The Roman burgus of Trebur/Astheim in FDEMI multi-system data

Dennis Wilken [1*], Elena Appel [2], Peter Fischer [2], Lea Obrocki [2], Timo Willershäuser [2], Sarah Bäumler [1], Thomas Becker [3], Andreas Vött [2]

1 Institute of Geosciences, Kiel University, Kiel, Germany
2 Institute of Geography, Johannes Gutenberg University, Mainz, Germany
3 Hessian State Office for Monuments and Sites, Archaeological Unit (HessenARCHÄOLOGIE), Field office Darmstadt, Darmstadt, Germany
* Corresponding author: E-mail: dennis.wilken@ifg.uni-kiel.de

Abstract
We present a rare multi-system FDEMI survey at a Roman burgus in Hesse (Germany). The dataset shows the benefits of EMI/ERT system combination for investigating archaeology and embedding paleolandscape.

Keywords
archaeological prospection; ERT; FDEMI; Hesse; Roman castle

Introduction

During the 1st century AD the Romans performed several river alterations in the vicinity of the River Rhine in Hesse. These planned water ways were of great strategic and economic importance and were protected by small forts, the so-called burgi (Heising 2012). In this work, we investigate such a fortress near the town of Trebur-Astheim. Its construction is dated to AD 364/375 (Heising 2012). The fortress belonged to the Rhine Limes of late Antiquity and controlled the supply of two bodies of water on the right bank of the River Rhine (Heising 2012). Due to the exposed position, such systems could only be supplied from the riverside. The fortification walls were usually open to the river, providing a protected harbor in which the ships could be safely landed. This combined function – fortress and sheltered pier – corresponds to the ground plans of most of these structures on the rivers Rhine and Danube (Heising 2012).

Earlier earth resistance mapping performed by Posselt and Zickgraf in 1999/2000 using the RM15 device revealed a first floor plan of the fortress. A tower-like core (burgus) stood in the center of the fortress. Slightly less massive wing walls were attached to its narrow sides. From here, the wing walls led into the river and shielded a 45 m wide section of the bank as a harbor basin (see Fig. 1a). A shallow ditch surrounded the entire building at about 20 m distance (Heising 2012).

Excavations in 2003 showed that all Roman remains were completely missing because of stone robbery (Heising 2012). The Roman surface may have been about 80 cm higher than today. The only layers from the Roman period were found in the filling of the enclosing ditch, which was designed as a flat, trough-shaped ditch with stepped walls (Fig. 1b). Nothing was left of the original fortress, although foundation ditches reflect the former structure quite well.

In this work we investigate how those kinds of features can be investigated with frequency domain electromagnetic induction (FDEMI) data. This has three reasons. First, magnetic gradiometry often shows a low contrast of Roman remains to the sandy background sediment of the region, so another fast mapping method is needed for archaeological heritage purposes in Hesse. Second, we know of a contrast in conductivity, and third, when using different coil separations in different EMI devices, we pose the question, whether it is possible to access both, fluvial landscape and archaeological remains.

