# An integrated geoarchaeological approach to the investigation of multi-period prehistoric settlements – the case of Neolithic Drenovac

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**Abstract**
A multi-method geoarchaeological investigation was performed to reconstruct multi-phase Neolithic settlement. Invasive and non-invasive surveys showed potential for providing archaeological and environmental landscape data in this complex setting. Large-area geophysical surveys showed potential for deriving stratigraphic information.

**Keywords**
archaeological prospection; frequency domain electromagnetics; geoarchaeology; Neolithic settlement

## Introduction

The Neolithic site of Drenovac, located in the Middle Morava Valley of central Serbia, was occupied during two distinct settlement phases relating to the Early Neolithic Starčevo Culture (6100–5900 BC) and the Late Neolithic Vinča Culture (5300–4700/4500 BC), separated by a ca. 600-700-year hiatus. This has led to an extensive settlement with archaeological deposits up to 6.5 m thick (Perić 2017), in which Starčevo occupation layers are separated from the Late Neolithic ones by a sterile layer of uneven thickness. These are in turn covered by later colluvial deposits.

After excavations in the 1970's and 1980's, a research program was initiated in 2004, combining excavations with magnetic gradiometry surveys (Perić 2016, 2017) to fine-tune the chronological framework, inform on site formation and occupation dynamics, and provide insight into the spatial layout of the settlement. Based on these data and surface finds, the later Vinča settlement is now assumed to cover at least 40 hectares, comprising approximately 700 houses related to the late 6th to early 5th millennium BC occupation. Excavations show that these are among the best-preserved examples of Neolithic houses across Europe due to their burning, and subsequent covering with colluvium, offering strong potential for magnetic survey methods.

Despite these insights, understanding the evolving environment and land use from Starčevo through Vinča phases, as well as the evolution of the settlement's spatial layout, lingers behind. Addressing these research imbalances is complicated by nature of the settlement activity and the complex stratigraphic sequence of extensive natural and cultural deposits. Key aims were to investigate:

