime, between the years 1018-1079. The bailiff then governed most probably the same territory from here. According to Zsoldos, this meant that Visegrád county was 'renamed' to Esztergom from 1070 onwards. (*Fig. 14, Fig. 15.*)

As no other mention is known on Visegrád County it is highly probable that its territory dissolved between later counties. According to Kristó the area of the former county became parts of Fejér and Pest counties. According to Zsoldos however the area most probably broke up between Pest, Pilis and Esztergom counties. (Zsoldos 2001, p. 33.) Furthermore in the 13th century the Pilis forest became a stand-alone castle district. (Zsoldos 2001, pp. 49-50.)



14. Estimated territory of Esztergom county.



15. New counties at the area of former Visegrád.

In the medieval history of the Hungarian Kingdom - including the Pilis region - an important turning point was the Mongol invasion in the years 1241-42. According to the historical sources, the Mongol horde was able to cross the frozen Danube and made a huge devastation in the country, ruining also the town of Esztergom.²⁹ This devastation motivated later a change in the settlement system and generated a structural development in the Kingdom. I closed my investigations here, at the end of 13th century, as in 1301 the rule of the Arpadian-dynasty ended with the decease of King Andrew III. (1290-1301).

²⁹ Rogerius: Carmen Miserabile super Destructione Regni Hungariae per Tartaros. http://www.hs-augsburg.de/~Harsch/Chronologia/Lspost13/RogeriusApulus/rog_intr.html last accessed: 2017-03-23.

V.3 Topography of Pilis region

The Pilis region, covering a 600 km² area, consists of two mountains, the *Pilis-mountain*, and the *Visegrádi-mountain*. The mountain consists of sedimentary rocks and also andesite, a volcanic rock which was a popular raw material for constructions in the area. The highest peak of the area is the Pilis-tető, with a height of 756 m. The name *pilis* stems from Slavic origin and means ‘tonsure’ referring to the treeless peaks of its mountains. Except from the bare peaks the mountains are mostly covered by forest. The Pilis is separated from the Visegrádi-mountain by the Pilisvörösvári-valley. The highest peak of the Visegrádi-mountain is Dobogókő, at almost 700 m. In the area of Pilis caves were also detected. There are only a small number of streams within the mountains, with small discharge. The two longest streams are the Szentléleki-stream (runs NW) and the Dera-stream (runs SE) in the Pilisvörösvári-valley. In the Visegrádi-mountain, the most important streams are the Bükkös-stream and the Apátkúti-stream. There are also several smaller ponds and 170 springs in the area. (Fig. 16.)



16. Topography of the Pilis region

A core feature in the geography of the area is that it is bordered from two sides by the Danube which draws here an almost 90° curve. Compared to other part of the Danube the water level is lower here and the river runs more slowly, building several larger and smaller islands within its water body. One of the largest islands, the Szentendre-island, belongs also to this area, with its app. 60 km² large arable land. The area at present belongs to the Duna – Ipoly National Park, while the forested areas are under the authority of Pilis Parkforest Company.

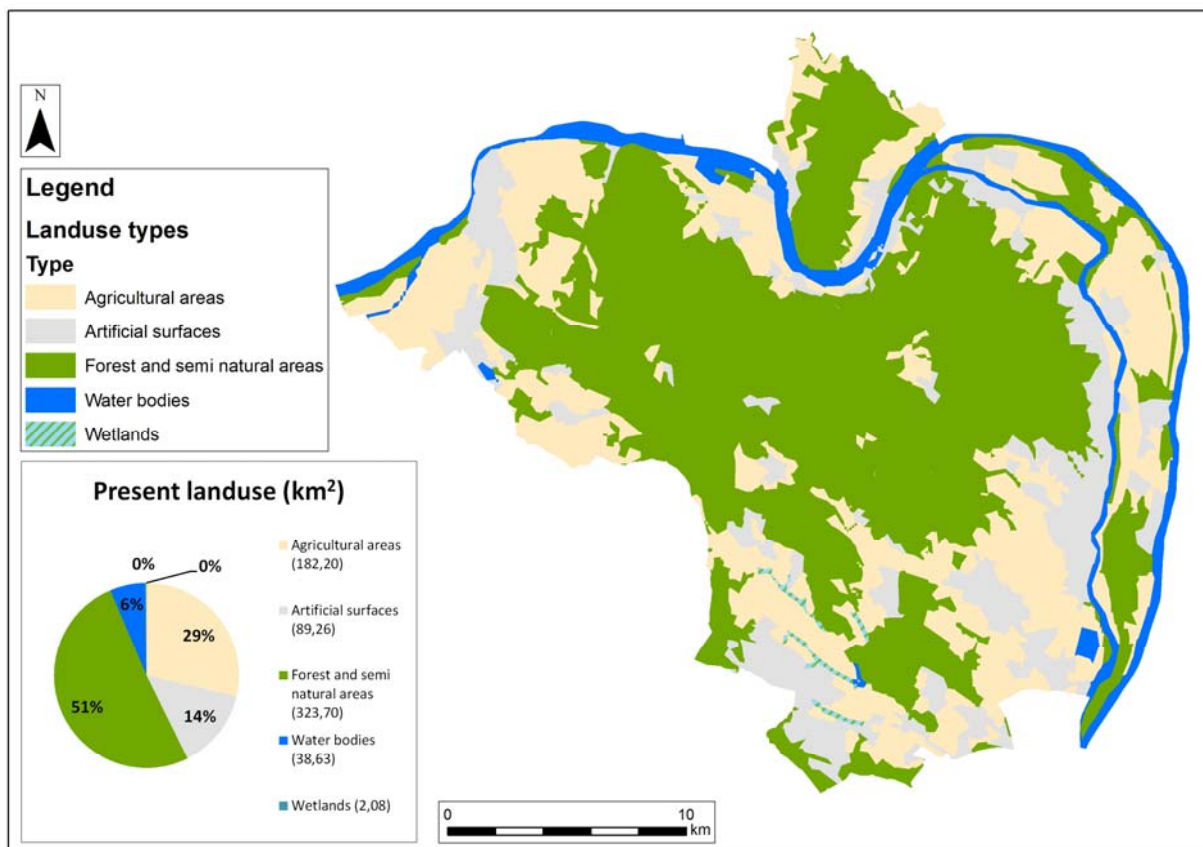
For the present research I defined the case study area of the Pilis region by the extent of the settlements within the Pilis and the Visegrádi-mountain including the Szentendre-island. To have a more complete picture I also included two more settlement areas (Zebegény, Nagymaros) from the left side of the Danube, north from Visegrád. This area is also hilly and forested belonging to the southern feet of the Börzsöny mountain. The case study area includes at present 24 modern settlements and belongs to the present day counties of Pest and Komárom-Esztergom.

V.4 Overview of the data corpus for the present research

V.4.1 Background maps and the present landuse

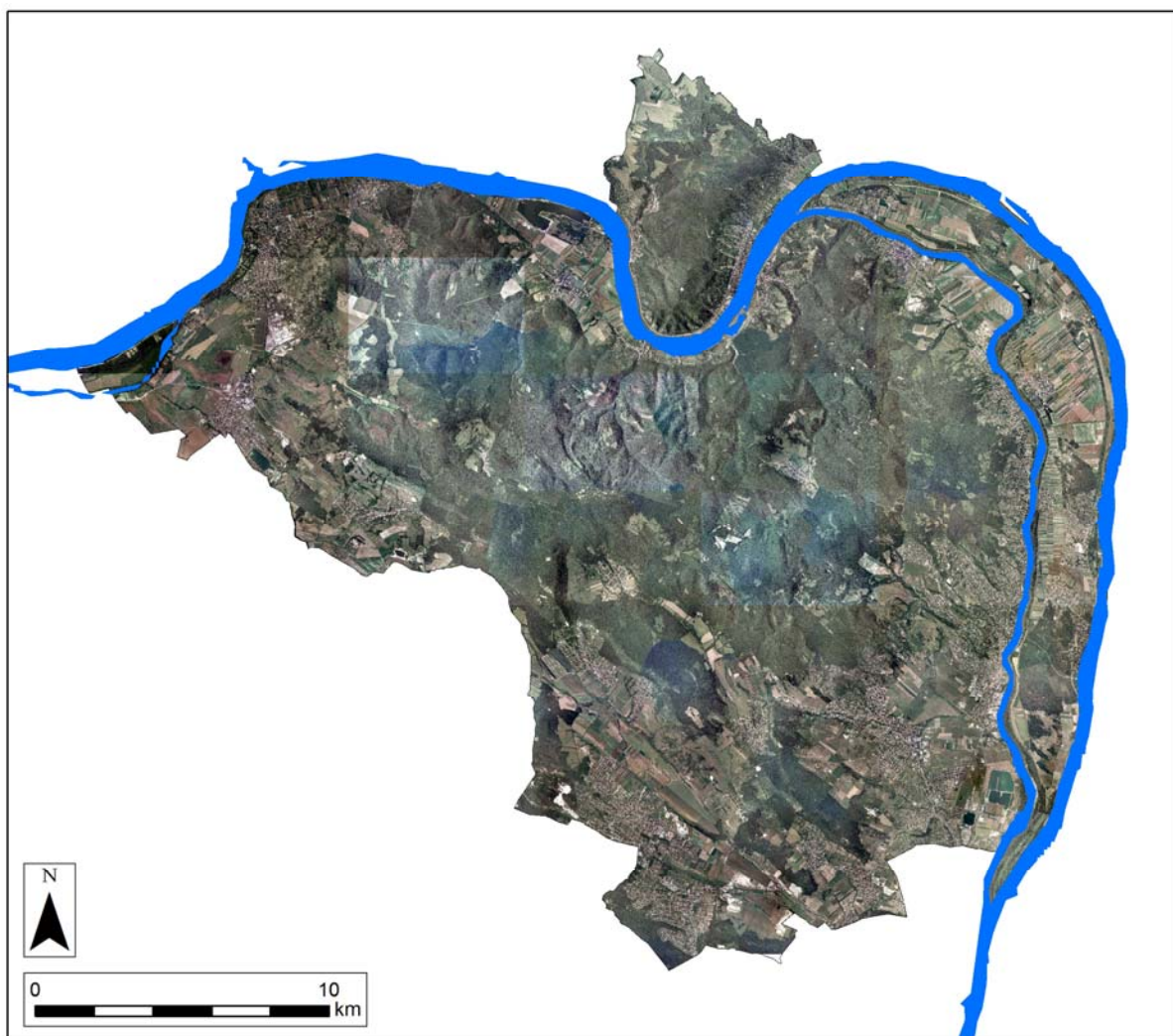
I started the data collection for my database with the background maps. The area covers 37 pieces of the 1:10000 topographic maps. To have a digital elevation model of the Visegrád complex I digitised the contour lines from the corresponding topographic maps which I also supplemented with on-site measurements. For the Pilis region I used the relief model from ASTER GDEM. I added the waterways, places and boundaries as vector layers downloaded from Openstreetmap.

I used the CorinneLC 50 dataset to understand the present landuse of the case study area. At present the half of the area is covered with forest, while only 29% is used as arable land. The arable lands are located to the lowlands and to the riverbank. As a result of the industrial development within the area, c.14% of the total is now covered by the artificial surfaces of the settlements. (Fig. 17.) Most recently the Government Office of the Capital of Budapest provided the orthophotos from 2005 for free download from the website of Department of Geodesy and Remote Sensing. I added these images to the background database, as they show in more detail the different land cover types.³⁰ (Fig. 18.)



17. Land use types of the Pilis area

³⁰ www.geoshop.hu

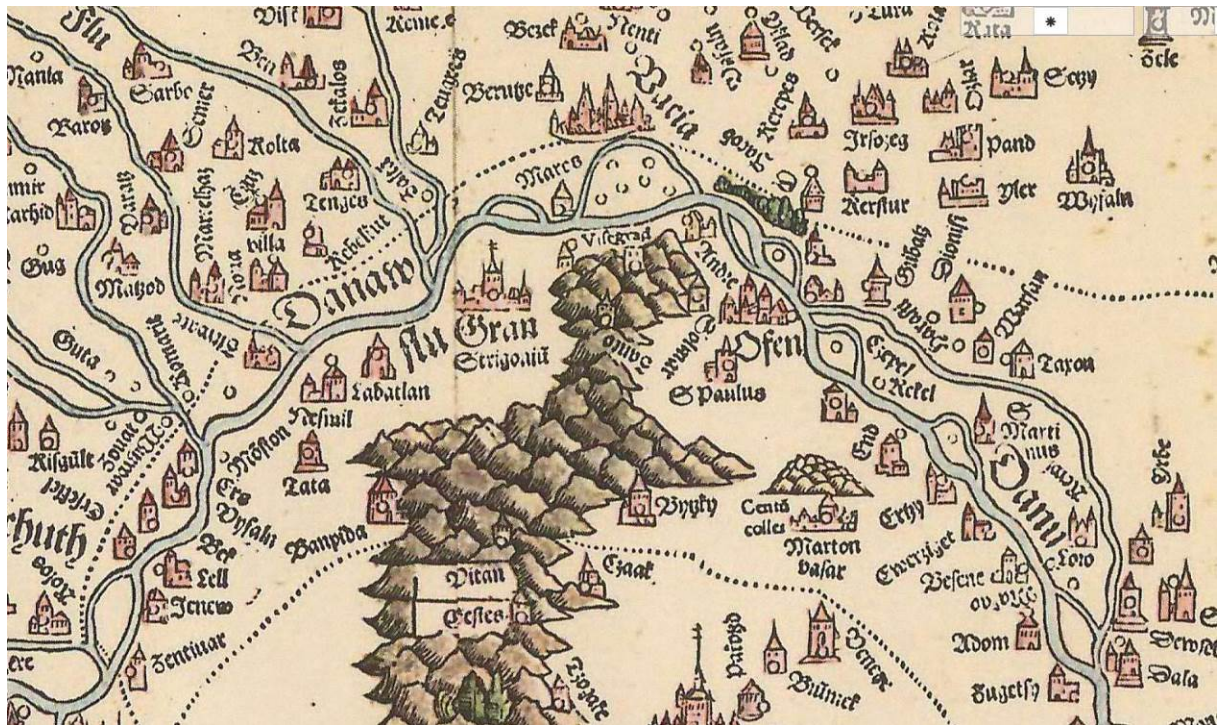


18. Land cover of the region

V.4.2 Historical maps

In the Hungarian research both archaeologists and historians use historical maps intensively. Various observations and conclusions were derived from these sources; furthermore, a large number of them are available online or in digitized form. Maps depicting the whole case study area rarely exist before the 20th century. The first, printed map illustrating the whole Hungarian Kingdom is the so-called *Tabula Hungariae* drawn by *Lazarus secretarius* in the 16th century. This map illustrates the Kingdom before the Turkish attack of 1526. The map depicts the location of towns, villages, castles, palaces, rivers, hills and forests. It illustrates the settlements with circles and names. Towns and castles are further illustrated with depictions, these however most probably not show the contemporaneous state of the settlements. (Plihal 2013. pp. 59-60., 123.) In the case of the Pilis region the map depicts the following places: Gran/Strigonia as Esztergom, Maros as Nagymaros, Visegrad as Visegrád, Andre as Szentendre, Solmar as Solymár and Zanto as Pilisszántó. It further illustrates a castle-like building with straight top without naming it in the middle of the rectangle of Visegrád, Pilisszántó, Solymár and Szentendre. Nor its location neither its shape on the illustration

helps in the identification of this feature however. The map illustrates the Szentendre Island as a large island between the present day Vác (Vacua) and Visegrád. Within the island the map illustrates 6 settlements, all without names. Comparing these with further maps and historical sources I identified these settlements with high probability. In my opinion the four settlements lying on the right side of the island facing the Pilis area can be identified with (Kis)Oroszi, Tótfalu, Megyer and Monostor (from North to South). The two settlements lying on the left side, facing Vacua are most probably Szentgyörgy and Vácrév. It is notable, that according to the depiction the river flows on the right side of the island, while the curve on the left is a less wide channel. (Fig. 19.)



19. The case study area on the Tabula Hungariae³¹

Another map from the 16th century is that of Wolfgang Lazius from 1575.³² The *Hungariae Descriptio* depicts Esztergom as Strigonium/Gran, Visegrád as Plindenburg, Vissegrad, Nagymaros as Maros, Solymár as Salmar and Szentendre as S. Andre. The map depicts only a church in the northern area of Szentendre island, without naming it. Based on its location I find it feasible that this church can be identified with Kisoroszi or Szentpéter. The map names the island as Visse Insula. (Fig. 20.)

³¹ Image credit: https://hu.wikipedia.org/wiki/Tabula_Hungariae#/media/File:Tabula_hungariae.jpg

³² <https://maps.hungaricana.hu/en/HTITerkeptar/366/> (last accessed 2018-06-26)



20. The case study area on the *Hungariae Descriptio*³³

I also included maps from the 18th century into the analysis. Here the name of Samuel Mikoviny should be mentioned who created detailed maps of the Hungarian Kingdom for the work of Mátyás Bel, the *Notitia Hungariae Novae Historico-Geographica*. I included three different maps into the present research, made by Mikoviny, from the years of 1731, 1737 and 1790. From 1731 the map of Pilis county *Mappa Ichonographica Comitatum Pest Pilis et Solth* was included here.³⁴ This map depicts six settlements which are deserted: Pr. Tahi, Pr. Borosjenő, Pr. Várad between Bogdány and Szentendre, Pr. Sz. Péter on the Szentendre Island, Pr. Kissing at the area of Pomáz and Pr. Szempesz further south from Kissing. A detailed presentation of the area is available from 1737: the *Mappa Comitatus Pilisiensis methodo astronomico geometrica concinnata* which is a supplement to Bel's work.³⁵ This map illustrates a castle-shaped settlement Várad in between Bogdány and Tahi. It further depicts Izbek and S. Endre as two separate settlements, while it also shows a place Mola (mills) in the area of the present day Pilisszentkereszt. It calls the island as Insula Ros and here it depicts also the village of Szt. Péter. Another map *Generalkarte von Ungarn samt den angränzenden Laendern* made by Hell [Miksa] Liesganig, [Joesph] Mikowiny [Mikoviny Sámuel], Islenief [Islen'ev, Ivan Ivanovic]Wussin, I. Wensely, A. was also used from 1790.³⁶ This map shows fewer settlements than the previous ones from the century, and it also contains mistakes as it calls Tahi mistakenly as Telki. This mistake might stem from the fact, that Tahi was already a praedium on the map of 1731.

I studied the First Military Map in more detail in the present research as it illustrates the streams and the roads of the area. The first military map or the so-called *Josephinian Land Survey* was created between the years 1763-1787. It was meant to provide a comprehensive map of the whole Habsburg Empire. It has geographical names as well as the relief and the land use elements. The map was

³³ <https://maps.hungaricana.hu/en/HTITerkeptar/366/> (last accessed 2018-06-26)

³⁴ <https://maps.hungaricana.hu/en/HTITerkeptar/554/> (last accessed 2018-06-26)

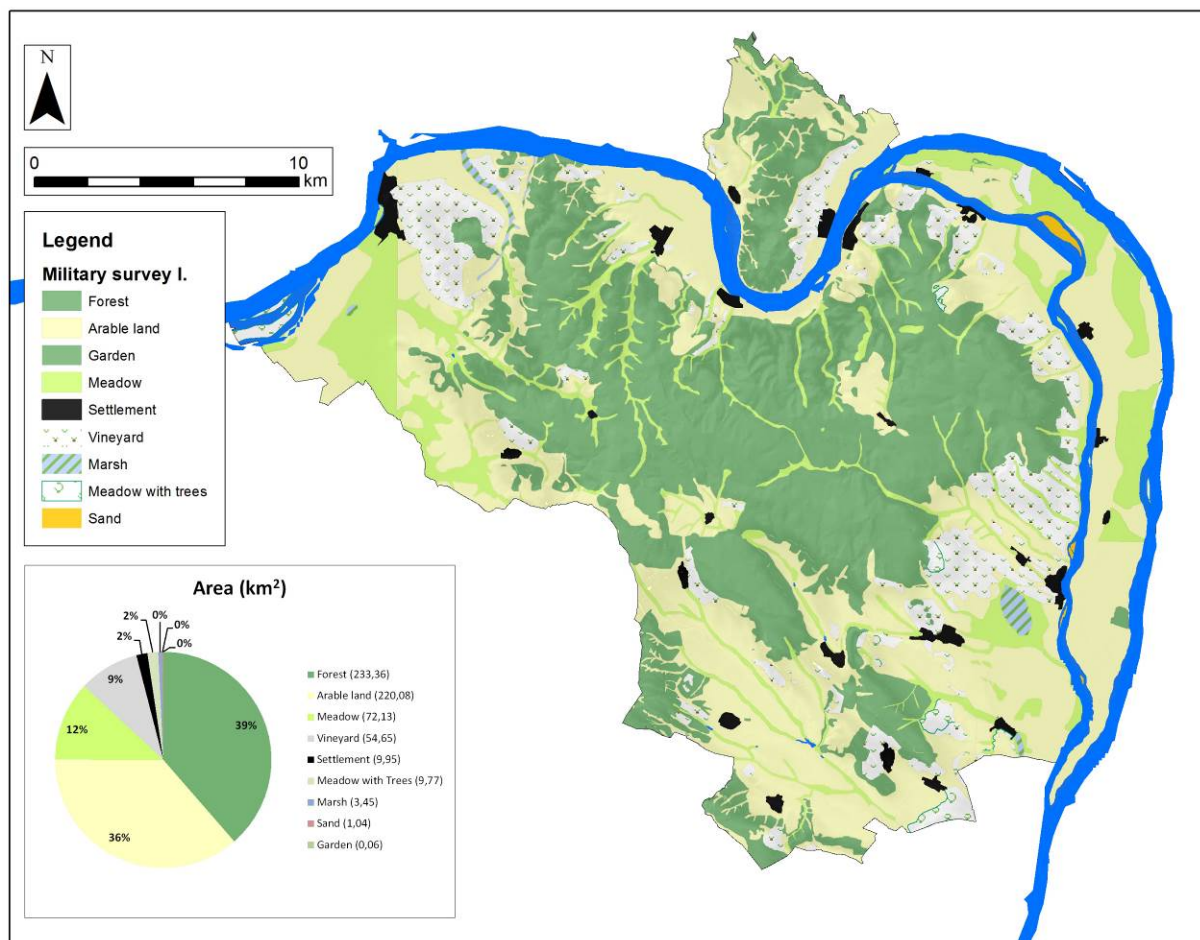
³⁵ <https://maps.hungaricana.hu/hu/MOLTerkeptar/9976/?list=eyJxdWVyeSI6ICJtaWtdmlueSaxNzM3In0> (last accessed 2018-06-26)

³⁶ <https://maps.hungaricana.hu/en/MOLTerkeptar/10412/> (last accessed 2018-06-26)

compiled in 1:28800 scale. In contrast to the above mentioned maps I was able to georeference this map and include it directly to my GIS database. I conducted the georeferencing manually to which I identified identical points between the map and the present land cover. Even though I only managed to georeference the map with 100-150 m accuracy, I found it is still useful to illustrate the overall area. As a next step I vectorised the elements depicted on the map to my GIS database in ArcGIS software. I used three different layers. Linear features - like river basins and roads - were grouped to polyline layers. Points - like bridges or crossing points - were digitised as points. The areas with different land cover types were digitized as polygons. I conducted spatial analyses on the vectorised map content using various methods. I studied the extent and type of the land use and landcover; the naming of the settlements and the road connections between them. I also analysed the water network depicted on the map. The land cover of the area was grouped into 10 different categories on the map. 39% of the study area was covered with forest, while 36 % was used as arable lands. By the time of the map compilation viticulture was also important in the area, 9% of the whole area was used as vineyard. Settlements and habited areas only covered 2% of the whole area, hardly reaching 10 km².

In comparison with the present-day topography it can be seen, that the forested areas were smaller in extent at the end of the 18th century, while arable lands were larger as at present. Nowadays only app. 4 km² of the study area is used as vineyard which can be explained as a result of the phylloxera plague of the years 1885-1890. (*Fig. 21.*)

A few peculiarities can be observed in the labelling of this map. Szentendre Island shows both previously used names, the Ros and Andre insel. Püspöki appears on the map at the area of the former Izbeg. Szent Kereszt and Szent Lélek appears for the first time on this map and Maros gets its attribute "Nagy" meaning as great or large.

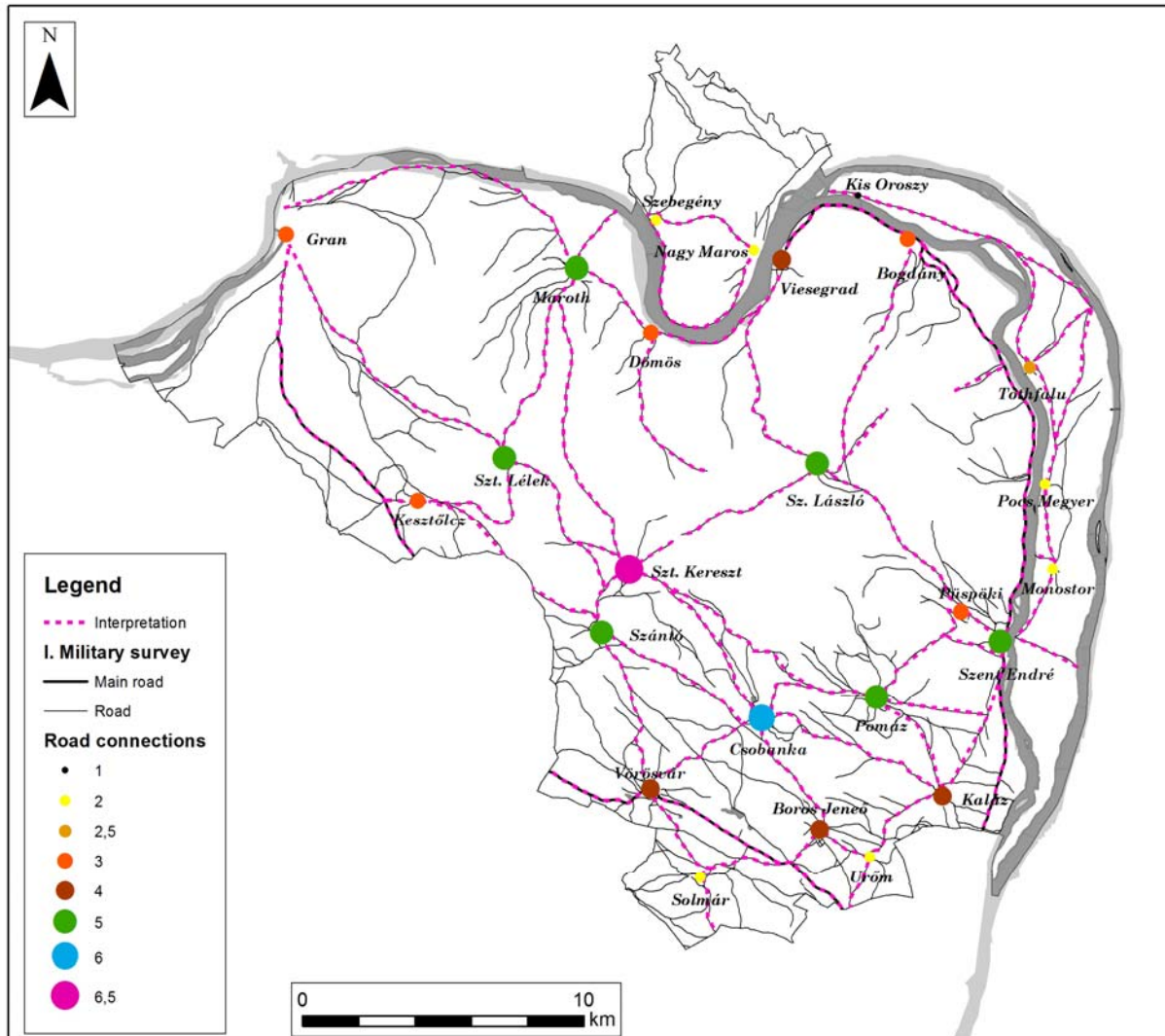


21. Landcover on the First Military Map

The First Military Map is the currently available eldest map, which is detailed enough to study the regional road network within the case study area. I found it useful to use this road system as a starting point in my analysis so I created a vectorised dataset from the roads. Only two roads are depicted with a wider, red line on the original map, which I signed here as 'main road'. One of these roads runs along the Danube bank from Esztergom via Dömös, Visegrád, Bogdány Szentendre in the direction of Óbuda. All these settlements are located to the river bank except Maróth which is located to the foot of the mountain, and the road follows its location. The other main road runs from Esztergom via Vörösvár further south also in the direction of Óbuda. Further roads, depicted with narrow black lines crisscross the area in different directions. Roads within the mountains run in the valleys or next to streams. Their shape and curve follow land forms, the arable lands and the boundaries of the vineyards. On the Szentendre Island 4 settlements are located in a row, right next to the river. One road connects all the four of them. There is one further point on the other side of the island to where roads run from every of the settlement. This point is the river crossing facing to the town of Vác, on the other side of the Danube.

On the basis of the vectorised road network I analysed the road system in between the settlements. First I created a generalized map which illustrates only the roads leading from one settlement to another. I used this as a generalization to find out how the roads are structured in

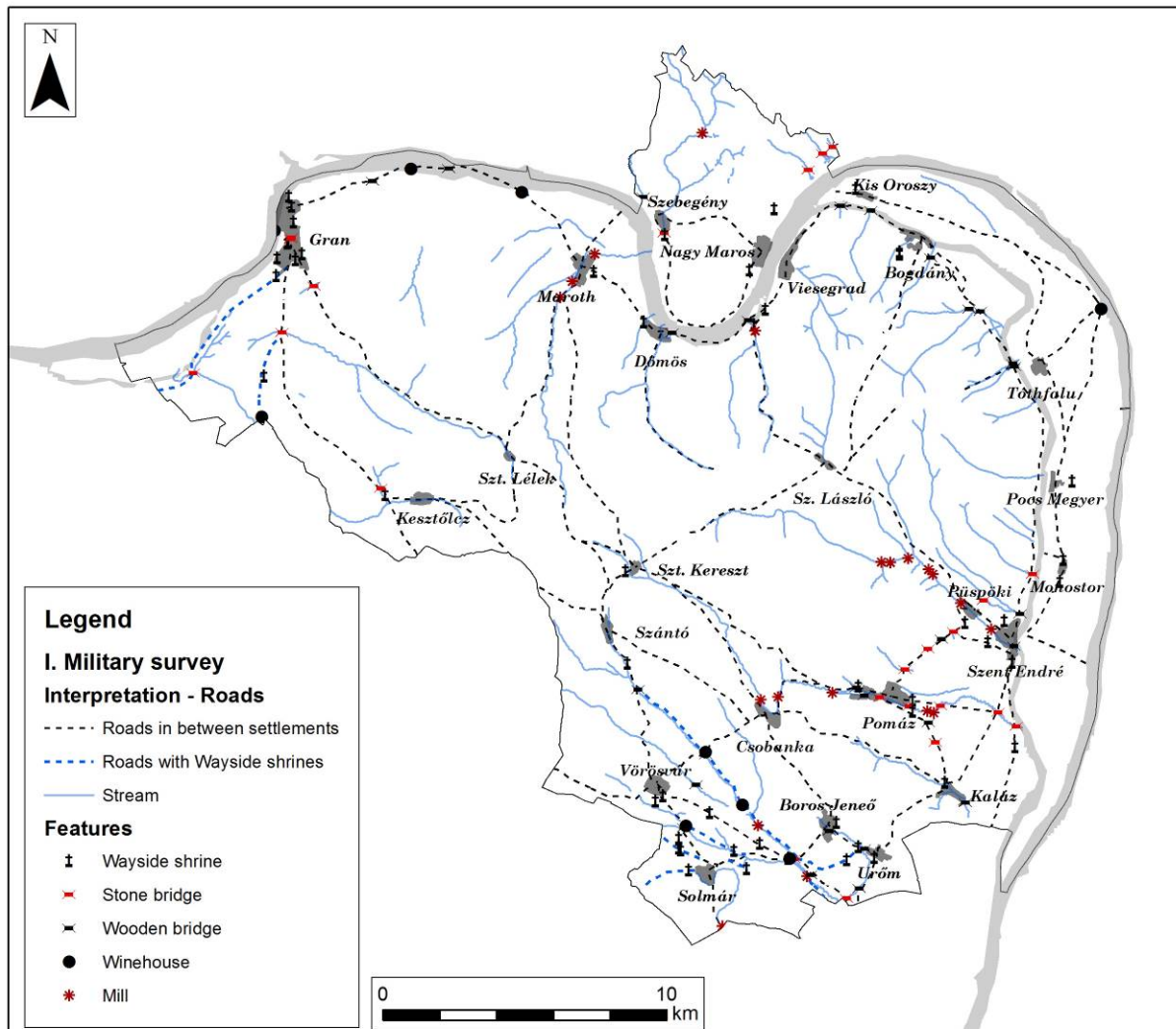
between the settlements. As a next step I created a list on the road connections between the settlements. For that I counted those roads which connect one settlement to another. Even though at the southern part of the settled area more roads and paths connected the same settlements crisscrossing the arable lands, I counted them as only one connection. I counted as half connection those roads, which were not depicted as connected directly to each other, but based on their location it is highly feasible that they were joint together.



