Pasieka, Paul P. – Ullrich, Burkart – Jessica Meyer – Franceschini, Mariachiara

The Hidden Cityscape of Vulci. Geophysical Prospections Providing New Data on Etruscan Urbanism

aus / from

Archäologischer Anzeiger, 2023/1

DOI: https://doi.org/10.34780/m6af-c144

Herausgebende Institution / Publisher:
Deutsches Archäologisches Institut

IMPRESSUM

Archäologischer Anzeiger
erscheint seit 1889/*published since 1889*

AA 2023/1 • 454 Seiten/*pages* mit/*with* 436 Abbildungen/*illustrations*

Herausgeber/*Editors*
Friederike Fless • Philipp von Rummel
Deutsches Archäologisches Institut
Zentrale
Podbielskiallee 69–71
14195 Berlin
Deutschland
www.dainst.org

Peer Review
Alle für den Archäologischen Anzeiger eingereichten Beiträge werden einem doppelblinden Peer-Review-Verfahren durch internationale Fachgutachterinnen und -gutachter unterzogen./*All articles submitted to the Archäologischer Anzeiger are reviewed by international experts in a double-blind peer review process.*

Redaktion und Layout/*Editing and Typesetting*
Gesamtverantwortliche Redaktion/*Publishing editor*:
Deutsches Archäologisches Institut, Redaktion der Zentralen Wissenschaftlichen Dienste, Berlin
(https://www.dainst.org/standort/zentrale/redaktion), redaktion.zentrale@dainst.de
Für Manuskripteinreichungen siehe/*For manuscript submission, see*: https://publications.dainst.org/journals/index.php/aa/about/submissions
Redaktion/*Editing*: Dorothee Fillies, Berlin
Satz/*Typesetting*: le-tex publishing services GmbH, Leipzig
Corporate Design, Layoutgestaltung/*Layout design*: LMK Büro für Kommunikationsdesign, Berlin

Umschlagfoto/*Cover illustration*: Archive of the Archaeological Museum of Thessaloniki (Orestis Kourakis) © Archaeological Museum of Thessaloniki, Hellenic Ministry of Culture & Sports – Hellenic Organization of Cultural Resources Development

Druckausgabe/*Printed edition*

Druck und Vertrieb/*Printing and Distribution*: Dr. Ludwig Reichert Verlag Wiesbaden (www.reichert-verlag.de)

P-ISSN: 0003-8105 – ISBN: 978-3-7520-0762-6

Druck und Bindung in Deutschland/*Printed and bound in Germany*

Digitale Ausgabe/*Digital edition*

Webdesign/*Webdesign*: LMK Büro für Kommunikationsdesign, Berlin
XML-Export, Konvertierung/*XML-Export, Conversion*: digital publishing competence, München
Programmierung Viewer-Ausgabe/*Programming Viewer*: LEAN BAKERY, München

E-ISSN: 2510-4713 – DOI: https://doi.org/10.34780/xyb3-a9yb

ABSTRACT

The Hidden Cityscape of Vulci

Geophysical Prospections Providing New Data on Etruscan Urbanism

Mariachiara Franceschini – Paul P. Pasieka – Jessica Meyer – Burkart Ullrich

For a long time, Etruscan cities, their physical appearance, diachronic evolution and cultural and social figurations have largely been neglected in archaeological research. Only in recent years has this begun to change thanks to the systematic application of new methodological approaches. By using a combination of non-invasive, geophysical prospections and targeted excavations at neuralgic points, the Vulci Cityscape project aims to examine the cityscape of Vulci and its transformation over the longue durée. Geophysical surveys conducted in 2020 on 22.5 ha north of the so-called decumanus resulted in a new and more complete plan of this part of the city, identifying different functional areas, differentiating street systems and revealing the complex historical palimpsest of the urban structure. Among the functional areas, a new sacred district to the west of the tempio grande, including a new monumental, late Archaic temple stands out. Not only do the results improve our knowledge of the urban layout of Vulci, but they also shed new light on Etruscan urbanism in general.

