

THESES OF THE DOCTORAL DISSERTATION

ANDRÁS BÖDŐCS

A STUDY OF THE ROMAN ROAD NETWORK IN HUNGARY USING GIS

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Dissertation Supervisor: Dr, Miklós Szabó

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Theme and objective of the dissertation

The study and mapping the Roman road network of Pannonia again became a priority in archaeological research from the later 1970s. Several studies discussing new advances in this field of research in western Hungary and along the Danube have been published during the over thirty years since then. However, very little is known about the roads passing through the interior of Pannonia, even though a better knowledge of these roads would be of prime importance not only for Roman period studies, but for the archaeology of other periods too. My choice of theme was motivated by two considerations: the first, that this field of research has been severely neglected during past decades, the second, that the application of GIS would lead to major advances in the study of Roman roads.

GIS has come to play an increasingly important role in archaeological research. The analysis and evaluation of local and regional data using this analytical procedure will undoubtedly yield exciting new results in this field too. Compared to the technical possibilities of earlier decades, the currently available methods and analytical tools enable more precise survey and mapping results during a shorter period of time. Any study of the Roman road network calls for the analysis of data whose location has been precisely fixed and thus the usefulness of archaeological GIS can hardly be challenged in this field of research.

Complex research was needed to realize the objective of the dissertation. The integration of the primary and visual geographic data, as well as of the available archaeological evidence into a uniform system formed the backbone of the research. My research was predominantly based on the archaeological aerial photo archive of the GIS Laboratory of the Archaeological Institute of the Eötvös Loránd University created by René Goguey and Zoltán Czajlik, and the vertical aerial photos made with for mapping purposes.

The initial aim of the dissertation was the reconstruction of the road network of Roman Pannonia by collecting the data on identifiable Roman road remains on the territory of modern Hungary, the collation of the data with other information on the

known archaeological sites, and its integration into an archaeological GIS. During the collection of the data and the linking of the data to sites and locations (and geographic co-ordinates), I found that the reliability of the available data could be seriously challenged and thus the initial objective slipped farther and farther away. It became apparent that the seemingly secure courses of Roman roads as reconstructed by previous research were often based on inadequate and imprecise information, and thus the emphasis shifted to the mosaic-like collection of the available evidence.

Research methods and the structure of the dissertation

Chapter 1 covers the objectives and the nature of the inquiry and the rationale behind the choice of theme and the applied methods. The analytical techniques of GIS and their brief theoretical overview are covered in Chapter 2, together with a discussion of which technical and theoretical methods were applied. Discussed in this chapter are the potentials in the interpretation of aerial photographs, their visual and photogrammetric analysis, as well as the creation of a database from various types of data and the modes of integrating information collected during field surveys and their testing. This section offers an overview of GIS for those, who are unfamiliar with GIS, and for whom it is a vague umbrella concept for the analytical techniques used by different disciplines, together with a discussion of possible archaeological applications. Even though GIS has been employed for over one and a half decades in the disciplines which can be associated with the earth sciences (including archaeology), and it might therefore seem superfluous to devote an entire chapter to a discussion of this type, this was necessary because most GIS analyses rarely move beyond visual and textual data registration and automatic mapping procedures, in spite of the fact that GIS has the potential for the creation of complex analytical and experimental models. This is especially important in the case of research, which has a relatively limited set of data at its disposal, such as Roman period roads.

Chapter 3 seeks to summarize the findings of previous research on the Roman road network since, in spite of the many studies on the Roman road system, a systematic overview is still lacking. I did not undertake a review of the international literature in part because of the recent publication of Florin Fodorean's study on the Roman roads of Dacia, which offers a more or less exhaustive discussion of this theme, and in part because the major studies in this field are quoted in the dissertation's other chapters.

Chapter 4 is made up of several larger sections. This chapter covers the problems concerning the terminology of Roman period roads, their construction technique and the applied engineering techniques. The first main section of Chapter 4 provides a list of the concepts used in the terminology of Roman roads. This was prompted by the consideration that this would enable a more precise determination and description of the identified road sections, irrespective of whether they are major traffic arteries or part of a settlement, and of the various parts of Roman roads. This section is followed by an overview of the sources on Roman road construction techniques, with a focus on the creation of the road network and the employed construction techniques in the strict sense, while more general road descriptions and the legal regulation of roads were omitted. The other sections of this chapter contain a list of ancient surveying terms and a review of land surveying techniques, which were probably applied during road construction. The land surveying inscriptions and instruments from Pannonia are presented in this chapter since these too suggest the employment of these techniques in the case of the roads built in this province. One controversial issue of Roman engineering techniques is whether there existed land surveying maps and how survey mapping was actually performed. The issue of ancient survey mapping, a prerequisite in the construction of modern roads, has not received too much attention in the study of Roman roads. Another fascinating issue is how straight roads were planned, how the layout of roads leading through uneven terrain, river valleys and marshland were designed and the problems encountered during their construction. Also discussed in Chapter 4 is the cross-section of Roman roads based on excavated roads in various provinces of the empire, alongside a description of the various parts of roads, such as ditches and embankments. The

chapter is rounded off by a description of the information provided by remote sensing and how these contribute to the recognition of various features, which can be associated with roads.

