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Understanding complexity: the case-study of al-Ḥīra, Iraq

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Abstract
The large-scale magnetometer prospection conducted in 2021 south of the al-Najaf International Airport, Iraq, reveals the complex settlement structure of the late Antique and early Islamic site of al-Ḥīra. The manual archaeo-geophysical interpretation resulted in 16 classes and the three most relevant archaeological classes will serve as a baseline for a (semi-) automated classification workflow.

Keywords
large-scale archaeological prospection; magnetometry; manual archaeogeophysical interpretation

Introduction

This paper presents the results of a large-scale magnetic prospection at the site of al-Ḥīra, Iraq. The fieldwork was part of the international project "The Late Antique and Early Islamic Hira – Urbanistic Transformation Processes of a Trans-regional Contact Zone" funded by DFG (grant nos. ES 286/9-1; MU 3169/2-1; SCHU 1562/10-1). The project is a collaboration between the Museum for Islamic Art Berlin (Dr. M. Müller-Wiener, DFG), the German Archaeological Institute (DAI) – Oriental Department (Prof. Dr. Dr. h.c. M. van Ess and Dr. I. Salman), the Technische Universität Berlin (Dr. M. Gussone), Eastern Atlas (B. Ullrich) and Leiden University (Dr. K. Lambers), as well as the SBAH (Iraqi State Board of Antiquities and Heritage) as local partner.

Materials and methods

The late Antique and early Islamic site of al-Ḥīra was founded in the 3rd century AD (Fig. 1, left). After flourishing in the 5th & 6th century, al- Ḥīra slowly lost its importance following the Muslim conquest (633 AD) but was continuously occupied at least until the 10th century. Following its demise, the site remained undisturbed by building activities until the 1970s. Since then, modern land use threatens the archaeological heritage of the site, the extent of which still has to be determined (Gussone et al. 2020; Müller-Wiener et al. 2019).

To address this, the "Hira Survey Project" (predecessor of the DFG project) reassessed between 2015 and 2018 previous archaeological research and conducted field surveys and prospections to understand the exact location, extent, chronology, and material culture of the settlement. In 2016 UAV (Stremke 2016) and magnetometer surveys were undertaken (HIRA2016/AoI1, Ullrich et al. 2016) in the area of a planned second runway of the al-Najaf International Airport. In 2018, the area south of the Airport was surveyed by UAV (Müller-Wiener et al. 2015; Müller-Wiener and Siegel 2018; Müller-Wiener et al. 2019; Stremke 2018).

Latter area is the focus of the DFG project. To understand and reconstruct the settlement history and chronology of al-Ḥīra carried out a magnetometer survey (HIRA2021/AoI2, Kniess et al. 2022). For both surveys (HIRA2016/

