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THE 'ARCHPRO CARNUNTUM' PROJECT – INTEGRATED ARCHAEOLOGICAL INTERPRETATION OF COMBINED PROSPECTION DATA, CARNUNTUM (AUSTRIA)

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The potential of large-scale, non-invasive prospection methods has been widely recognized in archaeology in recent years. Their outstanding possibilities for the exploration of urban centres have been realised early on and applied at selected sites. The 'ArchPro Carnuntum' project stands out for its extensive investigation of a Roman provincial capital by the combined application of a wide variety of survey methods (aerial archaeology, magnetometry, ground penetrating radar, extensive field survey) resulting in detailed information on the ancient infrastructure of the Roman metropolis. Within the project, it was not only possible to discover new settlement areas, but in some cases even to deduce their former purpose. As a result, the military administrative centre, newly built residential areas, and temporary military camps could be detected in the archaeological landscape of Carnuntum. This paper presents an overview of the results of this internationally unique prospection project.

Keywords: Carnuntum, LBI ArchPro, Roman legionary fortress, Roman town, archaeological prospection, ground penetrating radar, magnetometry

INTRODUCTION

The Roman town of Carnuntum (Lower Austria) is an outstanding archaeological landscape. As the capital of the Roman province of *Pannonia superior* and with its notable extent and infrastructure, Carnuntum has always been the focus of scientific interest and research. More than a century of excavations could only uncover a patchwork of archaeological information about this vast Roman settlement. Even fifty years of aerial archaeological surveys provided just a broad overview of the

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extent of the archaeological site and a few details of its infrastructure. Therefore, a large-scale geophysical prospection project was set up by the Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology (LBI ArchPro) and the Central Institute for Meteorology and Geodynamics (ZAMG) in cooperation with the county of Lower Austria to map the entire settlement area of the Roman capital city using efficient, high-resolution ground penetrating radar (GPR) and magnetometry. In this paper, we describe the applied methods and present the results of this large-scale archaeological prospection project which provide new information on the ancient infrastructure of the Roman metropolis.

THE SITE BEFORE 2012 – CARNUNTUM

The ancient settlement area of Carnuntum can roughly be divided into two parts. The military settlement in the east and the civil town in the west. Both settlement zones are situated along the banks of the river Danube, on a terrace about 30–40 m above the river.

Past archaeological exploration of the military settlement focused primarily on the legionary fortress *(castra legionis),* the outlines of which are still visible in the terrain today, and the associated Amphitheatre I. Furthermore, several areas outside the legionary camp *(canabae legionis)* were investigated in archaeological excavations such as a large sanctuary including a bath complex on the so-called 'Mühläcker' southeast of the fortress (Kandler 2004. 31. 56–59; Gassner et al. 2011). These investigations within the military settlement of Carnuntum also included the auxiliary fort, which was excavated due to construction works between 1977 and 1997 (Kandler 2008). But it was only through 50 years of intensive aerial archaeological research that many details of the layout of the *canabae legionis* could be captured and reliable conclusions drawn about the vast size (70 ha) and layout of the military settlement (Doneus–Gugl–Doneus 2013).

Archaeological excavations have also played a significant role in the investigation of the civil town ('Zivilstadt'). However, little more than 5% of the settlement area has been uncovered to this day and these traditional archaeological methods have only given limited insights into the chronology and the urban structure of the *municipium Aelium* or the later *colonia Septimia* (Humer–Kandler 2003. 5–13). Unfortunately, the results of the aerial surveys were less conclusive in the Western part of Carnuntum and, thus, only general conclusions about the layout of the civil town were until the start of the 'ArchPro Carnuntum' project in 2012 possible (Maschek 2011. 34–39).

THE 'ARCHPRO CARNUNTUM' PROJECT

In 2011, the 'ArchPro Carnuntum' project was initiated with the aim to map the entire ancient settlement area of Carnuntum and to gain new insights into the infrastructure and state of preservation of the site. Through the large-scale application of non-invasive prospection techniques, a unique dataset with extensive information on the Roman town was generated, providing a valuable basis for the efficient and detailed investigation of this exceptional archaeological landscape. For this purpose, three survey methods that have been proven to be ideally suited in archaeology (aerial photography, magnetometry, GPR) were applied. During the project (2012–2015) an almost seamless area of approximately 830 ha was mapped with magnetometry and more than 240 ha were explored with high-resolution GPR (see *Fig. 1*) (Neubauer et al. 2018a, b).

For the different image sources to be comparable and their interpretation results to be related, the positioning accuracy of the visualizations is crucial. For the highly accurate positioning of the motorised geophysical measurements, an onboard satellite navigation (RTK GNNS) was therefore used to ensure continuous positioning accuracy of approximately 5 cm.