KEYWORDS

classical archaeology, urban archaeology, Italy, Etruria, Vulci, geophysical prospection, urbanism

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The Hidden Cityscape of Vulci

Geophysical Prospections Providing New Data on Etruscan Urbanism

Approaching Etruscan Urbanism

1 As Simon Stoddart recently pointed out, the achievements of the Etruscans in the organization of their urban spaces are »one of main contributors to European urbanism«, although they have long been neglected in urbanistic research, overshadowed by Greek and Roman cities[1]. The Vulci Cityscape project aims to improve our understanding of the Etruscan urban phenomenon, our notions of the spatial syntax of the urban layout, its emic and etic conception and the related historical and social circumstances, using the example of Vulci, one of the main Etruscan centres, from its origins to the Middle Ages.

2 Etruscan cities have long remained invisible in our vision of the ancient landscape, on the one hand, because of the continuity of occupation of many settlements, and on the other hand, due to certain methodological challenges in approaching urbanism from an Etrusco-Italic perspective: these range from the relative lack of consistent and comprehensive modern archaeological data to difficulties relating to the use of heuristic categories and methods, adopted from the Greek and Roman world. In particular, an ever-increasing research and deeper understanding about early Rome served as blueprint for Etruscan urbanism and trapped it within the typical categories of Roman urban forms and processes[2]. A shift away from such a Helleno- and Romanocentric position in recent years has led to an emphasis on the autochthonous character of urban processes in Etruria[3].

3 In an effort to make urban spaces more visible and to understand their structure and inner logic, urban archaeology, in general, has undergone a rather dynamic development, both on a methodological and a theoretical level[4]. Projects that deal with urbanism from a regional perspective, placing urban spaces in greater landscape and

1 Stoddart 2020, 99.
2 Riva 2014, 3–8.
3 See among others, Riva 2014.
4 See Stoddart 2020; Potts – Smith 2021, § »What Has Changed?«; Gleba et al. 2021; Dimova et al. 2021, 1.

global contexts, have increased significantly, partly under the theoretical keywords of globalization or urban ecology[5]. Furthermore, there is a renewed interest in the urban form and development of individual cities, mostly because various and constantly evolving, non-invasive methods, e.g., Ground Penetrating Radar (GPR), LIDAR and multispectral imaging, have allowed entire cities to come into view, providing a comprehensive assessment of their urban macrostructure[6]. Exemplary are the recent publications of GPR prospections in Falerii Novi[7], which covered the entire urban area, but also the prospections in Ocriculum[8], to name just a few. Finally, the detailed interdisciplinary study of small-scale stratigraphies produce information-rich micro-narratives, which can shed light on very different aspects of cities[9]. Urbanism has, therefore, been increasingly conceptualized from a more dynamic, networked perspective that questions ontological boundaries, as Rubina Raja and Søren Sindbæk summarized under the keywords, »Urban Networks and High-Definition Narratives«[10]. Other research focused on a more holistic perspective, centred around the concept of the cityscape, theorizing the physical and literary recursive processes that shape urban spaces and our ever-changing perceptions of them[11]. The Vulci Cityscape project approaches the phenomenon of Etruscan urbanism from such a holistic perspective: the detailed analysis of urban spaces not only aims to better understand the emergence and design of urban environments, but to evaluate the social, religious and political dynamics, recursive processes, their cultural and social figuration, and the various challenges that influence urban development and contribute to its resilience to ever-changing historical events.

4 When we speak of Etruscan urbanism, we should first emphasize that *the* Etruscan city per se never existed[12]. Marzabotto[13] and Spina[14], for example, are among the best studied Etruscan cities, but as they lie in Etruria Padana and have their own specific histories, they are hardly comparable with the processes of urbanization in Southern Etruria[15]. The same holds true for Musarna[16], a settlement founded by Tarquinia in the 4th century B.C. or for smaller settlements like Cetamura del Chianti[17]. The latter is programmatically included in the series *Cities and Communities of the Etruscans*, to facilitate a dialogue between them and to reflect on the question of what defines an Etruscan city[18]. New research in the large cities of Veii[19], Tarquinia[20] and the Latin city of Gabii[21], where different methods (mainly surveys, geophysics and excavations) have been used in a complementary way, substantially improve our knowledge of urban spaces. Geophysical results in Spina were thoroughly reassessed after excavation[22].