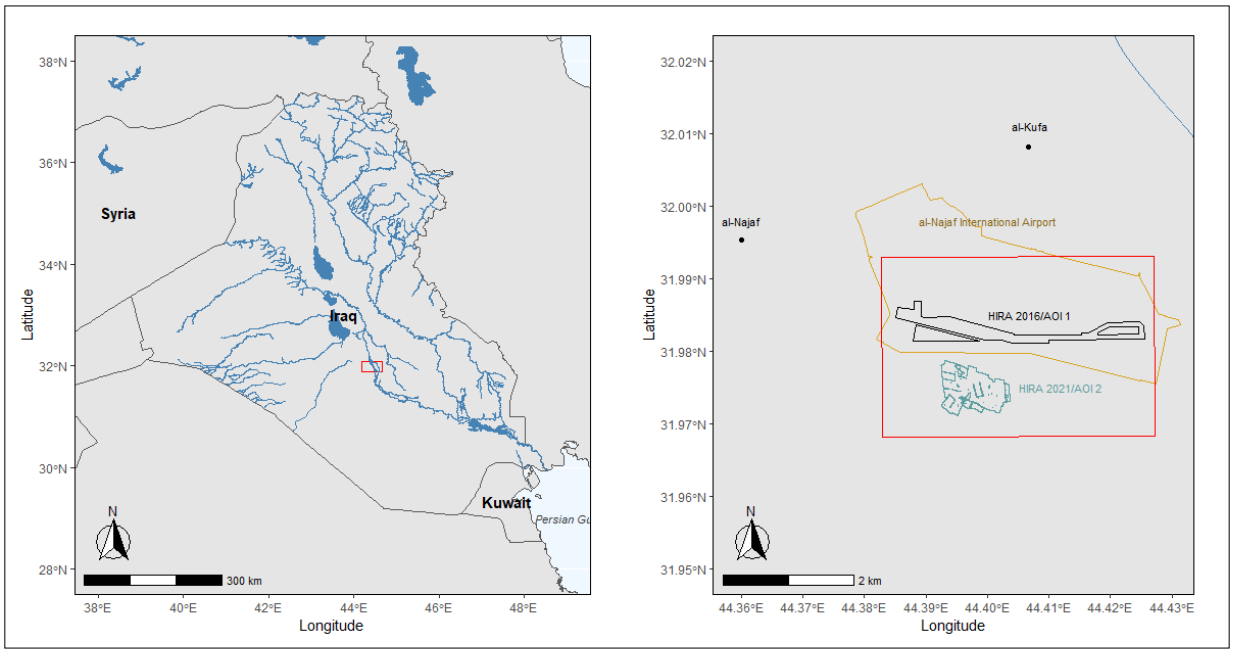

Fig. 1: Iraq and the location of the HIRA 2016/AoI1 and HIRA 2021/AoI2 surveys. © Agnes Schneider.

AOI1 and HIRA2021/AOI2, Fig. 1, right) the ultra-light LEA MAX System with ten Förster Fluxgate Gradiometer FEREX CON 650 probes with a vertical sensor separation of 0.65 m, 0.5 m profile distance and 0.1 m point distance was deployed. Two Forsberg ReAct GNSS receiver with an RTK accuracy of 0.02 m and an odometer were used for positioning. Large open and almost flat areas allowed the LEA MAX System to be towed by an ATV. Where needed, the LEA MAX System was adjusted to hand pulled mode. The data was interpolated by kriging with an image resolution of 0.15 m (Ullrich et al. 2016; Kniess et al. 2022; Ullrich et al. 2017).

Results

The 50 ha magnetometer survey conducted in 2021 (HIRA2021/AoI2, Kniess et al. 2022) is the continuation of the survey of 75 ha carried out in 2016 (HIRA 2016/AoI1, Ullrich et al. 2016). The manual interpretation of 40 ha of HIRA2016/AoI1 with 5298 identified anomalies delineating 9 classes was taken as baseline and extended to 16 archaeo-geophysical classes in the case of HIRA2021/AoI2.

The interpretation of the magnetometry is based on a primary distinction of the magnetic anomalies. On top level this distinction groups magnetic anomalies into either archaeologically relevant anomalies or anomalies of recent origin. Classes of anomalies, which might be of archaeological origin, have been included into the former, archaeologically relevant group (classes 1 to 8 and class 12), while anomalies, which are clearly of recent origin (classes 9 to 11 and 13 and 14), have been grouped into the latter, archaeologically not relevant group. On a secondary level, classes 5 and 7 were divided into subclasses (51, 52 and respectively 71 and 72), based on their archaeo-geophysical properties (Fig. 2).

In total 8317 individual archaeo-geophysical features were identified (Tab. 1). The identification was mainly undertaken on magnetic data with a dynamic range of ± 5 nT. 7074 anomalies were interpreted as archaeologically relevant, that is 85.05 % of all anomalies. 3225 slightly negative linear anomalies of class 3 (interpreted as in situ mud-brick walls) are accompanied by 2548 elongated negative linear or oval class 2 anomalies (interpreted as fillings) of more than 1 m diameter and complemented by 675 circular-oval positive anomalies up to 1 m in diameter of class 1 (interpreted as pits). These three classes form the incredibly dense settlement fabric of HIRA 2021/AoI2 and constitute 77.52 % of all anomalies (Kniess et al. 2022).

Discussion

The manual interpretation of HIRA2016/AoI1 using 9 classes was extended to 16 archaeo-geophysical classes, because