22. Road connections in the area

The result of this analysis showed that interestingly it is Szt. Kereszt, in the heart of the mountain that had the largest number of connections, as it was directly reachable from 6 or 7 (if counting Dömös) other settlements. The other most reachable settlement was Csobánka, with 5 connections. This can be explained by its location in the middle of the lowland. The least connected settlements are those on the island. It should be noted however, that these are located on the periphery of the study area which further means that their connections lie outside the area. The most frequent number of connection is 5. (Fig. 22.)

As a third step in the road analysis I added point-like features as waypoints to the interpreted map. I illustrated the wayside crosses, the mills and the bridges as points. I further added the wine houses too as in many cases they were located to the junction of the roads.

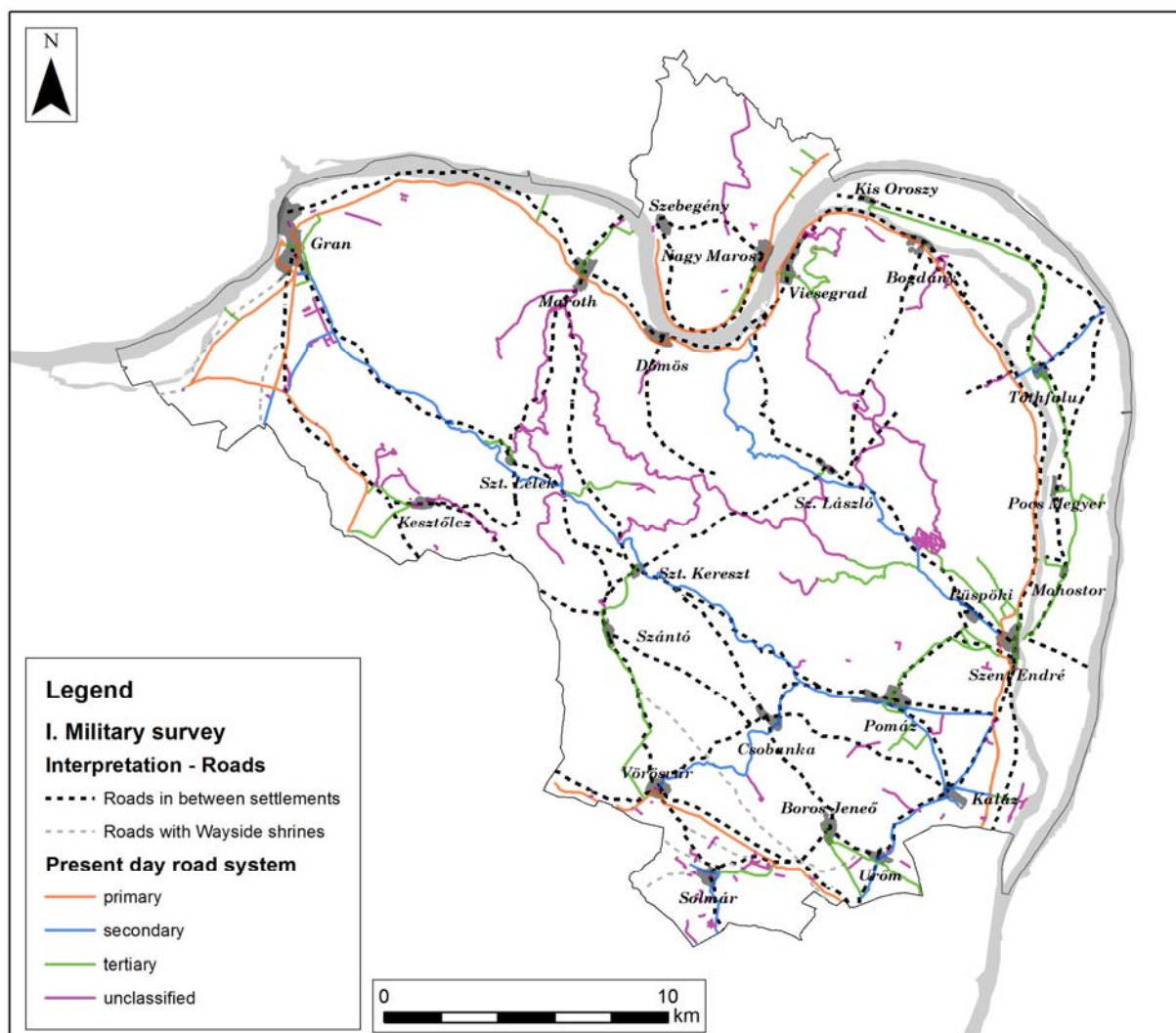


23. Road connections and waypoints

I observed differences in the distribution of these point-like structures. I found out that crosses can be found in the vicinity of all the settlements except Sz. László and Tóthfalu. Mills are located in large number around Püspöki/Izbég on the Bükkös-stream and in the vicinity of Pomáz and Csobánka on the Dera-stream. In the vicinity of Weindorf/Boros Jeneő however wine houses can be found in larger number. These waypoints helped me to recognize other frequently used roads. I compared the placement of the points with my interpretation of roads in which I found out that there are further 5 mayor roads which should be added to the interpreted road map. 4 of them however leading out from the case study area (2 from Esztergom, another 2 from Solymár) The 5th road however should have a special importance. This road departs from Szántó, half way between Vörösvár-Csobánka and Solmár-Borosjenő following a stream. In the valley here there were 3 wine houses depicted on the map, and mills, bridges were also located here. (Fig. 23.)

As a last step in my analysis I compared the interpreted road system of the I. Military map with the present day road network. This comparison showed notable similarities. The comparison shows that both of the main roads remained the main routes in the area (present day road Nr.10 and Nr.11). From the present day-secondary and tertiary routes the road from Esztergom to Pomáz should be mentioned via Szentlélek and Szentkereszt. This follows the same route as it was depicted on the I. Military map. The routes on Szentendre-island also follow the historical ones, including the one leaving from Tótfalu to the rivercrossing.

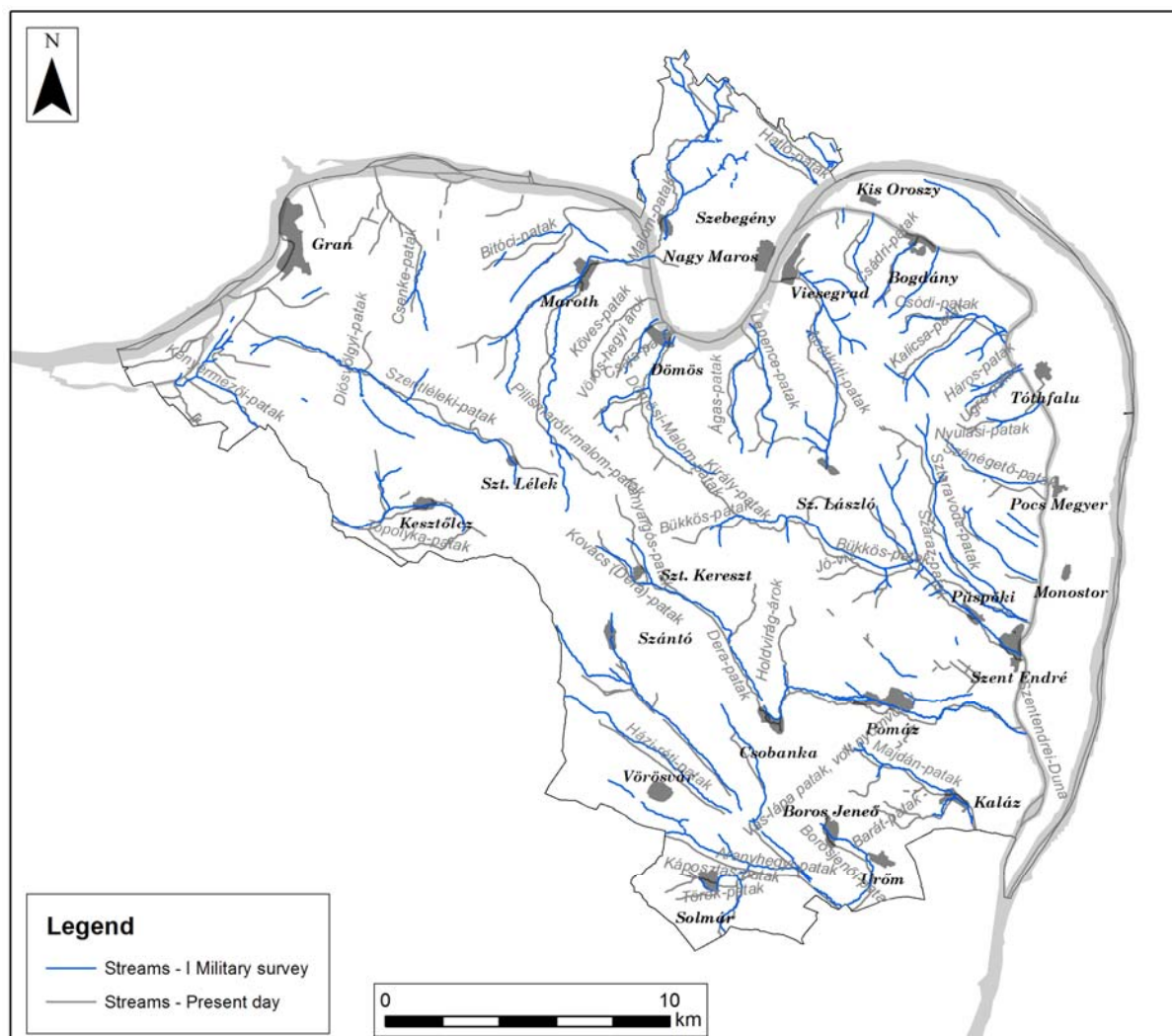
There are however further differences between the two states as well: a notable difference is that the original road between Szt. Kereszt and Sz. László seems to be not existing any longer but runs on different curve. The road system changed also in the vicinity of Csobánka. This might be explained however with the present extent of the settlements. (Fig. 24.)



24. Road system - a comparison

As a final comparison I studied the stream system depicted on the First Military Maps and compared it to the present-day streams. In this analysis I found out that the 18th century water system is fairly similar to that of the present-day. On the First Military Maps the streams were not labelled but this comparison enabled me to identify the depicted streams by their names. There are

discrepancies in the location of the streams of the present day map and on the First Military Maps. This can be originated from the measurements of the military maps on the one hand and from the inaccuracy of the georeferencing on the other. For this specific analysis however I found the discrepancies irrelevant as the streams can be unambiguously identified. (Fig. 25.)



25. Stream system - a comparison

To sum up I found useful the detailed analysis of the First Military Maps as it provided me the eldest historical information on the area. I accepted the elements depicted on the map as elements of the archaeological landscape and in my further research I used this as background map.

A further point should be mentioned here however, concerning the course of the Danube. According to the route of the main road on the north and the location of Maróth settlement it is highly feasible that the Danube changed its course at least at this certain point.

The last map I consulted in my research is the map of Joannes Lipszky, *Mappa generalis Hungariae partiumque adnexarum* from 1806.³⁷ Even though Lipszky contributed to the compilation of the first military maps, he did not use the measurements from that to his map. He used instead

³⁷ <https://maps.hungaricana.hu/en/MOLTerkeptar/4530/> (last accessed 2018-06-26)

the measurements from local surveyors and cartographers. As an appendix to his map he created a list of place-names with in total 20000 geographical names.³⁸ On his map the settlement names and their location are quite similar to the present day settlement network. A notable difference here is that Tahi is depicted as deserted settlement. Further two deserted settlements are depicted on the map: Kising and KisKovácsi. Izbég is still depicted as a standalone settlement (It only became part of Szentendre in the 1970's) In the vicinity of Esztergom, it depicts Szent György and Szent Tamás as also standalone settlements. This is the only map however where Leányfalu is signed, as praedium.

To conclude I used the historical maps in my analysis in two ways. I only used the First Military Maps directly within my GIS database. This dataset enabled me to create a layer with the presently known eldest state of the landscape elements. I tested the reliability of this dataset using present-day data. I used the other historical maps as comparative materials to study the naming of the settlements. In that I was able to identify the settlements depicted on the map of Lazar. I also highlighted those settlements which were depicted on the maps but which do not exist any longer. These settlements however were at some point also a part of the archaeological landscape of the study area.

To use the vectorised dataset as a base map for the analysis of the archaeological landscape I added data to the GIS project derived from textual and archaeological material. Below I summarize first how I inserted historical source data.

³⁸ Lipszky János: Repertorium locorum obectorumque in XII tabulis mappae regnorum Hungariae, Slavoniae, Croatiae et Confiniorum Militarium, Magni item Principatus Transylvaniae occurrentium (1808). <http://digitalia.lib.pte.hu/?p=2532> (last accessed 2018-06-26)

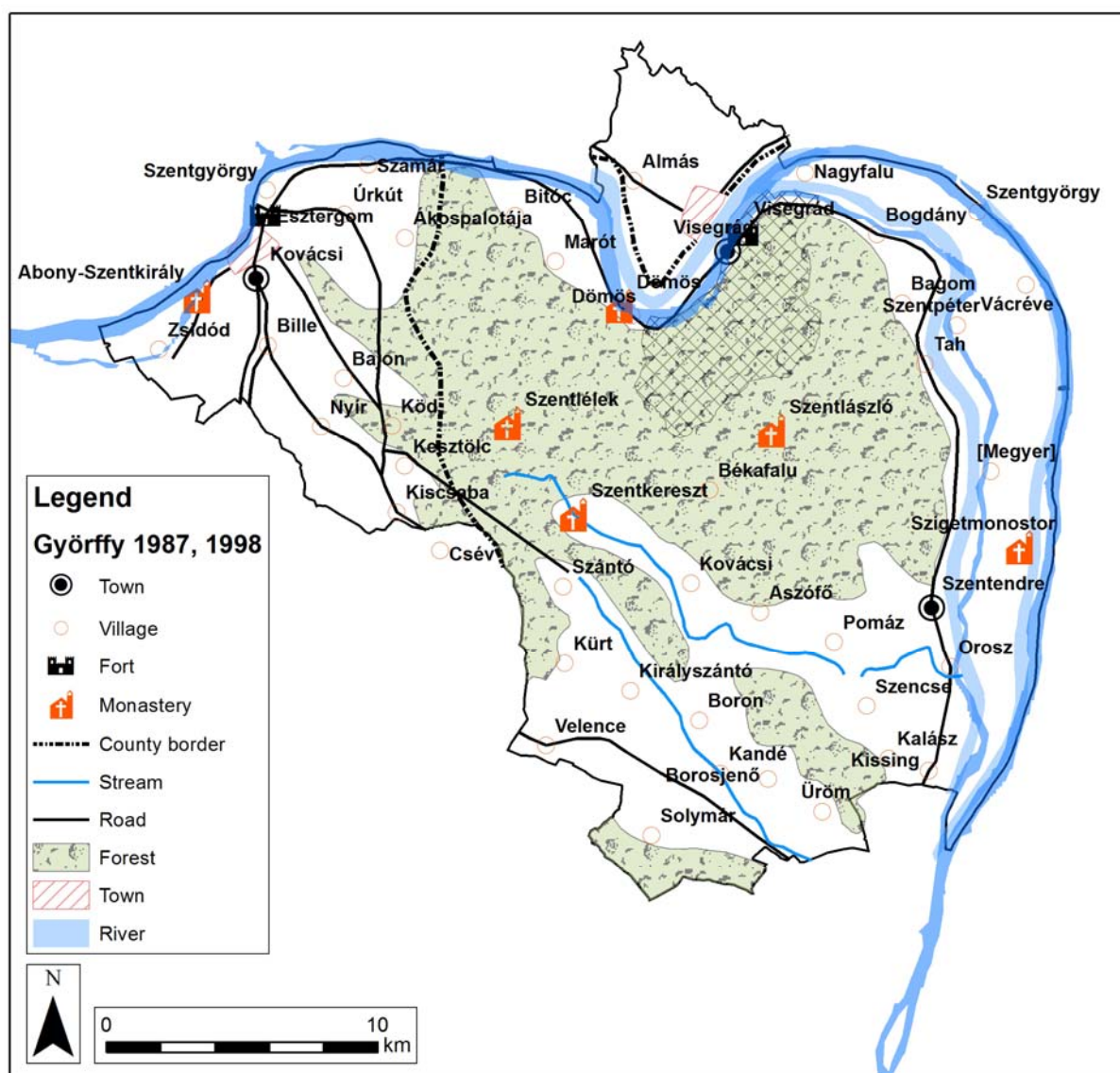
	<i>Lázár (1526)</i>	<i>Lazius (1575)</i>	<i>Mikoviny (1731)</i>	<i>Mikoviny (1737)</i>	<i>First Military Map (1763-1787)</i>	<i>Hell, Mikoviny (1790)</i>	<i>Lipszky(1806)</i>
Budakalász			Kalász	Kalász	Kaláz	Kalass	Kaláz
Csobánka			Csobánka	Csobánka	Cubánka vel Csobánka	Tschobanka	Csobánka
Dömös			Dömös	Dömös	Dömös	Dömösch	Dömös
Dunabogdány			Bogdány	Bogdány	Bogdány	Bogdány	Bogdány
Esztergom	Gran/Strigonia	Strigonium/Gran	Strigonium	Strigonium, Esztergom, Gran	Esztergom, Gran vel Ostrihom	Gran	Strigonium, Esztergom, Gran, Ostrihon
Kesztölc				Kesztölts	Kestölcz vel Kostelec		Kesztölcz
Kisoroszi			Oroszi	K. Oroszi	Kiss Oroszy	K. Orossy	K. Oroszi
Leányfalu							Prad. Leányfalu
Nagymaros	Maros		Maros	Maros	Nagy Maros	Marosch	N. Maros
Pilisborosjenő			Pr. Borosjenő	Weindorf	Weindorf, Boros Jeneő	Boroschjenő	Boros Jenő (Vendorf)
Pilismarót			Maróth	Maróth	Maroth		Maróth
Pilisvörösvár			Verösvár	Vöresvár	Vörösvár	W...röschvár	Veresvár
Pilisszántó	Zanto		Szántó	Szántó	Szántó	Sántó	Szántó
Pilisszentkereszt				Mola?	Szt. Kereszt		Sz. Kereszt
Pilisszentlászló			Sz. László	Sz. László	Sz. László		Sz. László
Pilisszentlélek					Szt. Lélek		Sz. Lélek
Pócsmegyer			Megyer	Megyer	Pocs Megyer	Megyer	Pócs Megyer
Pomáz			Pomász	Pomász	Pomáz		Pomáz
Solymár	Solmar	Salmar	Solmár	Solmár	Solmár		Solmár
Szentendre	Andre	S.Andre	Sz. Endre	S. Endre	Szent Endré vel S. Andre	S. Andre	Sz. Endre
Szigetmonostor			Monostor	Monostor	Monostor	Monoschtor	Monostor
Tahitófalu			Pr. Tahi	Tahi		Telki	Prad. Tahi
Tótfalu			Tótfalu	Tótfalu	Tóthfalu	T..tfalu	Tót falu
Üröm				Ierma	Uróm		Uröm
Visegrád	Visegrad	Plindenburg/Vissegrad	Visegrad	Visegrad	Vieseград vel Plintenburg	Wischegrad	Wissegrád
Zebegény					Szebegény	Zeb...ny	Zebegény
Szentendre-island		Visse insula		Ins. Ros.	Ros vel Andre Insel		Insula Szent Endre
			Pr. Várad	Várad			
				Mola			
			Pr. Sz. Péter	S. Péter			
				Izbek	? Püspöki		Izbék
					St. Georgenfeld	S. Győr	Sz. György (Esztergom)
			Pr. Kissing (Pomáz)				Pr. Kizing (Pomáz)
			Pr. Szempsz (Pomáz)				
							Sz. Tamás (Esztergom)
							Pr. K. Kovácsi (Pilisszentkereszt)

26. Place names on historical maps

V.4.3 Historical sources

To understand more the historical landscape of the Pilis region I consulted the historical topography collection of György Györffy. In his work Györffy collected and catalogued the Latin language charters issued in the Hungarian Kingdom until 1332/37. As a result of this life-long work he published 4 volumes of the historical geography of 40 counties. For the present research I used data from the second and the fourth volumes of his work. (Györffy 1987; Györffy 1998) The published volumes contain the list of settlements in an alphabetical order. For every settlement the author listed all the known charters in chronological order which mentioned the settlement. He also added an evaluation on the history of the places.

Besides the written documents Györffy also consulted the 18-19th century cadastral maps and the repertory of place names compiled by Lipszky and Pesty Frigyes along with archaeological data. (Györffy 1987, pp. 9-15.) Besides the descriptions of each and every mentioned settlement Györffy created maps on which he relocated them together with the elements of the landscape. He illustrated the waterways as rivers/streams/ditches and roads as national or regional roads. He invented a settlement hierarchy too, classifying settlements as towns/towns bordered with walls/market settlements/villages/farms. Furthermore he signed mines, earthen- and stone castles/keeps/palaces, bishoprics/monasteries and parishes on his map. From the Pilis case study area Györffy used a three-fold hierarchy between the settlements. He marked Esztergom and Maros as towns; Visegrád, Kovácsi and Szentendre as market settlements, while the other settlements as villages. (*Fig. 27.*)

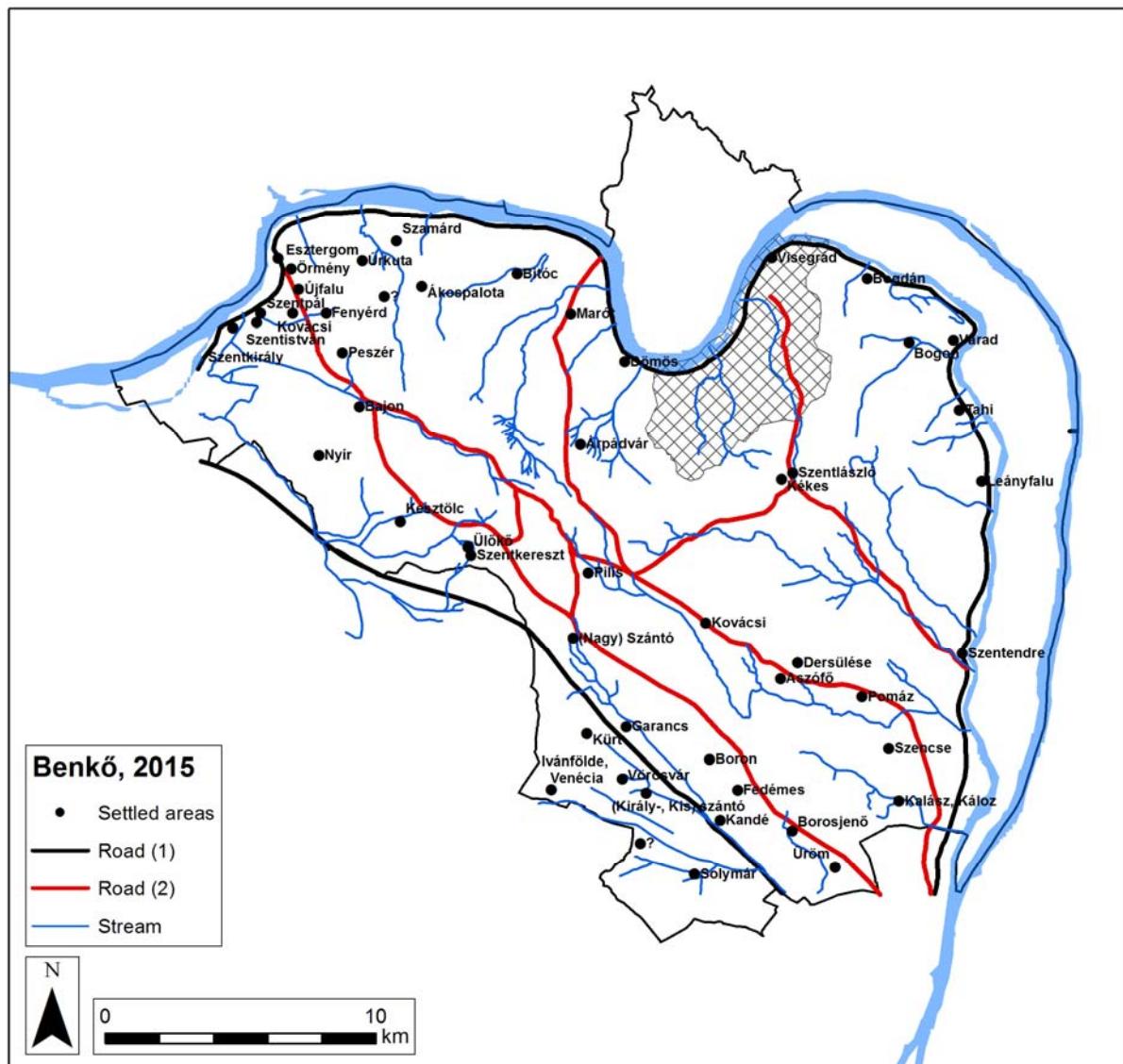


27. Pilis region reconstructed by Györfy

Lately, it was Péter Szabó who analysed more thoroughly the written sources of the study area. The main aim of his work was to study the forest of the Pilis, its woodland and tree types. In that he briefly discussed its settlement history too, including the places of religious and royal administrations. (Szabó 2005) In his work Szabó used the above presented collection of Györfy as a starting point and combined it with archaeological material. As his research material is similar to the present research I quote first those results which are relevant to the work of Györfy. Using the data from the written material Szabó created a chart on which he listed the existing settlements on a time line. He listed 37 settlements from the Pilis area and signed their first and last mentions. As a result of his investigations he found out, that his chart shows a settlement growth within the Pilis area. He also underlined however, that this might rather be a sign for the '*growing production and survival of charters*'. (Szabó 2005, Fig. 50., p. 106.) It is worthwhile to mention that the chart he was creating can be misleading in some ways. It is interesting for example, that Esztergom and Visegrád is completely missing from the chart even though the latter has at least one mention from 1009. It is

even more confusing that he allocated the same date to Szentendre referring to the village, mention in the donation charter.³⁹

Recently, the settlement system of the Pilis area was illustrated on a map by Elek Benkő in a book dedicated to various aspects of the *medium regni*. In compiling the map the author used the data from the volumes of the Archaeological Topography of Hungary and the collection of Györffy. Szentendre Island was also depicted, but left empty on this map. Nonetheless it is only Esztergom and Visegrád which were signed as towns or market towns. (Benkő 2015, Fig. 1.) (Fig. 28.)



28. Settlements and roads reconstructed by Benkő

I used the historical data as background information in my research. As in the above mentioned publications the settlements were already relocated I was able to use the published maps and include them into my GIS database. I also vectorised other landscape elements from the maps, like

³⁹ „[...] necnon in comitatu Vyssegradiensis civitatis villam unam sitam super Danubium, latere ex cuius dextro rivus, qui Apurig nuncupatur discurrit, [...]” (Györffy 1992, p. 52)

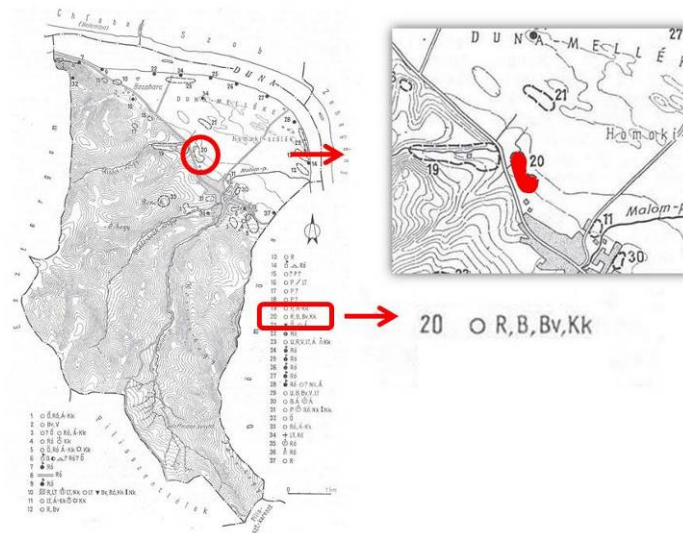
roads and the reconstructed extent of the forest. Written sources were thoroughly studied along with the compilation of the volumes of Archaeological Topography of Hungary too. As this work provides the core archaeological data for the present research I only inserted those sources to my GIS project which were quoted in the Archaeological Topography of Hungary. For these sources I created a table, in which I grouped them into two main contexts, '*secular* and *religious*'. With this categorization I was able to add those elements to my database which do not have known archaeological remains, like large number of former churches.

V.4.4 Archaeological data

The Visegrád complex is a subject of archaeological research since the 1940's. Previously I had the possibility to analyse various parts of the excavated material, the result of which I present briefly in this chapter. From a limited area magnetic and GPR measurement data is available for interpretation which I discuss together with the archaeological data.

To understand the Visegrád complex in connection with its close surroundings, I also consulted published archaeological material from the Pilis region. Large scale field surveys identified here a large number of sites during the compilation of the Archaeological Topography of Hungary (ATH), the data of which I studied thoroughly. The compilation of the ATH has long been one of the leading projects of the Institute of Archaeology of the Hungarian Academy of Sciences. The topography work started in 1964, when the methodological directions were laid down. The work based on the structured collection of the published archaeological materials, the unpublished collections of the regional museums and systematic and regular field surveys. Data collection also contained the evaluations of charters, the place names and historical maps of the area. As a result of this research project, 11 volumes have been published between the years 1964-2011, however it still covers only app. the 10% of the country area. Recently in 2017 a 12th volume of the series came to light in which several small scale topographical work were presented, underlining the importance and the need for the continuation of the work. (Benkő et al. 2017)

24 settlements of the Pilis area were discussed in Volume 5 (published in 1979), Volume 7 (published in 1986), and Volume 9 (published in 1993). Visegrád, unfortunately, is completely missing from this compilation. In total 601 archaeological sites were identified from the case study area. During the work a site meant an area where a concentration of archaeological remains was detected. The boundaries of the sites were determined based on their locations, independently from their dating or function. Therefore each listed site contained material from various periods and functions. This meaning of an archaeological site as a limited geographical area became standard in archaeological research. Data from the ATH furthermore provided the core for the archaeological site cadastre of Hungary. (Tolnai 2017) (*Fig. 29.*)



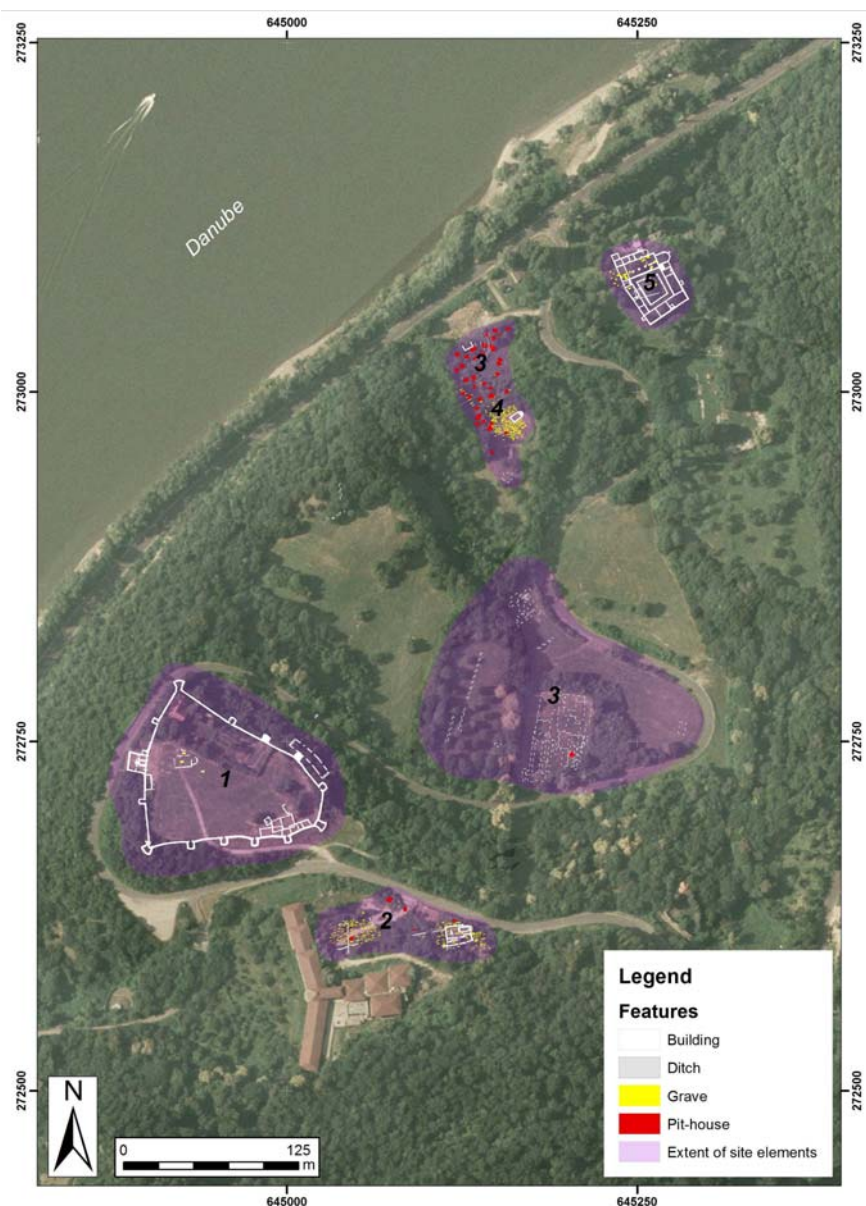
29. Example of sites in the Archaeological Topography of Hungary

In using ATH it was Péter Szabó, who combined the historical data with the archaeological material in connection with the case study area. As a result of his analysis he created two timelines, on which he supplemented the known settlements with their archaeological dating. He also created a timeline on which he illustrated those settlements which are only known from the ATH. As a conclusion to his work, Szabó illustrated the spatial distribution of the settlements with known names and those known from archaeological research. He however did not add any further elements to his map from the landscape. (Szabó 2005, Fig. 51, Fig 52.)