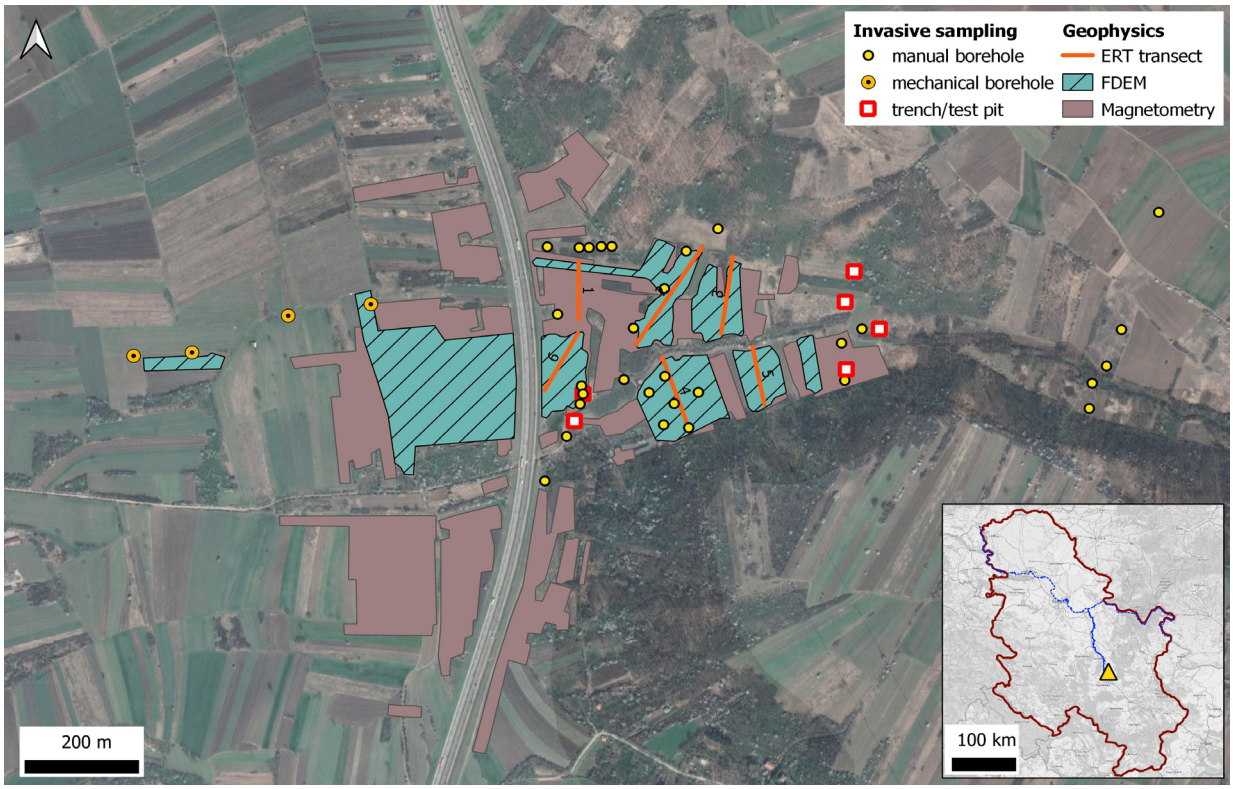


**Fig. 1:** Overview of the site with indication of the areas and locations covered by different survey methods (base map: ©2022 Google). The inset shows the site's location (yellow triangle) in Serbia.

- the extent and depths of Neolithic settlement remains;
- the presence and nature of buried soils contemporary with the Neolithic occupation;
- the occurrence and phasing of colluviated deposits;
- delineate any palaeochannels in the area.

These survey questions were combined with the goal to provide a chronological framework for reconstructing land use and environment from the 6th millennium BC onwards. Here, we focus on the contribution of different survey methods to resolving these research questions, with emphasis on the complementarity of electromagnetic and magnetic surveys at Drenovac.

## Materials and methods

To tackle the key research challenges, a multi-method geoarchaeological approach has been adopted that combines targeted test pitting with borehole and geophysical prospection. During the 2019-20 field campaigns, excavations were performed to sample extensive profiles for micromorphological and chronological information (Kinnaird et al. 2017). In one trench, exhaustive sampling was performed to support interpretation of available geophysical data and optimize planning future surveys. These data were complemented with manual and mechanical borehole logs. A sampling overview is provided in Figure 1.

Complementing magnetic surveys conducted from 2010 onwards (Perić (2016) and Fig. 1), frequency domain electromagnetic induction (FDEM) survey was performed with a Dualem-421s and Dualem-21HS sensor. An 11-ha survey area (indicated on Fig. 1) was surveyed with the Dualem-421s in horizontal coplanar (HCP) mode, providing 3 perpendicular (PRP) and 3 HCP datasets with coil separations of 1 m, 2 m, 4 m (each +0.1 m for PRP). Targeting large anthropogenic structures (buildings) and palaeolandscape features, measurements were made in snake-line pattern using a 3 m between-line spacing and an inline sampling interval of ca. 0.3 m. In addition, a 0.5 ha area was surveyed with a 1 m sampling spacing with additional geometries in HCP and VCP mode. Complementing the FDEM surveys, electrical resistivity tomography (ERT) was conducted to help discern the stratigraphic position of present deposits.


