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REPORT ON THE GEOMAGNETIC SURVEY AT MARGUM IN OCTOBER 2011

UDK: 902.3:550.83(497.11)"2011"
DOI: 10.2298/STA1262229R
Short communication

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Received: February 21, 2012
Accepted: June 21, 2012

Abstract. – In autumn 2011, the geomagnetic survey was conducted at Margum/Morava. The results significantly contribute to our knowledge of the history of the site, together with the ones of the recent LiDAR scanning of its wider area. The data show that the part of Margum surveyed was densely settled with stone structures, possible timber-frame buildings and, perhaps, some sunken dwellings of the “Grubenhaus” type, which corresponds both with the results of current excavations and earlier observations. The settlement patterns that can be identified were clearly planned. It is possible to identify two differing general orientations. This suggests that there were at least two main periods of occupation at Margum, during both of which there was a degree of planning as to how the site was laid out. Both orientations are found at either end of the surveyed area, suggesting that the entire site was settled in both phases.

Key words. – Margum/Morava, geomagnetic survey, settlement patterns.

Since 2004, the Romano-Germanic Commission of the German Archaeological Institute has worked in close cooperation with the Institute of Archaeology in Belgrade, conducting a large-scale programme of geophysical research at sites across the Republic of Serbia. This research programme was initially funded through the Stability Pact for Central Europe (until 2008), and has been extended successfully through several smaller projects¹. In autumn 2011, it was possible to geomagnetically survey a small area of the site of Margum as part of this programme in order to complement the various other research approaches taken at this site in the course of the ArchaeoLandscapes Europe (ArcLand) project².

team from Frankfurt (D. Peters, C. Rummel, G. Schafferer), I. Bugarski of the Institute of Archaeology in Belgrade and D. Jacanović of the National Museum in Požarevac. In the course of this trial survey, it was possible to investigate a total of 7 rectangular grids of varying sizes, grouped into three sectors, in the vicinity of recent excavations carried out by the Institute of Archaeology in Belgrade and the National Museum in Požarevac, within the scope of the project “The Town of Margum” (Cross-Border Programme Serbia – Romania 2007–2013). The total area surveyed amounts to c. 0.22 ha (Fig. 1). In view of the heavily wooded nature of the site, the survey grids had to be staked out primarily on the basis of where trees would allow for a

METHODOLOGY

The initial geomagnetic trial survey at Margum presented here was undertaken in October 2011, by a

¹ See Peters et al. (forthcoming), Introduction.

² <http://www.archaeolandscapes.eu/>; for site history of Margum and research question see Ivanišević, Bugarski, in this volume.

Fig. 1. Visualisation of the Magnetometry Data from Margum, Range +/- 10nT (RGK–DAI Rummel)

Сл. 1. Визуелизација магнетометријских података из Марјума, опсеи +/- 10nT (RGK–DAI Rummel)