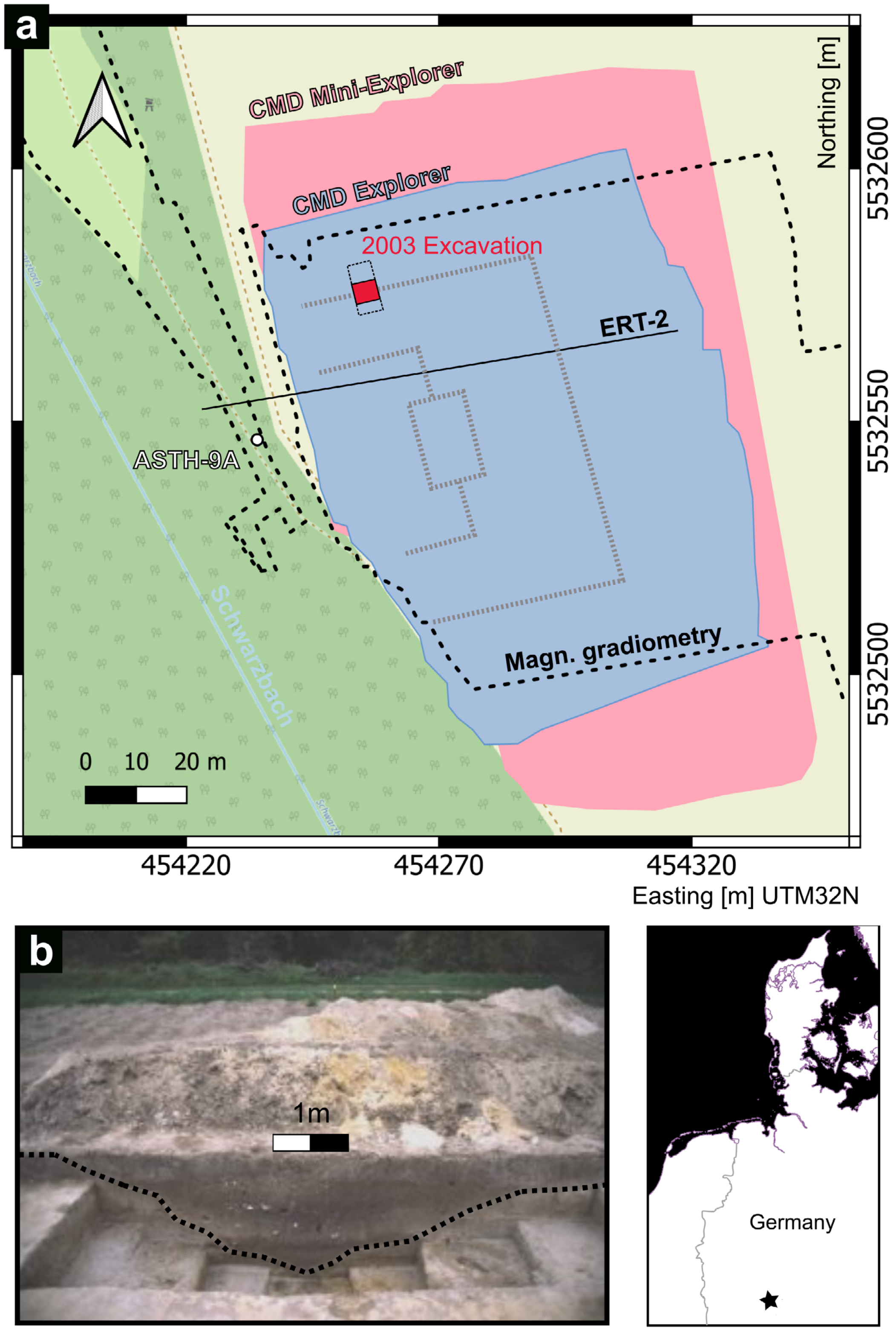

Fig. 1: a) Map of the investigation site and outlines of the different measurement areas, profile and core. The gray dashed line indicates the foundation ditches of the fortress as derived by ERM. b) Profile of a test pit crossing outer ditch (after Heising 2003).