The formerly mentioned map published by Benkő bears less information on the archaeological sites, but shows more on the landscape in general. Even though this map was made also using the results of the ATH it only illustrates those settlements which have written mentions. From the landscape however it depicts roads, mines as well as fishponds and ramparts. As the archaeological material of the complex of Visegrád lacks from the ATH dataset I began my investigation with listing its elements. (Benkő 2015, Fig. 1.)

V.5 The early medieval complex of Visegrád

The complex of early medieval Visegrád includes different archaeological sites. The core of the complex is a fortification, built in the late 4th century A.D. and rebuilt around the 9th -11th century. At this period it became most probably the centre of the county of Visegrád, one of the earliest counties of the Hungarian Kingdom. The fortification is situated northeast from the present-day town of Visegrád at the area of the so-called Várkert (Castle-ground) at Sibrik-hill. Besides the fortification (1), other remains of the centre were also unearthed in this valley: a two-phased church with a cemetery (Archdeaconal church and cemetery - 2), a settlement (Várkert village - 3), a parish church with burials (Várkert parish church and cemetery - 4) and a monastery (St Andrew's monastery - 5). (Buzás 1999) (Fig. 30.)

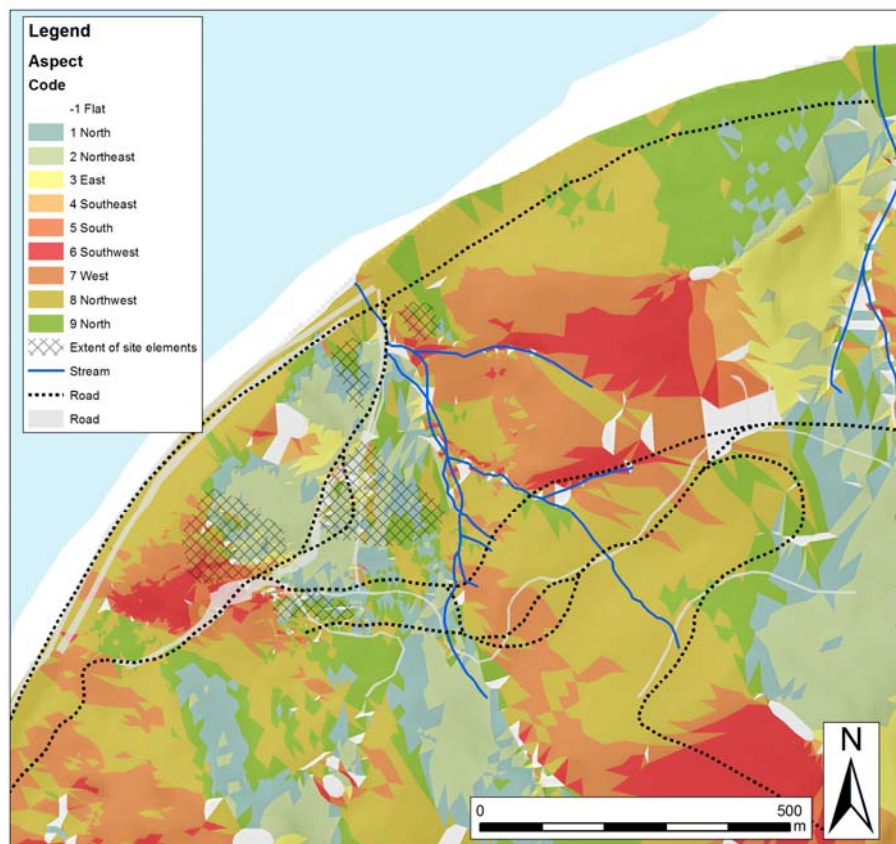


30. Elements of Visegrád complex

V.5.1 Topography of the complex

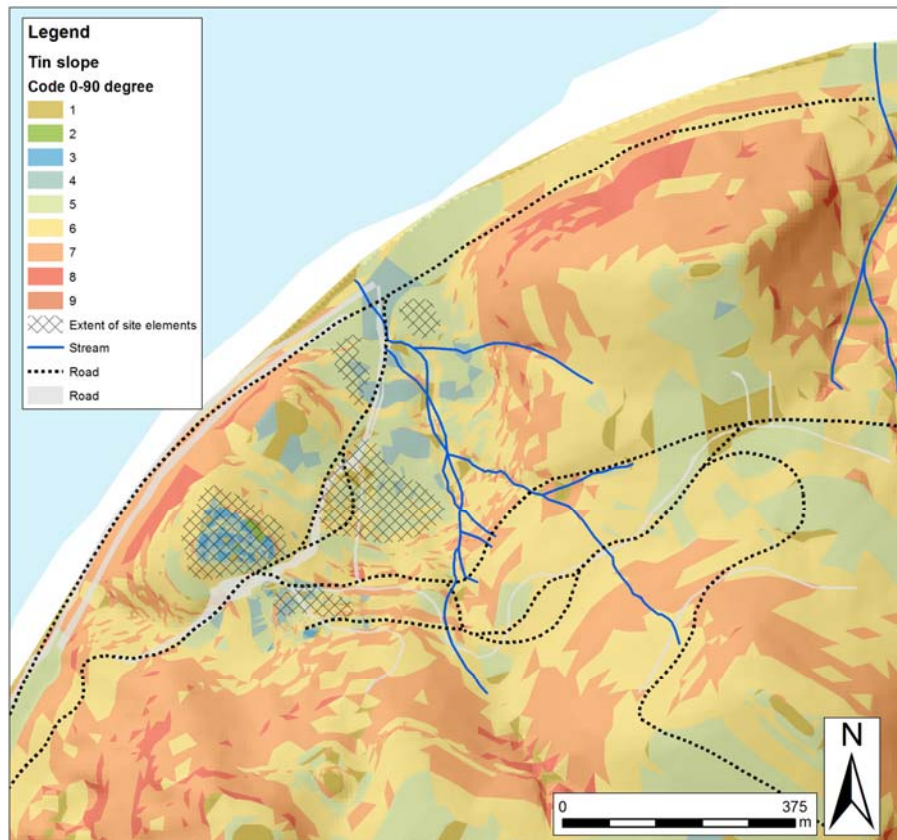
The early medieval complex of Visegrád occupies an app. 24 ha large area bounded by the river Danube and the feet of the Visegrád Mountain. It consists of two larger land formations, the Sibrik-hill, and at its slanting hillside, the Várkert-valley. Two peaks of the Visegrád Mountain are located in the vicinity of Sibrik-hill (Kisvillám 270 m, Nagyvillám 377 m). The area at present is covered by forest and open meadows. Earlier in the 19th century vineyards were here too. The present-day topography of the area is dominated by the Upper castle, located to the height of 328 m. The Matthias stream runs within the area east from the complex to the Danube dividing the area of the valley into two. The St Andrew's monastery and the northern part of the village is located to its eastern side, while the parish church, the bailiff's castle, the Archdeaconal church and the southern part of the settlement is located to its western side.

I consulted different maps and depictions to study the historical landscape elements of the area. First I created a detailed 3D map of the valley and the surrounding hills using the contour lines from the 1:10000 topographical maps. Then I generated a detailed elevation model using the digitized contour lines. The resulting 3D model presents clearly the height differences and the gullies on the hillside. (Fig. 31.)



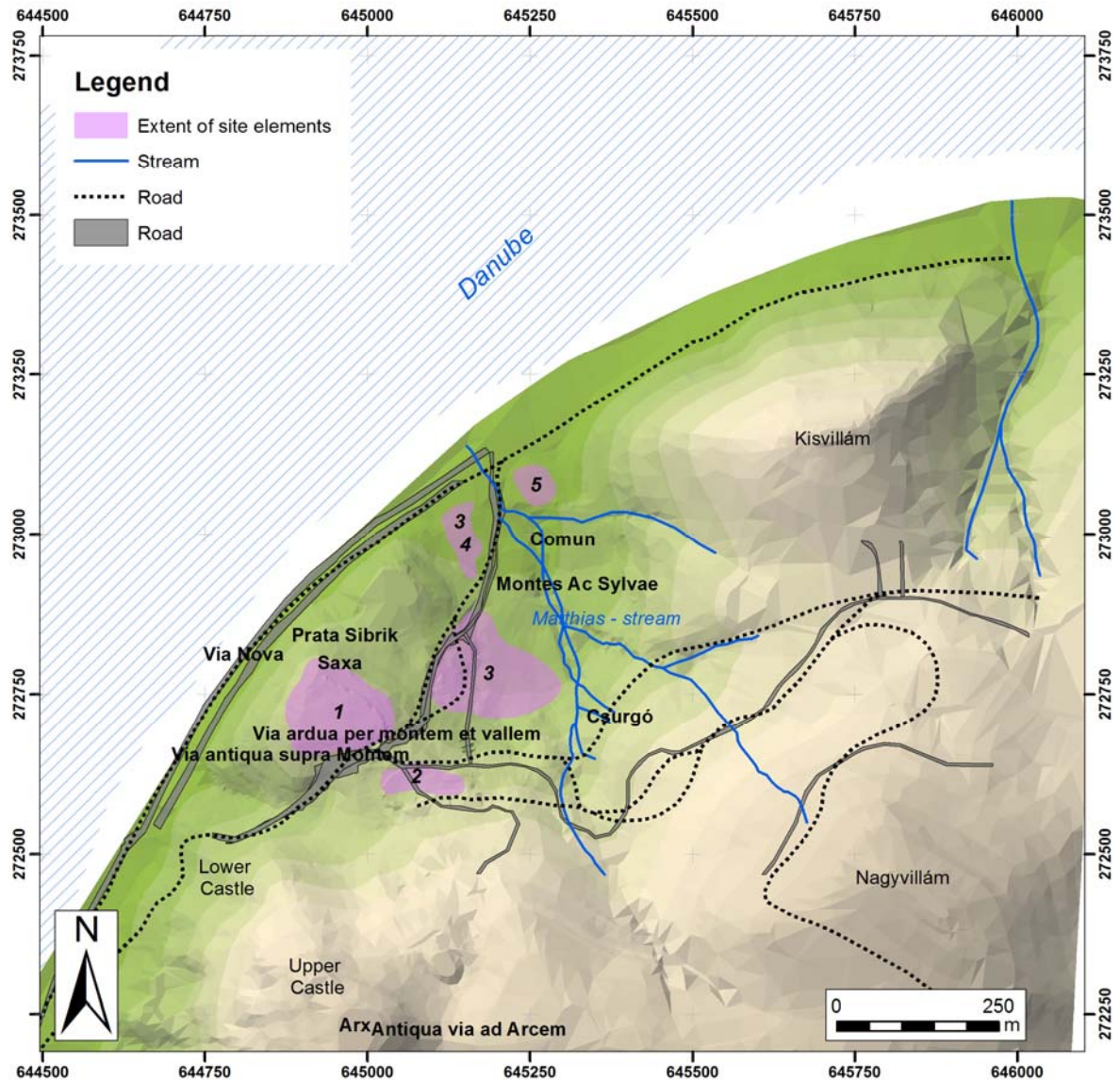
31. Aspect map of the Várkert valley

The 3D model was appropriate further in studying the slope and the aspect of the area. This illustrates well that the archaeological elements are mainly situated to the flat areas, with slope less than app. 10°. Interestingly the areas which belong to this category draw a U-shaped bay-like curve creating the Várkert-valley itself in between the sloping hillside. Presently known archaeological sites are located mostly to areas facing North-Northwest. (Fig. 32.)



32. Slope map of the Várkert valley

In the 1970's a new road was constructed in the area which had a huge impact on the former topography. Along the construction the layout of the earlier road system was extensively changed. To reveal the earlier state of the roads I consulted further 18th and early 20^h century maps. I used these maps in the GIS project as well. After georeferencing them I vectorised the course of the roads and the stream, as polyline and polygon features. I used the resulting layer together with the elevation modell as a background onto which the archaeological data can be added. (Fig. 33.)



33. Reconstructed topography and road system

The map of Karpe depicts the stream and a road which runs from the present day Solomon-tower to the river Danube. This road runs between the bailiff's castle and the Archdeaconal church on the southern part of the area and separates the village from the castle. At its northern endpoint, at the Danube, it joins to the course of the Matthias - stream and runs between the monastery and the northern part of the settlement. The road at the bank of the Danube is depicted on this map too.⁴⁰ The same road can be most probably seen on the map of Asboth from 1821.⁴¹ This map illustrates more clearly the road called *Via antiqua supra montem* which encircles the fortification from south. A notable observation can be made here: a part of this road runs within one arm of a Y-shaped gully.

40 National Archives of Hungary, S 11 No. 0207, *Visegrad domini*, Michael Karpe – Regio Cameralis ordinarius, n.d.

41 National Archives of Hungary, S12 DIV XIII No. 496, *Situationis Planum neo erectae Viae ... Wysegrad*, Michael Asboth – Jur. Geom., 1821.

The other road at the bank of the river is also depicted at the map, signed with the name *Via Nova*. The whole area is entitled as *Prata Sibrik* (Sibrik field). The presently known earliest map of the area is that of Antal Balla from 1777.⁴² Even though this map puts the emphasis on the area of the Upper castle, it still depicts the roads in question, calling the one on the hill as *Via ardua per montem et vallem* (The steep/high road across the mountain and the valley). It does not name the road at the river bank however. The map entitles the area of Sibrik as *Saxa* – rocks. The Y-shaped gully with the road in it can be also traced on the 19th century cadastral maps. It is also reflected in the boundary lines of the plots in the area. The upper parts of the gully's stems are connected with a straight, vertical line or path. This line can be traced on the cadastral map of the 19th century, as well as on the 20th century aerials, even though the exact dating of the feature is not known at present.

V.5.2 Written sources

As a next step in my analysis I consulted the written sources in connection with the early complex of Visegrád. The early complex is only known from two surviving documents. The first mention of Visegrád is in the donation charter of St. Stephan to the Bishopric of Veszprém from 1009.⁴³ The charter mentions the castle (*civitas*) of Visegrad and the surrounding county. In connection with Visegrád the source uses the term country, (in comitatu) and also mentions a village within the county (*villa*), which is situated to the right side of the Danube where a stream, called *Apurig* flows into the Danube. This village can possibly be located to the area of present-day town of Szentendre.⁴⁴ The source mentions other counties and lists different land use types as well: *meadows, vineyards, courtyards, buildings, fields, lands, cultivated or non-cultivated plough lands, fishing or hunting domains, waters and streams, mills, passable and impassable roads with or without 'exit/destination'*⁴⁵. It should be noted that, interestingly forest or forested area is not mentioned in the charter. It is a question whether the forests are missing intentionally or unintentionally.

The second mention of the early Visegrád complex is from the *Annales Posoniensis* from the year 1081. This source reports us, that as Ladislaus I. (1077-1095) had several conflicts with his contestant Solomon (1063-1074) - the son of Andrew I. (1046-1060) and Anastasia. In 1081 Ladislaus I. made Solomon confined in Visegrad. In 1083 Solomon was set free at the occasion of the canonization of

42 National Archives of Hungary, S12 DIV XIV No. 41, Delienatio angustias viarum ad ripam Danubii, circa coronale opidum Visegrad, ac reparationis ideam sistens, Antal Balla, 1777.

⁴³ *Proinde omnium Sancte Dei Ecclesie fidelium nostrorumque presencium scilicet ac futurorum noverit industria, quod nos anime nostre pro remedio quatuor civitates, nominibus Wesperen, in qua ipsius episcopatus sedes est constructa, atque Albam civitates, Colon et Vyssegrad civitates Sancti Mychaelis Wesprimiensi subicimus ecclesie cum omnibus ecclesiis, capellis atque titulis seu terminis et finibus.* (Györfy 1992, p. 52.)

⁴⁴ *[...] necnon in comitatu Vyssegradiensis civitatis villam unam sitam super Danubium, latere ex cuius dextro rivus, qui Apurig nuncupatur discurrit, [...]* (Györfy 1992, p. 52.)

⁴⁵ *cum omnibus utensibus iugiterque pertinentiis scilicet famulis familabusque, pratis, vineis, areis, edificiis, campis, terris, agris cultis et incultis, piscacionibus, venacionibus, aquis aquarumque decursibus, molendinis, viis inviis tam exitibus quam inexitibus, ut habeat omnium firmitatem perpetuam, sicut est donatum, possidendorum [...]* (Érszegi 2010)

Stephen I. He fled from here to the Pechenegs to the Lower Danube.⁴⁶ (Engel 2001, pp. 25-37.) From this it can be assumed that the early centre of Visegrád was in a state that it could accommodate a royal relative in custody.

The next turning point in the life of the complex was the time of the Mongol Invasion in the years 1241-1242. Neither written sources nor archaeological material provide direct evidence if conquering battles took place at the area of the complex but from the devastation of Esztergom it is probable that the Visegrád complex was also under threat. The construction of the Upper Castle in the vicinity of the complex refers however to the lack of the solid protecting system of the complex. In 1251 it was Queen Mary, the wife of King Béla IV (1235-1270), who, in 1259 ordered the building of a new castle on the higher, deserted hill of the Pilis forest.⁴⁷ From that time onwards, if the sources mention the castle of Visegrád, they refer to the new system of the Upper and Lower castle.

V.5.3 Archaeological remains of the Visegrád complex

The early complex of Visegrád consists of various sites. It includes a fortification, a two-phased church, a settlement with its parish church and a monastery. In my previous studies I had the possibility to study more deeply the excavated material from the fortification. (*Fig. 34., Fig. 35.*)

V.5.3.1 The Bailiff's castle

It was Flóris Rómer, the 'father' of Hungarian archaeology, who first recorded Roman remains at the Sibrik-hill. 52 coins were collected in 1941 from the site while the first excavations were started only in 1951 and 1952 by Sándor Soproni. The goal of Soproni was to find out the structure of the Roman remains but he also detected the early Arpadian-age reuse along the excavations. A new road construction motivated the next excavations in 1970-71, and 1974-77 led by Sándor Soproni and Mátyás Szőke. A rescue excavation was conducted in 1985. (Szőke2000) In 2009 a memorial was erected on the hill, the foundation of which was also researched. Research on the area got a new impetus in 2010, when geophysical measurements were done within the fortification area, showing remains of a church building. Excavations followed the measurements in 2013-2015 led by Gergely Buzás and Katalin Boruzs. The interpretation of the geophysical prospection data and the results of the excavations will be discussed below.

The 4th century fortification itself is a triangular shaped construction with 12 U-shaped towers. On its three corners 3 fan-shaped towers completed the construction. Its western sidewall was renewed two times: first an entrance was created than a square shaped tower was formed on the outer side of the walls. The walls were encircled with a triple-ditch, a *vallum*. Ditches were placed 6-23-33 m far from the walls. In the Roman period at least 4 buildings were attached to the inside wall of the fortification along with other pits and hearths. Besides the overall structure of the Roman

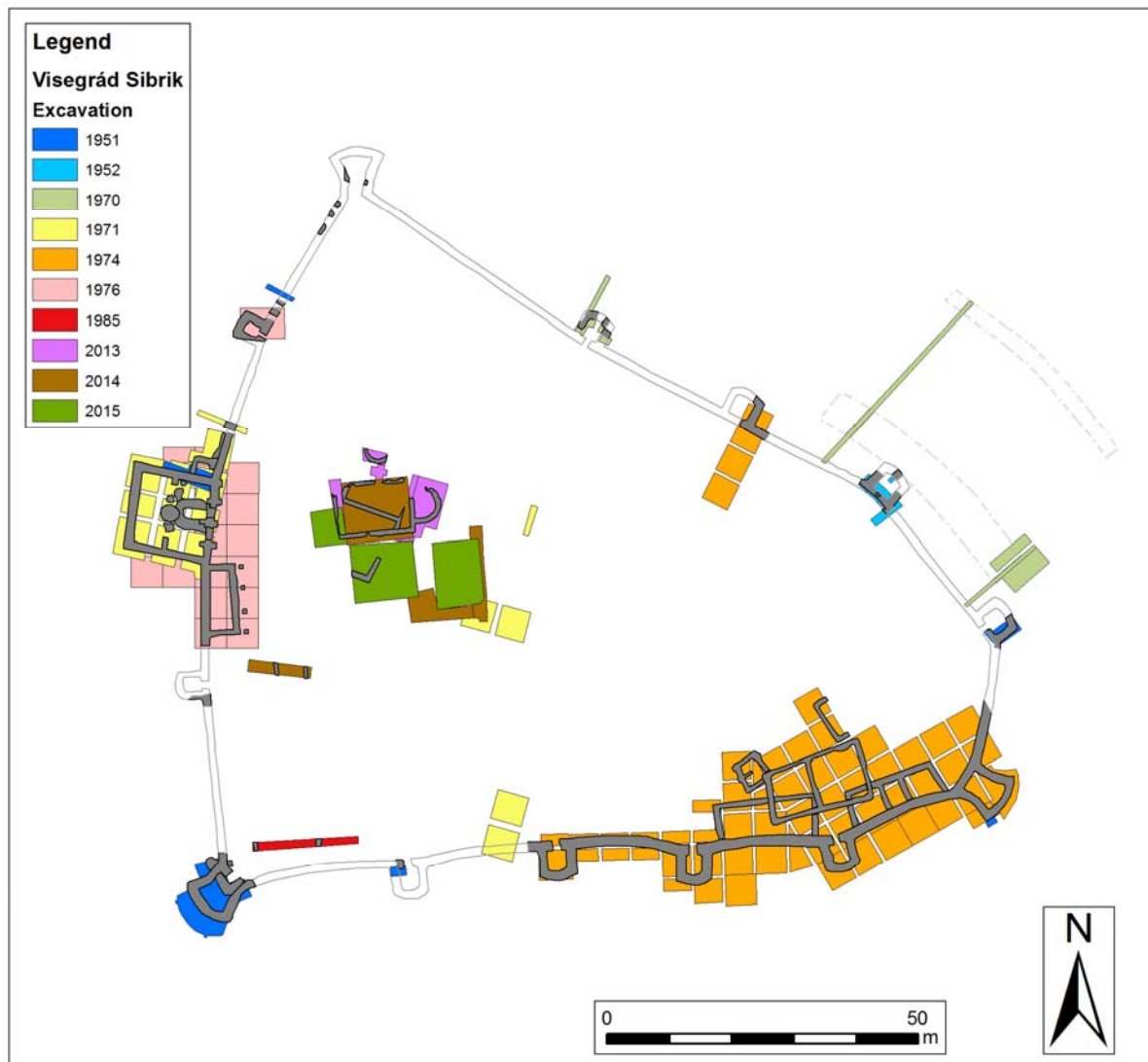
46 *Rex autem Ladizlaous deprehensio flagitio cepit Salomonem et in Vyssegrad retrusit in cacerem* (Szentpétery 1937-1938, p. 407)

47 [...] *desertum montem, in silva Pelys [...]* (Wenczel 1869-1874, p. 501)

fortification and the built elements on site, fibulae and belt fitting finds indicate owners from the military administration and confirm the dating of the site. After the Roman period Germanic inhabitants moved into the castle area, leaving remains of pit-houses as an imprint of the 5th century AD. Even though the excavations brought to light notable material from the 10-11th, material from periods between the 5th and 10th centuries were hard to identify.

My first encounter with the remains of the bailiff's castle was in 2007, when I analysed a part of the material as a master's thesis project. (Tolnai 2007) At that time I worked with the remains of the square-shaped tower, the rebuilt fan-shaped tower and the trenches on the outer side of the northern sidewall of the castle. Later I had the possibility to analyse more thoroughly the excavated material along with the fortification walls, the U-shaped towers and the inner structures in the vicinity of square-shaped tower. (Tolnai 2011) During my previous research I was not able to sort out any significant re-occupation of the area before the 10th century. Lately it was Szabina Merva, who identified signs from the late 8th – 9th century occupation within the fortification, suggesting the fortification was already in use and serve as a central place already that time. (Buzás 2015, p. 540.; Merva 2019, p.357)

In the 10-11th century a few transformations were made on the fortification; one of the fan-shaped towers was transformed to a rectangular-shaped one, most probably for a new entrance. The square-shaped tower was also renewed and transformed, creating a two roomed keep with a small additional tower. The inner area of the fortification was also transformed in two periods. First a square shaped building was erected in the south-eastern corner which was completely demolished later. At its place a two storey stone building was erected which was equipped with a stone hearth. Further signs of re-occupation were detected within the fortification walls and from the area of the vallum from where remains of pit-houses came to light.



34. Excavations at the fortification (until 2015)

Since 2016 excavations continue yearly on site. (Boruzs et al. 2018, Boruzs et al 2019) Even though the evaluation of the new discoveries goes beyond the limits of this thesis it is still possible to discuss the results partly. At present only short reports are available on these excavation, however, part of the ceramic material has already been discussed by Szabina Merva. (Merva 2018, Merva 2019). In her thesis Merva processed the ceramic remains as a result of which, she was able to classify the artefacts into 4 periods. According to her observation the material consisted of Roman (42,51%), end of 8th century/ 9th century (19,09%), 10-11th century (28,45%); and 12-13th century (9,95%) potsherds. Early types of ceramics also included some high class pottery remains as well as artefacts. (Merva 2018, p.169.) Even though this detailed ceramic analysis was only conducted on part of the whole material it still shed more light on the early life of the castle. This material helps to draw out more clearly the reoccupation of the site. It is getting more feasible that the castle was reoccupied already in the late 8th century, and maybe also served as a central place in that period. It should be noted however, that contemporaneous cemetery is not yet known from the area, therefore dating of the remains are

mainly based on the ceramic material. (Merva 2018, p. 204.) This evidence on this early use however shed new lights on the overall 9th century history of the area. New discoveries raise a new research question to be answered in the future, namely the role of the area in the 9th century, at the dawn of the Hungarian Conquest. As growing number of the evidence on the 9th century use of Visegrád came to light, but it is still a question how the fortification and the other part of the Pilis case study area was used and habited at that time. Most recently Béla Miklós Szőke published a monograph on the Karolingian Pannonia and especially on Mosaburg Zalavár. In this work, he describes the area as a part of Pannonia Inferior, having the Danube bend as its border area to the area of the Avar people. (Szőke 2019, p.167, Fig. 23/4.)



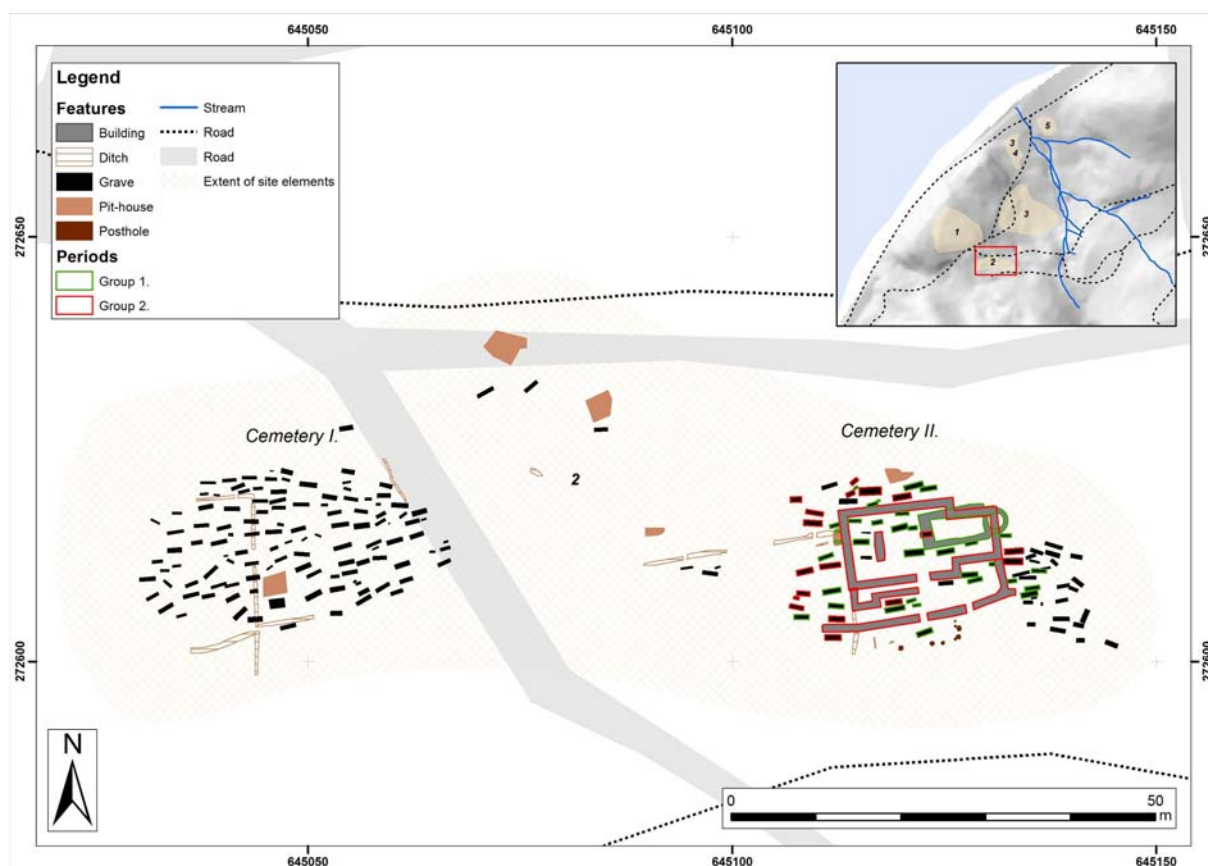
35. Aerial view of the fortification (2016)

V.5.3.2 Archdeaconal church and cemetery

In its close vicinity, southeast from the fortification a two-phased church - first probably a parish church and later an Archdeaconal church - was identified. Excavations began here in the 1950s at the area of the churches. Later, in the 1970s Mátyás Szőke conducted excavations in the area. The thorough examination of the results is available as an unpublished manuscript and a short report by Judit Kodolányi. (Kodolányi 2011, Kodolányi 2019) As a result of her investigations the architectural and chronological elements of the two churches were clarified. First, a small-sized church, probably a parish church, with a semi-circular chancel was built. The overall size of this building is around 10 x 4.4 m constructed from irregular stones plastered with clay. It was erected most probably around the turn of the 10th-11th century. After a while, most probably around 1070, the small church was completely demolished, only the base of the foundation remained. A new, larger church (18.35 x 9.4 m) with a square-shaped apse was constructed at the same place most probably not later than 1100. Later on the second church was altered too; a small tower was attached to it with stairs leading to the newly built upper storey. Furthermore an auxiliary building was attached to the southern part of the nave. The second church had a peculiar decoration scheme. Its outer side was covered with pure white plaster. The inside walls were richly decorated with frescoes. At a height of 1 meter, the legs of the walls were decorated with geometric motifs. Animal figures (tiger/lion attacking a roe deer, birds, fishes) and marble textured areas completed the decoration. Higher above, depictions of humans (male and female figures) decorated the walls in a style that shows eastern connections. Letters of inscriptions were also revealed within the remains. These frescoes bear special importance as they are among the earliest paintings of the Medieval Hungary. (Mecsi 2010) The stone decoration of the second church was also elaborate with highly decorated carved cushion capitals and stone carvings. The function of the second church is still a debated question, however; most commonly it is interpreted as an Archdeaconal church, a centre of the county's ecclesiastical unit. The second church became abandoned most probably by the 1st half of the 12th century.