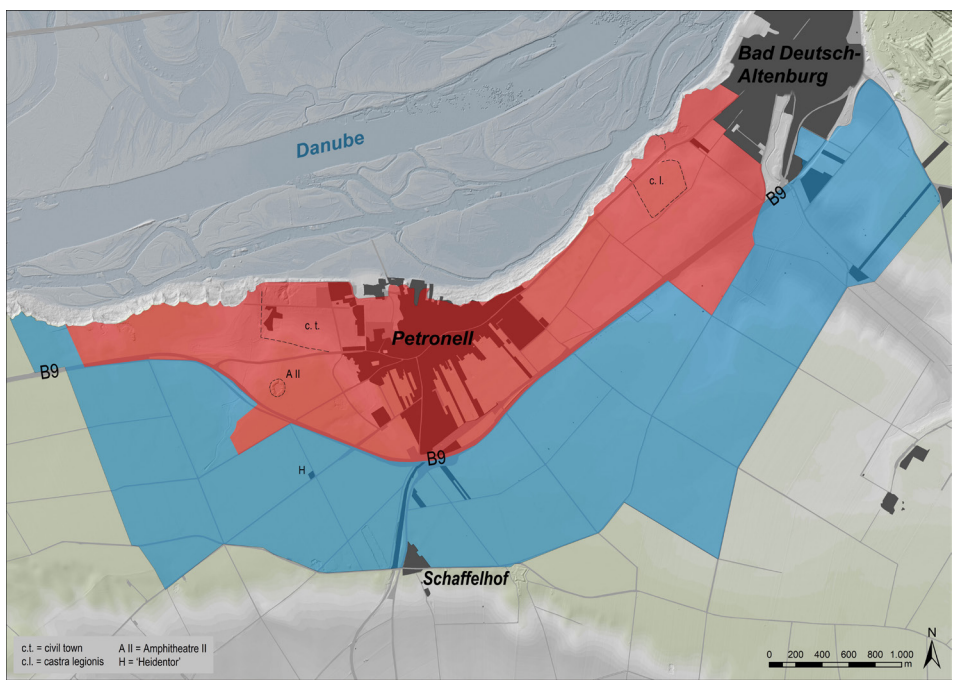

Figure 1. Overview of prospected areas within the ArchPro Carnuntum project (blue = magnetometry, red = GPR and magnetometry)

METHODS AND DATASETS

AERIAL ARCHAEOLOGY

The area of interest extends over several agricultural fields with different crops, as is common in this region of Austria. Vegetation marks are changes in the growth behaviour of field crops caused by different soil properties. The physical and chemical differences between the archaeological structure and the surrounding soil are responsible for the altered interaction between soil, nutrients, moisture, and plant growth. It has been observed that in the finer and more humid filling of pits and ditches the moisture is retained longer and a higher proportion of nutrients is available for the plants leading to a promotion of plant growth that favours positive vegetation patterns. In areas with stone walls or stone layers, which cause a draining effect, the plants tend to develop negative vegetation patterns, since the lack of water and nutrients reduces the growth of the plant. However, the development of vegetation marks depends on many factors and therefore the buried remains underneath the surface are not always visible (Doneus 2011, Doneus 2013). For this reason, significant results can usually only be obtained after several reconnaissance flights over the study area. Since aerial photographs were taken in Carnuntum in several years, cropmarks were recorded in almost every field of the target area.

MAGNETIC SURVEY

The motorised survey of the earth's magnetic field was carried out with eight Förster Fluxgate magnetometers mounted on a non-magnetic cart, with a crossline spacing of 0.25 m. The speed of the towing vehicle was adjusted so that an inline spacing of 10 cm was not exceeded. The recorded magnetic values were then processed into a georeferenced grayscale image. The pixels between the actual measured values were linearly interpolated to achieve an image resolution of 10 × 10 cm per pixel. For the interpretation process, a visualization of –6nT to +4nT proved to be most suitable.

The magnetic visualisations showed detailed information on differently magnetised structures such as pits, ditches, stone walls and stone layers of floors or road bodies. Stones, stone walls and compacted gravel layers (e.g., floors or road bodies) differ strongly from structures such as pits or ditches which contain a recognisably higher proportion of topsoil in their fill and are therefore more strongly magnetised.

GROUND PENETRATING RADAR (GPR)

The motorised GPR survey was conducted with a multi-channel system from Malå (MIRA), consisting of 13 antennas with a central frequency of 400 MHz, placed in a plastic box. The arrangement of the antennas resulted in a line spacing of 8 cm.