KIEL-UP • DOI: https://doi.org/10.38072/978-3-928794-83-1/p60

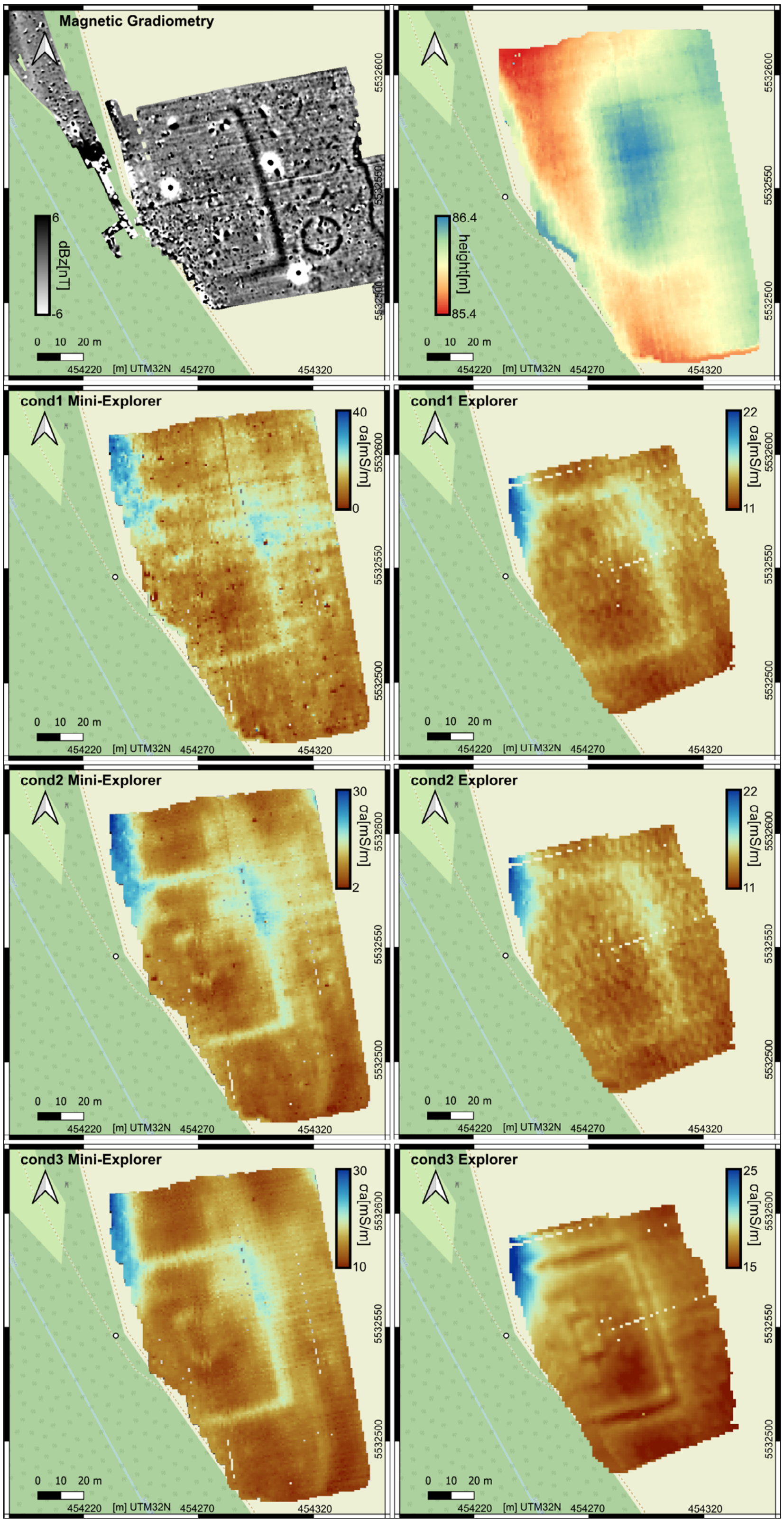

Fig. 2: Top row: magnetic map and topographic map of the site. Second to fourth row: apparent conductivities of the three coil separations of both EMI devices (left: CMD Mini-Explorer, right: CMD Explorer).

Materials and methods

In March 2022, we investigated the fortress with three different methods (see areas in Fig. 1a). Magnetic gradiometry was performed using an array of six Foerster fluxgate gradiometers with a horizontal sensors pacing of 0.5 m and a sampling frequency of 20 Hz. FDEMI data were collected using both the CMD Mini-Explorer (CMDME) and CMD Explorer (CMDE) by GF Instruments. The devices consist of one transmitter and three receiver coils. The planes of the coils were oriented horizontally (horizontal coplanar, HCP). The distance between the transmitter and receivers were 0.32, 0.71, and 1.18 m and 1.48, 2.82, and 4.49 m. Processing of EMI data included coordinate offset correction and inline spatial bandpass filtering to remove walking noise. A drift correction was not necessary for conductivity/quadrature data. Finally, all the data were interpolated using 2D linear interpolation. Positioning was achieved by RTK (Real Time Kinematic) DGNSS (Stonex S9i).