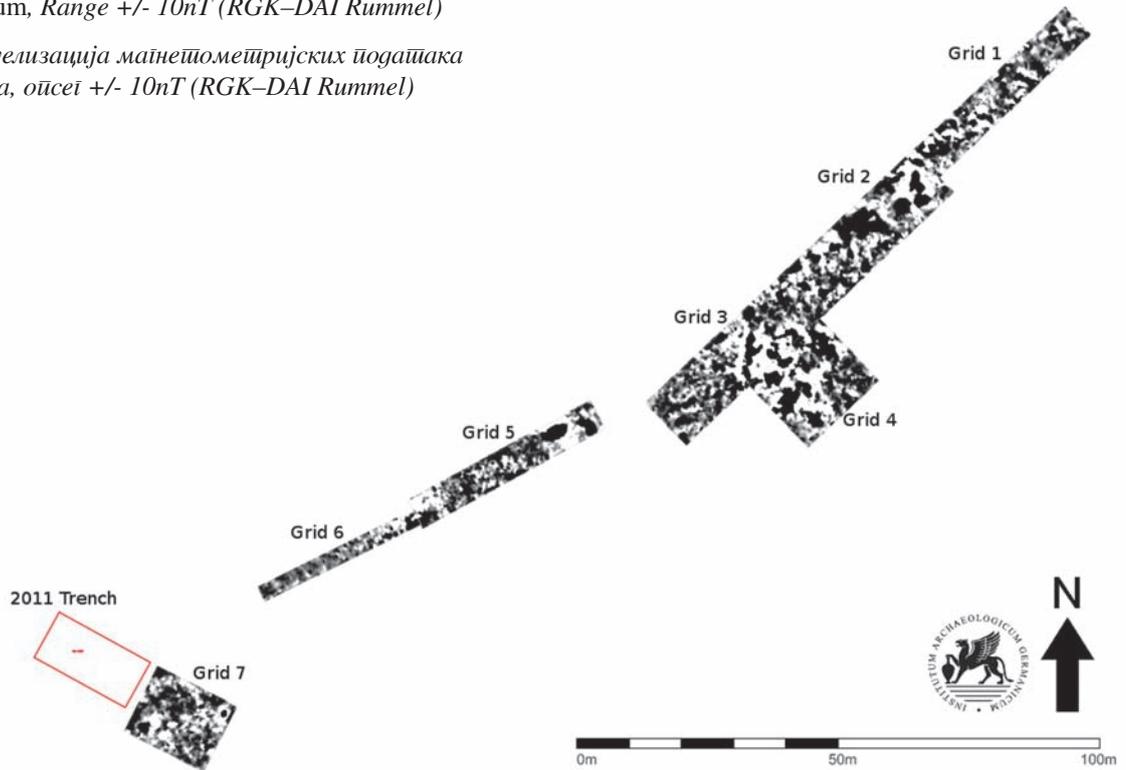
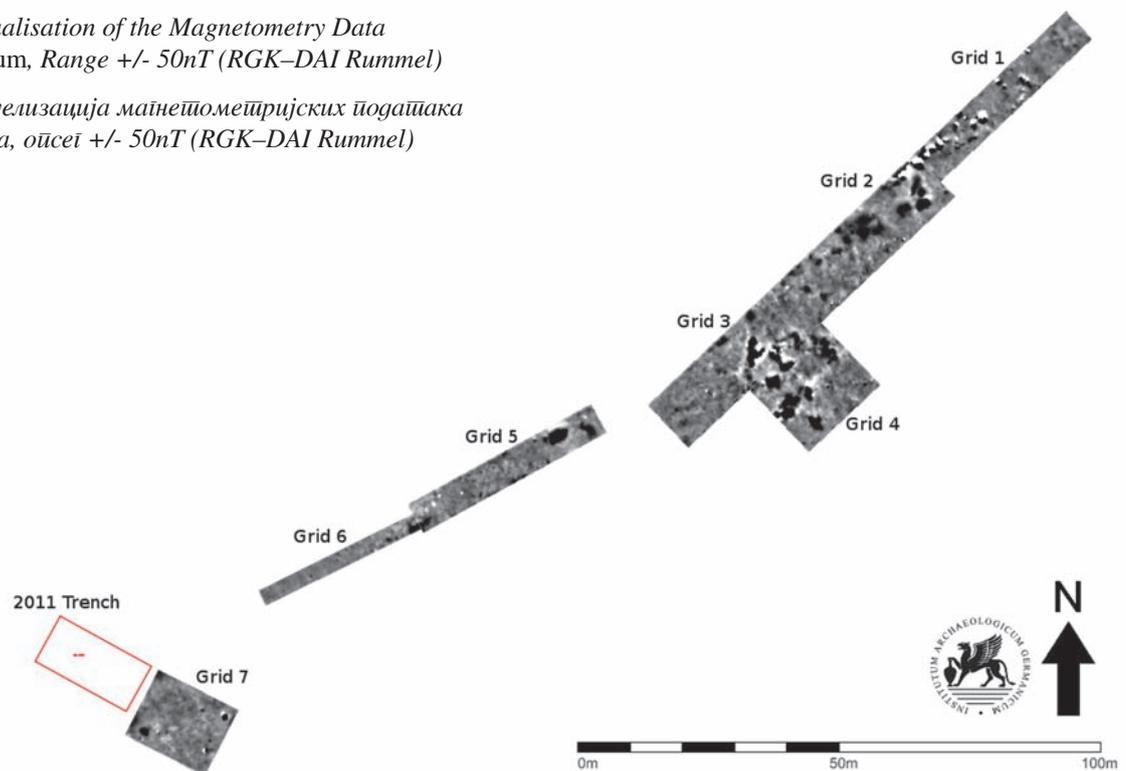


Fig. 2. Visualisation of the Magnetometry Data from Margum, Range +/- 50nT (RGK–DAI Rummel)

Сл. 2. Визуелизација магнетометријских података из Марјума, опсеи +/- 50nT (RGK–DAI Rummel)