5 See Smith 2020.
6 Verdonck et al. 2020.
7 Verdonck et al. 2020.
8 Hay et al. 2013.
9 Raja – Sindbæk 2020, 174–176.
10 See Raja – Sindbæk 2020; Riva 2020; Smith 2020.
11 Trümper 2019, 7.
12 For an overview of the old *status quo* on Etruscan urbanism, see Steingräber 2001; Bizzarri 2013.
13 Most recently Bentz – Reusser 2008; Govi 2018; Govi et al. 2020.
14 Most recently Reusser 2017; Kay et al. 2021b; Reusser 2021.
15 Stoddart 2020, 103; for an overview on the proto-urban and urban formation processes with further literature, see Riva 2014, 11–38.
16 Most recently Cinque et al. 2017; Jolivet 2018; Broise – Jolivet 2020.
17 Grummond 2020.
18 Grummond 2020, XI f.
19 Most recently Cascino et al. 2012; Tabolli – Cerasuolo 2019, particularly the contributions of Cascino 2019, and Campana 2019.
20 Most recently Marzullo 2018; Bagnasco Gianni et al. 2021.
21 Most recently Helas 2010; Helas et al. 2019; Mogetta et al. 2019; Johnston – Mogetta 2020; Samuels et al. 2022.
22 Kay et al. 2021b.

5 In particular, the more frequent use of non- or minimally invasive methods allows us to survey urban structures on a large-scale, gaining a comprehensive overview, even if only two-dimensional and without absolute chronological and historical depth[23]. Nevertheless, our idea of Etruscan cities remains incomplete and fragmented, often even static, trapped in a timeless situation; still missing is a vision of a city that is variable, dynamic and fluid[24]. We miss the picture of a multifaceted city in which different functional areas are intertwined, linked to greater archaeological and historical developments, and evolving over the centuries as breathing organs of the urban structure. Therefore, a new interdisciplinary project has been initiated in the city of Vulci, that combines archival research[25], geophysical prospections and targeted archaeological excavations[26]. The project is based at the German universities of Freiburg and Mainz, in cooperation with the Soprintendenza Archeologia, Belle Arti e Paesaggio per la provincia di Viterbo e per l'Etruria meridionale and with the Parco Archeologico di Vulci, and is funded by the Fritz Thyssen Stiftung[27] and the Gerda Henkel Stiftung[28].

The Urban Layout of Vulci: Open Questions and Terminology

6 The plateau on which Vulci lies covers an area of at least 91.5 ha (light blue in Fig. 1). If the so-called Pozzatella is also considered, the total area of the city measures around 130 ha[29]. The beginnings of the long process of city formation date back to the Early Iron Age, perhaps even to the end of the Bronze Age[30].

7 Vulci offers excellent conditions for large-scale investigations, since it was never built over after its definitive abandonment in the 8th century A.D. Intensive research using various non-invasive methods gives an approximate idea of the structure of the city, which seems to be following the natural morphology of the terrain (see below) but lacks detail, whereby some areas of the plateau could not be addressed at all[31]. It remains open as to whether the entire area was inhabited or whether certain empty and unbuilt areas existed, since aerial photographs did not provide clear results in this regard[32]. Of particular importance is the street layout and how it affects the structure of the city. Finally, we wished to establish whether it is possible to distinguish between different functional areas and the way in which the cityscape is organized and shaped. Evaluating the dialectic between different uses of space and the physical layout will complete the urban plan, and help understand the strategies and performative aspects of the urban design.

8 We, therefore, selected the entire area north of the so-called decumanus as a case study. This area is of particular interest for several reasons: first, the urban situation is relatively unknown, and although older aerial photos showed numerous anomalies,

23 Contrary to a recent attempt to assign different parts of the urban structure of Vulci to specific centuries (Forte et al. 2022, 13. 16 fig. 14) we think that, not *per se* but in most cases and particularly for sites with a complex archaeological stratification – such as Vulci –, it remains methodologically challenging to date solely on the basis of the orientation of streets and buildings without external archaeological evidence to support it.

24 Stoddart 2020, 108 f.

25 Especially at the Rome Department of the German Archaeological Institute, see Franceschini – Pasieka 2021.

26 Franceschini – Pasieka 2022a; Franceschini – Pasieka 2022b; see also the project homepage: https://vulcityscape.hypotheses.org/.

27 2020/2021: Az. 20.19.0.028AA; 2021/2022: Az. 20.21.0.005AA.