Beyond EMI mapping, we performed 1D conductivity inversions on two example profiles. For comparison and interpretation we added an example Electrical resistivity tomography (ERT) profile and core data (profile ERT-2 and core ASTH-9A, Fig. 1a). The ERT was recorded using a Syscal Switch 48+ with 48 electrodes of 2 m distance. Measurements were done in Wenner-Schlumberger configuration. The subsequent inversion was done using the RES2DINV software. The regarded sediment core was a closed vibracore of 4 m length in total that was later investigated and described in the laboratory.

Results

Figure 2 shows the results of the geophysical measurements. In Figure 2 (top row) the magnetic gradiometry map is shown in the 6 nT range, showing the surrounding ditch of the fortress as well as three round anomalies that can be addressed as medieval burial mounds (Heising 2003). The second, third and fourth row of Figure 2 show the apparent conductivity maps of the three different EMI coil separations for both devices (left: CMDME, right: CMDE). All maps show the surrounding ditch, whereas the castle itself is only visible in the Mini-Explorer data and strikingly in the largest coil distance of the Explorer data. Beyond the burgus, all maps show long wavelength changes probably indicating the background geology.

Discussion

Figure 3 summarizes the observed features and effects of the data sets and is the basis for the following discussion and interpretation. Figure 3a shows an example profile of inverted CMDE data in comparison to the ERT-2 profile and the facies description of core 9A. The comparison supports the idea that this kind of data contributes as well to landscape reconstruction, as it images the transition to the lower Terrace sands (dotted lines), but also maps the large-scale archaeological features, meaning surrounding ditch and castle (as indicated by the black dashed lines). The result is comparable to the ERT tomogram down to a depth of 6.5 m. Figure 3b again shows the apparent conductivity map of the largest coil distance of the CMDE. Figure 3c shows the inversion result for both example profiles in both devices. In Profile 1 we added the sensitivity curves for all coil distances after McNeill (1980) (white lines). The sensitivity curves explain for example, the high noise level of the maps of shortest coil distance, which is the influence of the high conductive plow layer, where the first coil distance of CMDME has its maximum. In contrast, this layer is not resolved by the CMDE. The maximum of the first coil distance of the CMDE is in the air, because the instrument was carried at 1 m aboveground. The second maximum reaches the surface level, so both are probably influenced by the rough plow layer. The largest coil distance of CMDE however has its maximum coincidentally at the depth of the archaeological remains (see black dashed line; which is the outline of the ditch after the excavation profile.), which explains why the shallow archaeology is imaged so well in the CMDE data. In CMDME data the ditch already is at the lower part of the depth range. A joint inversion of both data sets would be obvious. However it would need a proper regularization and discretization because of the different value ranges in the topsoil, and the hardly overlapping depth sensitivity. A combined dataset however offers the possibility to investigate archaeological structures such as the Roman burgus of Astheim together with the surrounding landscape even in 3D in reasonable time and thus offers a feasible method for Roman heritage investigation in Hesse.