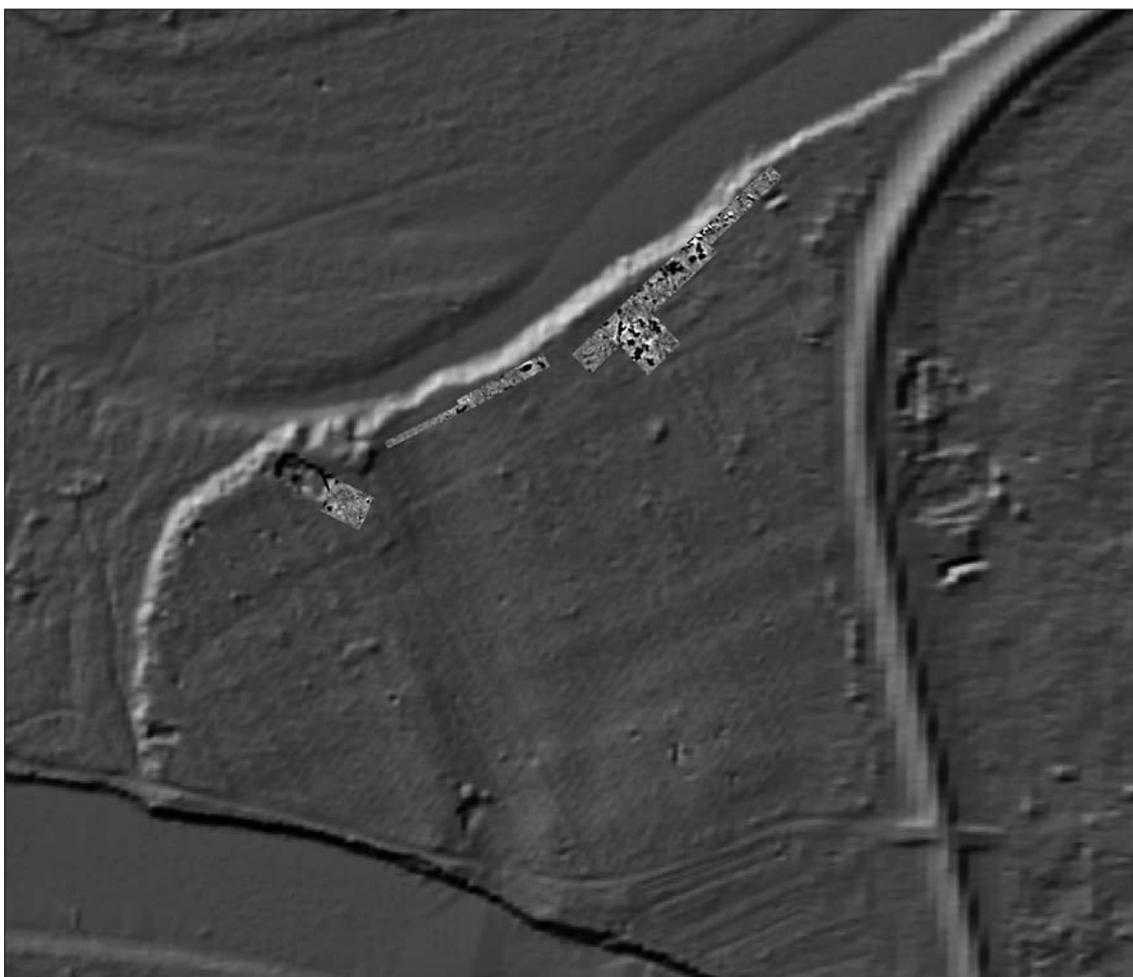


Fig. 3. The +/- 10nT Magnetometry Map referenced to the LiDAR Scan Visualisation (V. Ivanišević, I. Bugarski)

Сл. 3. Магнетометријски план ојсећа +/- 10nT референциран на ЛИДАР подлози (В. Иванишевић, И. Бујарски)

rectangular grid to be placed, with archaeological considerations only influencing the overall positioning of the survey area.

The survey was conducted using a five sensor multi-channel array designed by the German company SenSys (Sensorik und Systemtechnologie GmbH) that employs five FGM650B fluxgate vertical gradiometers spaced at 0.25 m intervals, resulting in 1 metre transects. Within rectangular survey grids, measurements were taken at 0.1 m intervals resulting in a high resolution of data plots (10 cm x 25 cm). The generated data were processed by interpolating the measurements using a bilinear algorithm at a resolution grid of 100 mm and an interpolation radius of 500 mm and then filtering it using a median filter included in the Software package MAGNETO-Arch developed by SenSys.

As the interpolation plot using a 256 shade grey-scale to depict nT values with thresholds set to +/-10nT (Fig. 1) shows, there is a fair amount of background noise, as well as numerous strong dipoles that negatively influence any interpretation of the dataset. Nonetheless, some linear anomalies that may indicate structural remains can be suggested even on the basis of this plot. It must be borne in mind, however, that the immediate proximity of the survey area to the river means that deeper layers of soil would have been completely saturated with water – a factor that would further have affected magnetic susceptibility in these layers³.

³ For a discussion of the effects of high groundwater on magnetometry see Kattenberg & Aalbersberg (2004).

Nonetheless, as the upper levels of the site were more than 3m above the waterline, cultural layers appear not to be too affected by this. By adjusting the threshold values to +/- 50nT, it is possible to generate a clearer image that can serve as a basis for more reliable interpretation (Fig. 2). In order to simplify the visualisation of anomalies, the edges of all anomalies interpreted as archaeological features have been outlined in blue with semi-transparent fills in red for probable walls / stone structures and beige for pits / ditches (Fig. 4).

The corner points of the surveyed grids were staked out and geo-referenced on the ground in Universal Transverse Mercator (UTM) coordinates using a Leica GPS900 real-time Kinematic (RTK) GPS system consisting of a Leica RX900 controller and two communicating ATX900 GPS antennas. As such, the relative accuracy of all measurements lies in the centimetre range. Three local reference points used by the Serbian excavation team for the 2011 season were also recorded in order to ensure transferability of data despite differing projection systems. In parts of the site, however, the tree cover was so dense that it was impossible to receive an accurate satellite image. Grids 5–7 were therefore staked out using a Leica TC605L Total Station. The relative data from this instrument was joined with that from the GPS using the Autodesk AutoCAD MEP2011 Software package, thereby not compromising accuracy. For local reference, the outline of the 2011 excavation area was included in the plot. The individual interpolated data plots from each grid were then joined into a single georeferenced magnetometry map of the 2011 geophysical survey at Margum (Figs. 1–3).