28 2022/2023: AZ 20/V/22.

29 Moretti Sgubini 2006, 332; Russo Tagliente 2016, 22 f.; Sabatini et al. 2021b, 11.

30 See Pacciarelli 1989/1990, esp. 20–25; Moretti Sgubini 2006, 318 f.; Pacciarelli 2010, 20 f.; Marino 2015, 106; Russo Tagliente 2016, 22; Bianchi 2017, 9–13.

31 See § 23.

32 See the reconstructions in Pocobelli 2003, 149 fig. 269; Pocobelli 2004, 134 fig. 8.

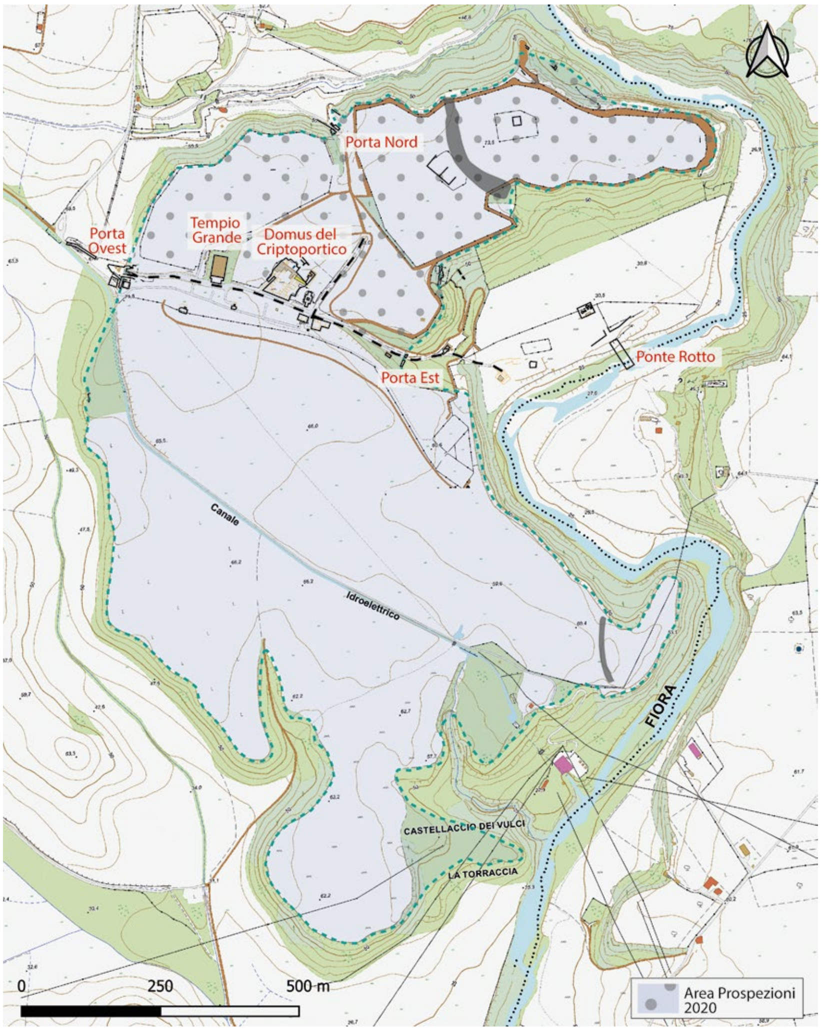

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Fig. 1: The plateau of Vulci with indication of the geophysically surveyed areas

they could not be analysed and interpreted coherently[33]. At the same time, the area contains a large number of the archaeological excavations on the city's territory, such as the tempio grande, the various gates and the domus del criptoportico, which, although not or not fully published, can serve as reference points for different periods relating to the diachronic development of Vulci. Various functional areas are to be expected here or have been postulated based on the aerial photographs[34], but they are not clearly located.

9 We surveyed an area of around 22.5 ha with magnetometry (dotted in Fig. 1; light blue in Fig. 2; Fig. 3) and two test areas (red in Fig. 2) using GPR, from September 21st to 26th 2020. All measurements were carried out by a team of geophysicists from Eastern Atlas[35]. In summer 2021 and 2022, excavation campaigns were undertaken at a temple which we discovered during the geophysical prospections (green in Fig. 2), therefore, the results of magnetometry, GPR and archaeological excavation could be compared with one another. In order to allow a better comparability of the data, all results from archival research, geophysical prospections and excavations are incorporated into a Geographical Information System (GIS[36]).