It seemed convenient to assemble a gazetteer of sites containing the relevant literature and archival data on each known site, together with a precise geographic description and its co-ordinates. This catalogue, presented in Chapter 5, forms the backbone of the dissertation. The descriptions of the sites are not a supplement to the dissertation, but represent one of its principal objectives, this being the reason that it was incorporated as a separate chapter. The catalogue contains the road sections identified during topographic surveys and the road sections generally regarded as Roman roads, which can be linked to a specific geographic unit. Earlier reconstructions of various roads have shown that it is impossible to draw any conclusions about roads as a consistent system without a precise knowledge of the relevant sites and the alignment of known road sections. The technique of identifying road courses by connecting road sites depicted as one-dimensional points on relatively small-scale maps proved impracticable. The procedure of squeezing tentatively identified road sections between known road directions and known road stations is similarly unviable. The known road alignments contained in the gazetteer were recorded in a GIS, in which their linear chain-like form, direction and precise (or assumed) location could be depicted both jointly and separately. This enabled the joint study of sites lying at a greater distance from each other, which would have been rather difficult in the case of traditional paper maps.

The known sites were catalogued according to a system based on the units formed by the boundaries of modern administrative units with a breakdown according to modern counties, and thus larger continuous road sections appear as several sites, corresponding to the modern settlement boundaries. Even though this resulted in a higher number of sites, its advantage was a more precise definition of the position of road sites. The catalogue does not contain assumed routes, which cannot be associated with a strict geographic region, but are merely generally described, conjectural roads. The site co-ordinates were determined in four co-ordinate systems (Hungarian National Grid system [EOV], stereographic, Gauss-

Krüger, WGS-84) for control purposes; the imaging of the linear chains assigned precise co-ordinates was a prerequisite for the GIS analyses presented in the later chapters.

The theoretical reconstructions and the potentials for testing models, one of the major advantages of GIS analyses, provides many new perspectives for the research of Roman roads: for example, if a hypothetical graph of the communications network between the known Pannonian settlements is created instead of using the data contained in itineraries, we are presented with theoretically possible road directions, which include ones coinciding with the direction of road sections, which were earlier perhaps excluded or rejected. A few reconstructions of this type are presented in Chapter 6. The GIS modelling included analyses, which can be regarded as a form of experimental archaeology. These include terrain studies, in the course of which the differences between the distances measured in the field and those calculated from the maps were compared and time zones linked to distances were modelled.

Chapter 7 provides an overview of the conclusions, which can be drawn from the analyses and the road data. In contrast to the reconstructions earlier accepted in Roman studies, the available evidence was not used for reconstructing complete routes, but for mapping mosaic-like road data. The complete road site database and the proposed reconstructions, as well as the co-ordinates of the Roman sites appearing in the various archives according to the EOVS system are presented on an A2 sized map based predominantly on the NASA SRTM data and Hungarian soil type maps.

The findings of the dissertation

Road cross-sections

One of the main findings of the dissertation is the presentation and description of various types of Roman roads constructed in a variety of manners based on the comparison of the known cross-sections of Roman roads (ranging from simple roads

without any layers to multi-layer roads. It became clear that we cannot speak of one single, typical mode of Roman road construction, which can prove helpful in the interpretation of controversial features. According to the generally accepted view, Roman roads were multi-layer constructions surfaced with gravel and their identification in the field is generally based on the localisation of a gravel band. However, the Roman road sections uncovered more recently indicated that these did not always feature several, well-discernible layers, and very often even the gravel layer of the running surface could be barely identified. At the same time, other structural features, such as the ditches flanking the road, could be clearly identified. The ditches flanking the road can be identified using remote sensing (e.g. aerial photography), enabling the reconstruction of the track of former roads in areas where the *agger*, the one-time embankment has not survived, or where the road was not surfaced with gravel. One case in point are the dirt tracks, which were part of the centuriation grid, whose single surviving features still visible in the landscape are the ditches made during their construction. In the case of dirt track-like roads, the road's running surface itself does not modify the vegetation cover, while the ditches flanking the road influence the soil's water retention properties and thus the differences in plant growth may indicate the line of a former road. Several instances are cited for the identification of former roads of this type on aerial photographs from international Roman studies.

Road data

One achievement of the dissertation is the projection of the information gathered from various sources on a map with precise co-ordinates, enabling the identification of known sites relatively easily. While the association of the data on roads with actual locations and the determination of their alignment are instrumental for avoiding the reconstruction of erroneous directions, it does make reconstructions more difficult. The primary aim of the mapping of the road sites described in Chapter 5 and the integration of sites known from various archival sources into a uniform map system was to accurately determine the position of the main roads traversing Pannonia, a since long controversial issue. The results remained well

below my expectations. Only in the case of the two main roads, the *limes* road and the Amber Road, which virtually “frame” Pannonia, have there been detailed and systematic studies, whose findings contrast sharply with the largely neglected regions in the province’s interior. Even though the exact course of the roads in the province’s interior could not be drawn, the GIS comparison of the data provided a wealth of new information. The findings were illustrated on a map. The so-called search codes appearing on the maps can be found in the description of the road sites listed in Chapter 5.