RESEARCH QUESTIONS

The area surveyed can be roughly divided into three sectors. The first, north-eastern, sector (Sector 1) comprises grids 1–4 and was positioned in order to trace the course of the supposed fortifications of a Roman military camp at the site⁴. Sector 2 lies further south-west and consists of grids 5 and 6. These grids were placed to investigate the relationship of the western part of the site, presumed to have been densely occupied, with a notable depression in the modern topography that was identified as the possible site of a medieval defensive ditch, as can be seen clearly in the LiDAR scan of the site (Fig. 3). The final sector of the survey (Sector 3) comprises grid 7, the most accessible part of the wooded south-western section of the site. The aim of grid 7 was to

attempt to further define the structures identified in the 2011 excavation trench and to understand whether this part of the site was settled in a dense urban occupation pattern with common orientations, or whether individual structures were spaced widely apart and haphazardly.

DATASETS AND INTERPRETATION

The interpretative rendering of the magnetometry data within a +/- 50nT threshold (Fig. 4) clearly shows a linear series of dipoles (circled in yellow) in grids 1 and 2. These, as well as further isolated dipoles in grids 4, 5 and 6 are most likely caused by iron objects or modern waste in the ground. The same can be said of the three smaller dipoles in grid 7 – the strong dipole in the eastern tip of this grid, however, is caused by a local reference point consisting of a concrete post encasing an iron rod. As such, this dipole serves as additional evidence that the georeferencing of the survey grids was completely accurate.

In **Sector 1** (Grids 1–4) we can postulate that the thicker linear (north-west to south-east) anomaly running across the grid at an almost right angle indicates the course of the presumed fortification wall (Fig. 4). Such an interpretation appears especially likely in view of the anomaly width of between 1.7 (N edge) and 1.9 (S edge) metres which matches that observed in a nearby trench⁵, although it must be borne in mind that a magnetic signature does not necessarily keep the exact dimensions of a structure or object. The density of anomalies indicating structures to the west of this anomaly, as well as the general topography of the site, would then make the area to the west the urban or inner part of Margum, whereas the area to the east would have been *extra muros*⁶. If such an interpretation were to be accepted, however, it is of particular interest that there is a further anomaly to the east of this wall that forms an L-shape and could therefore be interpreted as the corner of a building (Fig. 5). As this anomaly runs

⁴ See e.g. Gudea 2001, 52, who states that a large military station, possibly legionary, existed at the site and that fortifications of 720 m x 820 m are visible in the terrain (N.B.: Kanitz 1892: 15 gives 864 m x 720 m and interprets the observation as a *civitas*) – an observation not corroborated on the ground at the time of the survey.

⁵ Oral communication on site, I. Bugarski.

⁶ See also considerations regarding site layout (with drastically changed river course) in Marić 1951, Fig. 4.

parallel to the one discussed above, the one clearly respects the orientation of the other, suggesting that the anomalies coexisted at some point. The presence of a stone structure a mere 5 m outside a fortification, however, would seriously undermine any defensive military purpose. As such it appears unlikely that the first anomaly actually was a true fortification delimiting the edge of an urban area that served a defensive purpose at the time that the structure to its north-east was built. One possible scenario is to see the easternmost anomaly as a later structure that orients itself along a fortification line no longer in military use, for example as part of a post-Roman settlement that orients itself along the still standing remains of an earlier, now at least partly abandoned or reduced, centre. It is equally possible, however, that the outer structure pre-dates the presumed fortification. Which of these hypotheses turns out to be accurate, or whether the actual remains identified in the survey do in fact tell an entirely different story, however, is a question that cannot be resolved on the basis of geophysical data alone⁷.

The south-western half of Grid 1 – as well as Grids 2 and 3 – produced a number of anomalies that seem to indicate sub-surface walls. All of these can be hypothetically joined into right-angled structures – although there is no way to clearly identify the ground plans of individual buildings (Fig. 4). The image is typical for a multi-period settlement site that follows an organised layout; in the case of this part of the site the orientation of the vast majority of anomalies follows a north-south / east-west alignment. Nonetheless, there is an anomaly in the south-western part of Grid 1, running into Grid 2, that does not follow this orientation, but seems to run from the north-west to the south-east – therefore following the orientation of the proposed fortification wall and the individual structure further east. The same considerations regarding phasing and dating as in the above paragraph also apply here. Of further interest is that the row of dipoles discussed above runs almost directly parallel to the anomalies interpreted as walls that do not follow the east-west orientation. This may be simple coincidence, but could also mean that either the structures should be seen as modern, or the dipoles as metal objects of archaeological interest deposited along the walls of a structure.

The number of possible pits and middens identified across Grids 2–4 reflect the nature of a settlement occupied over several centuries (Fig. 4). Some are clearly positioned in the corners of structures and may be seen as pits, while others cannot be associated directly

with the linear anomalies tentatively interpreted as building remains. Some of the smaller anomalies could possibly be seen as postholes, although it is impossible to connect them into coherent shapes in view of the quality of data and limited survey area. The smaller anomalies in Grid 2 (beige rendering), for example, could be connected to form a rectangular shape that continues into Grid 3 (Fig. 5). This may reflect an actual archaeological trace of a large wooden building (which would then break with the east-west orientation, instead paralleling that of the anomaly observed in Grid 1). Such a hypothetical connection of anomalies, however, is, in the end, mere speculation. Equally, the larger anomalies could be seen as the remains of “Grubenhäuser”-like habitation – the largest at the centre of Grid 2 extends to a maximum of 5 by 3.5 metres – but cannot be interpreted as such with certainty (Fig. 4). Finally, it must be borne in mind that the natural process of filling up of pits created in the uprooting of trees – a process highly likely to have occurred in places across the wooded site over the past 1500 years – would have resulted in anomalies indistinguishable from pits and completely unrelated to any human activity. This applies to all anomalies here discussed as hypothetical pits or middens.