10 Following a brief overview of older, non-invasive research into the urban area of Vulci, we will present the methods, methodological challenges and results of our geophysical campaign. Subsequently, we will propose a new city plan for the northern region of Vulci and will briefly discuss the different functional areas identified in the process, as well as the consequences for our image of Etruscan urbanism.

11 Before going *in medias res*, a short methodological premise is needed. Etruscan urbanism still lacks a systematic overall assessment and interpretative models, but also an adequate formulation of its own categories. This is also reflected in the language and the terminology we use to define Etruscan cities and their urban spaces, but also relates to social structures and phenomena[37]. For example, the terms »acropolis« and »forum«, as well as »decumanus« and »cardo« were established for Vulci, using terminology typical of both Greek *and/or* Roman town planning, to make up for the lack of purely Etruscan terms

33 This is still the case despite the new plan in Forte et al. 2022, 10 fig. 8, as it is based for the most part of this area on the old aerial photos and thus does not significantly change the *status quo* in respect to the publications from Pocobelli.

34 Such as ritual and public spaces, namely, the so-called foro orientale, see Pocobelli 2010/2011, 120.

35 Surveys were undertaken by Annika Fediuk, Ronald Freibothe, Burkart Ullrich and Henning Zoellner.

36 We use the open-source geographic information system QGIS – current version 3.26.3; https://www.qgis.org (01.10.2022).