Two cemeteries were revealed in connection with the churches from which in total 220 graves were excavated, dated to the Medieval period. Pit-houses were excavated in the area of the cemeteries, which were cut by the graves, thus belonging to the period preceding the cemeteries. Kodolányi created a detailed study of the graves based on their orientation, depth, stratigraphy and find material. Anthropological analyses of the deceased are also available for further research. (Susa & Pap 1986) According to Kodolányi's observations the two parts of the cemetery were most probably used in the same period in parallel with each other. As the area between the two parts have not been yet excavated it is highly feasible that there are more graves unearthed. *Cemetery I* is a row cemetery with a central group of the wealthiest graves. The development of *Cemetery II* is highly determined by the position of the churches. Graves associated with the first church were determined by their orientation and position within the graveyard systematically around the first church. Graves belonging to the second church belong to two different groups: the group located to

the eastern side of the chancel containing male burials including graves with ecclesiastic objects; and those located at the western wall of the building at the area of the auxiliary building with rich grave goods. (Kodolányi 2011, p. 59., Kodolányi 2018, pp. 12-14.) There are special burials within *Cemetery II* which signs the social status of the deceased. There is one, small sized (136 x 46-52 x 58 cm) stone built tomb within the 2nd church. The body was transposed from the tomb while only 3 pieces of phalanges bones (digital bones of the feet) and a patella (a kneecap) was found within, along with iron nails of the coffin and remains of an iron knife. (Kodolányi 2011, pp. 26-28.) According to the size of the tomb Kodolányi suggested that it might be a tomb for a child. This hypothesis was challenged lately by Gergely Buzás in the light of the results of the recent archaeological research. An emptied tomb was unearthed in 2013 within the fortification. Buzás suggested that the deceased was first transposed from the tomb in the fortification and then the remains were placed into the small-sized tomb within the second church. He suggested that as a third step, the same body was transposed again from the second church to another burial place into most probably to the own land of the family. (Buzás 2015, pp. 595-596., Kodolányi 2018 p. 14.) Transposition of the deceased was discovered in other cases as well. In two cases the disposal can be connected to the construction of the second church, but 4 graves (including the stone built tomb mentioned above) were completely emptied and the remains most probably were transferred to another churchyard. Rich grave material further refers to the special role of the population using the cemetery. Three graves contained golden rings (two female and a male burial) which - due to the rarity in the contemporaneous burials - implies the high social status of the deceased. (Kodolányi 2011, pp. 26-35.) Two graves contained objects which refer to ecclesiastical activities. A grave of an adult man contained an iron belt, identified as penitential belt. Another grave contained a chalice and a pater implying that the deceased was an ecclesiastic. (Kodolányi 2011, p. 44) (*Fig. 36.*)



36. Archdeaconal church and the cemeteries

V.5.3.3 Várkert settlement

Besides the fortification and the above presented churches a settlement belonged also to the complex located to the foot of the Várkert-valley, close to the Danube bank. Habitants of settlement most probably served the castle and the monastery nearby. First systematic excavations were conducted at the settlement area by István Méri in 1955. Further excavations were led in 1962-63 and in 1980-81. The field seasons in 1983-84 were led by Júlia Kovalovszky while since 1994, Péter Gróf and Daniel Gróh headed the excavations. (Kovalovszky 2001, p. 81.) Until present almost 4000m² of the valley area was researched from where Roman and Middle age structures came to light. The medieval settlement had a southern and a northern part. None of the settlement parts is systematically published, only short reports with partial excavation plans were presented. At the northern part of the settlement the average size of the houses were 2,5-3 x 2,8-4 m. In two dwellings the excavator observed wooden cover inside the pit belonging most probably to the former side walls. In some cases stairs leading into the pits were also observed on their southern or eastern side. Every pit-house was equipped with stone oven and some of them were identified as workshops for iron producing and bronze melting. The excavator suggested that there were most probably timber frame buildings too within the settlement, standing right on the surface. Ditches were not identified in between the dwellings. The southern part of the settlement is still under investigation where excavation trenches are opened almost yearly. In the last decade at least 9 dwellings were dug up along with other features like ditches, hearths and a lime-kiln from an app. 1500 m² large area.

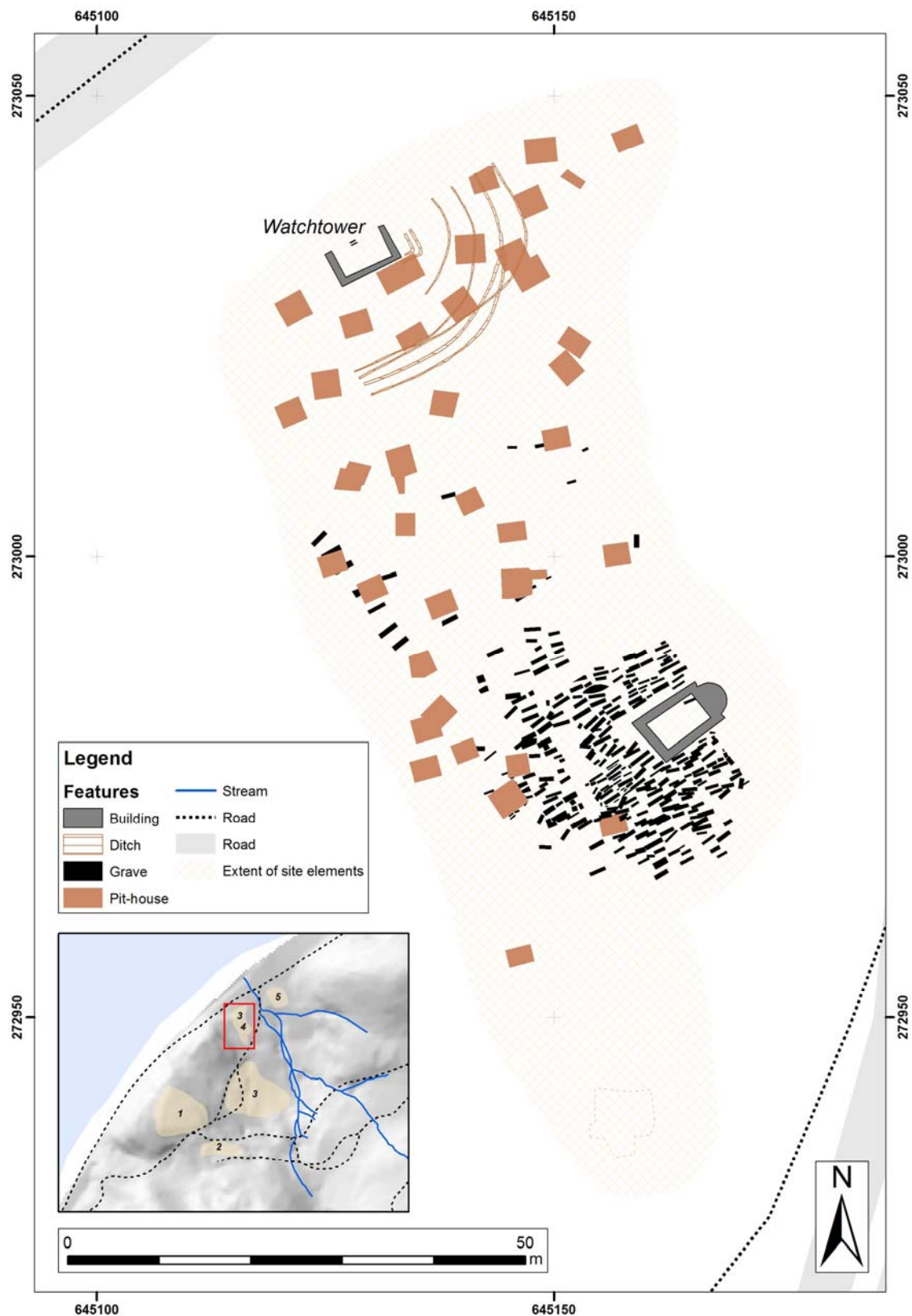
From the overall topography of the area it seems that – based on the now available information – the settlement was located on the western side of the stream, while the road '*Via antiqua*' ran within the settlement. Furthermore the dating of the dwellings is also debatable. Based on the find material it is feasible, that the northern part of the settlement was already in use in the 9th century, while the dwellings further south are from later periods. It is feasible that this settlement part remained in use after the Tatar invasion as well. (Gróf 2001, Gróf 2012a, Gróf 2012b)

Detailed analysis of the ceramic remains along with the pit house types were conducted recently by Szabina Merva. (Merva 2018, Merva 2019). In her thesis research Merva challenged the chronology of the site. With detailed observations on the ceramic remains, she was able to separate two periods within the settlement. She dated the first, earlier horizon to the end of 8th - beginning of 9th century. With the analysis of the house types and the objects, she assumed that the community inhabited here in the first horizon was rather lived on agriculture (Merva 2018, p.114) This settlement consisted mainly of 11 dwellings, which served habitation for app. 50/80 people. The second phase, dated to the 2nd half of the 10th century, seemed rather to be a settlement of craftsmen and habited by app 110/150 people in 21 buildings and 5 workshops. (Merva 2018, p. 386.)

A parish church with a churchyard belonged as well to the settlement. The small church building had a single trapezoidal nave and semi-circular sanctuary. The inner area of the church was 4,5 x 5,5 m, with 110 cm wide walls. The walls were most probably decorated with frescoes while the building was equipped with a *terrazzo* floor. There was only one grave within the church area but without any grave goods. This grave was not contemporaneous with the use of the church however, as it was dug into the church only after its collapse or when it was already in ruins. 463 graves of a multi-phased cemetery were excavated around the church. S-ended hair rings, simple rings and beads came to light from the graves along with silver coins. The use of the cemetery was dated to the 10-13th century by the excavators. (Kovalovszki 1986, pp. 61-63.) Coffins were used frequently in the cemetery and some cases large flat stones were laid also on the graves. In one case (grave Nr.362) a 2,60 m large boat was identified, used as coffin. In further cases iron clips of boat constructions were detected referring to more boat burials. Further information is not yet available on the boat burials but different suggestions have already been raised on their meaning. It is a notable question whether the buried boats were used in everyday activities or were built for the burial. The boat from grave Nr. 362 however was probably too small for using it on the Danube while its size and shape resembles to those boats used for burials at the Scandinavian areas. It is further a question whether the use of a boat refers to an ethnicity or rather to an occupation. According to the excavator it is rather an honour to a fisherman why boats were used as burials. (Kovalovszki 1994b)

The chronological sequence between the parish church and the cemetery and the Várkert settlement is still questionable, but it seems that the position of the dwellings does not align with the

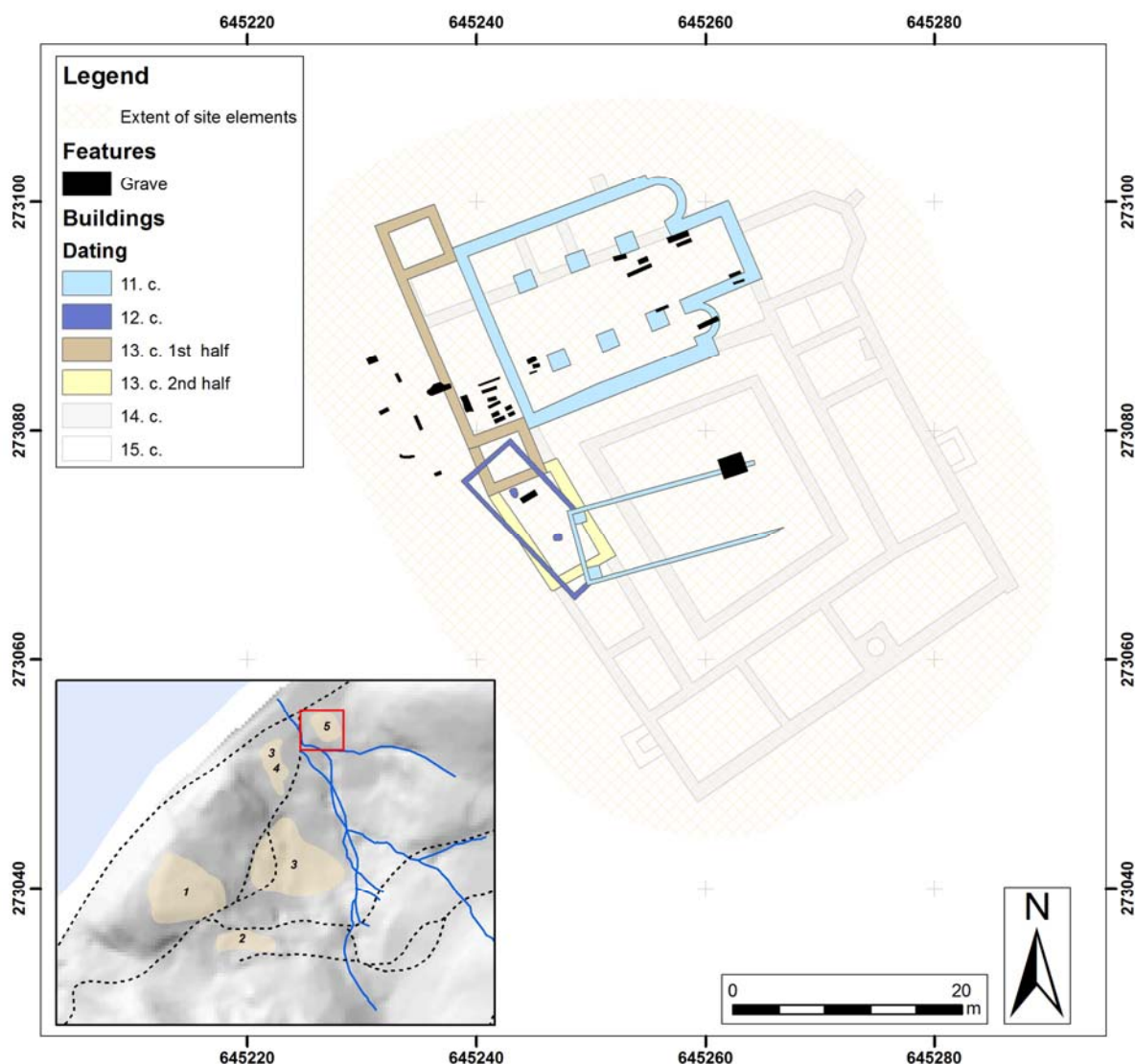
orientation of the church or the graves. The eldest pit-houses however do not cut the graves of the cemetery. (Kovalovszki 1995, p. 74.) (Fig. 37.)



37. Parish church and the cemetery

V.5.3.4 Saint Andrew's monastery

A peculiar element of the early complex, the St Andrew's monastery is located to the foot of the Várkert–valley. It was founded by Andrew I. (1047-1060) and was in continuous use until 1544. First excavations at the site were led in 1890-1895 when the remaining walls were still significant. Small scale excavations were led by Mátyás Szőke in 1986, and systematic excavations were carried out by Gergely Buzás in the years 2001-2003. During these excavations an 11th century pit came also to light under the wall of a church building. The size of the three aisled church building is 16,5 x 22,35 m. The middle nave is square shaped most probably with straight sanctuary but with semi-circular closing on the two side-aisles. The decoration of the fragmented cushion capitals are similar in style to fragments found at the Archdeaconal church. The stylistic similarities are strongly connected therefore it is possible that both of them were made by the same stonemason or at least in the same workshop. Besides the church another building, a *trapeza* or refectory was also identified. It is a rectangular building, 6,5 x 15,5 m large in size, built of wooden logs.



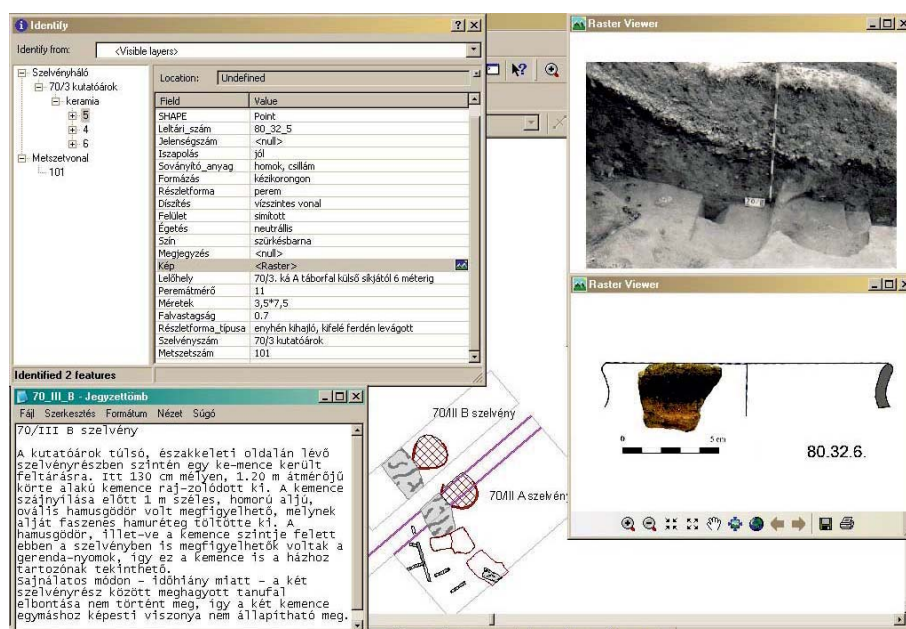
38. Saint Andrew's monastery

The monastery was first used by Greek monks or monks who followed a Greco-Byzantine ritual. The plan and the ornamentation of the monastery show strong connections with other contemporary Hungarian and north Adriatic structures. Andrew I. (1047-1060) married the daughter of Yaroslav I. the Grand Prince of Rus (1019-1054), Anastacia, in 1037/1038. Most probably it is also her influence that monks of Byzantine rites arrived to the Kingdom. In 1221 the monastery was conveyed to the Benedictines. The buildings were most probably damaged during the Tatar invasion and needed renovation most probably in parallel to the construction of the Upper Castle. The church building was renewed while the *trapeza* was demolished and another stone house was built instead. Further on the monastery remained in use until the 16th century. Around 1333, the elder church building was completely demolished and a new monastery was erected with a single-aisle church, a polygonal sanctuary and the cloister. In 1493 the monastery was conveyed to the Pauline order and become desolated after 1544. (Buzás & Eszes 2012) (*Fig. 38.*)

V.5.4 GIS-project of the Visegrád complex

Above I presented briefly the archaeological elements of the Visegrád complex. As the different elements were considered previously as different sites the methods of excavations and documentation differ highly from each other. To get an overall image on the archaeological elements of the area I collected published and unpublished excavation plans and descriptions and inserted them into the GIS project. I have laid down the basis of the GIS project of the Visegrád complex in 2007. (Tolnai 2008, Tolnai 2009) My initial aim in using GIS was to store information on the fortification. Even though the area was seemingly not large (the size of the fortification is 114x130 m), the information was quite sporadic. Several trenches were opened at different areas of the fortifications by different excavators. Excavation plans and excavation diaries written on a daily bases were available along with cross-section drawings and depth measurements from different periods. Fortunately the 1970's excavations involved land surveyors who made systematic measurements at the site. As these measurements were conducted in local system my first task was to find a joining point in between the excavation plans and the present terrain. The stone remains, unearthed during the 1970's excavations were rebuilt as parts of on-site outdoor archaeological exhibition area. With the help of my colleagues we measured the present location of the walls which I joined as a next step to the digitized excavation materials. The overall accuracy of the re-positioning of the drawings was app. 30 cm, which I accepted along the evaluation process. The inaccuracy was detectable only in the location of the features, not in their size or proportion. As an overall map was available for the location of all the trenches, and the drawings matched to this net, the georeferencing of the images did not show distortion in any direction. I also included artefactual data into the analysis. With the help of ArcGIS the vectorised archaeological features were joined with the description and drawings/photos of potsherds. Data on potsherds was stored in a separate MS Access database and

were joined together via the identification number of the artefacts. This solution worked nicely for displaying ceramic data one-by-one. (Fig. 39.) A problematic point was to model the 3 dimensionality of features. Depth information was added to the features while cross-section drawings were digitized as different data layer, for a visual representation.



39. GIS project Visegrád-Sibrik (2007)

At the present research I opened further up the initial GIS project, joining in material from other sites of the Visegrád complex. In these cases I found out that the accuracy of the georeferencing and therefore the reliability of the data varied site to site. Excavation plans of the Archdeaconal church and the corresponding cemeteries correlated directly to the plan of the fortification. In the georeferencing process I used excavation plans. A base map, created in 1974⁴⁸ depicted the trenches on the Eastern side. Here a net system was used which I managed to join to the plan of the fortification. Re-location of the cemetery plan was more problematic. Here the position of the trenches was signed only relatively to a road. This road however was rebuilt in total and until present no map was available showing its original position. Recently however aerial photographs from the 1950-1970's became available online. An aerial taken in 1966⁴⁹ shows the exact curved road depicted on the map. (Fig. 40.) This aerial helped me to join in the western excavated area to the project in an accuracy of app. 25 cm. This inaccuracy however distorts the map via the transformation. Even though the distortion is acceptable in the overall location of the cemetery, it is not sufficient for detailed measurements. To avoid creating unreliable data, I did not vectorise completely the grave drawings; instead, I only signed their positions with rectangles. With this solution I was able to generate a layer on which the graves can be identified and onto which their further descriptions can

⁴⁸ Visegrád – Sibrik domb római castrum, várispánság központ és XI.-i sz-i temető 1974 XII.

⁴⁹ www.fentrol.hu : 1966_0683_0138.tif

be joined. Their size and measurements however should be taken from the original drawings and descriptions.



40. Aerial photo from 1966

In the case of the southern part of the settlement only the extent and the location of the trenches were available for me, provided by Péter Gróf. From these areas detailed plans with the excavated trenches are not available in published format. Furthermore the plans of those dwellings or workshops which were published separately were not published with plans showing their location. Therefore the compilation of a general site plan for this part of the settlement is still a task for the future.

Only brief reports were published on the parish church and its cemeteries by the excavator, Júlia Kovalovszki who, most regrettably, passed away in 2014. As processing the legacy of her life-long research will involve a number of researchers I was only able to insert to the GIS project data which was published by her in 1986 and in 1994. (Kovalovszki 1986, Excavation plan; Kovalovszki 1994a, Fig. 1.) The cited figures show the plan of the excavation. The problem with these base maps was that in their published form they did not contain any information on the exact location of the trenches. A base map was created by György Sándorfi in 1980 on which he illustrated the area of the excavations of 1979 and 1980. Terrain points however were not sufficient enough for the georeferencing. The solution came again from the previously mentioned aerals. An aerial photo was taken in 1988, when the location of the trench 1979 and the curved ditches from the 1980 excavations were traceable as

cropmarks.⁵⁰ (Fig. 41.) After georeferencing the aerial photo, I was able to match it with the plan of Sándorfi with an accuracy of app. 40 cm (measured at the buildings and the on road as control points). Sándorfi also depicted the boundaries of the parcels around the excavations which were also traceable on the plan published in 1986, therefore, I was able to join the two maps together.



41. Aerial photo from 1988

The curved ditches served as control lines for the georeferencing. In total I was able to achieve an app. 60 cm accuracy within the georeferencing. At present this accuracy of features are not sufficient for taking measurements (i.e. area or perimeter) however their positioning and spatial locations are sufficient enough for future work. Therefore I followed the same methodology as at the Archdeaconal church: I used generalization in the digitization, and vectorised the graves and pit-houses into rectangles. Features of the St. Andrew's monastery were treated differently. Even though here the excavations were led with the assistance of surveyors the general plan of the excavations were created in local system, so I needed to georeference this too. For that I used the present-day cadastral map and the general plan and determined control points in between the two. The general plan stemmed from the publication of Buzás & Eszes 2012, Fig. 4. As this general plan rather put the emphasis on the buildings instead of any other feature (like pit-house, ditches or grave) these are hardly identifiable. Graves therefore were added similarly to the other areas, as rectangles. As a result of this work I created a complex project which contains data on all the

⁵⁰ www.fentrol.hu : 1988_011_2368.tif

elements of the complex. The GIS project provides a common platform for various data from the different elements as well as for future results.

V.5.5 New discoveries – the prospection data

In the recent years only small scale excavations were led in the area of the settlements while the other elements of the complex were not subjects of research. The research on the fortification became more vivid following the geophysical measurements in 2010 the result of which were connected directly to the GIS project.

V.5.5.1 Geophysical measurements and the identified features

Magnetics and ground penetrating radar measurements were conducted by Archeo Prospections® under the leadership of Sirri Seren (Zentralanstalt für Meteorologie und Geodynamik) within the context of the collaboration between Dr. Falko Daim (Römisch-Germanisches Zentralmuseum, Mainz) and Dr. István Feld (Eötvös Loránd University, Faculty of Humanities, Institute of Archaeology) on the project of *Römisch-Germanisches Zentralmuseum* entitled *“Reiterkrieger-Burgenbauer. Die frühen Ungarn und das Deutsche Reich vom 9. bis zum 11. Jahrhundert.”* Magnetic measurements were carried out with a Foerster system. GPR measurements were conducted with 25 cm in-line spacing with Pulse Ekkor Pro system, using 250MHz and 500MHz antennas covering an app. 4000m². Due to heavy raining prior to the measurements the area was rather wet, but the measurements still revealed new buildings within the inner area. Positioning of the measurements followed the Hungarian projection joined directly to the GIS project.

Depth slices of the GPR were created on different width and depth levels. 5 cm width depth slices were created until the depth of 2 m below the present surface. Furthermore 10-20-30-40-50 cm width depth slices were also created until 2 m. In the interpretation of the time slices I used the Raster Mosaic tool of the Archaeo Analyst GIS extension developed by the LBI ArchPro. Features appeared on the radargrams from app. 50 cm below the present surface and disappeared in a depth of app. 150 cm depth.

Contemporary features (Fig. 42.)

Path (a)

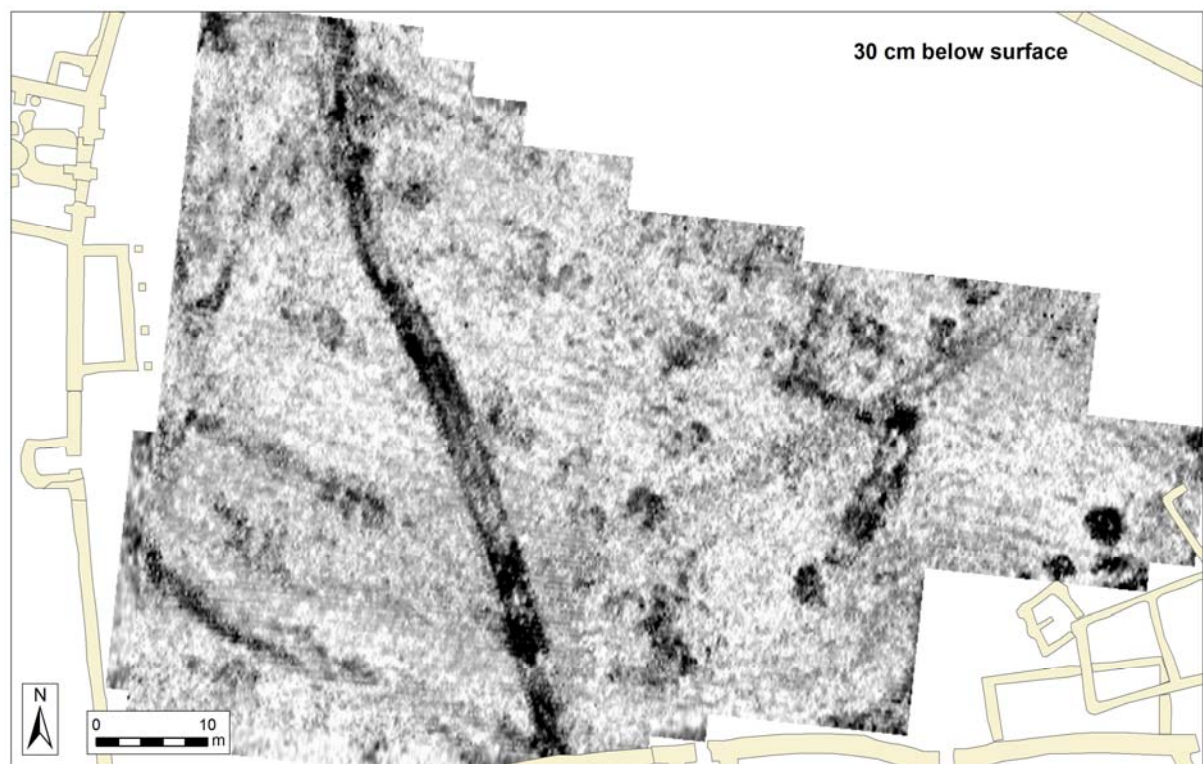
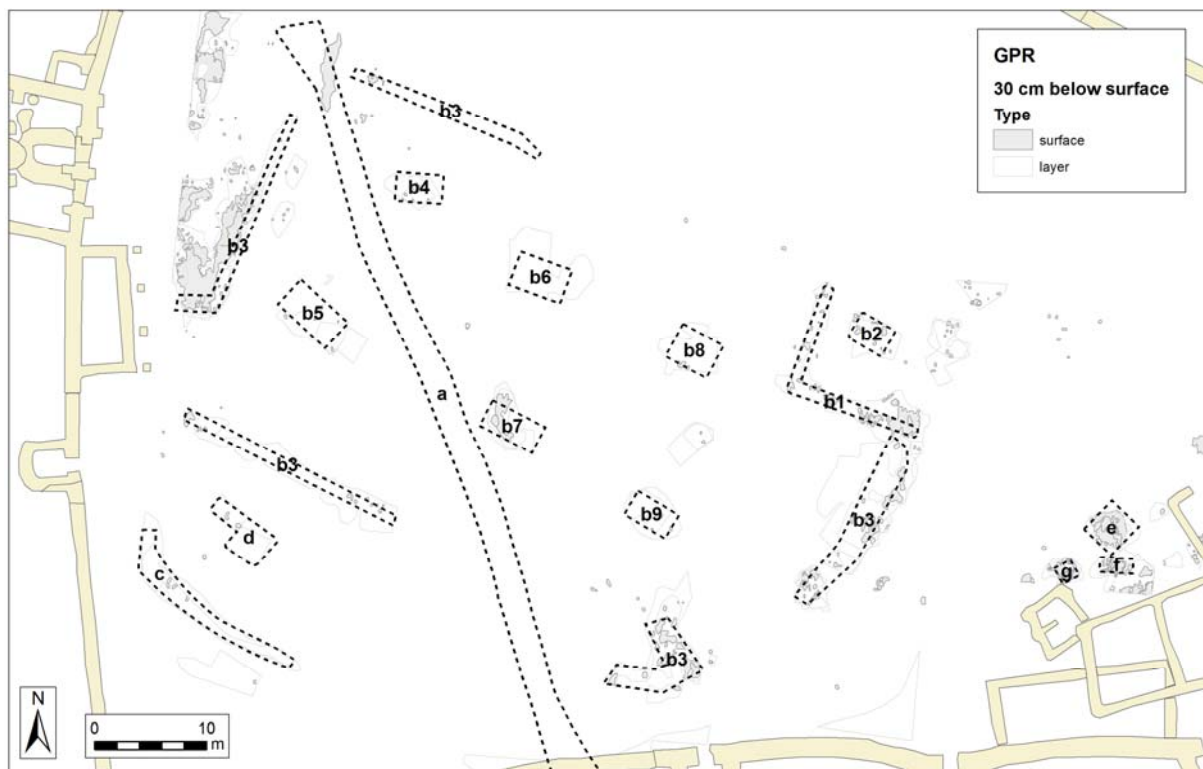
The measured area is cut into two parts by a contemporary path leading from the entrance of the site to the still standing building on its north-western corner. Anomalies corresponding with this path can be detected through all the depth slices on the radargrams in a width of 3 m. The magnetogram however does not show this feature.