Many options and analytical procedures need to be tested in order to demonstrate the presence of former Roman roads from the data provided by remote sensing (aerial photographs and satellite images). The “experiments” were first conducted on the already known sites, such as various sections of the *limes* road investigated by Zsolt Visy. I found that even the well researched *limes* road posed numerous problems and that new observations could be made.

The limes road

The stations of the so-called *limes* road appear in both the *Itinerarium Antonini* and the *Tabula Peutingeriana*. In the *Itinerarium Antonini*, smaller sections of the *limes* road appear among the listed road sections, while the *Tabula Peutingeriana*, a visual itinerary, depicts it as a continuous imperial road. This is the most intensively researched and best known Roman road in Pannonia. Zsolt Visy published the findings of his many decades long research in a comprehensive monograph, noting that the road running along the Danube could be traced along several diverse tracks in some areas.

The variations in the track of the road in some areas raise several issues. On the one hand, it seems likely that the *limes* road was not a road running along the same course through the centuries, but that it had several variations, as shown by the reconstructions. This, in turn, raises the problem of the constancy of the roads running in the province’s interior.

The other problem relating to the *limes* road is the question of why the road playing a key role in the defence of the empire’s frontier departed from the Danube

in several spots since we know that the river acted as the empire's Pannonian frontier. Why were there roads branching off towards the former Danube bank (probably leading to the forts along the river), and why weren't these forts connected by the *limes* road? If there was a military road running directly along the river bank, how were certain sections of the most recently reconstructed *limes* road planned and constructed? Can the road along the Danube described in the ancient sources be indeed identified with the *limes* road, or was there another road running parallel to it, which was used for civilian traffic and was not a military road in the frontier zone? These questions remain unanswered for the time being. Even so, several striking observations can be made regarding the line of the mapped sections of the *limes* road and the road sites outlining the roads leading towards the province's interior. One such observation concerns the middle section of the road along the Danube. The road section between Aquincum and Mursa known from the *Itinerarium Antonini* did not run along the Danube south of Csepel Island in the Dunaújváros area, but led across a higher plateau and ran to Paks along a more or less straight line. Aside from the road section leading out from the legionary camp at Aquincum, this is the section enabling an adherence to the Aquincum-Mursa alignment. This section of the *limes* road corresponds to this alignment and virtually runs along the hypothetical line between the two settlements. The difference between the two is negligible in view of the great distance (about 1 km on the average) and the road's alignment to the hypothetical line is so precise as to suggest a pre-designed course and land surveying activity. To the south of this section, the road again runs along the Danube bank and deviates towards the west. Although the Roman period bed of the Danube and the changes in its course are not known, it seems likely on the testimony of the aerial photographs showing the remnants of the river's one-time meanders that one of the river's branches meandered west of the modern, regulated river channel in the area south of Paks, explaining the change in the road's alignment. The road could not be re-aligned in the ideal direction along its Hungarian section from this point.

The other interesting observation concerns a possible branch of the *limes* road towards the province's interior in the area between Dunaújváros and Paks. A

milestone was turned up by the plough in the 1930s west of Nagyvenyim, on which the distance from Aquincum was specified as LI MP. Eszter B. Vágó, who published this find, suggested that the milestone had been transported to the Nagyvenyim area from a more southerly location somewhere in the Kisapostag area, meaning that it had been found in a secondary position. However, the finds from Nagyvenyim indicate that there had been a major settlement here and the satellite images of the area indicate the presence of a former road between Nagylók and Nagyvenyim (Sites F21, F19, F22), which reached the outskirts of Nagyvenyim near the probable findspot of the milestone. This stone was probably erected along one of the roads leading westward from Intercisa/Dunaújváros to the province's interior, which branched off the *limes* road, or at the junction of a north to south road branching off the known section somewhere south of Adony and the east to west road. The first option is supported by the strategic position of Intercisa, although in this case, the milestone would represent a unique instance of a distance data calculated for a road leading towards the province's interior measured from Aquincum. The second option is supported by the very erection of the milestone (Pliny the Younger mentions milestones erected at road junctions for orienting travellers), in spite of the fact there are only a handful of road sites along the assumed line of a road extending between Adony and Szekszárd. Even though the exact course of the road is not known, the findspot of the milestone roughly corresponds to the distance of LI MP from Aquincum.

Nagylók–Nagyvenyim

The importance of the road west of Intercisa/Dunaújváros starting from Nagyvenyim, whose course can be traced to the River Sárvíz on satellite images (Sites F21, F19, F22), is indicated by the milestone found on the outskirts of Nagyvenyim. It suggests a north to south road section and it also implies the existence of another road (not mentioned in the ancient sources), which can probably be assigned to the category of *viae vicinales*, leading to the province's interior. The course of this road is remarkable in several respects because it corresponds to the line between Intercisa/Dunaújváros and Ságvár/Tricciana (?), which reached the

Sárvíz between Sárszentágota and Sárbogárd, most likely in the Kálóz area, where the remains of a marching camp and several early Roman graves have been uncovered.