A 3D data block was calculated from the measured reflection values, which was virtually cut into 5 cm thick horizontal depth slices (Trinks 2018). These depth slices showed detailed information about the intensity values of the reflections, which then were converted into grayscale images. The resulting high-resolution images made it possible to obtain detailed depth-dependent information on the archaeological structures up to a calculated depth of 250 cm.

EXTENSIVE FIELD SURVEY

The method of extensive field survey is based on the assumption that human activities produce distinct patterns, which can be identified by the analysis of the distribution of surface finds. Field walking surveys were carried out in three different areas (*canabae legionis*, *ludus*/school of gladiators and *suburbium* west) within the ancient settlement. Their main objective was to obtain information on the spatial and temporal delimitation of the settlement and to identify settlement dynamics.

By dating and spatial analysis of the collected finds, temporal conclusions could be drawn about the expansion and shrinking processes of the Roman metropolis. In combination with the results of the geophysical surveys and the excavations, it was possible to define individual activity zones and to reconstruct the overall chronology and the development of settlement areas on the periphery of the *canabae legionis* and the Roman town (Gugl–Radbauer–Kronberger 2015; Gugl–Radbauer–Wallner 2019; Gugl et. al 2020).

INTERPRETATIVE MAPPING AND INTEGRATED ARCHAEOLOGICAL INTERPRETATION

For the recognition of a subsurface archaeological structure, a measurable contrast to its surroundings is crucial. This contrast is based on local physical conditions resulting in differential visibility of the respective features, such as stone walls or pit fills, in the different geophysical prospection methods. Consequently, the combination and integration of different survey methods can contribute to a better understanding of buried archaeological structures and exploit the full potential of non-invasive prospection methods through an integrated analysis of all available data sets.

The specific maps and visualisations generated from the archaeological prospection data were compiled in a Geographic Information System (ArcGIS 10.2), which on the one hand serves as an information system on Roman Carnuntum and, on the other hand, ensures the long-term availability of the data for sustainable cultural management and urban planning. The physical archaeological landscape is thus transformed into a virtual landscape, which can be explored by the archaeologist with the help of software-based tools.

Within the GIS environment, each geophysical anomaly which was identified as an archaeologically relevant structure received both a vectorised archaeological interpretation and a textual description of its geophysical properties, which was entered into the corresponding attribute table. In the following spatial analysis, the features described and drawn in the various prospection datasets were combined into archaeologically relevant structures (walls, stones, or stone layers), which in turn could be grouped into larger spatial units such as roads, buildings, or burial grounds. This step was essential to obtain a detailed and coherent picture of the Roman settlement, but at the same time represented a major challenge within the interpretation process: the classification into housing units or single structures can be associated with considerable uncertainties caused by incomplete data due to the poor state of preservation of the prospected structures.

RESULTS

Within three years, it was possible to map more than 10 km² of the central area of ancient Carnuntum with motorised archaeological geophysical prospection methods and to generate high-resolution 2D- and 3D-images of the buried Roman structures. The integrated archaeological interpretation of the prospection data allowed to derive the topography of the settlement in exceptional detail, unprecedented for Roman urban areas *(Fig. 2)*.

The high-resolution prospection data sets contain an exceptional wealth of information, therefore only an overview can be given within the scope of this paper. In the next chapters, a brief description of the detected archaeological structures, starting from the east (military town) to the west (civil town), is presented and the interpreted structures are integrated into their spatial context to permit conclusions about their chronological sequence.

THE MILITARY SETTLEMENT *(CANABAE LEGIONIS)*

THE LIMES ROAD

The so-called **Limes road** was the most important west–east connection along the Roman Danube border. Consequently, it also runs through the entire area of Carnuntum crossing the legionary fortress and the *canabae legionis* in the east, and the civil town in the west. Large parts of the *canabae legionis* are oriented towards the Limes road. Between the western *canabae* and the eastern wall of the *colonia*, the course of the road is largely unclear as this area is overbuilt by the modern village of Petronell. Within the Roman city, the Limes road is identical with the *decumanus maximus*. Outside the town walls in the western suburb, the Limes road served as the main axis of an elongated extramural settlement, and further out of the city it was accompanied by a typical Roman *necropolis* (see *Fig. 2*).