Near-surface rectangular features (b)

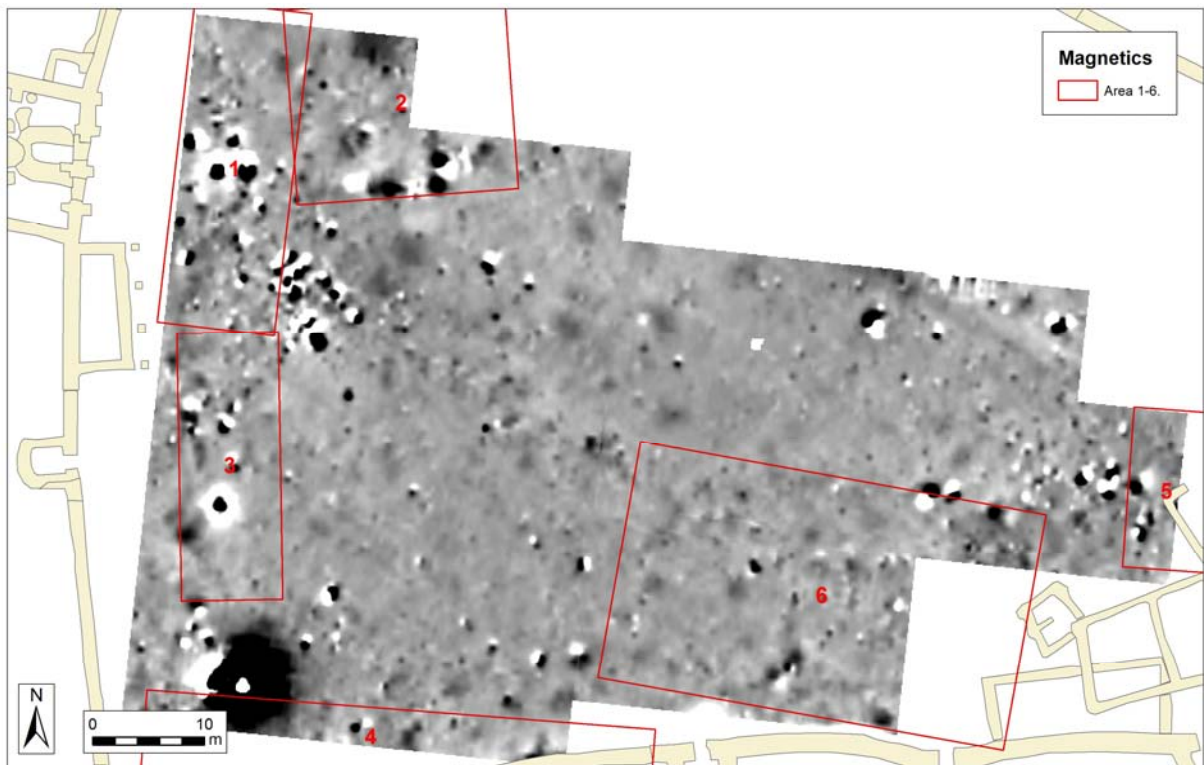
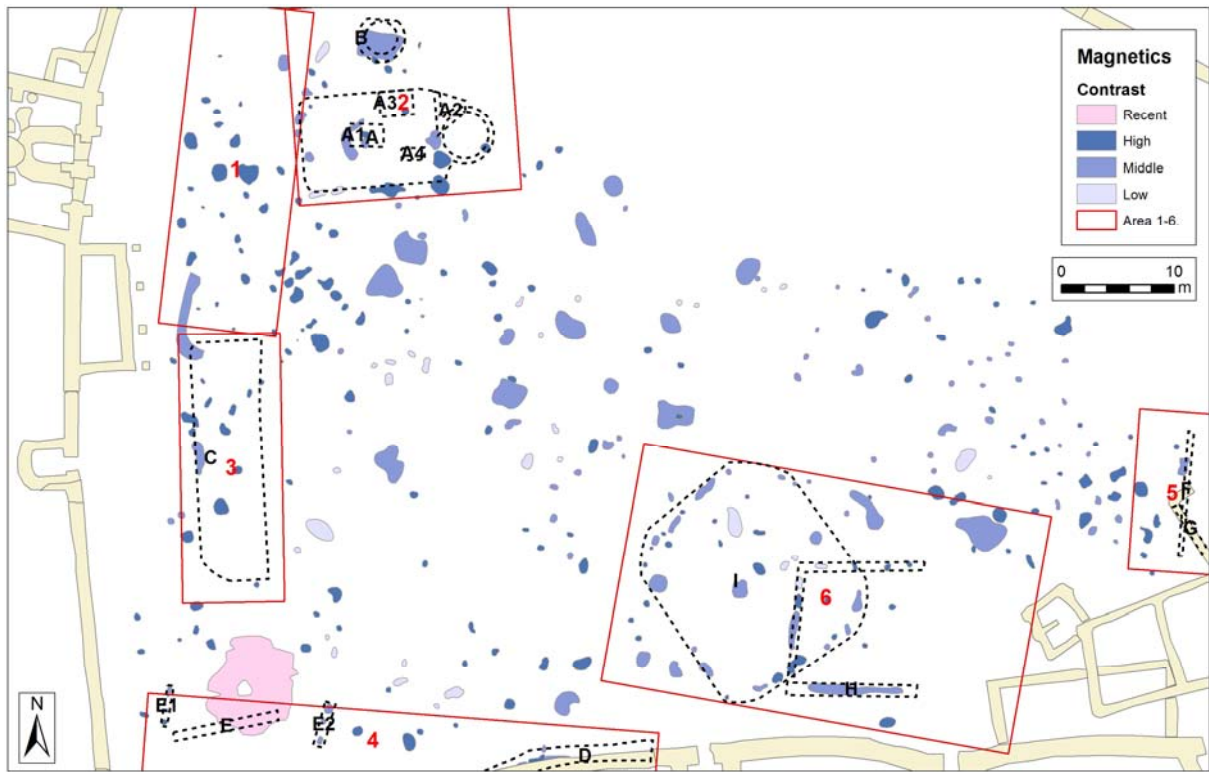
At the layers 10-20 cm below the present surface remains of most probably recent features can be seen. In the north eastern corner remains of square shaped feature can be seen, enclosing an app. 11*12 m large area **(b1)**. Within this area an app. 4*3 m large, oblong-shaped anomaly shows an inner structure **(b2)**. The square-shaped enclosure is joined to a larger enclosed area of app. 34*63 m **(b3)**. Within the larger rectangular shaped area 6 smaller features can be seen **(b4-b9)**. One smaller **(b4)** feature is located to the area of the church; another **(b5)** is located south form the church on the other side. The exact shape of the latter (*feature SW from the church*) cannot be clearly seen on the depth slices. On the magnetogram however it shows high, contrasting magnetic properties.

Besides the large rectangular area a smaller area app. 20*15 m large, is bounded with an arc shaped anomaly at the southwestern corner **(c)**. This strong anomaly can be seen through the whole series of the depth slices. Within this bounded area another 7*4 m large anomaly can be detected through the whole series of depth slices **(d)**. In the south-eastern corner of the measured area, right beside the excavated trenches, further strong reflecting anomalies can be seen on the radargrams starting from the uppermost layer. One of it is oblong shaped and 3,2 x 2,4 m large **(e)**. There are two smaller features **(f)** which are app. 3,4 x 1,4 m and **(g)** 1,7 x 1,4 m large consequently. These features become rather faint in the lowest layers, but still detectable through all the depth slices. Due to their locations and the average depth of the archaeological remains the above mentioned features most probably belong to recent activities.

In the northwest corner a strong magnetic anomaly can be seen on the magnetogram. This feature or object has by far the largest and strongest magnetization in the whole measured area. The anomaly corresponding with this feature is app. 8 m in diameter. This anomaly corresponds to the present day memorial; built of stone and metal material. It should therefore be kept in mind, that this memorial and its magnetic properties might affect the measurement results of its immediate surroundings in both the magnetics and GPR measurements. (Fig. 43.)

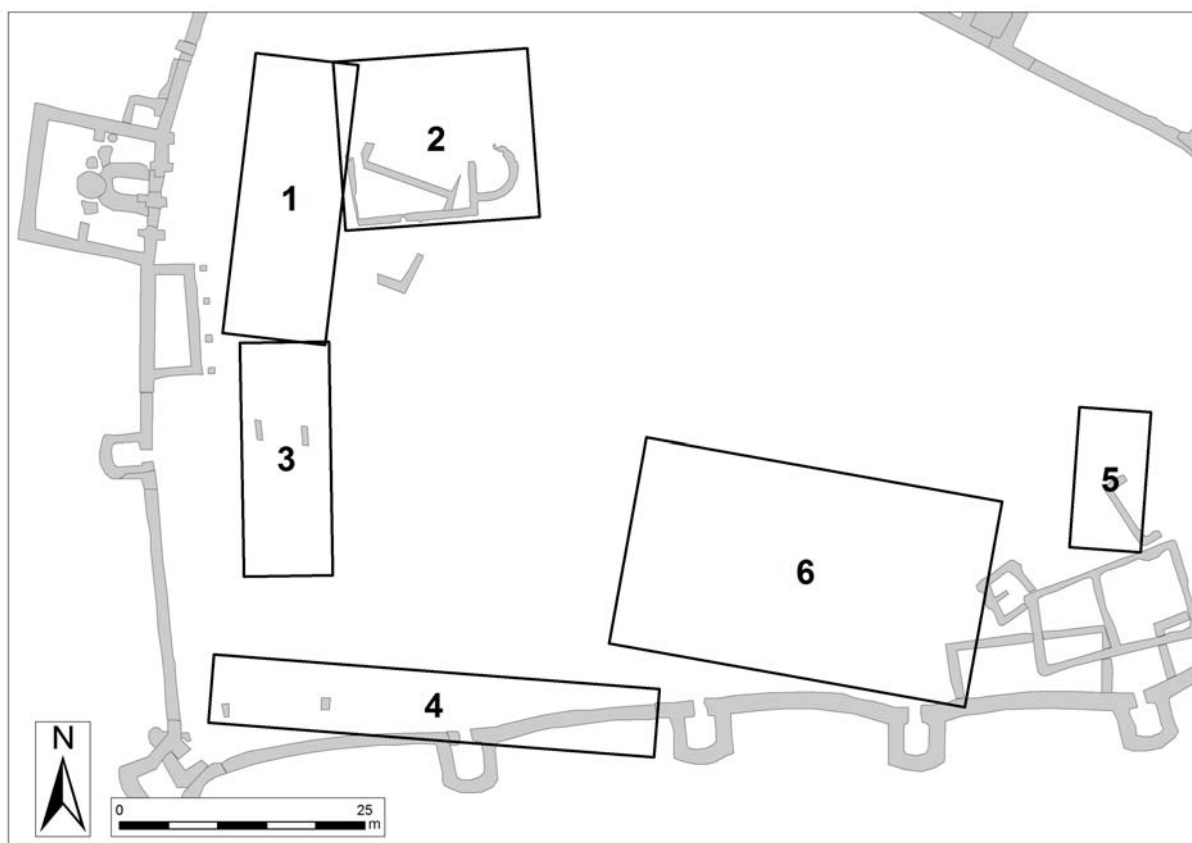


42. Contemporary features – 30 cm below present surface (Interpretative mapping, GPR radargram)



43. Magnetic measurements (Interpretative mapping, Magnetogram)

As different features were detected from the inner area of the fortification, I marked 6 areas in which I give below a more detailed interpretation. From the area in between the 6 marked areas I could not differentiate exact features within the measurement results. (Fig. 44.)



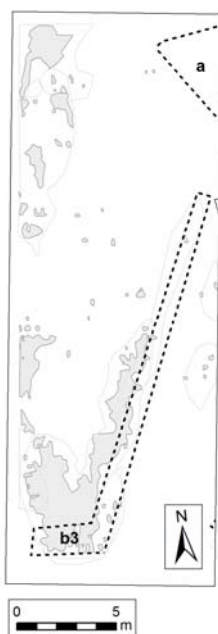
44. Location of areas No. 1-6.

Area 1.

Features in front of the square-shaped tower

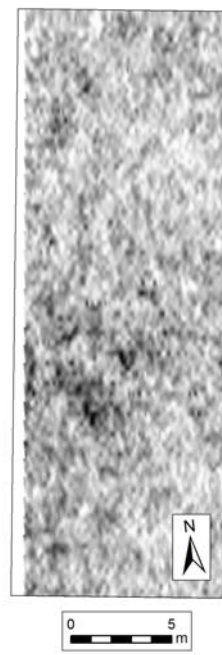
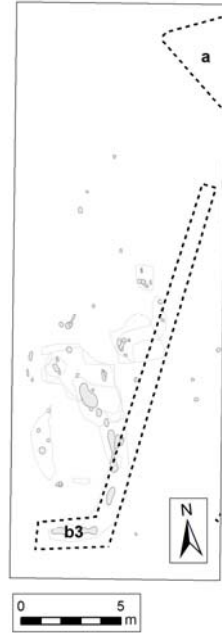
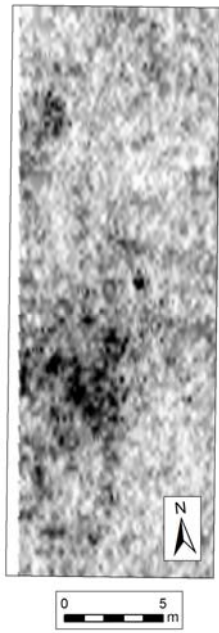
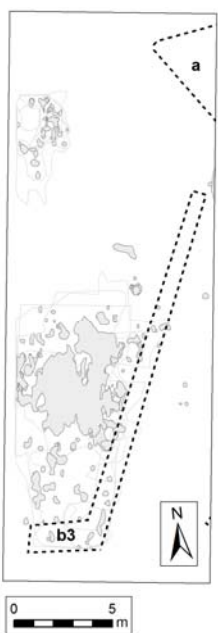
During the excavations at the inner side of the square shaped tower a large number of different archaeological features were identified, including pit-houses and hearths cut by the excavation trenches. The measured area runs close to the excavated area however I cannot observe the continuation of the cut-features within the radargrams. Strong reflecting anomalies still can be seen on the depth slices however. A U-shaped anomaly appears app. 10 cm below the present surface enclosing with one of its legs a large rectangular area. From app. 30 cm depth the U-shaped feature begins to 'fill-up', its southern side becomes more thick and square shaped. At the depth of app. 50 cm the feature reaches its largest extension 17,75 x 2,9 - 5,6 m. Its sides are slightly rounded and become narrower on its southern side. Further down in the depth slices the anomaly becomes smaller, its southern part mostly disappears only its two slightly bent side leg and the southern line can be seen. Its centre part can be seen further as a rounded anomaly until app. 100 cm below surface. Under 100 cm the area differs: at the place of the anomaly a circular, bent feature can be seen with contrasting properties in its inside area. This might belong to a different feature, app. 4,4 m large in diameter, or can belong to the strong anomalies from the higher levels. Beneath 130 cm the radargrams does not show further strong contrasting anomalies.

The periodization and interpretation of this feature is rather problematic as it is located to the uppermost layer and it is possible that it belongs to the recent features. It should be noted however that due to its position within the fortification area, the anomaly can include archaeological features as well. The magnetogram shows a different image of the same area. On the northern side of the feature two strongly reflecting features can be seen. The southern and western side of the anomaly cannot be identified. The above presented feature feasibly corresponds with another feature further north which appears at the western edge of the measured area at a depth of 20-30 cm. Further down this anomaly draws a square, 2,7 x 2,7 m, with a prolongation to south. Going deeper, it becomes faint and almost completely disappears at a depth of 100 cm below the surface. (*Fig. 45.- Fig. 48.*)



45. Area 1. 40cm below present surface (Interpretative mapping, GPR radargram)

46. Area 1. 40-60 cm below present surface (Interpretative mapping, GPR radargram)



47. Area 1. 60-100 cm below present surface (Interpretative mapping, GPR radargram)

48. Area 1. 100-130 cm below present surface (Interpretative mapping, GPR radargram)

Area 2.

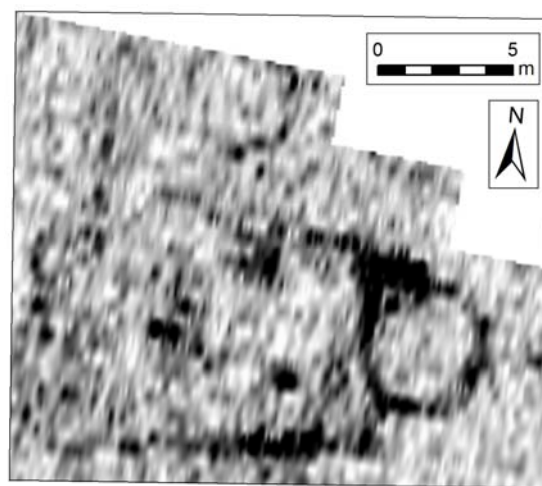
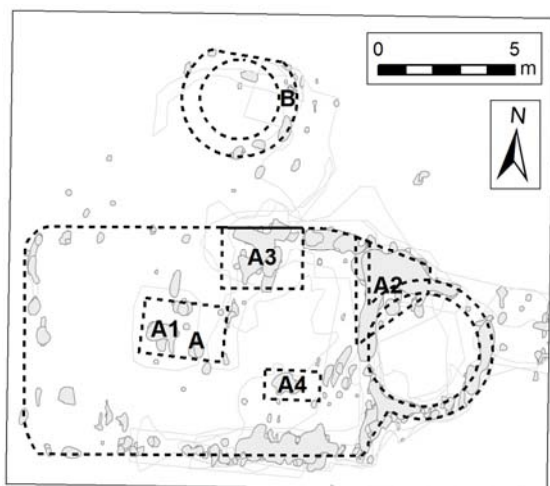
Church building (A)

Due to the wet surface conditions the GPR measurements provided limited results. One of the most spectacular results however is the discovery of a church building in the northeast area of the fortification. The anomaly appears at the depth of app. 60 cm below the present surface showing a stone wall of app. 80 cm width. Comparing with the other time slices at this depth the feature is the southern sidewall of the building. The building becomes most recognizable at the depth of app. 110 cm with a circular apse and an inner structure of 100 x 160 cm. The anomaly showing the building becomes faint at the depth of app. 150 cm. According to the radargrams the building consists of two parts: a rectangular nave and a semi-circular apse. The nave is app. 12 x 8 m, while the apse is 4 m in length and 4,80 - 4,40 m wide. The church is oriented to east-west with the apse facing towards east. The anomalies showing the sidewalls of the building are the most traceable at its eastern part, while on the western part of the building they become fainter which might refer to the present state of preservation of the sidewalls. The width of the anomalies varies in between 60-100 cm at the nave. The widest part here is on the south-eastern corner, while the apse is app. 50-70 cm except from the south-eastern part, where the anomaly shows an app. 80 cm wide wall. **(A1)** The joining point of the apse and the nave is clearly shown on the southern side of the building, while on the northern side a triangular shaped strong anomaly covers the joining point. **(A2)**

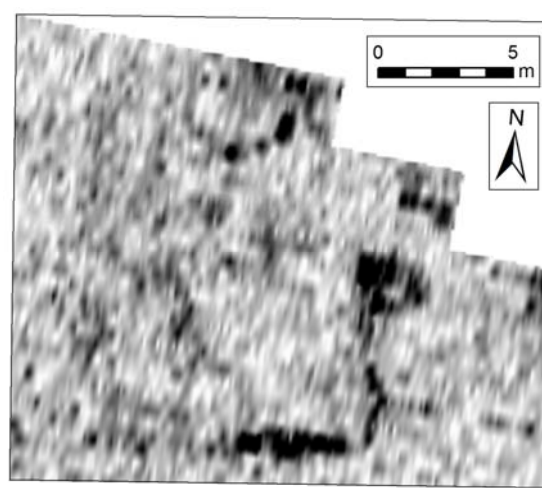
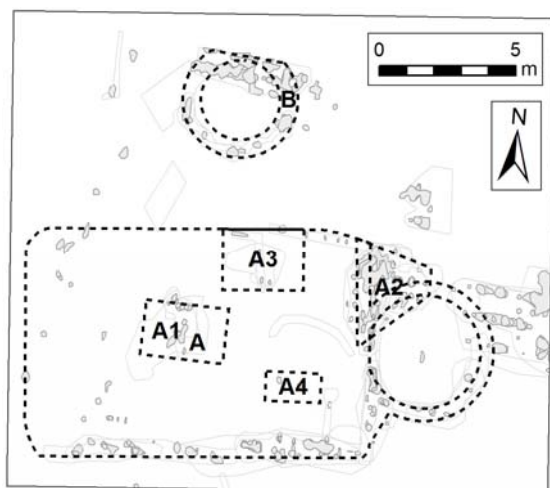
Within the church three stronger anomalies are shown. A strong rectangular anomaly with a size of 1,6 m x 1,8 m is located on the inner side of the northern sidewall of the building, app. 2,80 m far from the north-eastern corner of the church **(A3)**. On the other side of the church 3 m far from the eastern and 2 m from the southern sidewalls another, smaller anomaly can be seen, less rectangular in shape and app. 80 cm in diameter **(A4)**. A larger accumulation of anomalies can be seen in the centre line of the nave, app. 6,40 m from the northern sidewall. The anomaly covers an area of app 1 x 2 m. Due to its location it may be interpreted as a grave with some sort of stone or highly reflecting packing. The magnetogram shows the above mentioned feature less clearly. Strong anomalies are visible on the southern sidewall of the building, and also at the area of the apse, while the eastern wall of the building is only hardly identifiable. Among the inner features inside the building, the grave like feature shows strong contrasting anomaly, while there is also one small but significant trace for the northern sidewall. It is located outside of the measured area however.

Circular feature (B)

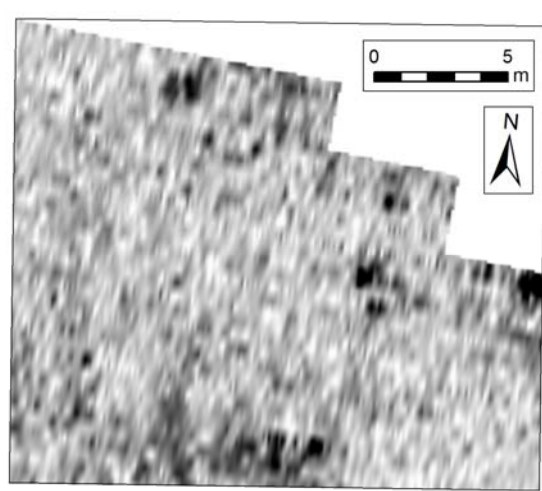
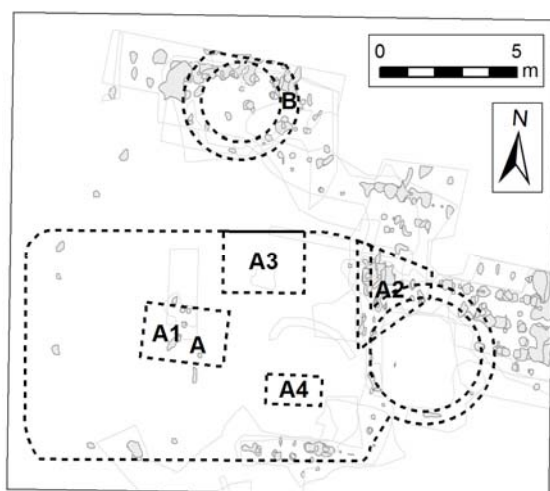
On the GPR depth slices at a depth of 90 cm an even, circular shaped anomaly is shown and is traceable until the depth of 160 cm. The width of its wall is app. 50-60 cm, except at its northern part, where the anomaly is more than 70 cm. The size of the circle is 3,7m-in-diameter in the inner side, and 4,60 in the outer side. On the magnetogram a stronger anomaly shows the extent of this feature; however it does not show its exact shape. *(Fig. 49. – Fig. 51.)*



49. Area 2. 100 cm below present surface (*Interpretative mapping, GPR radargram*)



50. Area 2. 100-130 cm below present surface (*Interpretative mapping, GPR radargram*)

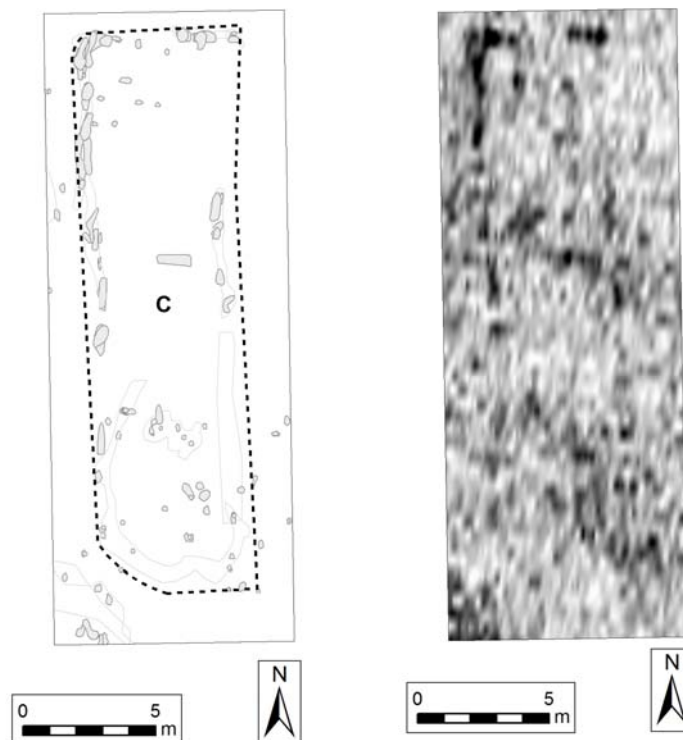


51. Area 2. 130-150 cm below present surface (*Interpretative mapping, GPR radargram*)

Area 3.

Rectangular building (C)

The anomalies corresponding to the building are shown from 90 cm below the present surface. At this depth the northern sidewall and the northern part of the western sidewall of the building can be seen. The building is located parallel to the fortification wall app. 10 m from it. The building is oriented to the North with the shorter sidewall facing to it. The width of the anomalies is app. 50-60 cm. The width of the building is app. 5 m while its length is app. 20m. At a depth of app. 110 cm a partition wall can be traced therefore it is feasible that the building was parted into two rooms. The northern room is 8*5 m. On the southern part of the building mixed surface and further anomalies can be detected. These however most probably do not belong to the building itself, as at this area anomalies can be seen right after from the present surface and it is rather correspondent with a recent feature. The anomaly corresponding to the building disappears at an app. depth of 130 cm below the present surface. Comparing the area of the building with the magnetogram, it is only a small part of the western sidewall which can be traced. Within the area of the building remains, smaller features can be seen on the image while at the southern part of the building 2 strong anomalies correspond to the recent objects. (Fig. 52.)



52. Area 3. 100 cm below present surface (Interpretative mapping, GPR radargram)

Area 4.

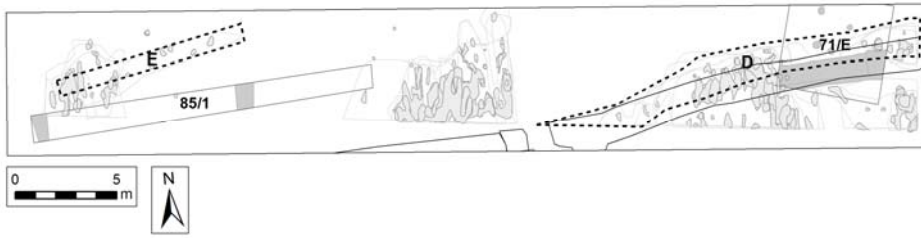
Southern fortification wall (D)

Measurements reached until the southern fortification wall. Here GPR depth slices show the continuation of the fortification wall in 8 m length. The wall is 1,5m wide and slightly bent which corresponds well with the excavated wall parts. The anomaly corresponding with the wall becomes visible at a depth of 60 cm and disappears at a depth of app. 130 cm. The magnetogram draws nicely the line of the fortification wall showing the slightly bent wall. Furthermore, a 'prolongation' towards north from the inner side of the fortification wall might refer to an inner structure besides the wall.

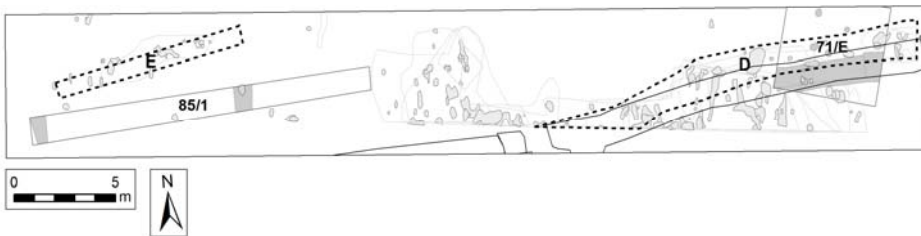
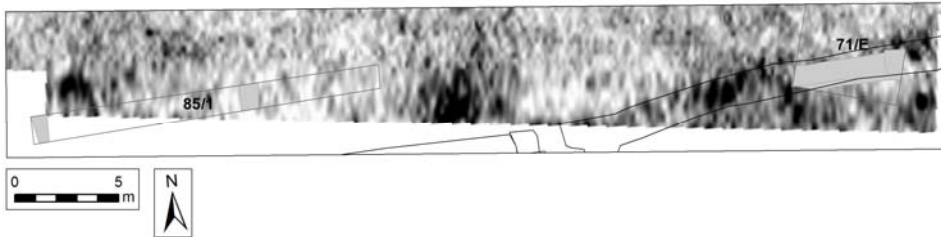
Building at the SW corner (E)

In the southwestern corner of the measured area two different types of anomalies should be mentioned. Measurements here partly covered the area of Trench 85/1 in which remains of building walls were observed. Based on the location of these wall parts the northern side wall of the building should be seen on the radargrams. It is however more problematic to identify remains of this wall in the depth slices. A reason for that is that only measurement *ab* reached the area which was measured with 500 MHz antenna with wet surface conditions. In general, looking through all the depth slices it is evident that the other measurement with 250MHz with better weather conditions provide clearer images of the features. This however did not reach the area of the trench. Despite these conditions it is possible to see a reflecting anomaly in the area which might correspond with building (E). This linear structure - which might correspond with the northern side of the building - appears at a depth of app. 90 cm below the present surface and disappears at app. 110 cm at a width of app 80 cm. This feature runs 2 m far further north from the excavated wall parts.

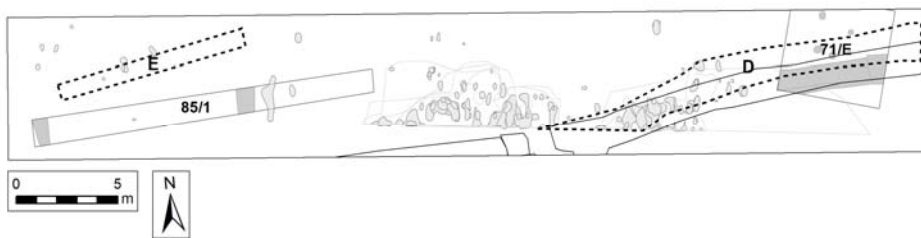
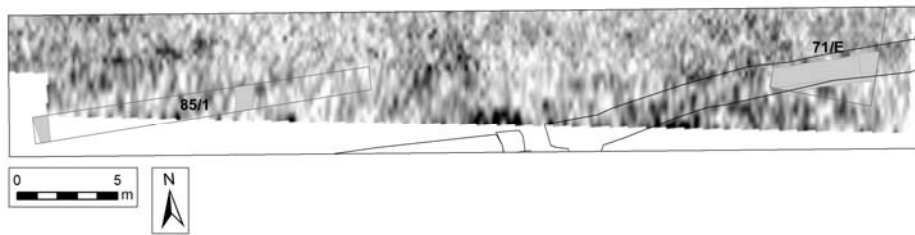
On the magnetics two features lie in the line of the western wall part which can be considered as its continuation. Furthermore, app 14 meters further to east a similar, parallel row of anomalies can be seen, which might also refer to a sidewall of a building. This can also be supported with a linear anomaly shown at a GPR depth slice at 100 cm depth. In the continuation of this line however wall remains were not found in 1985. (*Fig. 53. – Fig. 55.*)



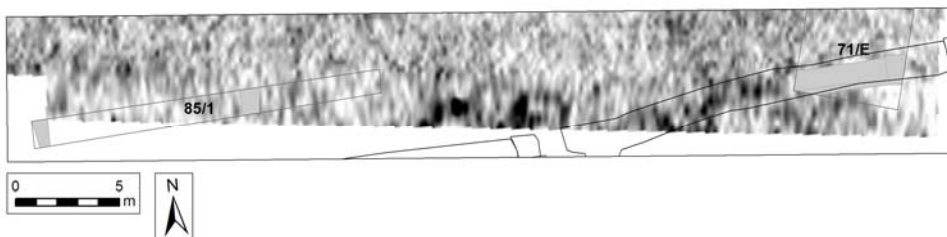
53. Area 4. 60 cm below present surface
(Interpretative mapping, GPR radargram)



54. Area 4. 60 - 100 cm below present surface
(Interpretative mapping, GPR radargram)



55. Area 4. 100 - 150 cm below present surface
(Interpretative mapping, GPR radargram)



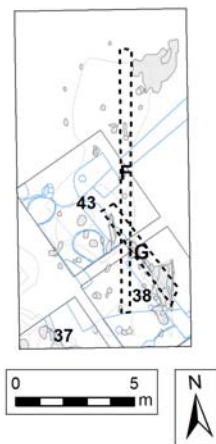
Area 5.

Linear feature (F)

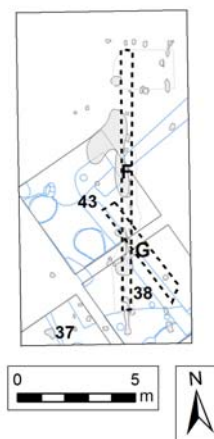
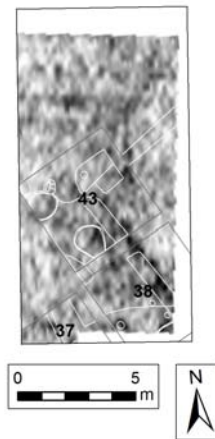
The feature is located to the easternmost side of the study area. The linear structure becomes clear at a depth of app. 100 cm below the present surface, and faintly traceable at the depth of 200 cm. It can be most clearly seen at a depth of app. 130 cm. The anomaly shows an app. 40 cm wide feature, running from north to south through the measured area. As it is deep down in the earth it is feasible that it is recent under earth channel. This feature cannot be located on the magnetogram as it is located just outside the measured area.