In view of the density of anomalies indicating walls and pits, as well as the 2-dimensional nature of geomagnetic data plots, it is impossible to identify phases or individual structures on the data plot from Sector 1. It is clear, however, that this area saw dense and organised settlement over several periods, suggesting that it was part of the core urban part of Margum/Morava (Fig. 5).

The two grids that comprise **Sector 2** of the survey are of interest in that the density of anomalies in Grid 5 is noticeably higher than that observed in all of sector 1 – particularly in terms of linear anomalies interpreted as possible structural remains. Grid 6, however, is practically devoid of anomalies – a break that coincides with the area identified as a defensive vallum and ditch, possibly for a reduced medieval settlement at Margum (Fig. 3)⁸.

The majority of structural remains in this sector follow the same north-south / east-west alignment observed in sector 1 (Fig. 4). As such, it is fair to suggest that they are likely to belong to the same general

⁷ For a somewhat more reliable interpretation, see Ivanišević, Bugarski, in this volume.

⁸ See Kanitz 1892, 15, who suggests it may have been a former canal that had fallen dry a long time before he visited the site.

Fig. 4. Interpretation of the Survey Data from Margum.
 Blue: Edge of anomaly; Red: suggested stone structures;
 Beige: suggested pits; Yellow: dipoles
 (RGK–DAI Rummel)

Сл. 4. Интерпретација података добијених
 скенирањем Марјума. Плаво: ивице аномалија;
 црвено: предположено структуре од камена;
 беж: предположено јаме; жуто: диполи
 (RGK–DAI Rummel)