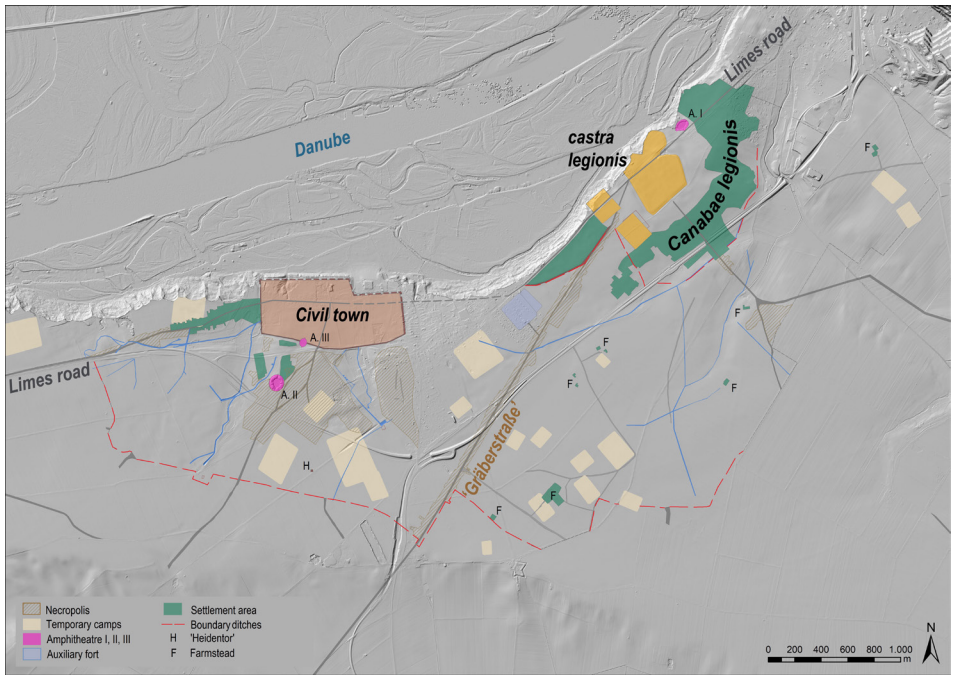

Figure 2. Integrated interpretative mapping of the Roman landscape around Carnuntum

CASTRA LEGIONIS (LEGIONARY FORTRESS)

The area of the legionary camp was not accessible for geophysical prospection surveys because no agreement could be reached with the landowner. About 70–80% of the legionary camp, which is almost 18 ha in size, was excavated in the decades before the outbreak of the First World War (Gugl–Kastler 2007). However, the related excavation plans are not reliable making it impossible to locate the exact position of the main buildings within the camp. Aerial photographs also vaguely show the interior structures of the camp. Large-scale GPR studies would be the most efficient and promising archaeological method to address this major research desideratum in the future.

CANABAE LEGIONIS

The large area of the ***canabae legionis*** south and southeast of the legionary fortress revealed different settlement patterns in the geophysical datasets. On the one hand, winding alleys with irregularly shaped and randomly oriented buildings can be observed (see C in *Fig. 3*), while on the other hand, building complexes and streets with an orthogonal layout and aligned perpendicular to the main road which left the le-

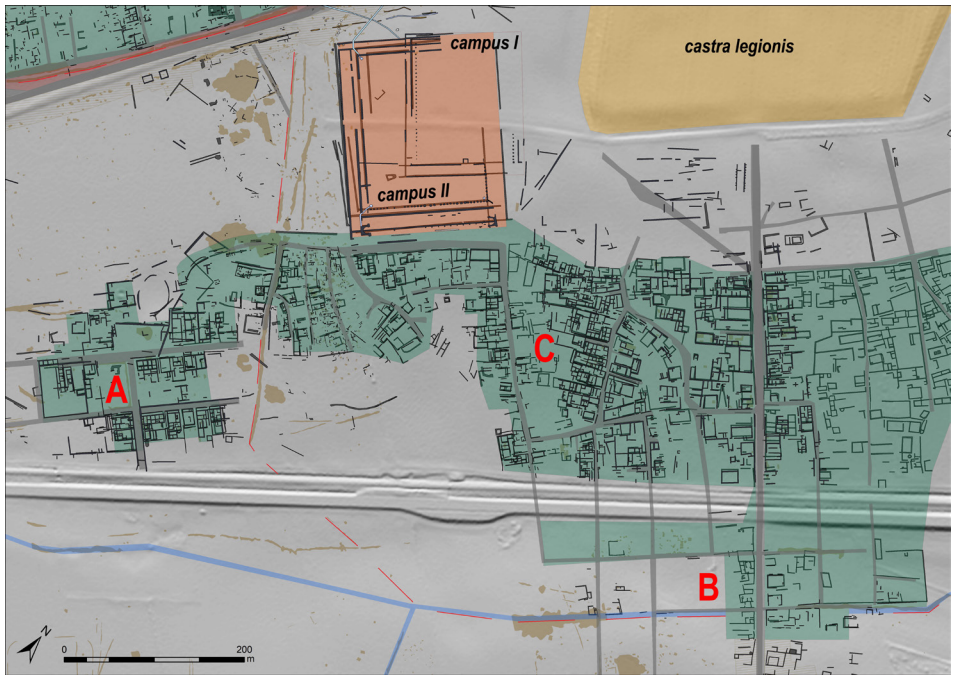

Figure 3. Detail of the southern and southwestern *canabae legionis,* showing areas of different settlement layouts