KIEL-UP • DOI: https://doi.org/10.38072/978-3-928794-83-1/p60

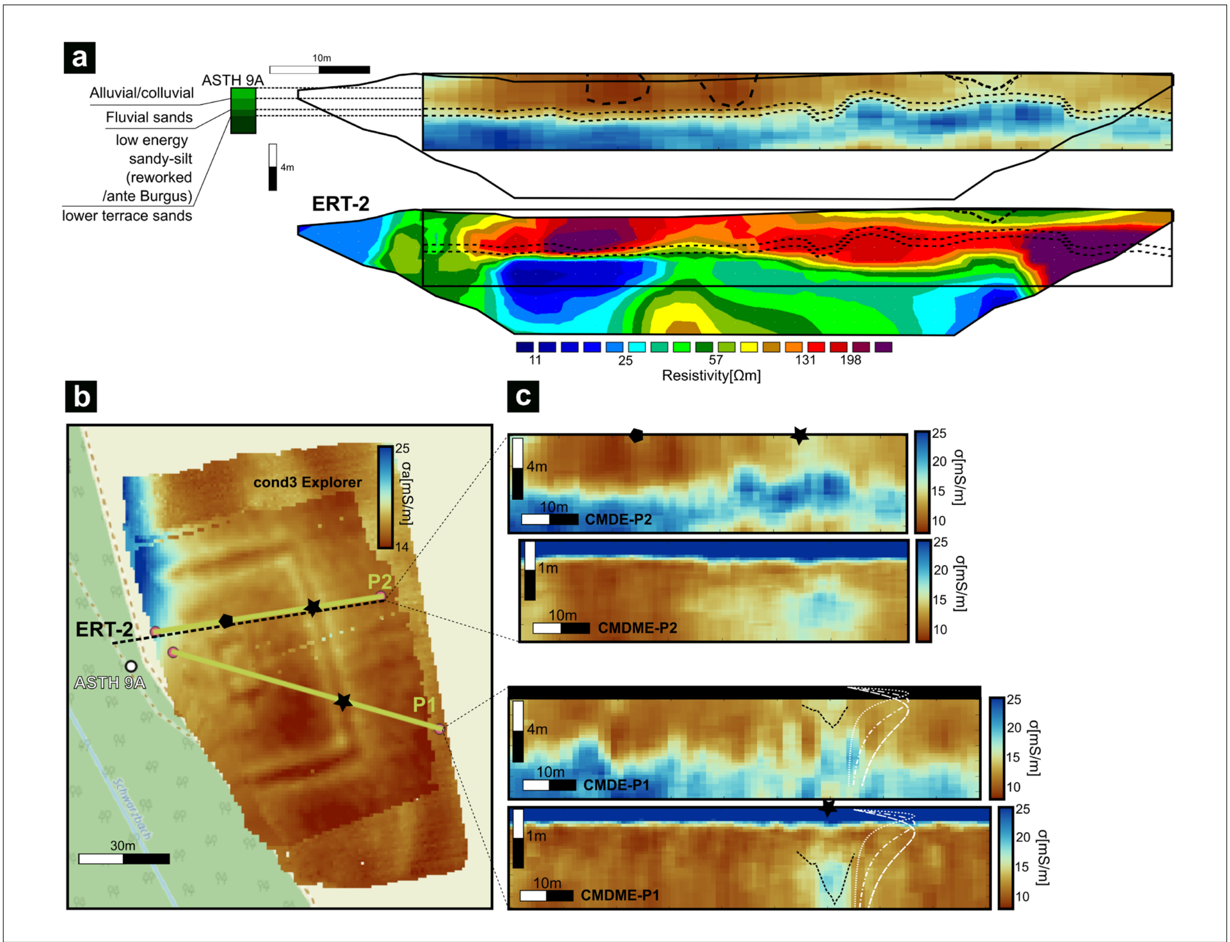

Fig. 3: a) Facies in core 9A in comparison to CMDE inverted profile 2 and inverted ERT-2. Black dotted lines show the lower terrace sand and reworked ante Burgus layer. Dashed line on the right shows the excavation based ditch bottom. b) Overview map showing CMDE largest coil distance and the position of all profiles and the core. c) Two inverted example EMI profiles together with depth sensitivity curves (white lines) and ditch outline based on the excavation.

References

Heising A. „Sensationsfund im Kartoffelacker". Spätrömische Kleinfestung und frühmittelalterliche Gräber an der Schwarzbachmündung bei Trebur-Astheim. Hessen-Archäologie 2003 (2004) 119-123. German.

Heising A. Der Schiffslände-Burgus von Trebur-Astheim: Schicksal einer Kleinfestung in Spätantike und frühem Mittelalter, in: Raeck, W., Steuernagel, D. (Eds.), Das Gebaute und das Gedachte: Siedlungsform, Architektur und Gesellschaft in prähistorischen und antiken Kulturen, Frankfurter archäologische Schriften 2012. Verlag Dr. Rudolf Habelt, Bonn, pp. 151–166. German.

McNeill JD. Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers. Geonics Ltd. 1980, Technical Note TN-6.

Open Access