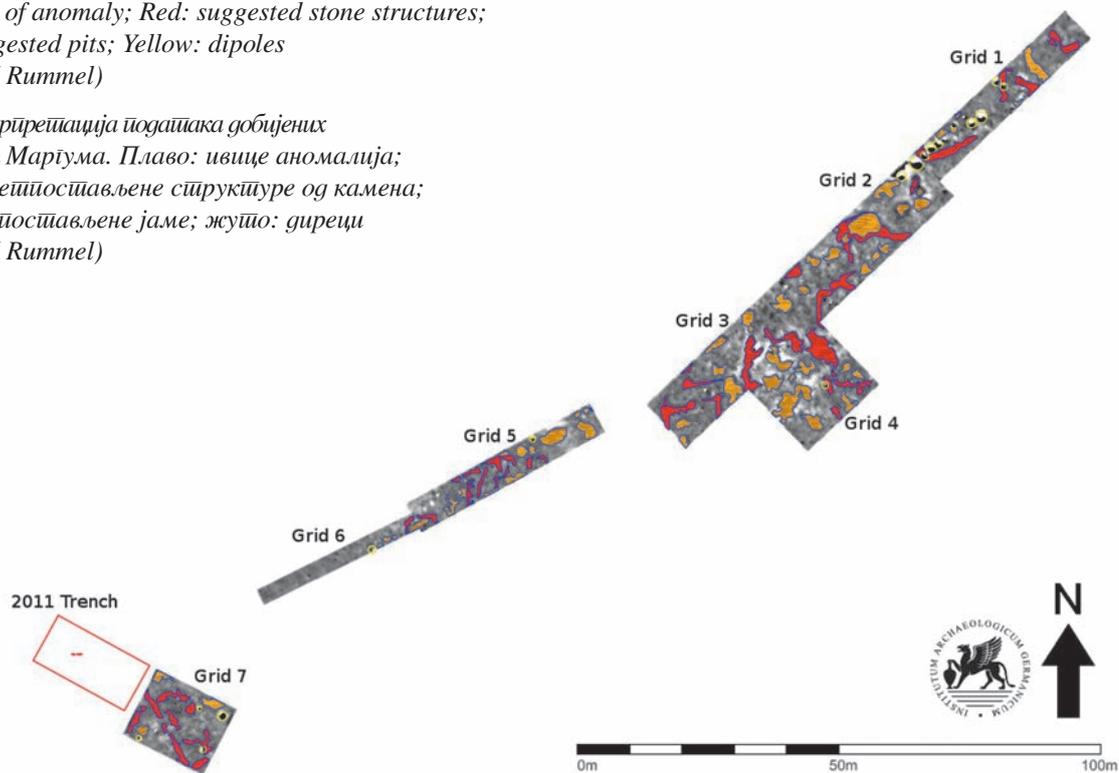
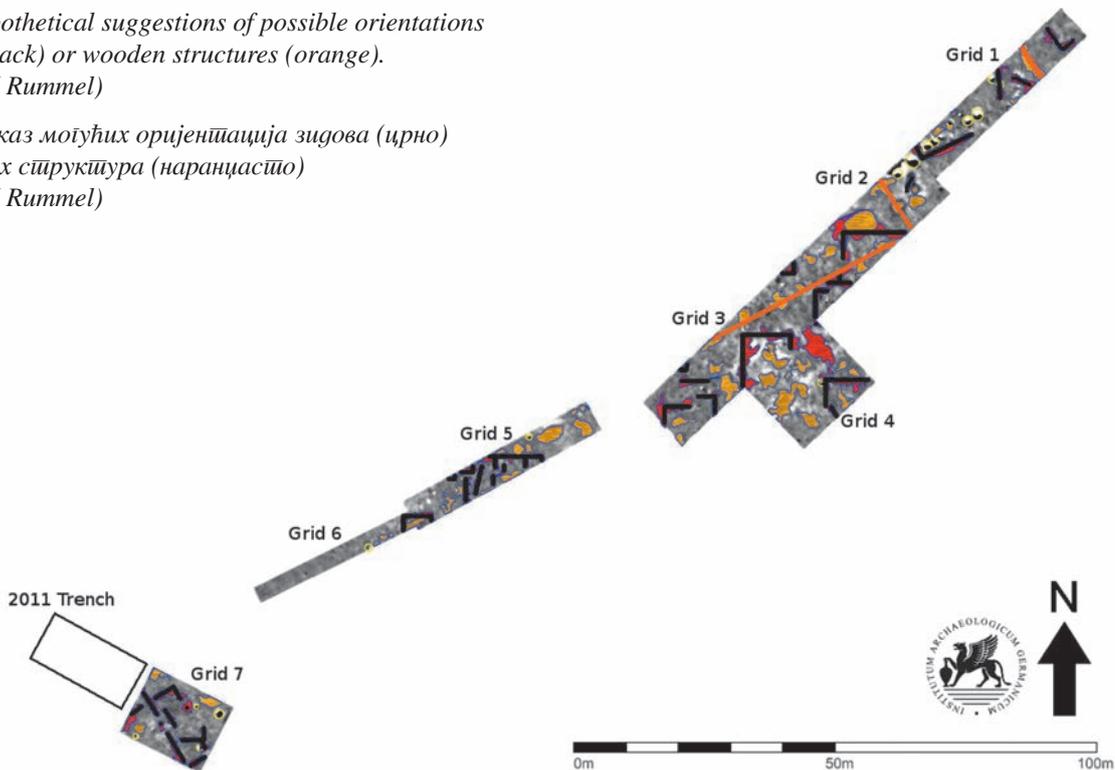
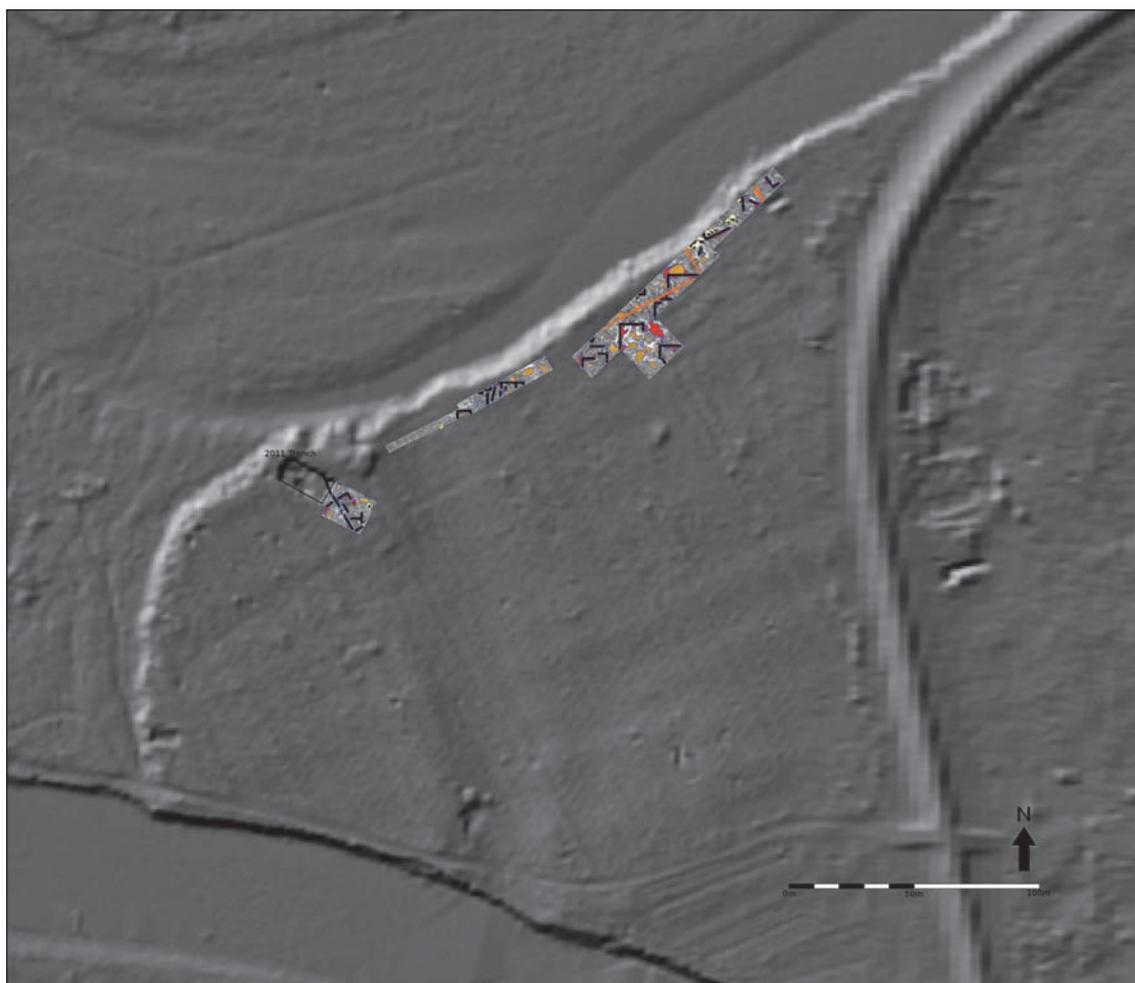