gionary fortress through the *porta decumana* to the south are visible (see B in *Fig. 3*). Thus, grown settlement structures once seemed to merge seamlessly into planned residential areas. This phenomenon becomes especially evident in district 'A' in *Fig. 3*, which appears to have been developed later compared to the areas close to the military training ground (*campus*) and the southern *canabae*. In this district, individual parcels had already been built, while others were only very sparsely or not yet developed. However, they are easily recognisable in the geophysical data by the streets enclosing them. This was presumably a Roman settlement expansion area where construction was not completed and can therefore most likely be dated to the 3rd century AD, when extensive shrinkage processes took place in the *canabae legionis* (Gugl–Radbauer–Kronberger 2015. 135–143).

GOVERNMENTAL COMPLEX

The **residence of the governor** (see A in *Fig. 4*) of *Pannonia superior* was located immediately to the west of the legionary camp, directly at the steep slope of the Danube. In this area, the magnetometry and GPR surveys revealed another military

Figure 4. Overview of the governmental complex with the newly discovered *castra singularium* in the military settlement of Carnuntum

complex that was located between the *campus* (see D in *Fig. 4*) and the excavated areas of the governor's palace. This newly discovered military garrison once housed the governor's guard, the *pedites* and *equites singulares,* and was therefore termed *castra singularium* (see B in *Fig. 4*), in reference to the quarters of the imperial guards in Rome (Gugl–Wallner 2019).

The enclosed area of the ***castra singularium*** measures approximately 183 × 99 m, which represents about 1.8 ha. The massive enclosure wall is visible on all four sides in the geophysical data. At least three gates can be located: the east gate *(porta praetoria)* as well as one gate each on the south and north side *(portae principales).* Within this enclosure, six to seven barracks for the soldiers have been identified, which can be further subdivided into the head buildings (officers' quarters) located in the north and double chambers *(contubernia)* provided for the soldiers. The barracks are situated close together in the western part of the fortress, right behind the central building, the *principia,* which measures about 21 × 28 m. The function of at least six other buildings in the eastern half of the garrison cannot be specified at present. One of them probably housed the commander of the governor's guard, others probably served as barracks for other soldiers detached to the governor (see B in *Fig. 4*).

Several architectural features point to the exceptional position of this fort not only in Carnuntum, but also in Roman military architecture as a whole: the eastward orientation towards the legionary fort instead of towards the Danube, as was common for most Roman Limes forts, and the lack of interval and corner towers as well as defensive ditches in front of the wall.

To the south of the fortress, another large, isolated building was discovered, which was partially heated by hypocausts and is, thus, most likely to be interpreted as *thermae* (see C in *Fig. 4*), which were certainly part of the governmental complex.

The orientation of this complex establishes a chronological link to the younger phase of the nearby campus, thus forming a coherent complex of buildings extending from the governor's residence on the banks of the Danube, to the newly discovered garrison, to the military campus. This administrative and military complex interrupted the route of the so-called 'Gräberstraße' approaching from the southwest and deliberately blocked the main traffic route coming from the south to divert it to the north. Consequently, all traffic had to pass between the Governor's Palace and the *castra singularium* (*Fig. 4*).

Southeast of the legionary fortress two chronologically successive ***campus* areas** (formerly named *forum* I and II) with large open squares are located (Gugl–Trumm 2015. 106–109). These two *campus* areas overlap and show a well distinguishable chronological sequence, which is particularly visible in the GPR data. The long *porticoes* and *basilicas* of the two *campi* are clearly identifiable, as well as the different orientations of the smaller, older *campus* and the younger one (D in *Fig. 4*).

ROMAN FARMSTEADS

The prospection data reveal a clearly structured network of **boundary ditches** related to both the Roman roads and other identifiable structures. Thus, a system of territorial borders can be identified around the western and southern *canabae legionis* as well as on the periphery of the *colonia* for the first time *(Fig. 2)*. However, the administrative significance of this boundary system is still unclear (Gugl et al 2016. 37–40).