Linear feature (G)

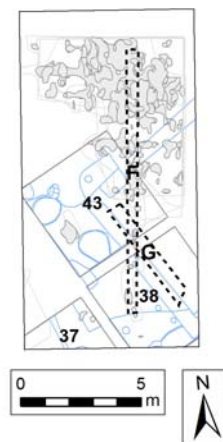
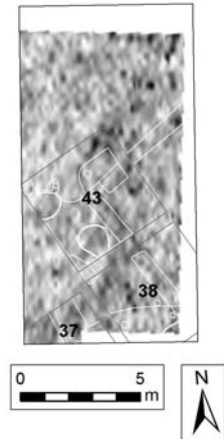
This anomaly might correspond with the sidewall of a building, found in trenches 47-48. The anomaly is however only shown at a depth of 60-80 cm. Here the anomaly is 60 cm wide and 4,5m long. (Fig. 56. – Fig. 58.)



56. Area 5. 100 cm below present surface (Interpretative mapping, GPR radargram)



57. Area 5. 100- 130 cm below present surface (Interpretative mapping, GPR radargram)



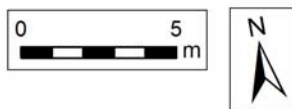
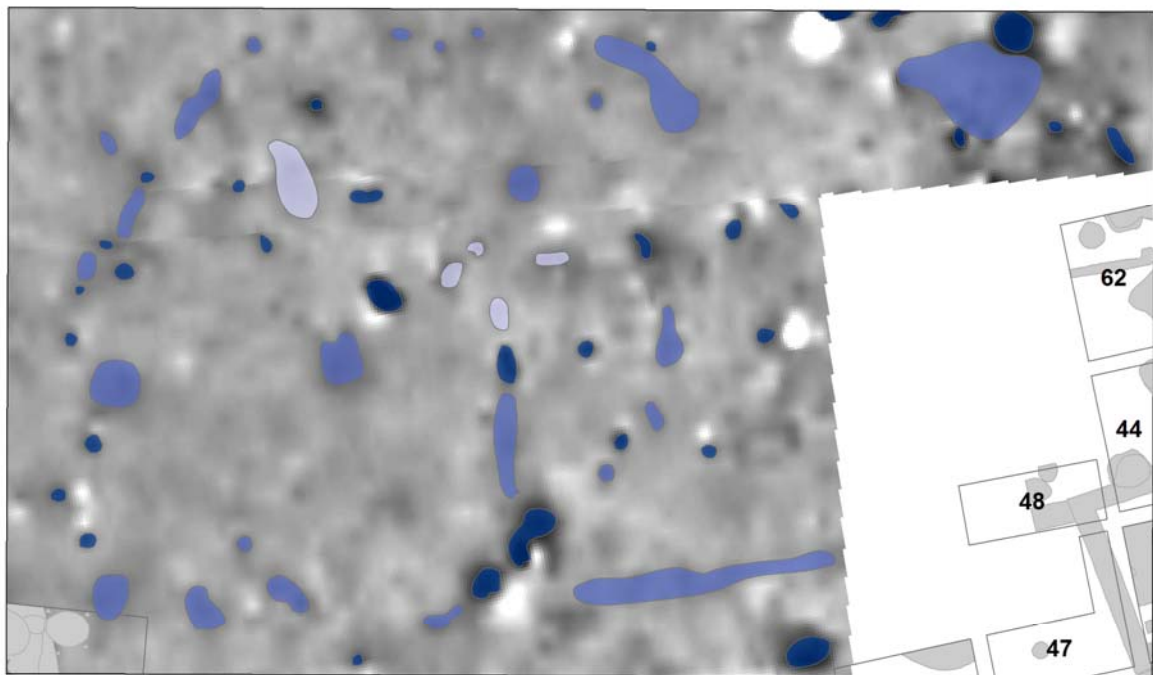
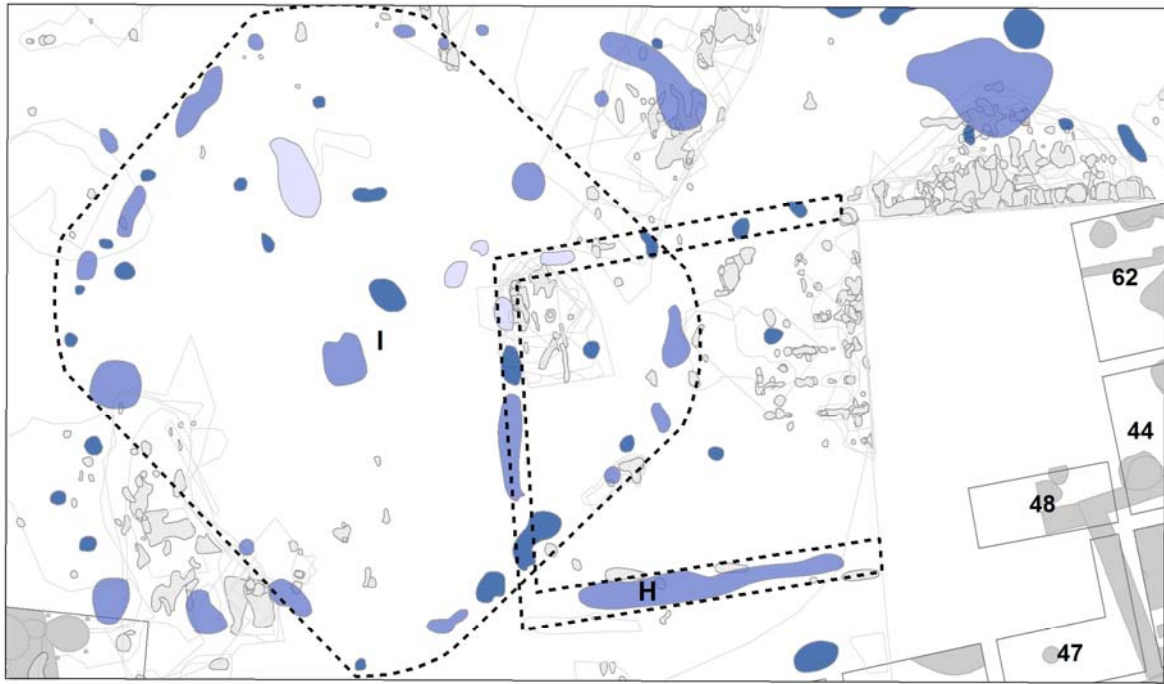
58. Area 3. 130-150 cm below present surface (Interpretative mapping, GPR radargram)

Area 6.

Inner area at the south-eastern corner (H and I)

Towards east along the fortification wall in the inner area of the fortification a large enclosed area can be seen on the magnetogram. Its southern sidewall is located app. 4 - 4,5 m from the fortification wall and it is oriented towards east-west. The shorter side of the oblong shaped feature is 10-11 m, while the longer side is also 11 m but the measured area most probably does not reach its western side. The width of the walls of the feature is 50-60 cm. On the radargrams it is more problematic to recognize this feature; it is only at the depth of app. 110-120 cm where parts of the northern and the southern sidewall are recognizable. Concerning the function of the feature it should be noted that by far this is the largest feature within the fortification area. Furthermore it is most probably did not preserved well. Inside this enclosed area in its north-eastern corner a rectangular shaped, 2*3 m sized feature can be seen on the uppermost layers of the GPR depth slices. Even though this feature is recognizable until app. 110 cm below surface it is more feasible that it belongs to the recent near-surface rectangular features and its location identical with the feature (H) is unintentional.

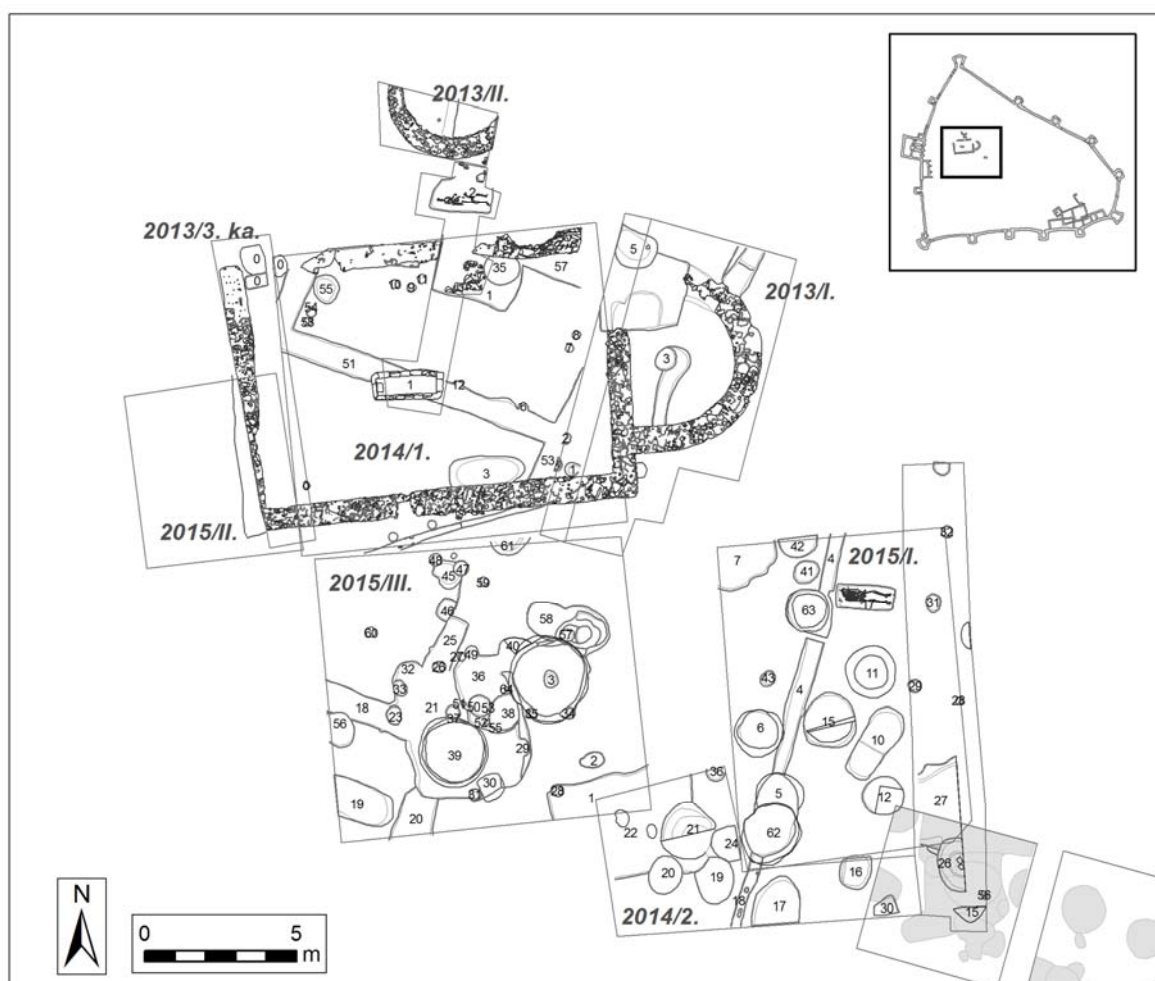
West from the above mentioned feature, partly covering of its north eastern corner another enclosure-like feature **(I)** appears in the magnetogram. This feature is even less visible than feature **(H)** therefore it is also possible that corresponding anomalies does not form the feature intentionally and therefore they cannot be considered as a part of one feature. However their locations in a line with a central one in the middle make it feasible that it is acceptable as a feature. In that case Feature **(I)** is square shaped with rounded corners and with app. 17 m sidewalls. In the middle a contrasting anomaly can be seen along with a less strong anomaly with the size of 1,3 x 1,3 m. The 'walls' of the enclosure is app. 50 cm. The identification of this feature within the GPR depth slices is rather problematic as I could not recognize clear parts of the feature and its existence is still ambiguous. (Fig. 59.)



59. Area 6. Interpretative mapping, magnetogram

V.5.5.2 Excavations following the geophysical measurements

As the geophysical measurements provided impressive results, archaeologists at the King Matthias Museum of Visegrád decided to conduct targeted excavations at the area of the church (A), the circular feature (B) and at the rectangular building (C). The excavations were led by Gergely Buzás and Katalin Boruzs in 2013-2015. Along the three consecutive field seasons a total of 440 m² was unearthed. In 2013 the apse and the western sidewall of the church (A) and the circular feature (B) was unearthed along with the inner structures within the nave area. Trench 2013/1 was aimed to locate the eastern side wall of building (A). The uppermost 40-50 cm earth was ripped as the area was formerly used as a vineyard. At the southern end of the trench a wall appeared at a depth of 50 cm below the present surface. Its width was 85 cm. In the northern part of the trench the wall was robbed. On the outside of the wall the occupation floor was observed at a depth of 85 cm. At app. 40 cm below the present surface the arc-shaped wall of the apse came to light. Its largest diameter in the E-W axis of the nave is 3,40 m. The size of the inner area of the nave is app 7,50 x 11,60 m. In the middle of the apse a 60 cm-in-diameter large post-hole came to light to runs a ditch which is 40 cm wide and app. 40 cm deep. (pit No. 3). A similar ditch was unearthed on the outer side of the apse wall running towards north-west. From this ditch a Carolingian-type bronze spur came to light from a depth of 1,07 m. (Pit No.4.) The dating of the material and the stratigraphical position of the ditch implies that this structure predated the construction of the church building and most probably can be dated to the 9th century. The joining point of the apse with the eastern wall was completely demolished by a large pit. Underneath the pit another feature, most probably a hearth was observed which seems to predate the church building. Trench 2013/2 was meant to study features within building (A) and the circular feature (B). At the southern end of the trench a large pit came to light within which a brick-walled, E-W oriented grave was unearthed. The brick-walled grave was 50-55 cm above the present surface, and it was 45-50 cm deep. It was 1 m wide and 1,75 - 2 m long measured on its outer side. The grave was positioned to the east-western axis of the nave, 6 m from the western sidewall. The covering stone of the grave was missing and the deceased was disposed from it too. The only find was nonetheless exceptional: a phalanx, 'wearing' a golden ring. The ring is 2,5 cm in-diameter with narrowing, rhomboid ring shank made of 1,5-3 mm wide golden wire. Based on the size of the golden ring and the location of the burial Buzás interpreted the grave as a burial of a bailiff. (Buzás 2015, pp. 595-596.) (*Fig. 60.*)



60. Excavation base plans.

In the continuation of the trench at north the robbed wall of the nave was identified. Further to the north beside the presumed outer wall of the nave another grave came to light. This grave was 1,94 m x app. 0,80 m, oriented to East-West (with the skull lying on the western side). The deceased held a tin chalice in his left hand. Furthermore around the right hand of the deceased tin remains were found, most probably remains of a paten. Based on the location of the grave and the grave goods the deceased was interpreted as an ecclesiastic. In the same Trench 2013/2 further to the north remains of the circular feature B came to light at a depth of 50 cm below surface. The feature was interpreted as a cistern. The stone wall of the cistern was 75 cm wide. There was a horizontal line of stake holes below the top of the wall. The cistern was excavated until a 2 m depth. Even though the cistern was not completely excavated its inner diameter can be estimated to 3,5 m and 4,8-5 m with its built sidewalls. Trench 2013/3 was opened to locate the western side wall of the church building. Here at 50 cm below the present surface a wall came to light with its joining corners both on the northern and southern side.

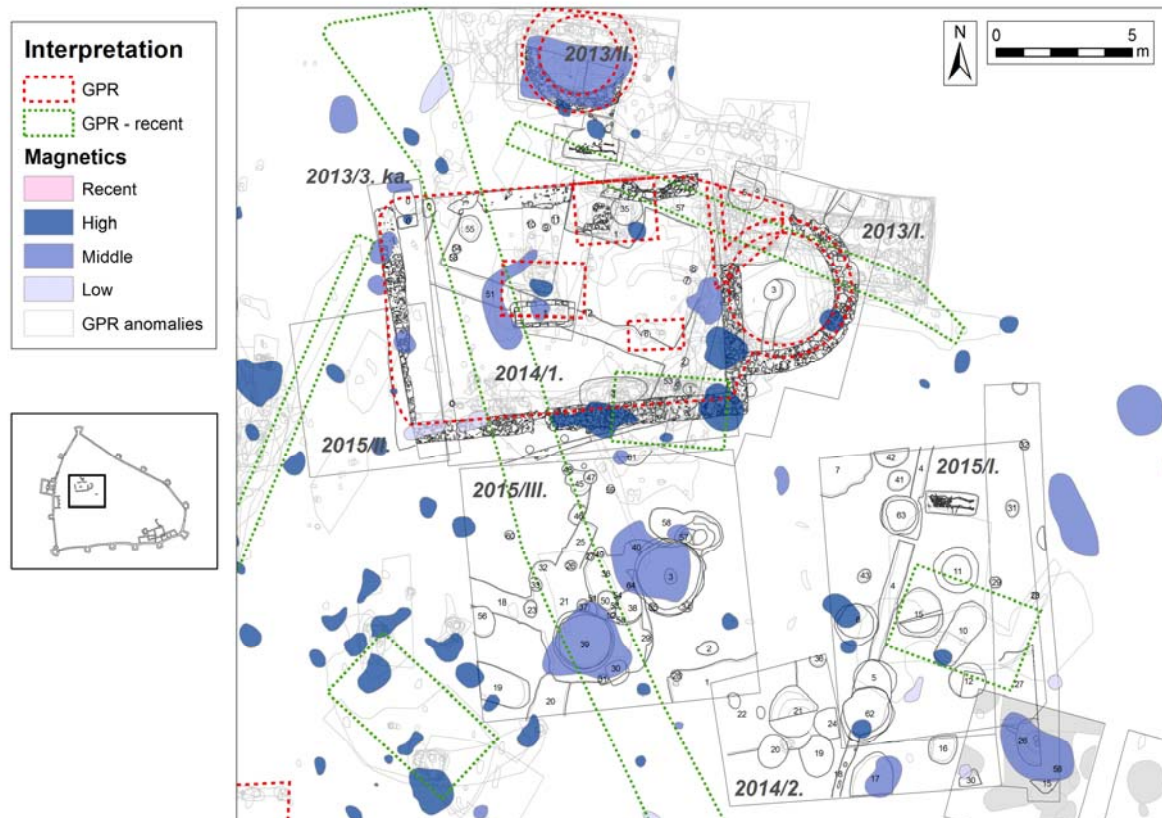
In 2014 the complete area of the nave was excavated along with its northern and southern sidewalls. Furthermore another trench was opened southeast from the nave. Within the centreline of the nave the brick built grave was further unearthed. At its eastern end a carved stone, a head support, was found and also another phalanx. (Buzás 2013-2014) Within the nave further features

came to light. Pits and postholes were found along the sidewall of the church building. Furthermore an H-shaped robbed wall was also found, most probably the foundation ditch of a former Roman building. The walls of the ditch were app. 15-20 cm deep. The continuation of the eastern sidewall was excavated in 2015 along with another perpendicular robbed wall, running towards NW. If these features belong together than the complete structure was at least 15,7 m x 10 m with at least two rooms and with a 2,5 m wide entrance facing towards SE.

Along with the research in the vicinity of the church another trench was opened in the area of the rectangular building (C). Within the trench two app. parallel walls came to light. The western wall is 60 cm wide, 30 cm high with 60 cm foundation. The wall on the eastern side of the trench is 55 cm wide, 60 cm high out of which 15 cm is the wall and another 45 cm is the foundation. Beside the walls smaller postholes came to light from the trench. In 2014 and 2015 there were excavations outside the area of the church further south. Post-holes and large pits came to light from the trenches. A grave was found in the area too without any grave goods only with nails from the coffin. One of the most notable unearthed features is an app. 4,3 x 3,8 m large dwelling, most probably a 13th century mint. From here 5 Friesacher pfennings came to light and 2 coining dies, used most probably for coin minting. Based on these materials this feature was interpreted as a coin mint. (Boruzs 2015) As a result of the excavations archaeologists further observed a notable objects implying more clearly the 8th-9th century occupation of the site. This assumption of early occupation can be further confirmed with objects from a metalsmith's furnace discovered in 2017. Based on the find material the existence of the furnace further underlines the central role of the site even as early as the 8th-9th centuries. (Merva 2017)

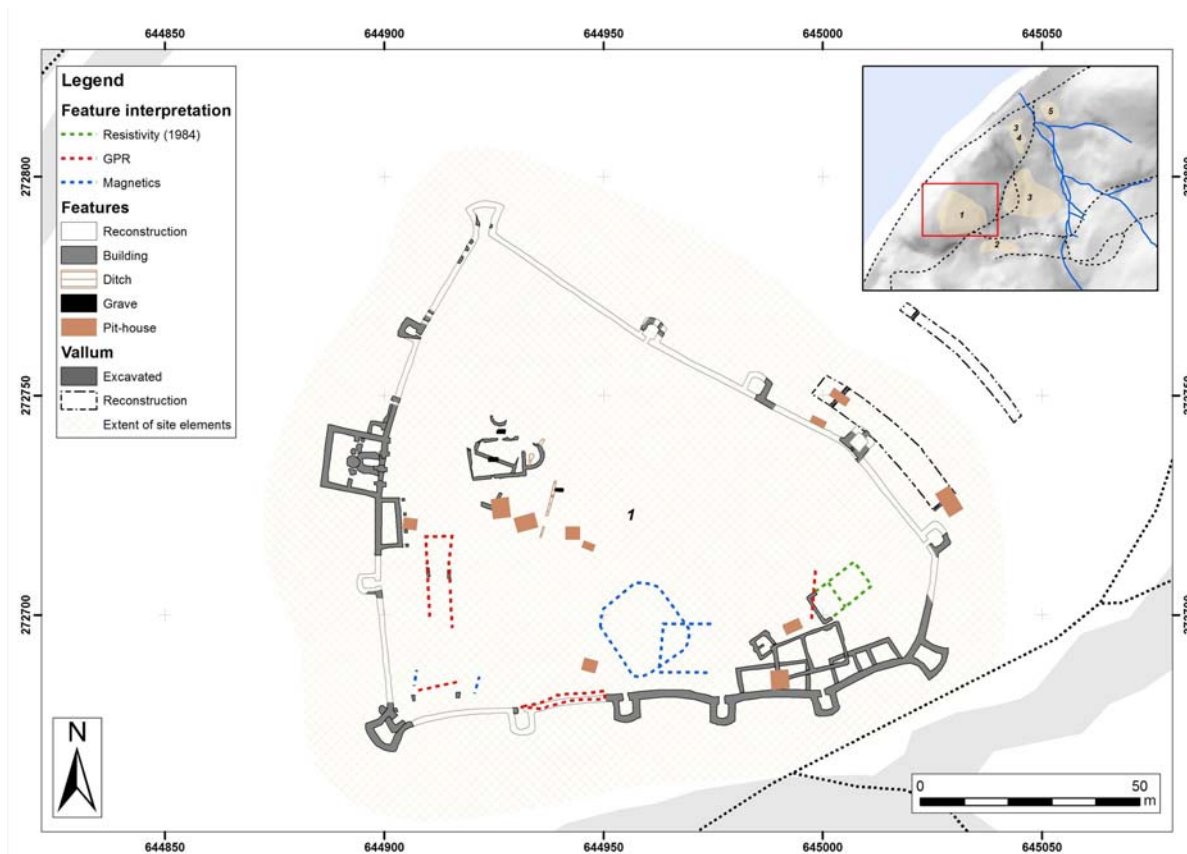
V.5.5.3 Prospection and excavation data, a comparison

The excavations, as they followed the geophysical measurements, were first aimed to study the church-shaped anomaly presented above. Here the GPR measurements corresponded nicely with the excavated results in the case of the position and width of the eastern and western wall of the nave, and in the rounded shape of the apse. The joining point of the northern and eastern sidewall of the building - which showed a large anomaly of app. 2,3m-in-diameter - turned out to be a pit, demolishing completely the wall. On the GPR radargram the anomaly corresponding with the church appeared at an app. depth of 60 cm below the present surface, while in reality they were somehow higher at a depth of 45-50 cm. Magnetism followed nicely the lines of the stone wall, with the highest magnetic properties at those places where the walls were preserved the best. From the inner features, the brick built grave was nicely detected, even though its exact shape was not shown. Archaeologist observed different features from the inner area of the church which were not to be seen on the radargrams. I could not recognize those anomalies which correspond with the H shaped building foundation or the inner ditches. The circular feature (B) corresponded well within the excavation results and the prospection data. On the GPR the anomaly was shown at a depth of 90 cm, while in reality it was app 50-70 cm below the present surface. Its shape otherwise corresponded nicely with those detected on the GPR depth slices. In this area however magnetism rather showed a strong anomaly, not the exact shape of the building. In the case of Building (C), both magnetism and GPR measurements corresponded well with the excavated material except the linear structure (a possible inner wall), which was not found during the excavation. It is highly feasible however, that the overall measurements of the building can be correctly estimated based on these measurements. Rather problematic is the detection of those features in the area which were not stone-built, i.e. the pit-houses, pits, ditches. In the area of Trench 2014/2., 2015/I and 2015/III a large number of earthen features were found which was not shown clearly on the radargrams. On the magnetism, the mint and the large pit nearby can be identified as anomalies from Trench 2015/III. The mint is shown as a large, middle strong magnetic anomaly. It is therefore feasible that the further strongly reflecting anomalies can be corresponded with other pit-like features. Earthen ditches however cannot be distinguished based on the presently available datasets. (*Fig. 61.*)



61. Prospection and excavation data - comparison.

Based on this comparison I can conclude that the presently available data is useful in the detection of stone-built features within the fortification area. Furthermore I find it feasible that another building-like feature can be found along the southern fortification wall, partly prospected during the 2010 measurements. The inner area of the fortification is most probably packed with archaeological features as it was detected in all the inner trenches, but I found it more feasible that these features are earthen-wooden features rather than stone buildings. A questionable point is the inner area at the square shaped tower where a large accumulation of anomalies can be seen on the radargram along with smaller magnetic features. Here however I rather suspect earthen features than built ones as the strongest anomalies are only detected in the uppermost layers. To conclude it is feasible that along the southern sidewall of the fortification another stone building or robbed walls can be predicted, while from the inner side of the area it is more feasible that area is packed with earthen archaeological features. To determine the chronological ordering of the features without excavating them is more problematic, as the features from different periods do not differ highly in depth. Therefore here, it is rather the size and shape of the feature, which can help in the chronological ordering. The presently discussed measurements only covered the southern part of the fortification area, and it was not possible to prospect along the fortification walls. It is highly feasible that a future research would reveal more stone-built buildings from the northern part of the inner area. (Fig. 62.)



62. Inner structures according to the prospection measurements

V.5.6 Visegrád as a complex

Above I presented the various elements of the early complex of Visegrád. Here my first task was to collect and systemically insert to my GIS database the available information on every element of the complex. In that I succeeded to create a detailed map of the whole complex including data on the landscape as well. This map provides a background for the further studies too, showing the relative location of the sites and the features together for the first time. In studying the overall topography of the complex I realized that the settlement was emerged most probably on both side of the road, *Via antiqua*, running within one of the legs of the Y-shaped gully. It is a question for the future how the Matthias-stream was treated, as it flows in between the monastery and the settlement structures. Geophysical measurements were only conducted in the inner area of the fortification. These measurements confirmed the assumption that there were more building structures within the fortified area too at the study period. A notable result of these measurements was the discovery of a new church building with a high status burial within its nave. With the discovery of this church it is possible to re-evaluate the question of the Archdeaconal church and its elaborate decoration and probably interpret it as a private church. Both the burials with golden rings, and the two-roomed stone building and the high quality church decoration imply that the complex was owned by people from high class. This can also be confirmed with the royal foundation of the monastery. Based on the donation charter mentioning Visegrád as a county, and the fortification of its centre it is further a

question how it was related to the other settlements nearby in the area and the Kingdom of Hungary as a whole. A comparative analysis of the castle system of the early medieval Hungarian Kingdom, Bohemia and Poland was published recently by Mordovin 2016. In his work the author listed the contemporaneous castles (including the available data on Visegrád) and also presented a typology to these centres. He also underlined the use of the castles as settlements or most probably constantly habited areas. From a landscape point of view it is worthwhile to open up this viewpoint and study the settlement system of the area as a whole, not solely the surroundings of the castle. Recently Bence Simon studied the Roman settlement network of the Pilis region, and in more detail the historical settlement pattern at the area of 7 modern settlements in the Pilis region⁵¹ from the Roman (1st-3rd centuries), the Late Medieval (13th-16th centuries) and Modern period (17th-19th centuries). (Simon 2018, Simon 2019, p.206.) In his research he used GIS-based nearest neighbour analysis, which showed a denser settlement network for the Middle Ages and he also determined possible ideal territories for the former settlements. Settlements from the present study period of the Pilis region are known from the Archaeological Topography collection. Next I study this dataset in more detail.

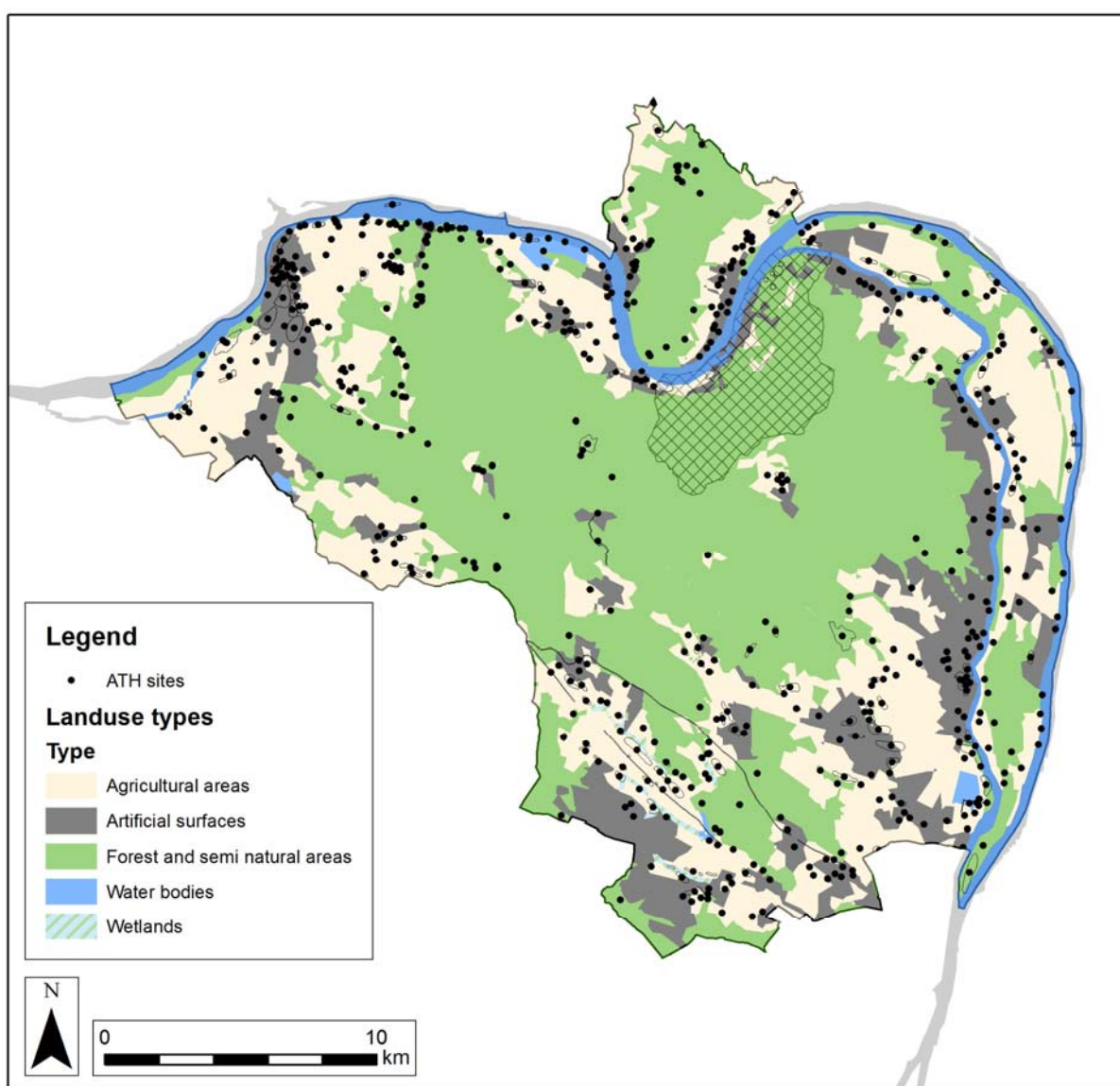
⁵¹ Pilisszentkereszt, Pilisszántó, Csobánka, Pilisvörösvár, Pilisborosjenő, Budakalász, Üröm, and part of Óbuda.