Fig. 5. Hypothetical suggestions of possible orientations
 of walls (black) or wooden structures (orange).
 (RGK–DAI Rummel)

Сл. 5. Приказ могућих оријентација зидова (црно)
 или дрвених структура (наранџасто)
 (RGK–DAI Rummel)





*Fig. 6. Interpretation Map referenced to the LiDAR Scan Visualisation
(RGK–DAI Rummel based on V. Ivanisevic, I. Bugarski)*

*Сл. 6. Интерпретацијски план референциран на ЛИДАР подлози
(RGK–DAI Rummel, према В. Иванисевић, И. Бугарски)*

period of occupation. The spacing between anomalies, however, is significantly closer, suggesting more frequent rebuilding of structures according to a similar plan or within similar plots. This could be taken to indicate a more central part of a settlement, where rebuilding occurs frequently in the same, or nearly the same, places. The limited width of the transect that could be surveyed, however, must leave such an interpretation hypothetical at best. Unfortunately, the dense tree cover in this particular part of the site makes it unlikely that it will become possible to extend the survey area in sector 2 in future.

As with sector 1, there are a number of pits in this part of the site, albeit less closely spaced (Fig. 4). The

larger ones in the north-western part of Grid 5 might once again be seen as “Grubenhaus”-type dwellings in view of their size, an interpretation that is hypothetical for the same reasons as in the case of Grid 2. Generally, the anomalies identified as pits seem to parallel the orientation of those in sector 1 and therefore break with the north-south / east-west orientation of most anomalies interpreted as walls. To what extent this reflects purposeful placement, or whether it is mere coincidence, however, cannot be defined on the basis of the geophysical data alone.

The main interest in the data from Grid 6, an elongated Grid purposefully placed across a depression in the modern terrain believed to have been left by a large

defensive ditch dug across the site, is that is practically devoid of any anomalies (Fig. 4). Nowhere else in the surveyed area is there such a homogenous image. Interestingly, this area without any anomalies matches directly with the depression of the ditch identified through a 2011 LiDAR scan (see Fig. 3). As such, it seems likely that any structural remains in this area were dug away during creation of the ditch (see also discussion below).

Sector 3, or rather Grid 7, was placed in a clearing adjacent to the 2011 excavation area in order to define the wider setting of the excavated structures. The area contains a series of linear anomalies that can be interpreted as walls (Fig. 4). These connect to form what appears to be a rectangular structure that takes up most of the surveyed area – with a large linear anomaly running across it from the north-west to the south-east. This anomaly appears to be the direct continuation of a wall identified during the excavation, as can be seen in the overlay of the geophysical data onto the LiDAR scan (Fig. 6). A small anomaly interpreted as a wall in the eastern part of Grid 7, however, forms a T-shape along a clear east-west axis. As such it indicates that there are further structures in this area that do not follow the same orientation as the structure excavated in 2011⁹.

As such, the survey data in this sector of Margum can be read to show that several periods – such as a Roman and a post-Roman occupation – existed in this part of the settlement. At the same time, the close proximity of rectangular structures that appear to cut or overlay each other, indicates that it was a densely settled, central part of the site – as had been suggested before¹⁰.

Of the three pits that can be identified in this sector the westernmost may be associated with the rectangular structure it is located in (Fig. 4). The two larger pit-like anomalies in the north-east of Grid 7, which cannot be connected to any structural data, might have to be seen as middens or even “Grubenhaus”-type sunken dwellings. This set of data sits well with visual observations of the 2011 excavation area made during the survey, where a number of deep apparently medieval pits were cutting through earlier Roman layers.

CONCLUSIONS

Despite the difficult conditions on the ground and limiting factors on data clarity such as background noise, the geomagnetic measurements undertaken at Margum in 2011 provide a significant amount of interpretable

data that addresses some key questions to the site (Fig. 5). As such, they help to increase current understanding of the general nature of the site – even though specific questions, particularly in respect to chronology and extent of occupation, cannot be answered.