Within about 500 m from the city area, at least seven **farming units** can be distinguished, which are linked by field paths and show a clear connection to the Roman boundary ditches *(Fig. 2)*. In these areas, both masonry buildings and pit houses within rectangular enclosure ditches are identifiable. At least one of these farmstead-like structures is presumably multi-phased showing a distinct change in the orientation of the buildings, from pit houses to rectangular structures built in stone. Close to some of these agricultural units small-scale field structures are recognisable, which suggest the cultivation of special plants (e.g. wine grapes).

TEMPORARY CAMPS

Close to Carnuntum, at least twenty **temporary military camps** were localised. Some of these camps appear to be related to each other based on their size, shape, and orientation *(Fig. 2)*. Although the chronological dating of these camps currently cannot be determined, their historical significance as a base for military campaigns against the northern neighbours seems undisputed.

NECROPOLIS ALONG THE 'GRÄBERSTRASSE'

A Roman **funerary zone along the 'Gräberstraße'** is clearly visible in the geophysical data. Starting from the 'Schaffelhof', it extended over a length of 4 km towards the western gate *(porta principalis sinistra)* of the legionary fortress, where the 'Gräberstraße' most likely joined the Limes road. A clear interruption in the course of the *necropolis* road occurred in an area of the hitherto unknown *castra singularium* close to the junction of the two roads *(Fig. 2)*.

AQUEDUCTS

The already well-known **water supply of the military settlement** coming from the area of the so-called 'Solafeld' can be traced up to the *canabae legionis* within the magnetograms. In this area, several other – so far unknown – water supply lines are recognisable to the south of the legionary camp. Another Roman aqueduct presumably came from the 'Pfaffenberg' in the east. In the aerial photographs, a sequence of massive stone foundations is visible, which can probably be interpreted as the remains of an aqueduct bridge (Doneus–Gugl–Doneus 2013. 107–110).

THE CIVIL TOWN (MUNICIPIUM, COLONIA)

The **civil town** with its reconstructed size of 45 ha was once protected by a massive stone wall (Maschek 2012). The city's layout is characterized by an irregular arrangement of several *insulae* (housing blocks), which is observable in the geophysical prospection data in its southern half. The interpretative mapping resulted in a detailed map of large parts of the Roman town. The urban pattern of the building blocks is orientated towards the Limes road, forming the *decumanus maximus* of the town, which runs between the ***forum*** (A in *Fig. 5*) and a macellum-bathing-complex ('Palastruine', B in *Fig. 5*) in west–east direction (Sedlmayer 2015. 355–364). From this road, the *cardo maximus*, a broad road with accompanying *porticoes* and *tabernas*, leads from the *forum* to the southern town gate. These two roads form the main axes of the civil town with the western part particularly characterised by a rather ir-

Figure 5. Interpretation of the GPR-data in the southwestern part of the Carnuntum civil town

regular street system. The available survey data makes it possible to trace the course of the town wall and to identify public buildings and private residential housing units as well as open squares and buildings of sacral character *(Fig. 5)*.

During the construction of the town wall, some older buildings were demolished to create space for the stone wall and two defensive ditches located in front of it. This development becomes especially evident within the building complex addressed as *mansio* where traces of this massive intervention – within the already fully developed city structure – can still be discerned.

The ***mansio*** (C in *Fig. 5*) is a building complex of approximately 30 × 50 m with an extended inner courtyard (approx. 20 × 30 m), which is surrounded by regular, small-structured rooms (Gugl et al. 2020. 14–15). The access to the complex is to the south, most likely through a side gate in the town wall leading directly to Amphitheatre II, which was located outside the town.

To the east of the *mansio* on the southern town wall, a large open triangular square is visible, which was probably created during the construction of the town wall. Based on the geophysical data, it was possible to identify another **Amphitheatre III** (D in *Fig. 5*), which apparently was demolished during the construction of the town wall, probably in Severan times. This early Amphitheatre III can be regarded as the precursor of Amphitheatre II, which is located about 400 m to the south and still

visible today. To the east of the Amphitheatre III a small **temple** (21 × 15 m, E in *Fig. 5*), with a rectangular foundation of an altar-like structure in front of it was situated.

The spatio-temporal analysis of the prospection data of another settlement area between the civil town and the Amphitheatre II indicated its close economic connection with the operation of the Amphitheatre II. This infrastructural area lies to the east of a road leading into the Roman town, whereas the so-called **school of gladiators** occupies the area to the west (Neubauer et al. 2014).

Considering the temporal development of the civil town, the construction of the town wall resulted in hitherto unknown, but drastic, infrastructural impact. Not only entire housing areas but also public buildings were demolished and rebuilt outside the city boundaries creating a spacious area for the entertainment of the inhabitants of the civil town, consisting of the Amphitheatre II, the school of gladiators and a service area for the up to 13.000 visitors of the gladiator fights.