Left bank of the River Sárvíz

The road running along the eastern bank of the Sárvíz was earlier described by Aladár Radnóti and Jenő Fitz, who reconstructed the line of the road from various sites. Jenő Fitz also noted that the remains of the road could be made out on aerial photos showing the broader areas of Sárkeresztúr. The aerial photo was made by Sándor Neogrády and published in 1950. Copies of the original photo can be found in the SzIKM Archives. However, a closer examination of the aerial photos revealed that they did not show the remains of a one-time road, but one of the north-west to south-east aligned, 30–40 meters wide terrain features corresponding to the prevailing wind direction. There are no traces whatsoever of the gravel surface of a possible road in spite of the fairly wide track. Various discolourations, usually light reddish-brown bands, can often be made out on the terrain features in the broader area. The various features on the aerial photos made by Sándor Neogrády can be identified at Aba-Tüskés-dűlő, but these features cannot be interpreted as the remains of a former road, and thus there is no conclusive evidence supporting earlier reconstructions of a road leading along the eastern bank of the Sárvíz – its possible one-time existence can only be assumed from a handful of sites.

Aquincum–Brigetio

This road section of the *Itinerarium Antonini* was identified at a fairly early date, based mainly on the milestones found along the road. The course of road is known along almost the entire section: it ran in the valley between the Pilis and the Gerecse Mountains, between the pedimentation of the two mountains. The raster GIS analysis presented in Chapter 6 revealed that the terrain is very favourable in this direction and that the travelling conditions (the distances on the surface and the time) can be compared to the conditions on a plainland. The road starting from Aquincum passed through Dorog and reached the *limes* road along the Danube at

Nyergesújfalu, from where its course was identical with that of the *limes* road.

The roads in the Aquincum area

A handful of road sites in the Aquincum area cannot be associated with any of the major roads described in the ancient sources; they can probably be assigned to the category of *viae vicinales*. These include the road forming the main street of the Celtic-Roman *vicus* uncovered at Páty–Malom-dűlő (Site P10), along which the settlement evolved. This road probably connected a road passing through the Zsámbék Basin to the north and a road along the southern piedmont of Buda Mountains in the Budaörs area, although it must be admitted in all fairness that there is no evidence for the existence of these two roads. It seems likely that the road identified in Esztergom (Site K16) led to a smaller settlement, as did the road section uncovered in Budapest, District IIA (Site Bp06). The origin of the paved forest road leading from Pilisszentkereszt to Dobogókő (Site P14) is still controversial; there is nothing to indicate its military nature, but neither can the possibility be discarded that the road sites in the area can be associated with the road remains from Site K16, indicating a road through the Pilis Mountains.

Although it has not been identified yet, it seems certain that there was a road (or perhaps several roads) leading from Aquincum to the Zsámbék Basin and the Érd Plateau. The many inscriptions from this area bear witness to the fact that the owners of the villas lying here were leading officials of Aquincum, the implication being that there must have been a durable road connecting the villas with the town. There is only indirect information on how the estates around Aquincum were parcelled out to their owners. Even though Aquincum was not a colony based on deduction, the many villa estates in the broader area suggest that the land was somehow parcelled out. A passage in Hyginus' work is most instructive because it states that *limitatio* took place even if the lands divided were not *colonia* lands. Since the presence of land surveyors has been documented in Aquincum and the practice of parcelling out land differed little in the various regions of the empire, it seems likely that the land plots and estates were created according to a rectangular grid system. In this case, the *limites* (roads) enabling access to the estates were eventually

constructed too. We may perhaps assume that the road at Páty–Malom-dúlő (Site P10) was a road of this type. The road remains in the Vál Valley (Sites F05, F32) perhaps represent a road with a similar function. The currently available evidence does not allow the identification of a larger network, even though this would undoubtedly be useful for determining the exact size and extent of the Civitas Eraviscorum.

Aquincum–Sopianae

According to the *Itinerarium Antonini*, this road section was one of the three main roads leading through the area between the Danube and Lake Balaton. The stations are virtually unknown with the exception of the starting point and the end destination, this being the reason that the course of this road section has been reconstructed variously. Unfortunately, the exact course of this road is still subject to educated guesses for there is little in the way of conclusive evidence.

Searching for road data along the Sopianae–Aquincum line – and assuming that the road skirted the Mecsek Mountains – there are some scattered bits of information from Mecseknádasd, Bonyhád (Site T08), Kajdacs (Site T16), Nagyvenyim (Site F22) and certain sections of the *limes* road (F13, F12, P06). It is possible that the north to south section between Adony and Szekszárd mentioned above in connection with the *limes* road ran towards Kajdacs and was part of the Aquincum–Sopianae road. In view of the Aquincum–Brigetio and Savaria–Brigetio road sections described in the *Itinerarium Antonini*, it is possible that the two roads had a joint section. One station of this road, described as *Gorsio sive Hercule*, has been generally interpreted as a single settlement. Endre Tóth has suggested that the word *sive* might in this context denote two different settlements rather than a change in the name of the settlement, the implication being that there were two roads. If this was indeed the case, there existed two settlements, one called Gorsium, the other called Herculia, both of which lay at a distance of 50 MP from Aquincum. The next station, Valle Cariniana lay somewhere near Kajdacs in the Sió Valley, somewhere around Site T16. Since, however, there is little information on the road sections between the two, the Aquincum–Sopianae road section cannot be reconstructed with any certainty.