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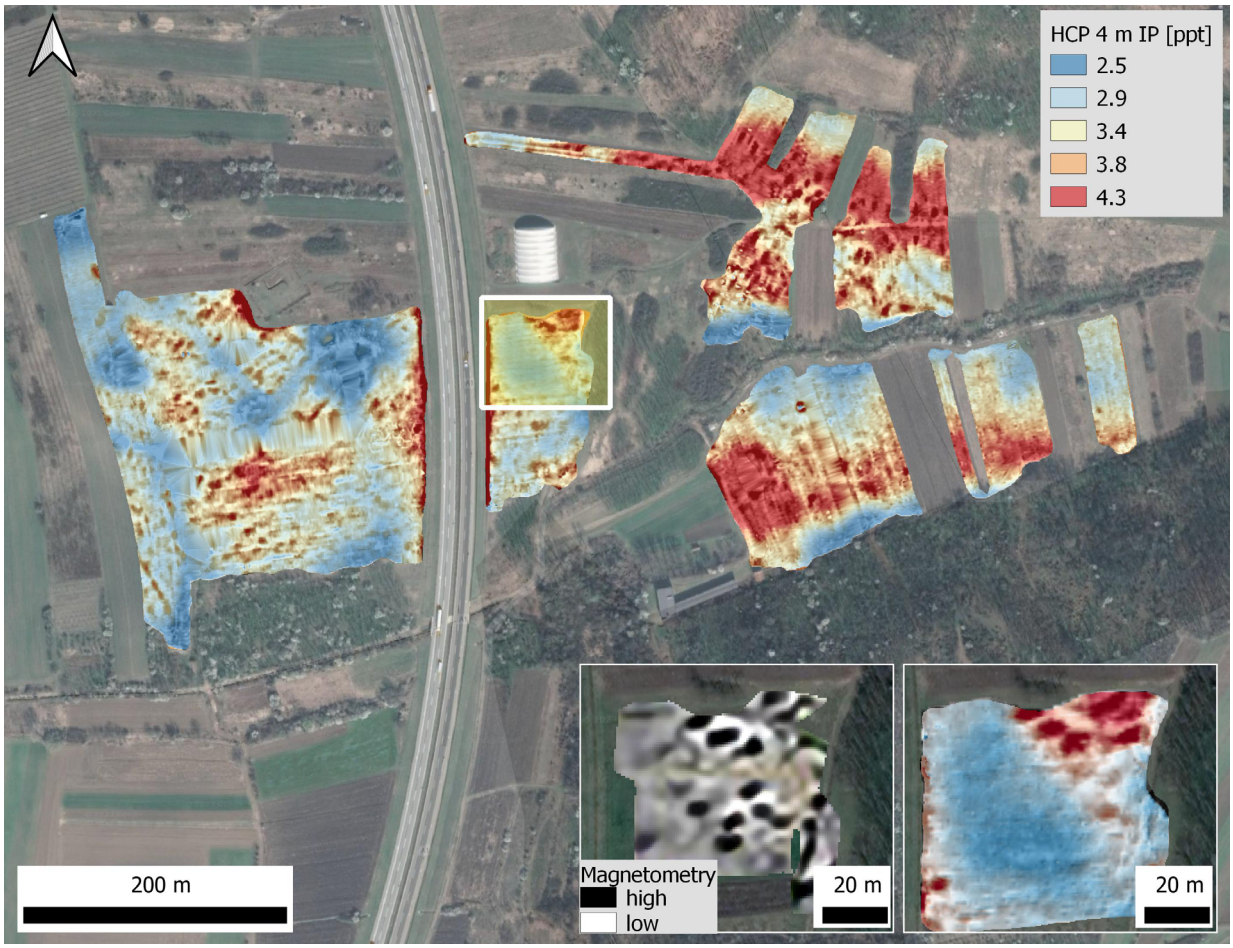


**Fig. 2:** Overview of the 4 m HCP in-phase data of the surveyed area (base map: ©2022 Google). The inset shows a comparison between the magnetometry data (Perić 2016) (left) and the FDEM in-phase data (right), showing a different expression of the magnetic anomalies, related to their stratigraphic positioning.

## Results

On the environmental setting of the site, the combined invasive and geophysical data showed distinct variations in the occurrence, thickness, and type of colluvial deposits. Borehole surveys and test pitting show that deposits range from a few centimeters to over 3 m in thickness, and are generally composed of eroded topsoils, suggesting substantial Neolithic and post-Neolithic clearance and soil erosion occurring from the mid-6th millennium BC. While ERT data allow examining the vertical extent of these deposits, FDEM data not only enable tracing these deposits through the landscape, but equally allow discriminating which likely have an anthropogenic origin based on their magnetic enhancement. These observations are confirmed through comparison with magnetic susceptibility readings on excavation and borehole samples.

Most strikingly, the combination of magnetometry data with in-phase FDEM data shows clear potential for investigating the stratigraphy of the site, as the different discrimination potential of assumed houses in FDEM and magnetometry data was related to their respective stratigraphic position.

## Discussion and conclusions

In this study, we demonstrate how in complex archaeological environments an integrated use of invasive and non-invasive survey methods enables a fuller insight on occurrence, type, and nature of archaeological remains as well as their environmental setting. Here, particular emphasis was put on the use of multiple magnetic survey datasets obtained through fluxgate gradiometry and multi-con-

figuration FDEM surveys. While magnetometry provides high sensitivity and clear discrimination of magnetically enhanced structures in-phase FDEM data from different configurations allows adding stratigraphic information, even when used qualitatively. Coupled with insights into the palaeotopography and configuration of archaeological features and deposits, this integrated framework provides a comprehensive basis for reconstructing the evolution of multi-period prehistoric settlements.

## Acknowledgments

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