37 Regarding the debate on categories and definitions for Etruria between Greece and Rome, see Riva 2014, 1–8.

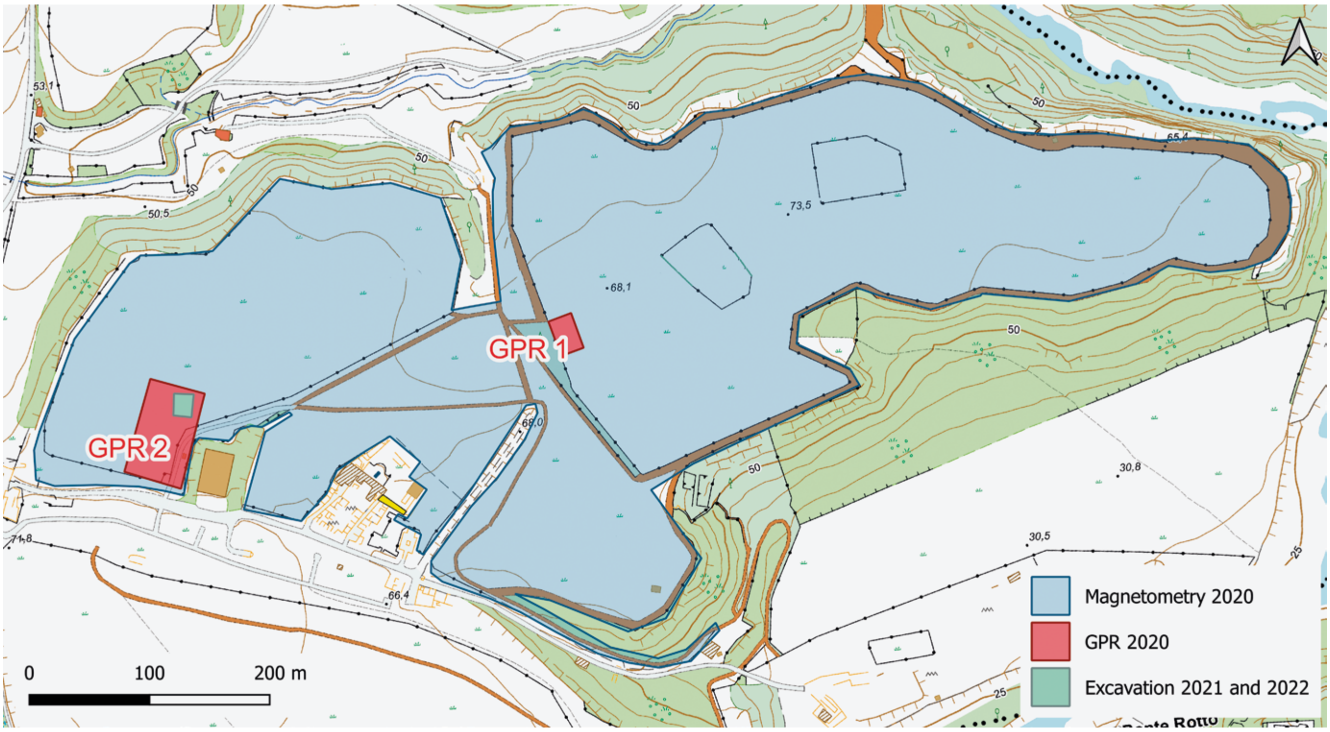

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Fig. 2: Vulci, geophysical prospection surveys 2020 and excavation area 2021 and 2022

or coherent independent concepts in Etruscology[38]. As these are not mere analytical categories but carriers of specific concepts, this means, from a postcolonial point of view, that we framed Etruscan cities in Greek/Roman terms before we even knew what an Etruscan city could have looked like. Even if there were Roman phases as in Vulci, we should be careful when using such definitions in regard to the Etruscan phases or its development over time, especially if there is a lack of consensus in the identification of certain areas, for example, the »oriental forum«[39]. Nevertheless, some terms are so entrenched in research, serving as reference points and orientation in the topography of Vulci, that it is difficult to avoid them; to maintain a kind of neutrality, we will use certain terms, such as proper names, specifying that it is the »so-called decumanus«, etc.[40].

Former Invasive and Non-Invasive Research in the City Area of Vulci

12 Besides the well-known excavations, Vulci has a rich history of non-invasive investigations. Archaeological excavations, which have been ongoing for almost 200 years, have concentrated mainly on the necropoleis, while large-scale investigations in the urban area have remained the exception. The first excavations in the city were conducted between 1834 and 1837 by the notorious Campanari family[41], but the trenches cannot be located with any certainty[42]. Renato Bartoccini began a more intensive activ-

38 Regarding the known Etruscan urban terms and their probable institutional meaning, see Colonna 2005; Bizzarri 2013, 709.

39 Pocobelli 2010/2011, 120; indeed, probably not a forum at all.

40 As in the new publication of Gabii, see Johnston – Mogetta 2020, 100.

41 Campanari 1836b; Campanari 1840; see also Buranelli 1991; Franceschini – Pasieka 2021.

42 Drawings of the excavated structures from Luigi Canina and Enrico Calderari – who both saw the excavation trenches before they were filled in – are attested, but have to be considered lost (Buranelli 1991, 20. 32. 288 Documento 18; Franceschini – Pasieka 2021, 356–361).

ity in the city, concentrated mainly around the so-called decumanus and the northern region of the city, from the 1950s onwards. The entire length of the so-called decumanus and part of the so-called cardo were unearthed[43]. Of particular importance, however, was the discovery of the late archaic tempio grande[44]. Other buildings in the northern part of the city (such as the domus del criptoportico[45]) near the acropolis and south of the decumanus[46], parts of the city walls and gates[47], as well as productive areas near the river plain[48] were excavated in the subsequent decades.

13 Renato Bartoccini's project in the late 1950s and early 1960s was conceptualized from an interdisciplinary perspective and envisaged not only large-scale excavations but also the inclusion of geophysical prospections, other disciplines like geography and the analysis of aerial photographs, so as to approach the city holistically and, in particular, to produce a new plan[49]. The Fondazione Lerici conducted electrical resistivity surveys between 1955 and 1957[50]; however, the death of Bartoccini in 1963 put an end to these projects for the time being. Only in 1996 were the first promising attempts resumed within the framework of the »scuola cantiere archeologica«[51]. Dario del Bufalo used resistivity, magnetometry and GPR comparatively on several areas south of the so-called decumanus, to assess the potential of the different techniques[52]. The electrical resistivity survey was considered to be the only promising approach and the GPR, in particular, gave poor results[53].