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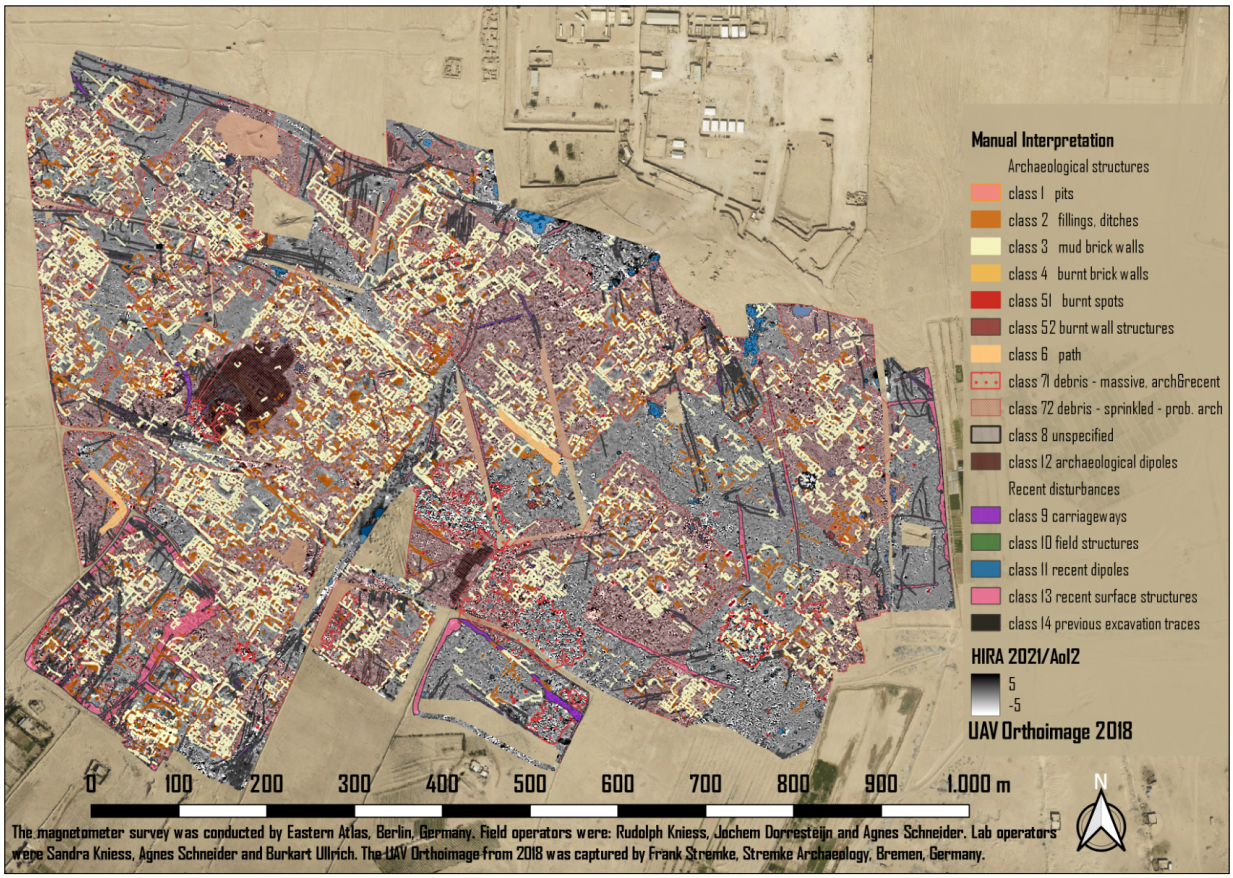

Fig. 2: Manual interpretation scheme of HIRA2021/AoI2 © Eastern Atlas.

Class	Colour	Anomaly Type	Amplitudes	Related Structures
Anomalies related to archaeological structures				
1		060 + < 1 m Ø	+3... +20 nT	Fillings of pits and post holes
2		linear/0 + > 1 m Ø	+3... +20 nT	Organically enriched fillings
3		linear -	-1... -10 nT	In situ unburnt mud brick walls & foundations
4		linear +	±1... ±10 nT	In situ burnt mud brick walls & foundations
51		+ high, dipole character	± 20.. ±400 nT	Burnt spots: furnaces, kilns, fireplaces, workshops
52		group of 51	±1... ±150 nT	Post hoc burnt wall structures
6		linear, moderate	± 1... ±10 nT	Roads, paths, streets
71		dipole character	- 10... ±10 nT	Debris of complete or partial buildings
72		<clear dipole character	- 5... ± 5 nT	Debris in/near buildings; under 5 nT
12		<clear dipoles	< ±35 nT	Dipoles, low amplitudes; archaeological origin?
Unspecified anomalies				
8		+/- dipole anomalies	-500... +500 nT	uncertain origin, archaeologically relevant
Anomalies of recent origin				
9		linear, often multiple	-4...+4 nT	recent carriageways
10		linear, at a distance	-5...+5 nT	recent field structures
11		dipole character	>±35 nT	recent iron objects above and below the surface
13		broad linear, connected	-15...+15 nT	diverse recent surface structures

Table 1: Manual interpretation scheme of HIRA2021/AoI2 © Eastern Atlas.

HIRA2021/AoI2 is the continuation of the same geomorphologic context. It is more compact and gives a glimpse of the real complexity of the settlement fabric. It was specifically chosen to identify as many classes as possible to understand the settlement structure, with a main focus on class 3 anomalies, which are the mainstay (and 38.77 % of all and 45.5 % of the archaeologically relevant anomalies) of the settlement structure of al-Ḥīra.

Conclusion

The manual archaeo-geophysical interpretation presented here serves as a starting point for the development of a Deep Learning approach for the automated analysis of the magnetometer data sets HIRA 2021/AoI12 and also of HIRA 2016/AoI1.

In the context of "The Late Antique and Early Islamic Hira – Urbanistic Transformation Processes of a Transregional Contact Zone" DFG project (grant nos. ES 286/9-1; MU 3169/2-1; SCHU 1562/10-1), the aim of the first author's PhD in the Digital Archaeology Group at Leiden University is to develop a reproducible and replicable workflow for the (semi)-automated classification of magnetometer data, considering the specific characteristics of the data type. This includes the reutilization of concepts, method, and code.

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