Brigetio–Sopianae

The course of this road, mentioned in the *Itinerarium Antonini*, is as uncertain as that of the Aquincum–Sopianae road and there are few sites providing clues to its course. It has also been demonstrated that the information contained in the ancient sources is erroneous since the distance between the two towns along a hypothetical line is higher than the one specified in the *Itinerarium Antonini*. It is difficult to reconstruct which road stations were possibly omitted and which distances were specified erroneously. The hypothetical line between the settlements is influenced by several geographic factors. These include the range of the Bakony and Vértes Mountains, as well as the marshland of the Sárrét to the south. Earlier reconstructions variously traced the course of the road in the Tatabánya area (in the basin between the Bársonyos Mountains and the Dunazug and Vértes Mountains) or in the Mór Dyke along the Császárvíz to Gorsium/Tác, where it was assumed to pass through Herculia. If, however, Endre Tóth's interpretation of the usage of *sive* is correct and the identification of Gorsium with Herculia can be rejected, while the identification of Gorsium with Tác is accepted, the Brigetio–Sopianae road did not pass through Gorsium/Tác. This reconstruction is problematic because the best crossing points can be found in the Tác area, meaning that one major road had probably passed through this area. If Herculia and Gorsium were indeed two separate settlements, it is baffling why the road did not lead by a larger settlement, especially if they lay close to each other. The River Sárvíz south of Tác again limits possible road directions, this being the reason that the course of this road was assumed to have led along the river's western bank. The road stations mentioned in the written sources are rather problematic. Aladár Radnóti described several Roman road remains from the Ságvár area, but did not mention their exact location, and they can therefore only be identified tentatively (Sites S01, S03, S06, S07, S08).

The gazetteer of the toponyms of County Somogy includes a road in the Ságvár area, which the locals associated with the Romans (Site S05); however, the orientation of this road is uncertain and its assumed east to west alignment is mere conjecture. The road beside Mezőkomárom (Site F20) east of Ságvár was first

described by Dezső Lackó; Jenő Fitz noted that remains of this road were identified beside the so-called Varga House. One possible reconstruction of its course is suggested in the description of Site F20.

Gábor Bertók recently identified the Iovia station with the extensive settlement at Szakcs–Gölösi-dűlő known from aerial photos, even though the analyses presented in Chapter 6 revealed that the site fell outside the area with a radius of 32 MP measured in the field from Sopianae/Pécs, the starting point of the road section, challenging one of the main arguments in favour of this identification. Moreover, only the distance measured along a hypothetical line could be used in the calculations, which do not include the additional distances owing to the bends in the routes. Iovia should therefore be sought within the theoretical maximum distance of 32 MP. Road remains with features characteristic of ancient Roman roads can be made out on contact copies of archival aerial photographs north of Szakcs (Site T24). Additionally, a system of roads, whose alignment corresponded to that of the centuriation grid reconstructed for the Savaria area, could be identified in the Szakcs area. An oblong, 130 m by 95 m large area enclosed within a ditch south of Dalmand can probably be interpreted as a Roman military camp. The memory of a Roman road is preserved in one of the toponyms in the Kapospula area, which, however, cannot be identified with the “Devil’s Dyke” appearing in aerial photographs. This dyke was earlier interpreted as a road; more recent research has convincingly shown that it was part of the early medieval marchland defence system. Even though the settlement at Szakcs–Gölösi-dűlő lies farther than 32 MP from Sopianae/Pécs, and thus its identification with Iovia is uncertain, the road remains visible on the aerial photographs and other road remains suggest that a major Roman road passed through the area, although its exact course to Sopianae is uncertain.

The Mánfa–Magyarszék–Oroszló route (B05, B12, B13, B14) is an assumed road, which is conjectured to have led north from Sopianae/Pécs towards Brigetio or perhaps Arrabona. It has been generally accepted that the road leading north from Pécs was marked by the watchtower/*beneficarius* station uncovered at the Lapis hunting lodge, even though the excavation diary makes no mention of a road and the excavator interpreted the tower as functioning as an outlook post. The Mánfa–

Magyarszék–Oroszló route is therefore hypothetical at most.

Savaria–Sopianae

The road between Sopianae/Pécs and Savaria/Szombathely is similarly uncertain. The stations of this road are also doubtful. It is difficult to associate road sites with this route. Of the possible routes from Sopianae to Savaria, the most widely accepted one is reconstructed as leading westward towards Szigetvár, although alternative ones suggesting a crossing point over the River Kapos have also been proposed. Endre Tóth identified *Valco*, one of the stations, with the *municipium Volgum* known from inscriptions, which he located south of the Little Balaton, challenging its earlier identification with the late Roman fort uncovered at Keszthely–Fenekpuszta. The early Roman sites in the Keszthely and Hévíz area reflect an intensive Roman settlement, as do the sites on the Zalavár Ridge. The roads corresponding to the alignment of the centuriation grid reconstructed in Chapter 6 show a concentration in the area bounded by Keszthely, Hévíz and Karmacs, and Zalavár, Sármellék and Felsőpáhok, suggesting that they may have been part of the centuriation system established in the Savaria area or that the centuriation in this area had a matching orientation. However, there is no conclusive evidence for the course of the important imperial road through this area in spite of the intensive traces of Roman settlement. Neither do we know the exact shoreline of Lake Balaton and the Little Balaton, or the extent of the surrounding marshland during the Roman period, which undoubtedly influenced the course of the Roman road.