THE 'HEIDENTOR' AND THE NECROPOLIS SOUTH OF THE CIVIL TOWN

To the east and south of the Amphitheatre II complex, reaching as far as the so-called 'Heidentor', a monumental tetrapylon-style gateway of the 4th century (Jobst 2001), is an extensive and densely occupied ***necropolis***, which comprises burials from the second half of the 1st to the 4th century AD (Ertel et al. 1999). Within the *necropolis* a system of roads is recognisable, the course of which changes through time and thus illustrates the long period of occupation of this vast cemetery well *(Fig. 2)*.

Four **temporary camps** are located to the north, west and east of the 'Heidentor'. A chronological classification and function of these temporary camps cannot be derived from the prospection data and therefore requires further investigation *(Fig. 2)*. Similarly, the archaeological prospections as well as the excavations have not yielded any concrete clues about the function of the 'Heidentor'. However, based on the results of the geophysical measurements, it can be assumed with high certainty that the monument was not placed at a prominent street crossing.

SUBURBIUM WEST

The Roman **Limes road** – coming from the west as an unpaved gravel road – is clearly recognisable in all datasets and crosses the entire area of the 'Gstettenbreite'. Along the road, graves can be identified over a length of about 600 m. Following the Limes road to the east, with a clear demarcation to the cemetery, a suburban *vicus*-like settlement area begins, which is well visible in the data over a stretch of about 800 m up to the town wall.

The western **suburban settlement** consists mainly of simple strip houses, narrow stone buildings that are situated perpendicular to the road (Gugl–Radbauer–Wallner

2019; Gugl et al. 2020). Approaching the town, the general layout of this extramural area becomes more complex, whereas further away from the town, the buildings were arranged in a single row on both sides of the road. In the rear area of the properties, further parcel delimitations in the form of boundary ditches are observable *(Fig. 6)*.

The typical layout of a strip house shows a narrow open space in front of the building which may have once served as an extended vendor area. Adjacent are the living quarters, while in the rear, usually one or two enclosed courtyard areas could be identified. In some cases, further areas can be attributed to building plots that were not enclosed by walls. These yard areas could have been used as workshops or gardens.

Due to the spatial overlapping of the settlement and a **temporary military camp**, the chronological sequence of the structures can be deduced. Based on the spatial analysis it becomes evident that the – younger – settlement, which probably started in the early 2nd century AD, overlaps the ditches of the – older – military camp (see A in *Fig. 6*). The prominent location directly at the scarp of the Danube and the relative chronological sequence suggest that this military camp dates to the 1st century AD.

South of the settlement, the **water supplying infrastructure** of the civil town (Konecny 2012) – coming from the west – is clearly recognisable in the geophysical data. Several water-collecting channels form a system of aqueducts outside the town wall, converging just outside the modern 'Tiergartenmauer' (see B in *Fig. 6*) and