14 Over the past few years, we have seen a renewed interest in the application of geophysical prospection techniques, although primarily in smaller areas. Between 2015 and 2018, a team led by Maurizio Forte surveyed an area of ca. 10 ha between the tempio grande and the domus del criptoportico and immediately south of them and of the so-called decumanus with GPR[54]. While magnetometry was mostly inconclusive for archaeological interpretation[55], the GPR worked well and confirmed the pattern of the older aerial photographs[56]. In addition, drone photos and multispectral images of the entire plateau were taken, even though the recently published map of Vulci is based mainly on older aerial photos and the results of the GPR[57]. In 2016, a research group led by Corinna Riva from University College London surveyed part of the plateau near the Ponte Rotto alongside the Fiora River[58]. The team used both magnetometry and GPR, however, the magnetometry produced results, whereas the GPR survey results were inconclusive. Finally, in 2019 and 2020, a team from the University of Gothenburg, together with the British School at Rome (BSR) and the Swedish Institute of Classical Studies in Rome conducted magnetometry and GPR surveys, the former without any tangible results and the latter with particular success, on an area of around 2.1 ha in the eastern part of the city, north of the so-called decumanus and between the edge of

43 Bartoccini 1960; Bartoccini 1961; Bartoccini 1963.
44 Bartoccini 1963; Moretti Sgubini 1997.
45 Cfr. Bartoccini 1961; Bartoccini 1963; Moretti Sgubini 1979, 259; Moscetti 2000.
46 Forte et al. 2020, 33–37.
47 Moretti Sgubini – Ricciardi 2001a; Moretti Sgubini 2008; Moretti Sgubini 2017a.
48 Carosi et al. 2017, 284–287.
49 Bartoccini 1961, 262–264.
50 Lerici et al. 1958.
51 Moretti Sgubini – Bianchi 1997.
52 Cfr. Geddo 1997. AG-858 magnetometer from Geometrics, with two probes, was used for the magnetometry. The data were processed using Geometrics' Megmap software. For GPR, a SIR 2 and SIR 3000 with 300 and 500 Mhz antennas were deployed.
53 Geddo 1997, 23.
54 McCusker – Forte 2017; Forte et al. 2020; Forte et al. 2022.
55 Forte et al. 2022, 5.
56 McCusker – Forte 2017, 97–99; Forte et al. 2020, 18–32; Forte et al. 2022.
57 See Forte et al. 2022, 10 fig. 8.
58 Lockyear et al. 2018.

the plateau and the so-called cardo, showing some evidence of the Roman occupation in this part of the city[59].

15 The Fondazione Lerici was already using aerial photographs in the late 1950s[60], taken between 1938 and 1945, however, only Dinu Adameşteanu developed the first city map from this[61]. Giorgio Pocobelli provided in the late 1990s and early 2000s a detailed map of the city[62] and gave a first glimpse of this »invisible« city, even though not all features discernible in the aerial photographs could be clearly identified, vectorized and mapped. He obtained the best results for the central area of the plateau, especially south of the so-called decumanus, where numerous buildings, some of them public, could be identified[63]. Other areas remain »empty«, due to the aforementioned reasons or because nothing was visible on the aerial photographs; this concerns, for example, both the southernmost sector and the area north of the so-called decumanus. As already mentioned, the new map of the team of the Duke University is based mainly on the same set of aerial photographs as the one of Pocobelli, but can fill some of the blank spots due to the use of new methods in georeferencing older aerial photos and a combination of other non-invasive methods[64].

16 Whereas previous geophysical research focused solely on small areas of the city and the aerial photographs provided only partial results, the project presented here considers a larger contiguous area of the city, combining geophysical methods and archaeological excavations in a multiscalar and interdisciplinary approach, to obtain a better understanding of the urban structure and its diachronic development.

The New Geophysical Prospections: Methods and Results

17 The boundaries for the magnetometer survey are defined to the south by the so-called decumanus and to the west, north and east by the morphology of the plateau or by the fences that surround the archaeological park, defining an area of 22.5 ha (dotted in Fig. 1; light blue in Fig. 2). After preliminary evaluation of the results of the magnetometry (Fig. 3), two smaller areas have been selected for evaluating the operational capability of a GPR: that in the north (GPR1 in Fig. 2) measures 600 m^2; the other, near the decumanus, (GPR2 in Fig. 2) 3600 m^2.