Roads in the Savaria area, Savaria–Aquincum (?)

While the centuriation grid reconstructed on the basis of the roads in the Savaria area, described in Chapter 6, does not correspond to the orientation of the earlier suggested rectangular grid, the two do not exclude each other. The seemingly contradictory bits of evidence can perhaps be explained by assuming the existence of another centuriation grid, which is also supported by the written sources. The road section between Szombathely and Sárvár identified and published by Endre Tóth can be fitted into this rectangular system. A system of similarly oriented roads could

be demonstrated over a rather extensive area, e.g. between the Rába and the Marcal rivers, as well as north of the Bakony Mountains. The orientation of Kazinczy Road, one of the east to west running main roads of Pápa marking the southern boundary of the Esterházy Mansion, corresponds to the orientation of this system and to the theoretical continuation of the Szombathely–Sárvár road. According to a report by Sándor Mithay, a milestone without an inscription found along this road was acquired by the Pápa museum. It is possible that the Savaria–Aquincum road ran north of the Bakony Mountains and that the data contained in the *Itinerarium Antonini* concerning the entire length of the road is erroneous. It has been recently suggested that the toponyms Mogetiana and Mogentiana marked two separate settlements, and were not variants of the same settlement; if this was indeed the case, this would also support the proposed reconstruction. The subsequent course of the road is uncertain.

Savaria–Brigetio

The settlement of Mursella, given the rank of town and one of the stations between Savaria and Brigetio, is generally identified with the settlement uncovered at Árpás-Dombiföld. The first section of the road leading from Savaria to Mursella is generally identified with the road section mapped by Endre Tóth between Szombathely and Sárvár, which crossed the River Rába at Sárvár-Végh-malom, from where it ran along the river according to the generally accepted reconstruction and then crossed the river again in the Egyházaskesző area, whence it led to Rábaszentandrás, where an uninscribed milestone was found. The road again crossed the river and continued towards the settlement uncovered at Árpás-Dombiföld. However, there are a few uncertainties in this reconstruction. The most recent reconstruction of the town walls of Savaria colonia assumes six gates: a pair along the road leading north and south, and two pairs along the road leading west and east. The south-eastern gate lay along the road leading to Sárvár. Did the north-eastern gate act as an entrance for a road whose course is still unknown? Can we assume that the course of the Savaria–Mursella road led along the theoretically shortest route on the western bank of the River Rába? What was the rationale behind this road course, proposed by the

generally accepted reconstruction, instead of the optimal course? The Szombathely-Sárvár road corresponds to the east-west axis of a centuriation grid probably created sometime after the 2nd century AD. However, there is now evidence that the road followed the course of an earlier road. It probably joined another road running along the river. Several instances of roads running along a river can be quoted from the entire territory of the Roman Empire, as noted in Chapter 4. Terézia Buocz suggested a road along the left bank of the Rába based on the road remains at Meggyeskovácsi, the controversial road site at Uraiújfalu and the settlement sites in the broader area. The section of the Amber Road identified at Csákánydoroszló (Site V05) and Magyarszecsőd (Site V05) can be fitted into this road course. It seems likely that there was a road along the river's right bank, whose direction is outlined by the sites at Egyházaskesző (Site Vp03)/Kemenesszentpéter (Site Vp06), Csöngye (Site V08) and Ostffyasszonyfa (Site V35), and the sites to the west at Kemenesmihályfa (Site V16), Kemenessömjén (Site V17) and Kemenszentmárton (Site V18). This road probably continued in a south-westerly direction along the Rába along the line of the so-called Roman Soldiers' Road. The road on the river's eastern bank probably connected the *limes* road (Arrabona) and the Amber Road (Salla).

The remains of a road could be demonstrated at Árpás-Dombiföld/Mursella both from the archaeological evidence and the data provided by remote sensing. Eszter Szőnyi's excavation revealed that the repeatedly renewed road was part of a settlement. The road was not aligned north-east to south-west, as one might expect, but north-west to south-east, which is surprising because this direction can be traced up to Gyarmat with the aid of former dirt-tracks. The continuation of the road, described in the MRT 4 volume, too has a north-west to south-east alignment. The currently known layout of Mursella indicates that the buildings were sited along this road. Other *vicus*-like settlements, such as the one uncovered at Páty-Malom-dűlő, were similarly laid out along a road, and the respective main roads of these settlements, corresponding to major traffic arteries, thus outline the direction of the roads in question.

"Roman Soldiers' Road"

Following their investigation of the Vasvár rampart, Endre Tóth, Gábor Kiss and Balázs Zágórhidi Czigány challenged the Roman origins of the road known as the so-called Roman Soldiers' Road or Soldiers' Road (Sites V01, V07, V11, V30, V49). The archaeological investigation of the Vasvár rampart suggested that it could be associated with the early medieval border defence system. The rampart cut through the so-called Soldiers' Road, which was dated to the same period as the rampart. The road itself has not been archaeologically explored yet. However, the possible Roman origins of the road's southern section adjoining the Amber Road, has not been wholly rejected. Seeing that no conclusive evidence for the rejection of a date in the Roman period has yet been proposed, and neither is there any archaeological proof to the contrary, its existence in the Roman period cannot be excluded.