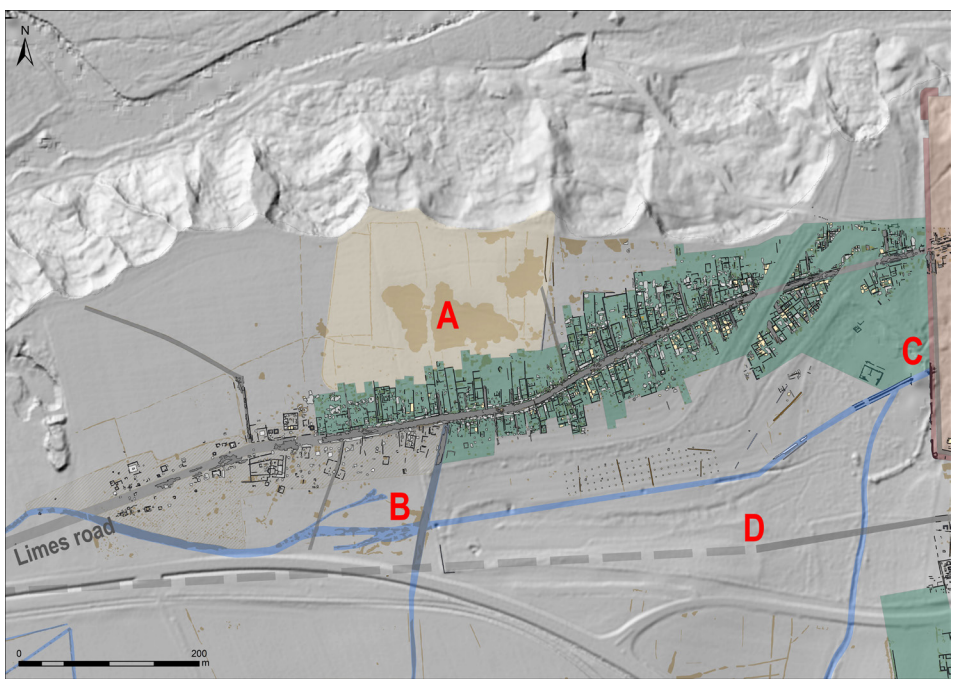

Figure 6. The extramural settlement to the west of the civil town

running towards the 'Fischteich', where it was uncovered during an excavation in 2012. In this area, the aqueduct passes under the town wall and forms one of the main water supplies of the Roman civil town (see C in *Fig. 6*).

The **necropolis along the Limes road** seems to have been occupied for a rather long period of time. Pottery finds from the fieldwalking surveys suggest that the extramural settlement was occupied at least until the first half of the 3rd century AD. This may also give a clear indication for the occupation period of the necropolis. During the spatial analysis it was observed that some of the graves – among them two remarkable sarcophagus burials – were not located along the Limes road. These burials were orientated towards a structure further to the south, a second – apparently older – arterial road, which led from the pre-municipal settlement to the west (see D in *Fig. 6*). The end of the occupation of this older necropolis falls in the period between ca. 180 AD and 210/220 AD and was probably triggered by the construction of the town wall, which blocked the course of the road. This might be the first archaeological evidence in Carnuntum that indirectly proves the dating of the construction of the town wall to the decades around 200 AD, probably to the early Severan period, i.e. under the reign of Septimius Severus.

CONCLUSION

The considerable gain in knowledge resulting from the large-scale application of geophysical prospection methods within the 'ArchPro Carnuntum' project is indisputable. The use of sophisticated techniques of archaeological survey and the development of efficient motorised prospection systems have opened up unprecedented opportunities for the non-invasive exploration of entire landscapes in archaeology. While motorised magnetometer measurements are particularly suitable for covering large areas, GPR measurements generate 3D data volumes that provide a detailed insight into the subsurface. In Roman archaeology, the possibility of three-dimensional interpretation of the surveyed structures is the key benefit of this approach. Furthermore, even small-scale structures such as Roman hypocausts can be recognised in the visualisations due to the high resolution of the collected data. By combining these methods with systematic extensive field surveys and subsequent analysis of excavations, it is possible to establish the database for a first chronological framework of the prospected structures.

The 'ArchPro Carnuntum' project demonstrates that the combination of geophysics, remote sensing and archaeological survey or targeted excavation can provide a maximum of archaeological information and thus represents an optimal research strategy for the exploration of large archaeological landscapes. By systematically applying a multi-disciplinary approach it was possible to investigate diverse settlement areas in detail, to gain unexpected information about infrastructure and urban development, and thus to contribute to a deeper understanding of the ancient city of Carnuntum.

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AZ „ARCHPRO CARNUNTUM" PROJEKT – KOMBINÁLT KUTATÁSI ADATOK INTEGRÁLT RÉGÉSZETI ÉRTELMEZÉSE, CARNUNTUM (AUSZTRIA)

Összefoglaló

Az elmúlt évek során széles körben felismerték a régészet tudományterületén alkalmazható nagyszabású, nem invazív jellegű kutatási módszerekben rejlő potenciált. A módszer települési központok feltárásának területén alkalmazható lehetőségei már korán valósággá váltak, és alkalmazásra kerültek a kiválasztott helyszíneken. Az „ArchPro Carnuntum" projekt a római provinciális főváros átfogó vizsgálatával a legkülönfélébb felmérési módszerek (légi régészet, magnetometria, földradar, kiterjedt terepi felmérés) együttes alkalmazásával kiemelkedik ezek közül, és részletes információval szolgál a római város antik infrastruktúrájával kapcsolatban. A projekt során nem kizárólag új települési területek felfedezésére nyílt mód, hanem egyes esetekben következtetni lehetett a területek egykori funkciójára is. Mindezek eredményeként a carnuntumi régészeti területen kimutathatóvá vált a katonai igazgatási központ, valamint az új építésű lakónegyedek és az ideiglenes katonai táborhelyek is. Jelen tanulmány ezen nemzetközi szinten is egyedülálló kutatási projekt eredményeiről nyújt áttekintést.

Kulcsszavak: Carnuntum, LBI ArchPro, római légiós erőd, római város, régészeti talajkutatás, földradar, magnetometria

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