V.6 Archaeological landscape of Pilis and its features

V.6.1 Registered archaeological sites

Above I presented the archaeological landscape elements of the early county seat of Visegrád. According to written sources and the find material this site can now be considered as one of the earliest royal and administrative centres of the kingdom. It became however soon abandoned and lost its importance. The reason for this change cannot be fully understood without studying the processes of the settlement network in its vicinity. As the Pilis region is a subject of archaeological research since the 19th century the thorough evaluation of all the excavated material would exceed the limits of the present thesis. Therefore I consulted mostly the collection of the Archaeological Topography of Hungary. Even though there was archaeological research in the area since this publication I did not expand my research to this material. I only included the new results if they were available in published form. Looking through the dataset from the ATH I soon realized that there is a large amount of information included in the descriptions of sites, which can be studied from a spatial point of view. Originally the ATH had only two levels of information, the (present-day) settlement and the site level. Under every site, features were described in a chronological order. To have a detailed image on the content of the sites I sorted further the information inventing further two levels to my analysis. In sorting of site data I determine first the context (*secular, religious, fortified, burial, road, royal*) of a feature. Then I added a type level, on which I stored the various feature types. ATH descriptions contain information on the archaeological activity with which the site was identified. A large number of sites were identified with archaeological field survey along the compilation of the ATH. In the descriptions of these sites the archaeologists added information on the amount of ceramics they found. I realized via the data processing that the authors of the ATH interpreted a feature as a 'settlement' or 'place of habitation' even if only one piece of ceramic was found from a period. From that I realized that the reliability of the interpretation is highly questionable. On the other hand however, excavations rarely followed the field surveys therefore, in a large number of sites this is the only presently known information on their habitation. Not to loose this information I found it essential to include the amount of find material - if mentioned - into the database as an attribute of the site. In my database I added a field with the number of ceramics to those sites which were identified with field surveys. I used the following 5 groups: *number is not determined in the description, few pieces (1-3 pieces), small amount, medium large amount, large amount*. This re-classification of sites helped me in two ways. On the one hand it highlighted those sites from where only a limited number of ceramics came to light. On the other hand it helped me to rank the sites in which I assumed that there is a relationship between the amount of surface finds and the type of the settlement. As a next step I joined in the data from written sources into the same database, grouping this information under 'source' activity type. I only listed the earliest or latest mentions within my database or those mentions, which contained place names or landscape

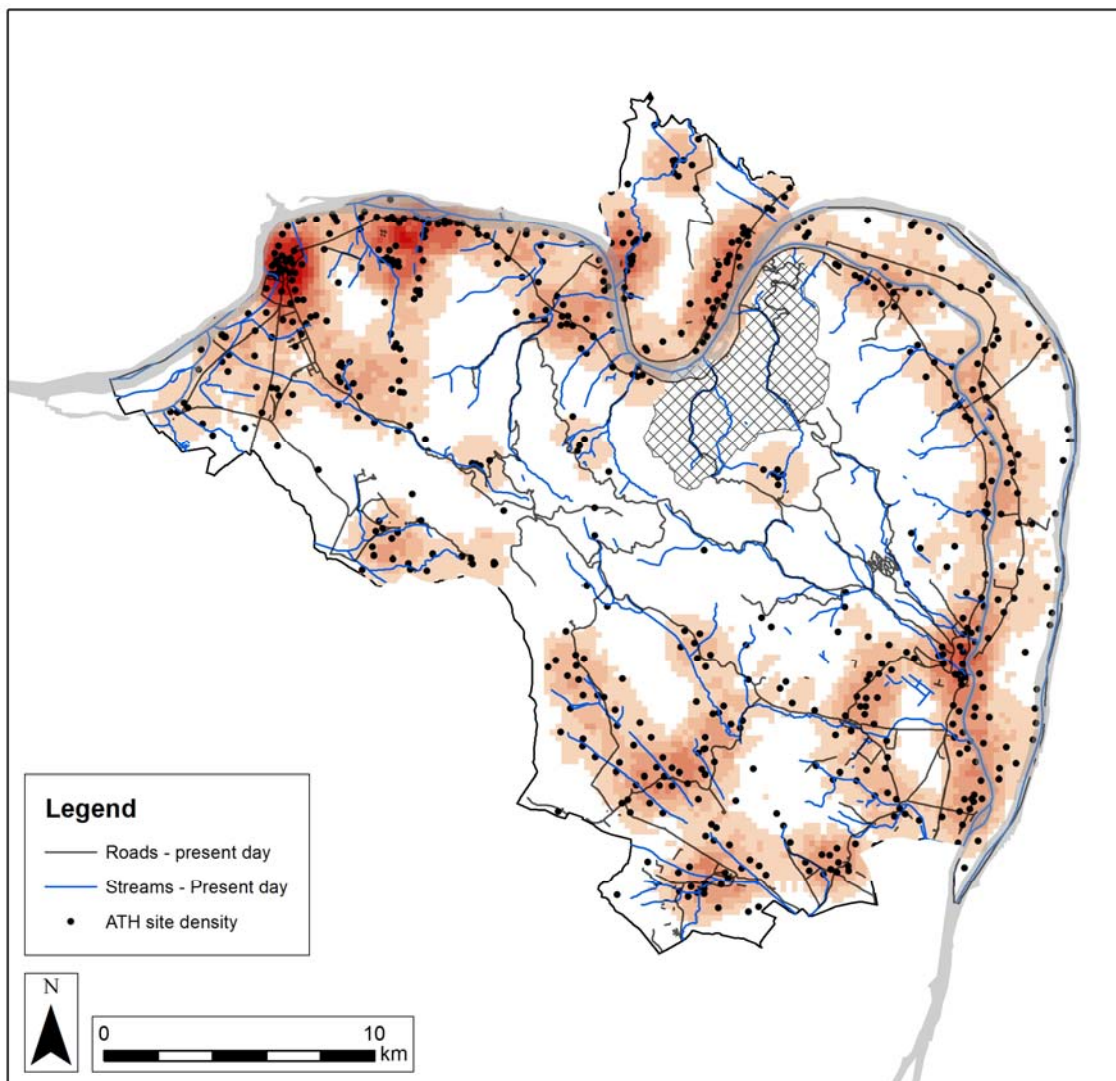
elements, or referred generally to the context of the source. In those cases where I was able to identify features within the source, I also added this to the feature type. (For example I grouped a mention on a church under 'religious' context and 'church building' as a feature type.) As a next step I added the resulting database to my GIS project. Here I georeferenced the published settlement maps from the ATH volumes and vectorised the site extents into my GIS database. Similarly to the descriptions, the geographical extent of the sites merged various periods and features. As a result of this the extent of a site was not equal with the extent of the included features. Therefore I found it misleading to connect directly the site extent with the feature type. An example for that if only 1-3 ceramics are known from a period the location of these most probably do not correspond with the whole extent of a site polygon. As I could not use the extent of a site as an attribute, I decided to generalize them into points. Points were determined as the centroids of site polygons. Further on I conducted the spatial analysis on these points. It should be underlined, that the whole settlement of Visegrád is lacking from these analysis, as it lacks completely from the ATH.



63. Archaeological sites and the land cover

I began the spatial analysis performing density analysis in GIS. To have a more complete picture on the distribution of sites within the research area I included sites from the 8th to the 13th centuries. In the distribution of the archaeological sites it is a tendency that very few sites are located within the Pilis forest. There are different explanations for this phenomenon. A straightforward explanation would be that there were no settlement structures within the forest. Based on the available material however it cannot be decided whether the authors of the ATH were not able to locate sites within the forest, or no field walking survey was conducted in the forested area. This latter could also be a result of a preconception that the area was continuously covered with forest therefore there was no need for research within the area.

Within the written sources there are mentions on a settlement, *Dersülése*, located within the presently forested area. The exact location of this settlement is still a question as it was not identified with field survey. Based on the location of this settlement it is conceivable that there were more habitation places within the forest. Until present, as no further information is available from the inner parts of the forest, neither on the exact routes of the former field surveys, the existence of sites within the forested area of the Pilis remains questionable. (Fig. 63.)



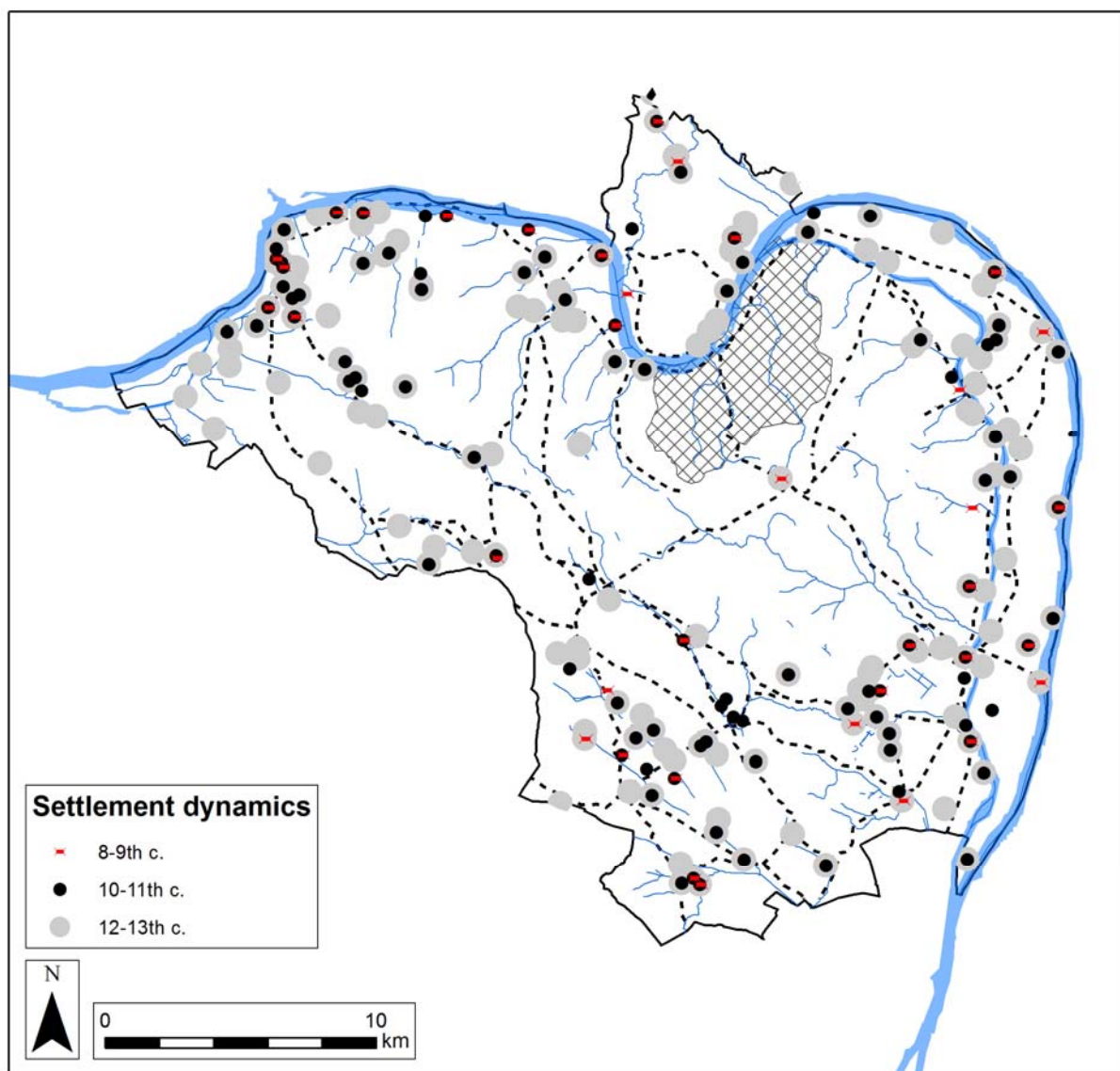
64. Density of archaeological sites

The density map shows the largest accumulations of sites in the vicinity of the present day Esztergom and Szentendre. It is also notable that a large number of sites can be detected along the river Danube, and also on both sides of Szentendre Island. A larger accumulation of sites was detected south from the forested area in the vicinity of the present day Pomáz. Comparing the location of sites and the location of present day roads it can be seen, that the known sites do not coincide solely with the present-day roads but there are sites in the vicinity of streams and also at present-day arable lands. This image confirms that the area outside of the forest was surveyed systematically in between the roads too. (*Fig. 64.*)

V.6.2 Settlement dynamics

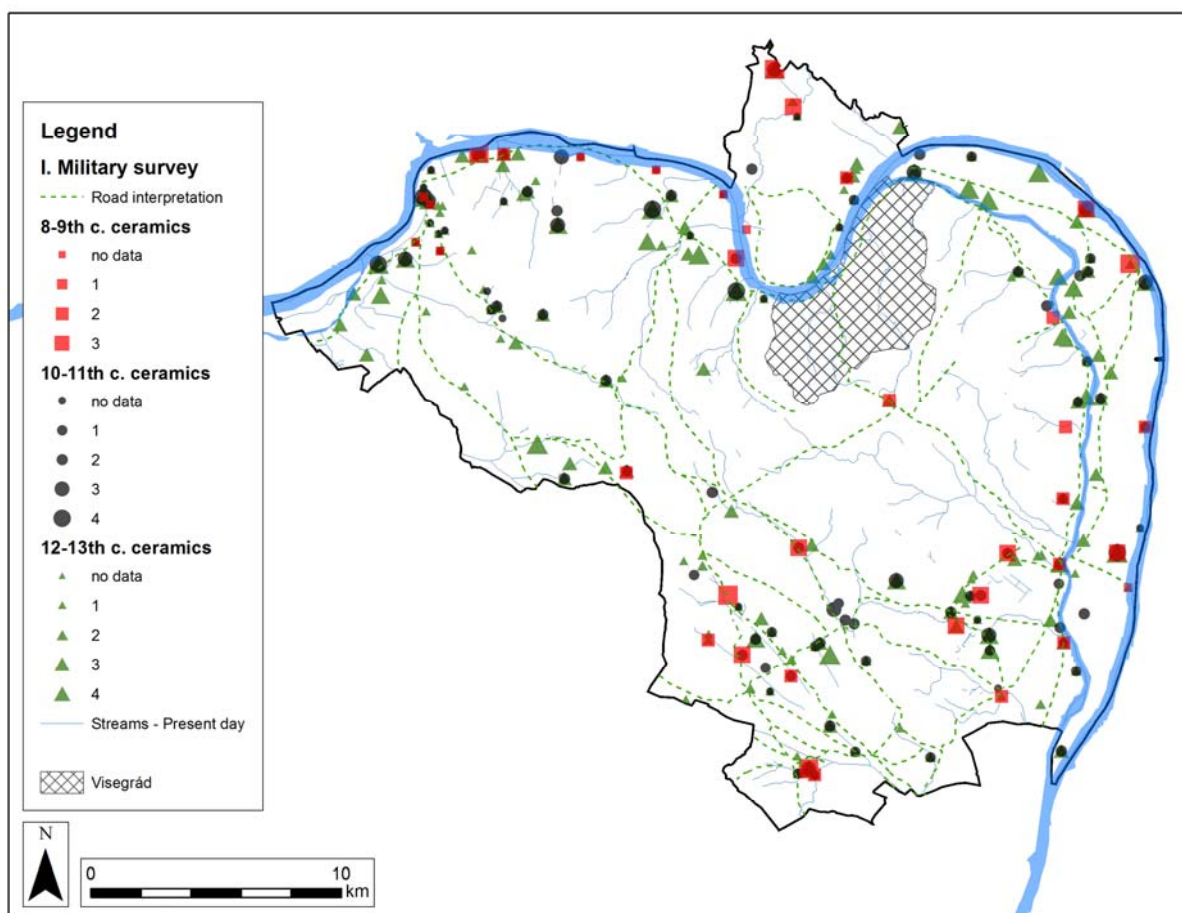
To understand the inner dynamics within the settlement system I grouped further the settlement sites on a period-basis. The time frame of the present study was set from around the Conquest period to the Arpadian-age which I separated further into 3 periods. The determination of the periods to the sites stemmed directly from the ATH. I grouped under the period of 8-9th century those sites where the earliest occupations were detected from around the Conquest Period. I further separated those features which were dated to the 10-11th century as this period witnessed the birth of the Hungarian Kingdom and the development of the state. The third period was the 12-13th century, the late Arpadian age as it can be considered as a period of inner consolidation. The end of the rule of the Arpad dynasty in 1301 provides a closing date for the present research too. With the help of the chronological ordering of the sites it is possible to visualize more clearly the dynamic changes of the settlement system. As a first attempt I visualized the use of sites through all the 3 periods. (*Fig. 65.*)

The resulting map shows that only a few sites were in use all along the study period. The area of Esztergom and the southern part of the study area are those where early occupation was detected. Furthermore the river crossing on Szentendre Island at the area of Vácréve seems to be an important crossing point on the Danube throughout the whole time period. A comparison of the 10-11th and 12-13th century sites illustrates that in a large number of cases those sites which provided material from the 10-11th centuries contained material from the 12-13th c. period too. This refers to the continuous use of these settlements through the Arpadian-age. In contrast to that the area south from Aszófő, close to the later Boron at a road crossing, provided sites with only 10-11th century material. The visualization of sites demonstrates clearly the settlement growth of the 12-13th centuries too. Furthermore from this period a notable phenomenon is the dense habitation on both banks of the western arm of the Danube, at the area of Szentendre Island. In parallel with the growing number of written sources from the period, the number of settlements which can be identified by name also grew.



65. Settlement dynamics through time

Even though in many cases their written mentions stem from a later period the find material from field walking or excavations makes it possible to connect ceramic concentrations with settlement names. It is however more problematic to determine a settlement typology between the sites based on the field survey results. According to the number of finds it seems that it is a tendency that at those places where 10-11th and 12-13th century period-material was both detected, the number of the artefacts increased through times. (Fig. 66.)

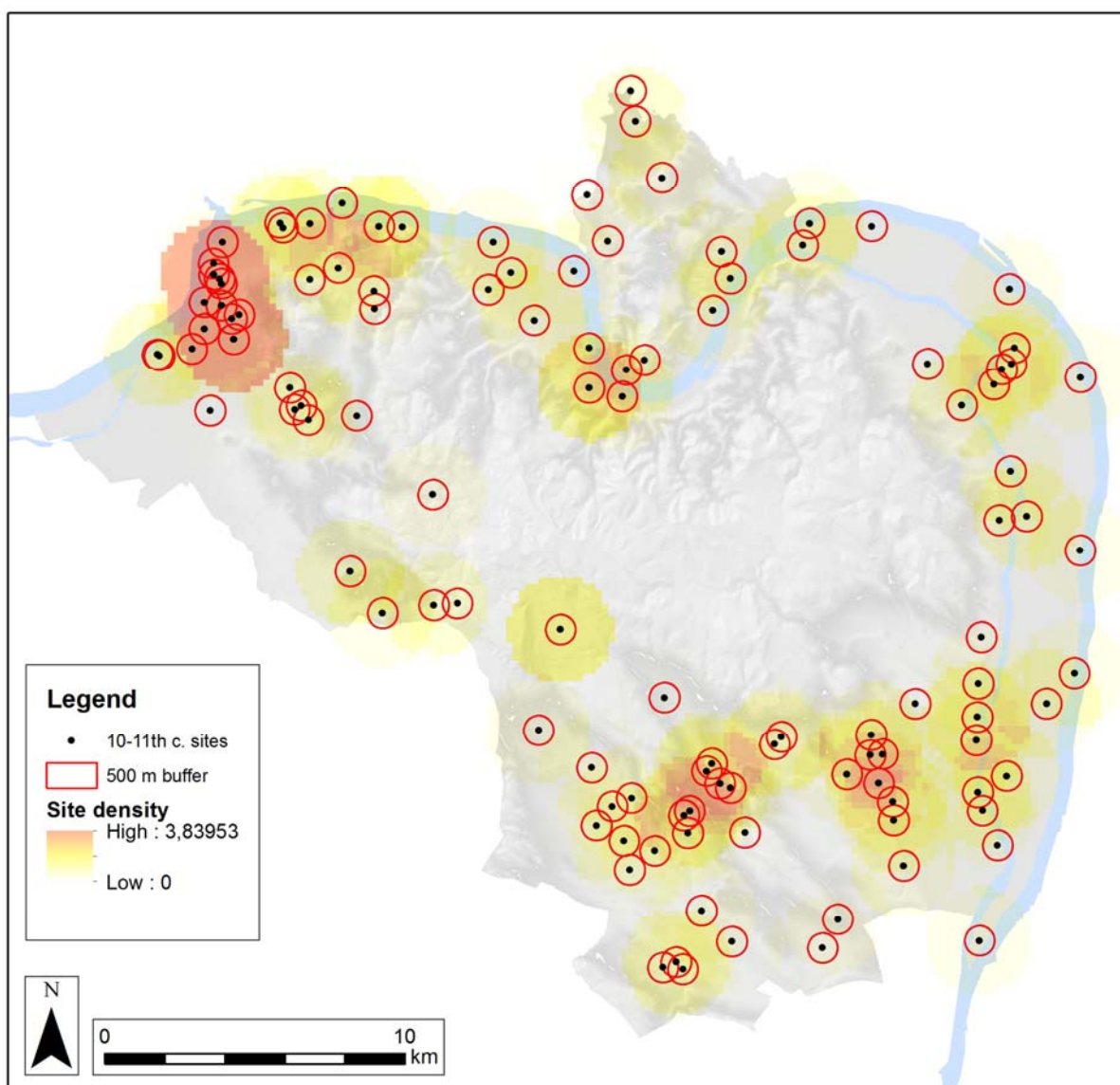


66. Number of ceramics through use periods

To visualize more clearly the differences in the amount of material I grouped the sites on period bases. It seems that the settlements in the 8-9th centuries were located along the Danube, and also south from the forested area. Interestingly, on the northern part of the study area the settled sites followed the curve of the Danube and were placed along its bend. Settlements encircled further the mountains on East, along the course of the Danube and at the Szentendre Island. According to the ceramic distributions, settled areas were located app. 2 km from each other. Larger concentrations of finds were detected in the vicinity Esztergom, at the later Vácrév village on Szentendre Island, at Solymár village and at the area of later Szántó village and around the area of Szentendre. Ceramics at Vácrév refer to most probably the use of the river-crossing from this period. A notable site is at Esztergom *Hidegtelelőskereszt*. Here a Roman castrum, built in the 4th century was found. Ceramics however were dated from the 9-11th century. Both the location and the dating of the later periods look similar to that of the fortification of the Visegrád-complex. To understand the connection between the two sites however needs a more thorough investigation in the future.

In the next period, at the 10-11th century the number of settled sites increased in in the whole area. The largest accumulation of sites was detected in the area of Esztergom. Furthermore, sites were in a larger number at the area of Dömös, Pomáz, Szentendre and Csobánka. Otherwise sites are located at an average distance of 500 m. (Fig. 67.)

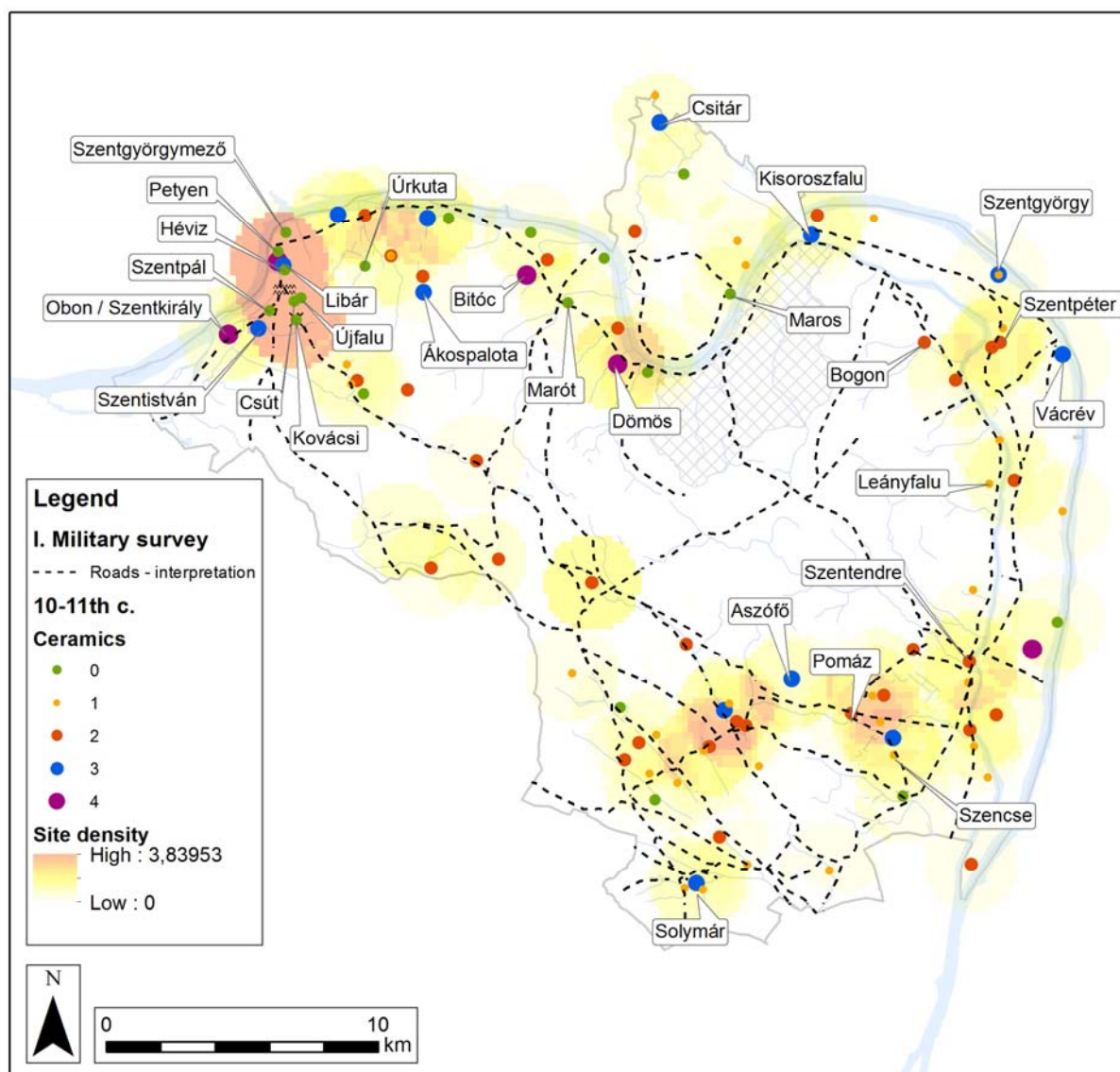
From this period the Medieval *Esztergom* is one of the largest towns not only in the Pilis region but in the Medieval Hungarian Kingdom. The town of Esztergom became the royal seat of Géza in 972 and his son, Stephen I. (997-1038), was also born here. The settlement had three focal points: the royal castle, the royal town and the town of the Archbishoprics which operated here from 1001. The town bore the '*jus stapulae*', the right of staple which gave it the privilege to block the imported merchandise to offer them on its own market.⁵² The royal seat operated at Esztergom until the Tatar invasion after which it became the Archbishop's property, and the possession of the Catholic Church. The distribution of sites in the area of Esztergom presents nicely the structure of the settlement which was formed from scattered settlement units.



67. Spatial distribution of 10-11th c. sites

⁵² <http://definitions.uslegal.com/j/jus-stapulae/> last accessed 2017-09-01.

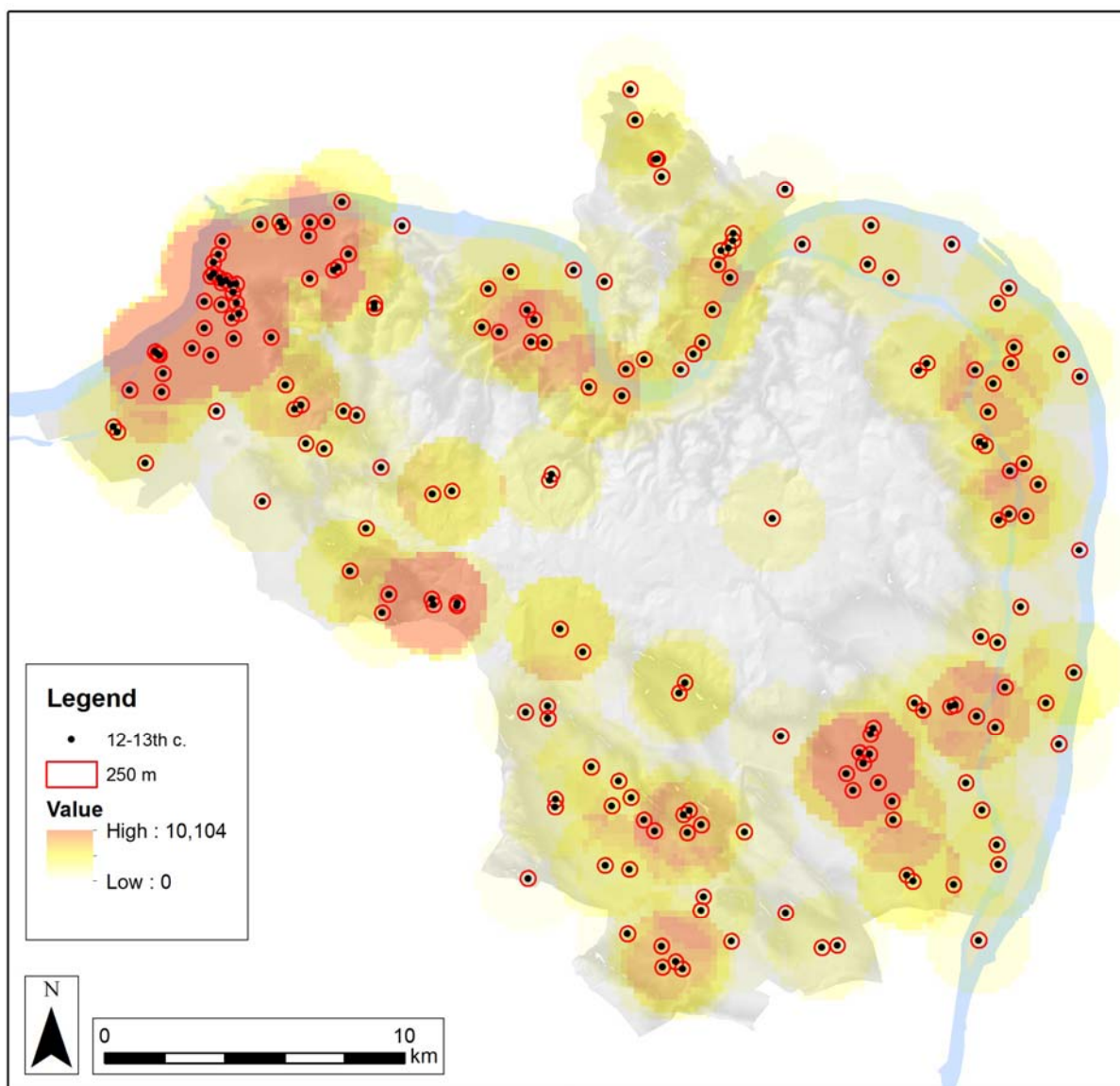
A combination of the 10-11th c. settlement distribution with the interpreted road map of the 18th century shows that the location of sites correspond well with the location of the interpreted roads. Furthermore it seems that on the southern part of the study area, habited sites are close to the road junctions. (Fig. 68.)



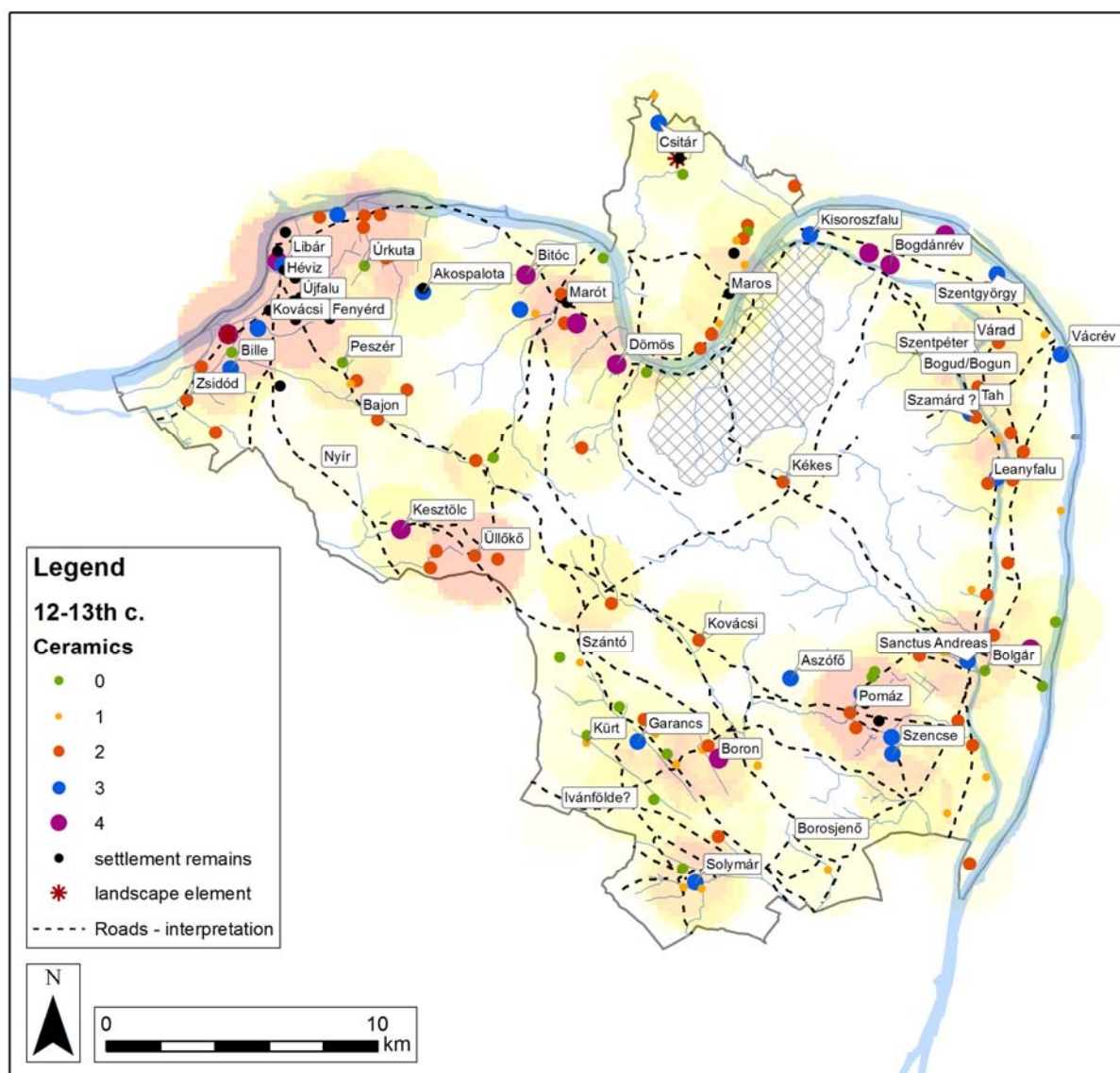
68. Ceramic density and site distribution

In the next period, in the 12-13th centuries, the number of registered sites further increased and the distance between the settled areas decreased consequently. In the area of Esztergom and in the southern part around Szántó and Pomáz smaller accumulations of finds were detected 500 m-1 km from each other. (Fig. 69-70.) The location of settlements followed further the location of the roads. In the case of the northern road of the Danube - in the area of Marót - the habitation places clearly followed the road instead of the course of the river. Further south on the Danube in the area of Szentendre Island it is notable, that the sites become more dense on the western side of the island

while on the other side smaller number of sites were found with larger number of ceramic remains. The dense accumulation of sites on the western arm of the river might refer to a more frequent communication line or easier river crossings here.