Specifically, the data show that the part of Margum surveyed was densely settled with stone structures, possible timber-frame buildings and, perhaps, some sunken dwellings of the “Grubenhaus” type, which corresponds both with the results of current excavations and earlier observations¹¹. The settlement patterns that can be identified were clearly planned, as they follow organised and parallel orientations (Fig. 5). It is further possible to identify two differing general orientations, one following a direct north-south / east-west alignment, the other running at a 45° angle to it. This shows that there were at least two main periods of occupation at Margum, during both of which there was a degree of planning as to how the site was laid out. Both orientations are found at either end of the surveyed area, suggesting that the entire site was – apart from the big ditch – settled in both phases. While the geophysical data alone cannot shed light on the dating of periods, it is interesting to note that the majority of identifiable stone structures follow the east-west alignment, while nearly all anomalies identified as post holes can be put into hypothetical relationships with the north-east / south-west alignment. The fact that an anomaly indicating a wall that follows the latter alignment can be identified in direct continuation of a late Roman wall documented in the 2011 excavation (Fig. 6) makes it possible to link the two phases of settlement planning directly to the stratigraphical sequence of the excavation¹².

A further important observation in the magnetic map is that in the area of a depression still visible across the site to date (Grid 6, see also LiDAR image in Figs. 3 & 6), no anomalies or dipoles are visible at all. Even in the interpolation plot with thresholds set to +/- 10 nT (Fig. 1) which is dominated by background noise, Grid 6 is noticeably calmer than any other part of the site. The LiDAR results clearly show that the depression is part of a larger ditch that cuts across all

⁹ See Ivanišević, Bugarski in this volume.

¹⁰ For considerations regarding the settlement of Margum in Antiquity and the early medieval period see Jovanović, Cunjak 1994.

¹¹ Petrović, Vasić 1996, 21, n. 17.

¹² See also Ivanišević, Bugarski in this volume.

that remains of a “peninsula” created by a loop of the Morava that formed the urban area of Margum. The fact that this ditch produced practically no anomalies – in stark contrast to the surrounding area – suggests that any structural remains in this area were, in fact, dug away in the construction of the ditch. As such, it is possible to propose on the basis of the geomagnetic data that the ditch was an additional defence for a reduced settlement in the medieval period, which destroyed any earlier settlement remains in this area, and was not subsequently used for any occupation.

In summary, the work carried out at Margum as part of a trial survey in 2011 was clearly a success – particularly so in view of the limited time frame and area covered. As such, it is to be hoped that further joint campaigns of research between the Institute of Archaeology in Belgrade and the Romano-Germanic Commission of the German Archaeological Institute will take place at Margum in the near future in order to build on the data presented here and further extend current understanding of the structure and development of the site.

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Резиме:

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ИЗВЕШТАЈ О ГЕОМАГНЕТСКИМ ИСТРАЖИВАЊИМА МАРГУМА У ОКТОБРУ 2011. ГОДИНЕ

Кључне речи. – Маргум /Морава, геомагнетска истраживања, матрице насеља.

У склопу, сада већ вишегодишње, сарадње Римско-германске комисије Немачког археолошког института из Франкфурта и Археолошког института из Београда, у јесен 2011. године извршена су геомагнетска снимања терена на локалитету Маргум/Морава. Резултати тих истраживања су комплементарни онима добијеним путем *LiDAR* скенирања шире зоне налазишта, које је такође приказано у овој свесци *Старинара*.

Геомагнетска истраживања су изведена у три сектора очуваног дела налазишта. У сектору 1 је, вероватно, потврђена траса бедема античког Маргума која је претпостављена током археолошких истраживања локалитета 2011. године. Простор западно од те линије био би *intra muros*, док се у источној зони, *extra muros*, примећује остатак једне паралелно постављене грађевине, чије хронолошко одређење није могуће утврдити само на основу изведених снимања. У већем, интрамуријалном делу истраживане површине сектора 1 наговештено је постојање објеката који су постављени у две главне оријентације – према странама света и под углом од 45°, од којих једна прати претпостављену линију бедема Маргума. Изнесена је и претпоставка о начину градње неких од њих. Добијена слика је типична за вишеслојна налазишта, при чему се истиче густина и организација просторног распо-

реда објеката из тих фаза. Испитани терен у сектору 1, дакле, представљао је део урбаног језгра Маргума /Мораве.

Густ шумски покривач онемогућио је снимање знатнијих површина у оквиру сектора 2, источно од сектора 1. Примећено је, ипак, да се објекти у истој оријентацији нижу у још већој густини, осим у самом западном делу којим је захваћена зона великог канала који пресеца читав очувани део налазишта. Постојање тог канала уочио је још Феликс Каниц. У оквиру те депресије није било никаквих забележених аномалија, па је закључено да је приликом његовог укопавања на том простору био уклоњен сав археолошки садржај. Најоснованија је претпоставка да је реч о одбрамбеном рову средњовековног насеља, који касније није коришћен.

Сектор 3 је испитиван још западније, поред широког ископа који је већ раније ископан 2011. године. Установљено је да се зид једне велике касноантичке грађевине пружа даље ка југу, али су и ту уочене другачије оријентисане аномалије, што је све у складу са археолошки документованим наслојавањем на овом делу локалитета. Приказани резултати, посебно у односу на ограничену површину и трајање снимања, представљају ваљан разлог за продужетак сарадње Археолошког института и Римско-германске комисије у пословима геофизичког испитивања Маргума/Мораве.