This road is not mentioned by any of the ancient sources, although the lack of ancient references to it can hardly be conclusive in the study of the Roman road network. While it is certainly possible that similarly to the section passing through the Vasvár rampart, some of the currently known sections are indeed of a later date, remains of an earlier road were identified during the survey of the woodland along this road (e.g. Site V07), even though there was no possibility for the detailed archaeological investigation of these remains. There is also a plausible explanation for how the route, made up of strikingly straight sections in some spots, fitted into the Roman road network. In view of the techniques used for determining positions in Roman land surveying, examples of which are quoted in Chapter 4, the possibility of a planning principle involving the creation of a link road between Amber Road and the *limes* road cannot be rejected. A military road enabling the gradual occupation of the province's interior may be assumed for the early Roman period and it is possible that this road later lost its importance. The road in question fits perfectly onto a hypothetical line linking Salla with Arrabona, the nearest military camp on the *limes* road, and continues along the course outlined by the sites at Kemenesmihályfa (Site V16), Kemenesszentmárton (Site V18), Rábaszentandrás (Site G32), Koroncó (Site G21), Gyirmót (Site G11) and Ménfőcsanak (Site G13). The assumption of an early road is supported by the road section uncovered at Ménfőcsanak–Shopping Centre (Site G13), which clearly had an earlier forerunner.

The Amber Road

The Amber Road is the second best researched Roman road after the *limes* road along the Danube. A good overview of research on the Amber Road has been recently published by Péter Kiss. Even though there are some still unmapped sections, we have a much better knowledge of this road than of the ones passing through the province's interior. The course of the Amber Road has been recorded on several 19th century ordnance survey maps and it also appears on archival aerial photographs. Several sections of the road have been excavated, providing valuable information on its structure.

Findings of the GIS analysis

Centuriation grids

Even though the courses of the roads mentioned in the *Itinerarium Antonini* could not be reconstructed along their entire length, the data collection and their analyses were not useless exercises. Very often, they yielded unexpected information for the reconstruction of the one-time Roman landscape. The assumed employment of the land surveying techniques described in Chapter 4 offers several new perspectives for the research of ancient roads. Thus, for example, it was possible to reconstruct a centuriation grid with a different orientation for the Savaria area than the previously published one, based on the sites described in Chapter 5. The various road sites showed a mosaic-like patterning in this grid. All the roads, ditches and watercourses with a $<1^\circ$ divergence were projected onto this grid on the map in the supplement (using the EOVS system). It was thus possible to register a dense network of linear features in Counties Vas and Zala, with a particularly dense concentration in the Rába, Marcal, Zala and Balaton (!) regions. Even though a Roman origin can hardly be posited for each and every linear feature, the dense patterning nonetheless suggests the existence of a former, ancient road or ditch perhaps also functioning as an estate boundary, which served as a reference for the distribution of land in later times too.