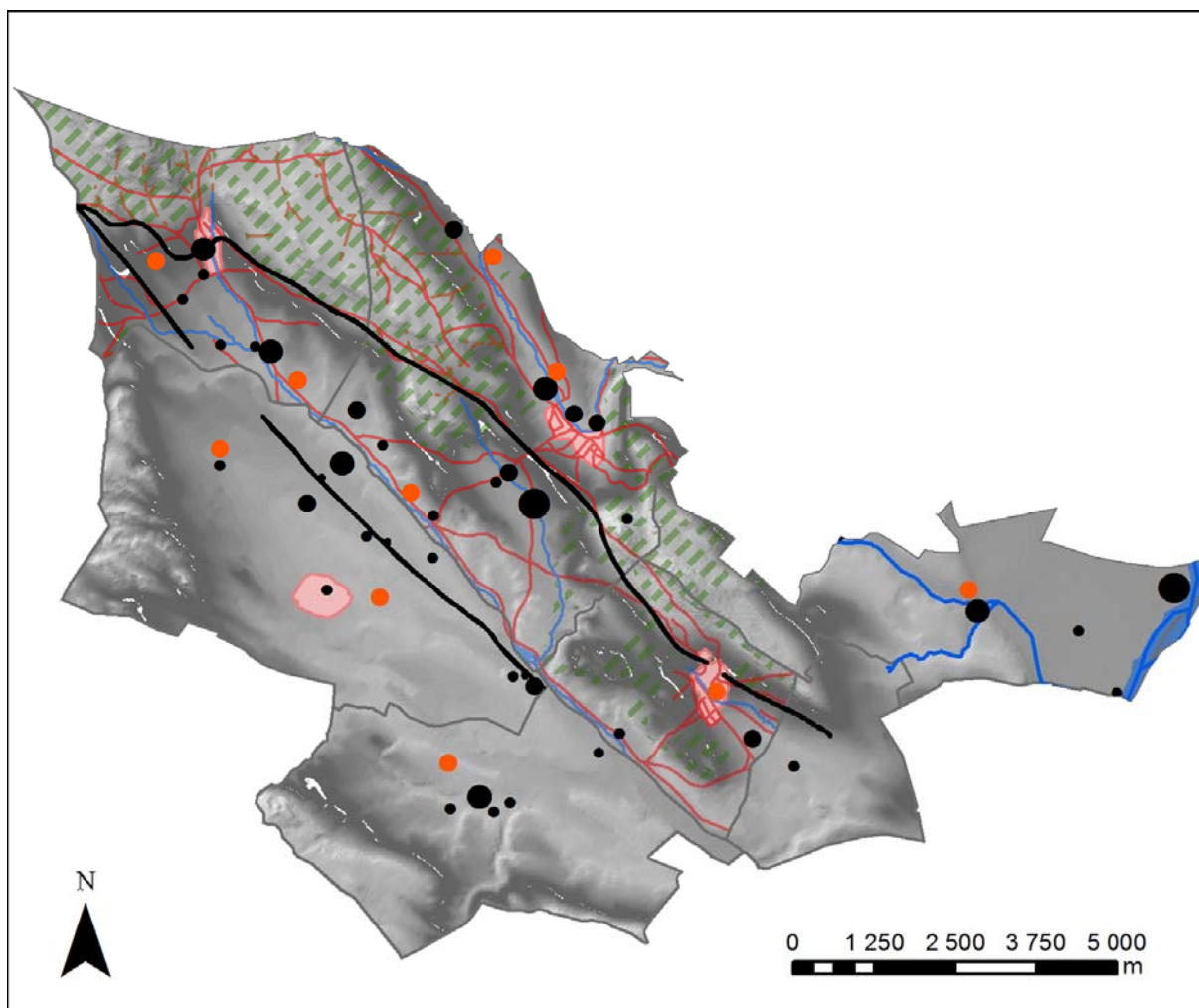


69. Spatial distribution of 12-13th c. sites



70. Ceramic density and site distribution

Looking through all the periods and visualizing the amount of find material at every site, the image becomes quite coarse. The information however can be of further use on small areas. As field survey data is not available from the area of Visegrád I tested the use of the dataset on a smaller scale, at the area of Szántó, at the southern part of the case study area. I found it feasible to choose the Szántó area as here more a detailed cadastral map is also available. I realized via the georeferencing that the large part of the present day settlement boundary is similar to those depicted on the cadastral map which enabled me to insert this map to the GIS project and vectorise information also from here. Interestingly, with a closer look the site distribution maps, it can be seen that the large part of the sites still follow the routes depicted on the First Military Map. Furthermore there is notable relation in the location of sites to the road and in the number of ceramics. From that it seems probable that the amount of the material together with its relation to a road indeed signs the type of the settlement. (Fig. 71.)



71. Ceramic distributions and location of roads around Pomáz

V.6.1 Roads and communication networks

As it can be seen from the site distribution, the location of sites correlates highly with the location of the transportation and communication network of their area. In the research of roads many different source material can be of use, a large part of which still need to be analysed more thoroughly in the future. One group of the most important source materials is that of the written sources in which roads and passes are mentioned.⁵³ In the case of the case study area this is a task for the future research. From the archaeological source material, both excavations and field surveys revealed parts of the main roads running in the area. The dating and development of these roads however is still debated. One of the main roads in the area was the Roman limes road running along

⁵³ On the methodology see: Magdolna Szilágyi, *On the Road. The History and Archaeology of Medieval Communication Networks in East-Central Europe*. (Series Minor 35.), Budapest: Archaeolingua, 2014.

the Danube bend. This was most probably used continuously along the whole Middle Ages. The other Roman road which crossed the case study area left from Brigetio via Pilisszántó into the direction of Óbuda. It is highly feasible that this road was also in use in the Middle Ages. Another road was detected by Elek Benkő with field survey. According to him this road was not Roman in origin but rather developed through the Middle Ages. This road ran on the borders of Pilisszántó and Csobánka, via Pilisborosjenő and Üröm to the direction of Óbuda (the so-called *via regis*, royal road). (Benkő 2011; Ferenczi et al. 2014) Based on his assumptions it was Zsuzsa Pető who recently entered a new methodological aspect into the question. In her research Pető used Least-Cost Path analysis using the elevation model of the area. According to her observations royal presence highly influenced the location of the roads, which might follow the previous Roman routes, but not exclusively. She was also able to detect a change within the main road system. She recognized that when Visegrád gained over the importance from Esztergom, the route between Visegrád and Óbuda became more notable. She however underlined, that for a more precise understanding of the local road network a more thorough investigation of the settlement network is inevitable. (Pető 2014)

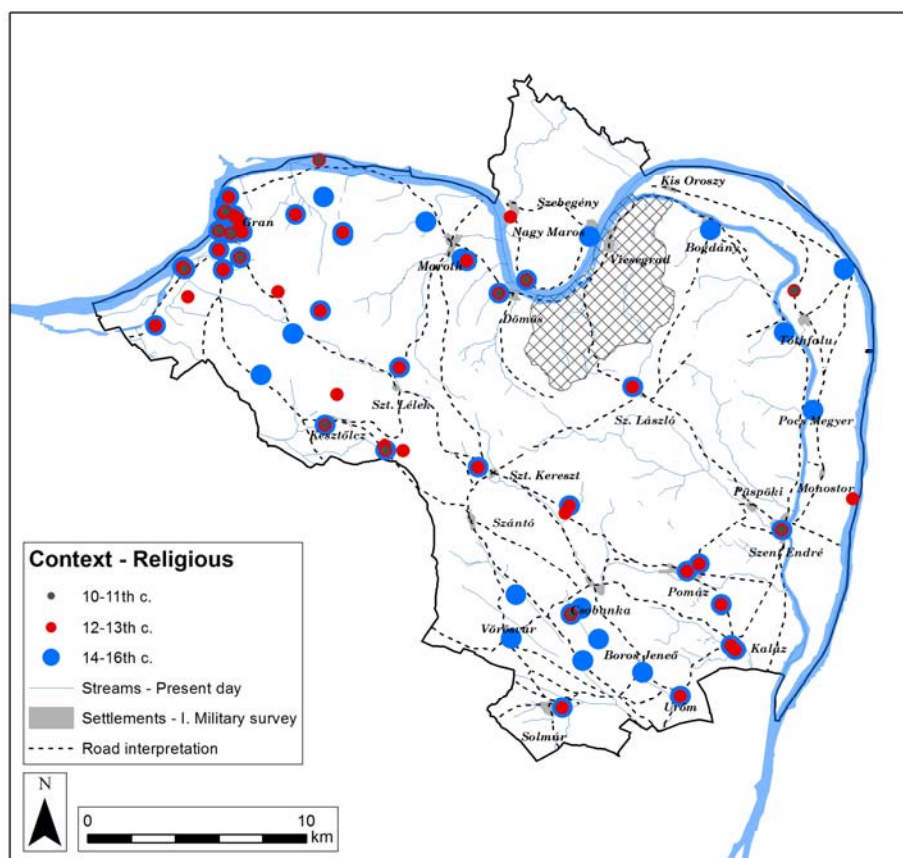
Even though the present thesis was not aimed to give detailed understanding of the road system there are some points which are worth mentioning. The above mentioned interpretations mainly based only the location of the royal centres or on places of royal importance. In analysing the settlement distribution I consulted historical maps on which I observed a notable phenomenon. At the southern part of the study area two legs of the Roman road were detected with field survey. It seems that here a larger number of settlements were located closer to the stream nearby than to the former Roman road. Roads within the forest mainly followed the streams, and have very much in common with the roads depicted on the First Military Map.

Supplementing further the distribution of archaeological sites with the historical maps I realized that the interpretation of Benkő on the medieval roads can be challenged at some further points. An interesting area is that of Pilismarót, where, according to Benkő's interpretation the road runs along the Danube bank. In contrast to that however the archaeological material, the historical maps and the present situation suggests that here, the road rather run at the feet of the mountain. The same can be applied to the area of Dunabogdány where the road looks like cutting into the fields instead of running along the river bank. At the other areas it is a tendency that there are settled sites along the Danube bank which was obviously a highly important communication line of the area.

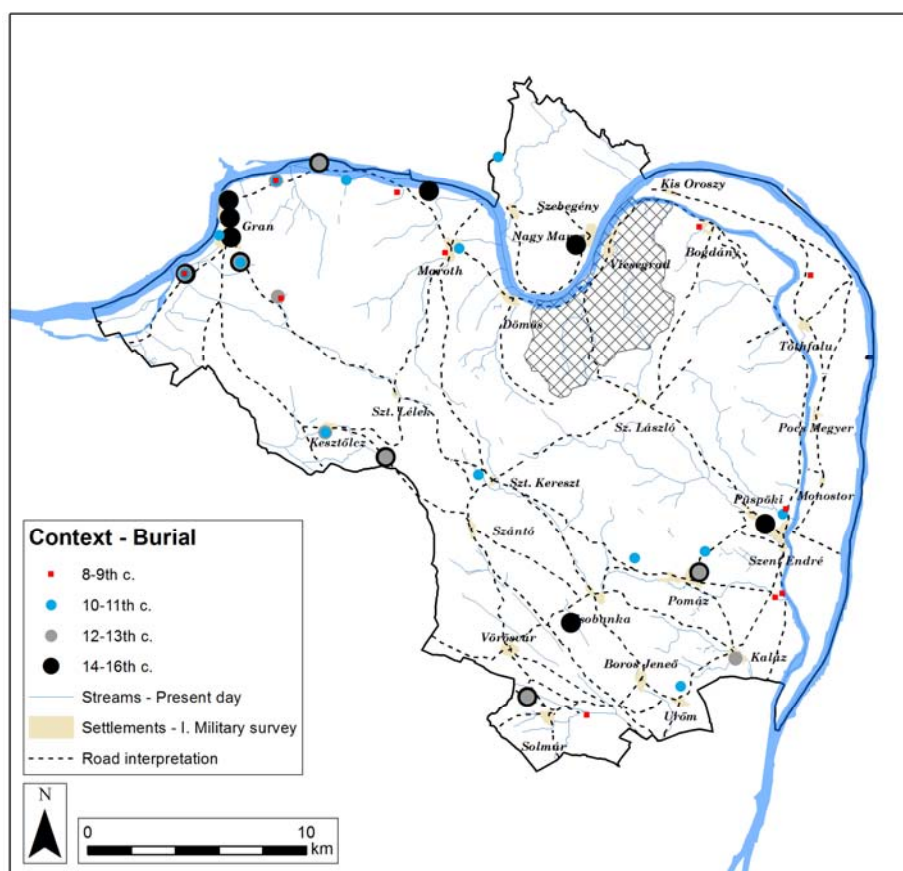
V.6.1 Religious elements and burial sites of the Pilis area

Above I presented in detail the settlement dynamics of the area based on field walking finds. Besides secular elements, the ATH dataset contains information on the religious elements of the area and on the burial sites. A detailed analysis of the medieval churches of the present Pest county was done by Edit Tari, however she followed the present day county boundary therefore settlements belonging now to Komárom-Esztergom county is missing from her analysis. (Tari 2000) In parallel to that, László Koszta gave a summary on the different religious elements of the landscape. According to him it seems that at the turn of the 11-12th century the net of the parish churches did not exist and also the settlements moved and left the churches behind. (Koszta 2001) Medieval monastic system of the Hungarian Kingdom is thoroughly analysed by Beatrix Rományi. In spite of the scarcity of sources, she was able to highlight the importance of the Medium Regni already around 1100. She also found spatial correlation between the first foundations and the late Roman and 9th century settlement system. (Romhányi 2015) In more detail Benkő Elek studies presently the relationships between the cloisters and monasteries and the royal properties within the area. According to his observation it is feasible that after the donation of a royal property, the king still had a place to stay besides the monastery and the two functions worked together. (Benkő 2015) Recently Mária Vargha analysed in her PhD research the development of the process of Christianization and the network of local churches of the 11th-12th century Hungary. Based on detailed collection of archaeological data on rural local churches, field cemeteries and ecclesiastical power centers, she was able to conduct GIS-based spatial analysis. For central places Vargha demonstrated the early churches are not in the vicinity of castles, and rarely found together with monasteries or bishoprics. (Vargha 2019, p. 154).

Based on the dataset from the ATH I found it problematic to provide an overview on the religious remains or even on the burials. I realized that the dataset was not detailed enough on the excavated material and the features in the religious context were in many cases stemmed from textual sources. In the case of burials and cemetery data the generalization of sites to points resulted in even more uncertainties within the data. (*Fig. 72., Fig.73.*)



72. Sites of religious context



73. Sites of burial context

V.7 Summary

In the present chapter I studied the early medieval complex of Visegrád. I presented the elements of its archaeological landscape from a topographical point of view. My first task was to collect the available material from the complex and insert it to a GIS project. A notable result of this compilation is the re-positioning of the excavation plans of the Várkert settlement and its adjoining cemetery. The resulting project let me the possibility to open up the boundaries of the complex as a whole. I interpreted GPR and magnetic data from the area of the fortification. In the interpretation process I marked out 6 study areas in which I described the geophysical anomalies. As a result of the interpretation process I recognized at least 5 buildings. I had also the possibility to present here the preliminary results of the excavation which followed the geophysical measurements and compare the unearthed features to those of my interpretation. In this comparison I found out that the stone features were interpreted correctly by their location and their size, but their depth was somewhat different. I was not able to identify the earthen features on the GPR dataset however. In the case of these features magnetograms provided more information. I concluded from the comparison that the prospection datasets highlighted clearly those features which were made of stone, but the earthen features are hard to recognize. I further realized that geophysical measurements did not reach until the fortification wall. As a large number of features have already been identified along the walls I underlined that most probably the resulting map is still incomplete.

Based on the already published material I considered the early complex of Visegrád as a place of importance. The settlement of the complex is also mentioned in connection with the early urbanisation. Recently it was József Laszlovszky and Katalin Szende, who analysed if the different elements of the complex can be considered as signs for proto-urbanism. In that the authors concluded that the settlement did not have urban character despite the existence of the county seat or the monastery. The authors explained this phenomenon with the general decline of the county centre. (Laszlovszky & Szende 2014, pp. 35-39.) Even though the settlement itself does not show special urban character the complex, as a whole, still has special importance. In the Hungarian research the theory of central places is not widely used in the question of early centres, but the elements of the complex and the value of the find material makes it possible to consider the complex as a central place. The high class of the habitants can be detected in many points: the two-roomed stone building, the elaborated decoration of the churches and the deceased with golden rings and the royal foundation of the monastery. This can be explained with royal ownership or high society habitants with close connections to the royal court. (Buzás et al. 2017)

It is still debated how the complex is related to the royal centre of Esztergom and to the settlements of the Pilis region. To present the complex within its wider landscape I consulted the material of the Archaeological Topography of Hungary. I reorganized the published material in which I found out that in many cases habitation places were determined based on only a few number of ceramic remains which makes the resulting dataset highly questionable. As in many cases no further

information was available of the sites I used the material despite its reliability. As a comparison between the overall approach of the ATH and the archaeological landscape approach I realized a notable difference. As in the ATH the main element was the site as a geographically delimited area, the contemporaneous sites were mainly separated from each other. In my approach first I regrouped the sites according to their context. As a next step I created period maps on which I was able to visualize the contemporaneous sites. These maps presented the overall site distribution of the area. It is however still a task for the future to compare each and every element of the complex with similar elements in the region on smaller scale. For that a possible solution would be to collect comprehensive datasets – like that of the Visegrád complex - which could provide more coherent information from larger areas.

VI. Evaluation of the potential of prospection data for landscape archaeology

In the previous chapter I presented elements of the Pilis region, considering it as an archaeological landscape. I studied the area on three scales which are the landscape, site and intra-site scales. A key question in my study was how prospection data can support the research of archaeological landscapes. At Visegrád I had the possibility to use geophysical prospection data on intra-site scale for this analysis.

VI.1 Prospection data and site analysis

From a methodological point of view my aim in the interpretation was to study if it is possible to extrapolate stratigraphic information from 3D prospection data. In that I also studied how the results of geophysical prospection can be compared to excavation data, namely, to compare the measured data with stratigraphic information. I also used the results of the interpretation to answer historical questions.

From the area of the Visegrád complex both GPR and magnetic measurements were available from the inner area of the fortification. Even though the extent of the measurements was limited the results generated new archaeological excavations. I began the interpretation process of the prospection data with the understanding of the GPR material and then I compared the Magnetogram with the GPR radargrams too. As a result I detected at least 5 building structures within the inner area of the fortification. Excavations, following the prospection measurements let me compare the results of my interpretation with the unearthed features. In that I realized that the stone features were correctly detectable on the GPR measurements. Earthen features however were rather detectable on the Magnetogram. I further realized that a large number of earthen features along with the former excavation trenches were not detectable on the measurement result. This might be a result of the general geophysical properties of the earth. It should be further noted that the bad weather conditions at the time of the measurements most probably influenced the results too. In the case of the features I observed a further discrepancy between the interpretation and the excavated features. On the GPR measurements features appeared a 10-15 cm lower than in reality. Otherwise the size of the detected features was equal to the unearthed ones.

In the case of Visegrád the stratigraphic sequence within the prospection data was hardly identifiable. In my opinion this is a result of the structure of the site itself. As it is clear from the previous excavations, features and layers from different periods appeared at almost similar depths. As the stratigraphical sequence is shallow, it is rather the cut of the features on which the relative chronology is based. The relative chronology is supported further with the evaluation of find material. In the case of the prospected material I studied the stratigraphic sequence with the help of

the semi cross-sections. In that I realized the chronological ordering of the features can be rather based on their general attributes (size, shape, material) then on their depth information.

To conclude the evaluation of the interpreted material it can be stated the prospection data can facilitate landscape archaeological research in many ways. In the case of Visegrád the extent of the measurements was limited but the results highly motivated the research. Excavations following the measurements confirmed in many parts the interpretation results. Discovery of the earthen features underlines the importance of the excavation work as well though. Furthermore it is highly feasible that prospecting at the presently blank areas of the Visegrád complex would provide notable new information from its archaeological landscape as well.

VI.2 GIS – based modeling and integrated archaeological landscape analysis

In my research I considered an archaeological landscape a geographically defined area within which archaeological elements were detected. The archaeological elements have been identified with various methods including archaeological excavation and prospection. Along the work I followed integrated interpretation as a methodological approach. In that I used various types of data supplementing each other to answer archaeological research questions. I realized along the data collection that the amount and extent of the available data varies on every data level. The aim of the data integration was therefore to supplement the groups of information - derived from various origins - with each other. As a theoretical starting point I defined an initial state for the archaeological landscapes. I considered this as a state into which the elements of the landscape emerged.

I conducted the research using a geographic information system (GIS). The use of GIS was a key feature within my research, as I studied the spatial relationships in between the elements. I determined 3 different levels - the intra-site, the site, and the landscape scale - onto which I grouped the archaeological elements. I collected data from various sources on each of the levels. The GIS projects enabled me to georeference all the available data into a common projection system. In the Pilis case study area, the use of the Hungarian System, EOVI HD72 was convenient. I began the data collection with datasets on the present-day topography which provided me a base map layer to my research. The base map layer included both raster and vector datasets on the characteristic land use types and on natural and artificial elements of the studied landscapes. As a next step I consulted historical maps. In those cases where I was able to find map-terrain identical points I georeferenced the maps directly to the GIS project. From these maps I vectorised datasets which were usable for spatial analysis. In those cases where I was not able to georeference the historical maps, I used them as a visual representation of the landscape. In these cases I studied the annotation and the legends of the elements. Data on the present-day topography together with historical maps provided me a background for the archaeological and historical data. The comparison of the two layers further helped me to highlight those elements in the landscape which are most probably from historical origins. I supplemented the results of the comparison with mentions on landscape elements from

written sources. From the Pilis region, written mentions were listed in relation with sites in the volumes of the Archaeological Topography of Hungary. Here I was able to re-group the content of these mentions according to their context and use the information from these groups in spatial analysis.

The core data for the integrated analysis stemmed from archaeological methods. Archaeological data was available both from site and intra-site scales. On the site scale data extent of archaeological sites were added as polygons and generated to points. Here I conducted spatial queries on the point data sets. I studied the density of points comparing their distribution to the present-day landscape. I grouped the sites according to their context and compared the distribution of sites with the geographical properties of the area. I concluded from the comparison that there is a notable relation between the distribution of site-types and their location. This observation is beneficial in landscape archaeological research in two ways. On one hand it can help in predicting the type of sites based on their geographical area. Furthermore it can validate the usefulness of the complex site catalogues in studying complete landscapes. In the case of Pilis region the site-scale density maps highlighted the differences in the data availability between sites. Furthermore distribution maps also traced out areas from which data was not available and which were represented as blank, siteless areas. Therefore, my research highlighted methodological issues concerning the use of complex archaeological site catalogues.

In my research I aimed to present the dynamic development of sites together with their landscape. In that a crucial point was to put sites into a chronological order. Even though the chronological description of sites was detailed in the case of the Pilis region, field survey data was only separable on period bases (that is app. 200 years). As a conclusion I found useful the integration of various types of data on site and landscape scale as it helped me to recognize elements from the historical landscape and their relation to the site distribution. Furthermore I was able to highlight trends within the site distribution which can be seen as a consequence of the data acquisition methods and the lack of information.

The integration of various types of information was particularly relevant on the intra-site scale analysis. On that scale I used the expression 'complex' to denote the unity of sites or site-parts. Furthermore I understood the sites or site-parts as elements of the complex. This approach let me include information from all the sites and from various sources. In the case of the Visegrád complex the available data on the elements of the site is still highly sporadic. Within the GIS project however, I was able to correctly relocate excavation plans. In that I found essential the use of archival aeriels. Along a construction work in the 1970's the topography of the complex was dramatically changed. The location of excavated trenches was measured relating to the former roads and road-signs which were not identifiable on the presently available maps. Archival aeriels however do exist, showing the previous location of the roads. Furthermore on one of the maps even cropmarks denotes the area of the excavation trenches. Geophysical prospection data was available for interpretation from one of the element of the complex. The results of the prospection measurements were inserted into the GIS

project. Interpretation of the data was further supported with excavated material. In that, prospection measurements highlighted under earth features and signed out areas to excavate. In parallel to that excavations supplemented the interpretation from the area of trenches.

To conclude integrated interpretation let me to connect various materials on geographical bases. It further helped me to get a complete image on the archaeological landscape. With the help of the GIS projects I was able to analyse the various datasets in combination with each other. It further let me the possibility to visualize the changing of the elements through time and in that to model the dynamic developments of the studied landscape.

I can also conclude that world wide (or Europe-wide) datasets are accurate enough to create an overall basis for large scale archaeological research. These datasets can be considered as a starting point; however, one has to take special care of their various projection systems. As these projections describe the form of the Earth based on varying parameters, this can result in distortion or drift in the dataset. In most GIS systems on-the-fly projection tools help to solve or at least manipulate these problems though. The same can be applied to the data without projection system (like topography data from historical sources or historical maps) or those, measured in local system without reference to the present coordinate system (like former excavation data, where objects were measured with reference to a grid system, but the grid system itself was not referenced to a coordinate system). These can only be added to the GIS system, when one can find joining link between the present day elements and the elements illustrated between the data. Along my research I realized that it is nearly impossible to exactly determine which are those elements which will be surely of use in this process. In many cases additional maps or drawings were needed to be inserted before a given excavation trench was georeferenced. In that I found similarity in the collection of a 'total' GIS database with the overall process of archaeological data collection. The more bits of pieces came to light from new excavations or from re-discovered archive material the more comprehensive the database can be. In that however one has to open up the data collection and look through different types of datasets too including archive maps and measurements. Furthermore one has to keep in mind that each and every georeferenced dataset has its own error based on the resolution and accuracy of the original data. I found this observation essential in the evaluation process as once the data is added to the database and become visualized on the resulting maps the original error will not be traceable any longer.

VII. Conclusions and summary

In this thesis I conducted GIS-based landscape archaeological analysis. I discussed methodological and theoretical issues on GIS-based archaeological research. My aim was to visualize the inner dynamics of central places in context to their surrounding landscape. In the thesis I presented the archaeological landscape of Visegrád. In addition, I discussed the spatial analysis of settlements from the area around the complex, in the Pilis region.

The selection of the case study area determined the time frame of my research, therefore I put the emphasis on the 10-13th century settlement network within the Pilis region. For a conceptual framework I considered Visegrád as a central place, as it had special importance for a certain period of time, but it did not later develop into a fully urban form. I considered Visegrád as a complex, a coherent unit of different archaeological sites. Furthermore, I considered it as a part of an archaeological landscape. In my work I considered an archaeological landscape an area in which the elements are archaeological sites and features were identified by landscape archaeological methods. I identified the elements of the archaeological landscape with archaeological remains on three levels: on the landscape scale, on site scale, and on intra-site scale.

I followed integrated interpretation in my research. As a first step I created a GIS, into which I collected and inserted various datasets. Present-day topography provided the common background onto which further datasets were joined or georeferenced. The integration of various types of material helped me to visualize and understand more clearly the inner dynamics of the sites. As a result, I was able to present here more than 70 maps and illustrations, which I mostly created directly from the GIS database. These maps and illustrations created the basis for the interpretations.

In the case of the Visegrád complex, one of the main results of my work is the compilation of the integrated GIS database. Here, the large part of the data was analogue, archive data which needed to be transformed into digital form. The resulting map shows the relative location of the elements together for the first time. From the sites of the complex, the artefacts are only partly studied. The GIS project therefore provides a core onto which further material can be embedded in the future. To understand the topography of the site more clearly, I studied the historical maps of the area. Here I observed that the former road runs most probably within the settlement area. I investigated in more detail the inner area from the fortification. Here small-scale GPR and magnetic data was available for my research. These measurements resulted in the discovery of a new church building, and a further stone building from inside the fortified area. I marked out 6 pilot areas within the fortification in which I detected at least 5 buildings. Recently, excavations followed the prospection measurements. The result of the excavations coincided well with those of the prospection in the case of the stone features. The identification of the earthen features was more problematic within the presently available prospection data. From the data collection I concluded that most probably the resulting map from the inner area of the fortification is still incomplete.

I considered the complex of Visegrád as an early central place, in which I studied how it is related to its surroundings. For that I consulted the archaeological site material from the Archaeological Topography of Hungary (ATH) to present the settlement distribution of the area. In that, I concluded that the locations of the settlements are highly determined by the former road system. In the ATH a large number of sites were determined by field survey. From these, however, in many cases the only available information was the number of ceramics found along the survey. For the hierarchical ordering of the sites I used these numbers as attributes. In that, I concluded that this information is sporadic, but still helps to determine smaller habitation units in between the settlements known by name from written sources.

One of my key questions of this thesis was the usability of GIS-based methods in archaeological reasoning. I found that GIS tools supported my work in many ways. They provided a geographical background for the whole dataset, and the built-in geoprocessing tools helped me to reveal spatial trends. They also helped me to visualize data in 3D. A core question of my research was whether GPR data can reveal the stratigraphic ordering of under-earth features. In that I observed two phenomena: depth information and the morphology of features. In the case of the Visegrád complex, stratigraphical ordering of the features was problematic based on the GPR data. Only the recent features of the uppermost layers differed in elevation. The archaeological features were located at similar depth levels, mostly independently from their dating. The same phenomenon was detected in the excavations. Namely it is rather the morphology of the features that can help in the chronological determination, than the depth information. At this site I faced another problem; namely, I found it problematic to recognize earthen features within the data. From that I concluded that at this site the presently available prospection data and its interpretation is useful for recognizing parts of the features, but more features can be most probably discovered within the fortification area. Nonetheless, in the case of Visegrád the discovery of the church highly motivated the research as it provided a reason to re-start those excavations that were inhibited for nearly forty years.

In general I found it problematic to insert data from historical sources into the GIS databases. I realized that historical data is so varied, and in parallel too sporadic, that it needs special attention via the integration. To avoid inserting misleading information I used historical data as a conceptual framework at this stage of the research. In the case of the Pilis region, I included those textual sources which were quoted (and sorted) in the ATH. As a future extension of the presently available GIS project, the full content of these textual sources should be consulted and sorted more thoroughly.

From the analysis presented in this thesis, I can conclude that the use of GIS enabled me to conduct integrated interpretation of various datasets, which revealed new information on the spatial patterns of the case study areas. In the case of Visegrád I was able to present the complex as a whole onto which the future results can be built in. On the landscape scale, the analysis of archaeological site data revealed a number of uncertainties in the resulting maps. Nonetheless, these maps revealed patterns within the system of the settlements.

To conclude, as presented in this thesis, I processed archive datasets together with data from new acquisition methods. I believe that it is also a task for the future to re-process the previously gathered data from new viewpoints. New technologies let us see the past from new perspectives and provide us information almost without limits. In my opinion, to find methods to combine the two sets of data is still a task for the future. In the present work I aimed to take a few steps on this road, revealing elements of the studied landscape. In that I found the observation of Haselgrove to be still fundamental, namely:

“human action has consequences, intentional or unintentional, which are expressed in the spatial patterning of our environment”. (Haselgrove 1986, p. 3.)

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