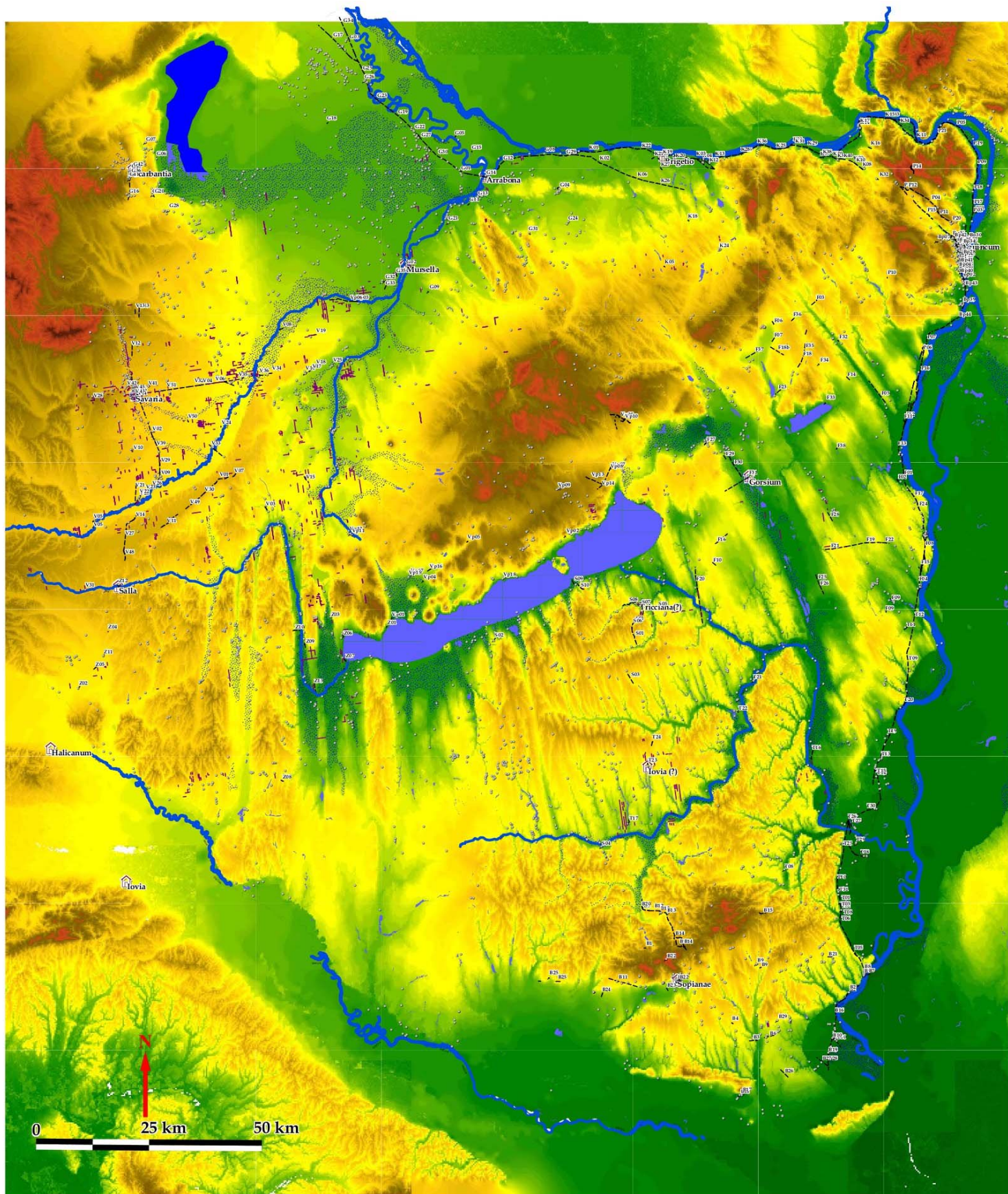
Mile data analyses

One of the obvious purposes of road network reconstructions is to attempt an identification of the Pannonian settlements recorded in the *Itinerarium Antonini*. However, as Endre Tóth has correctly noted, the identification of the settlements in the province's interior is far from conclusive. The reconstruction of roads based on the distances in miles is also uncertain if the starting points and the destinations cannot be precisely pinpointed. Another source of uncertainty is that the accuracy of the distances specified can sometimes also be challenged. It is now generally accepted that the data contained in the *Itinerarium Antonini* are not always reliable, meaning that the distances between two unknown settlements too may be inaccurate in some cases. The recurring distances of 20, 25 and 30 MP suggest that the road stations probably lay at a distance of one day's journey from each other. It has also been proposed that the distances in miles recorded in the itinerary did not denote precise distances, but rather the distance calculated from the time needed to complete the journey between two stations. The custom of specifying the time needed to cover a certain distance was an accepted practice until fairly recently, and very often distances are still calculated by time, rather than by kilometres by travellers undertaking longer journeys. Assuming the latter to be the case, one might reasonably ask what was the basic unit used for calculating distances in miles from the time needed to cover a distance. Even accepting that the distances between the settlements were based on the multiplication of the invested time and an average travelling speed, it is not known whether the average speed was calculated from a traveller journeying on foot, a traveller on horseback or perhaps the galloping courier of the *cursus publicus* (the postal service), the forced march of a military unit or the average speed of a heavier wagon. Seeing that little is known about the people who actually used these itineraries, we can at best only make an educated guess as to the possible relation between travelling speed and the specified distances. I attempted to find an answer to this question by applying the generally accepted formula for modelling movement and travel used in geographic studies offered by GIS. I chose securely identified settlements such as Aquincum, Brigetio and Savaria

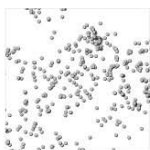
as starting points and included also settlements such as Sopianae and TÁC, whose identification too can be regarded as secure.

The results of the analyses indicated that in the case of plainland areas, there is no major difference between the distances calculated from the map and the modelled surface measurements, i.e. a distance of 30 MP measured on the map corresponds to roughly the same distance on plainland terrain. At the same time, a more varied terrain, such as the one west of Aquincum toward the Zsámbék Basin, or the areas north, east and west of Pécs can lead to considerable differences between the two. In these areas, the boundaries of the buffer zone with a radius of 30 MP as measured on the map showed a variation of $\pm 3-5$ MP on the modelled terrain. Moreover, this zone corresponded to the distances calculated according to a hypothetical line between two settlements, without accounting for the distortions caused by the bends in the road.

Calculating with time instead of miles, we get the following results: assuming that one day's journey corresponded to 6-7 hours, this can be equated with 20 MP (6 hours) or 25 MP (7 hours) on plainland, while in the case of passage through a more varied terrain, such as the one west of Aquincum, the same figures are 15 MP (6 hours) and 20 MP (7 hours). It seems likely that the 25-30 MP most often specified in the *Itinerarium Antonini* corresponds to the travelling time of a horseman not riding his horse at a gallop or the daily average of a more strenuous forced march.



Lápos réti talajok,
síkláp talajok,
lecsapolt és telkesített síkláp talajok,
mocsári erdők talajai
fiatal, nyers öntéstalajok



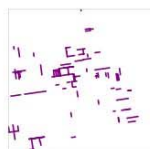
Adattári lelőhelyek
(MRT, megyei múzeumok
adattára, KÖH lelőhelyadat-
bázis alapján)



Ütlelőhelyek



Mócsy András és Soproni Sándor
centuriatio javaslata



Jelenleg javasolt centuria-
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