Methodology

Magnetometer Survey

18 In magnetometer surveys, slight changes in the Earth's magnetic field, originating from objects and structures lying in the ground are detected, recorded and displayed in a 2d-map[65]. As targeted archaeological anomalies from different time periods might be overlayed by magnetic anomalies, caused by geological formation and landscape forming processes, as well as modern impacts, small survey area results are often inconclusive. Therefore, almost complete coverage of the entire area of interest allows a better differentiation of the subsurface structures. This approach is traditionally im-

59 Kay et al. 2021a; Sabatini et al. 2021a; Sabatini et al. 2021b.
60 Lerici et al. 1958, 5.
61 Adameşteanu 1964, 71; see also Finocchi 1970, 43 f. fig. 3 a.
62 Pocobelli 2003; Pocobelli 2004; Pocobelli 2007; Pocobelli 2010/2011.
63 See the map in Pocobelli 2003, 150 fig. 270; 151 fig. 273; 154 f. fig. 278. 279; Pocobelli 2004, 134 fig. 8.
64 See Forte et al. 2022.
65 Gaffney – Gater 2003.

Fig. 3: Vulci, the results of the magnetometer survey

plemented in Roman archaeology, as shown by the examples of Wroxeter, Carnuntum and Ostia, amongst others[66]. The corresponding technology for large-scale surveys has developed enormously in the recent decade. Mobile, multi-channel devices with RTK-GNSS positioning make it possible to prospect large areas with high resolution. These advantages are implemented in the flexible, mobile, multi-channel system LEA, developed by Eastern Atlas[67]. In Vulci, the LEA MAX system, with 10 Förster FEREX CON 650 gradiometer probes, was used (Fig. 37). The magnetometers measure variations in the vertical difference of the Z-component of the Earth's magnetic field, with an accuracy of ±0.1 nT. For the positioning, an RTK-GNSS, with a fixed base antenna and a rover antenna, mounted on the LEA cart, was used, resulting in a real time kinematic solution of ±2 cm for the positioning data.

Ground Penetrating Radar

19 The GPR method is based on the transmission and reflection of high-frequency pulses of electromagnetic waves in the ground. Objects and interfaces with different electrical properties, especially the dielectric permittivity ε, cause diffractions and reflections of the electromagnetic waves, which allow to record and calculate the position and depth of the objects[68]. The most recent technical developments are moving towards multi-channel array systems, using antennas for inline and crossline measurements, resulting in a very high resolution of shallow archaeological objects and structures. A high resolution with a greater depth can be achieved with multi-channel devices, with relatively low frequencies or arrays and using the full spectrum of frequency[69].

20 For the GPR surveys in Vulci, a pulseEKKO Spider system (manufacturer: Sensors & Software Inc., Canada) with four 250-MHz antennas in parallel was used (Fig. 38). However, structures very near to the surface are quasi undetectable, due to the bistatic orientation of the antennas (transmitter and receiver antenna are separated). Again, differential RTK-GNSS, as described above, was used for the positioning of the data. The relatively high electrical conductivity of the pyroclastic soils and rocks in the survey area (see also below) results in a relatively high attenuation of the electromagnetic waves, providing high-resolution images to depths of approximately 1.8 m.

Interpretative Framework

21 The interpretative framework is based on the classification of specific magnetic anomalies into three main areas: we distinguish between anomalies originating from modern structures and objects, from natural occurring geological and soil features, as well as anomalies with archaeological evidence. To classify the magnetic anomalies, we define characteristic attributes, such as shape, intensity height, orientation and contextualization within the existing topography, and the nature of the surface.

Geological Disturbances and Modern Structures

22 The geology of the study area is dominated by the volcanic rocks of the Vulsini Volcanic District[70] (Fig. 4). These include pyroclastic sediments of the Grotte di Castro, Sorano 1 and Sorano 2 formations, as well as volcanic effusive rocks[71]. The pyroclastics form deposits of ash and tuffs, some of which are several metres thick and occur exten-

66 Wroxeter: Gaffney et al. 2000; Carnuntum: Trinks et al. 2012; Ostia: Keay et al. 2014.

67 Ullrich et al. 2011; Ullrich et al. 2020. The LEA system provides a high flexibility regarding the operating conditions (Meyer et al. 2014). In Vulci it was mostly pulled by an all-terrain vehicle (ATV).

68 Jol 2009.

69 Trinks et al. 2018.

70 Marchetti et al. 2014, 2.

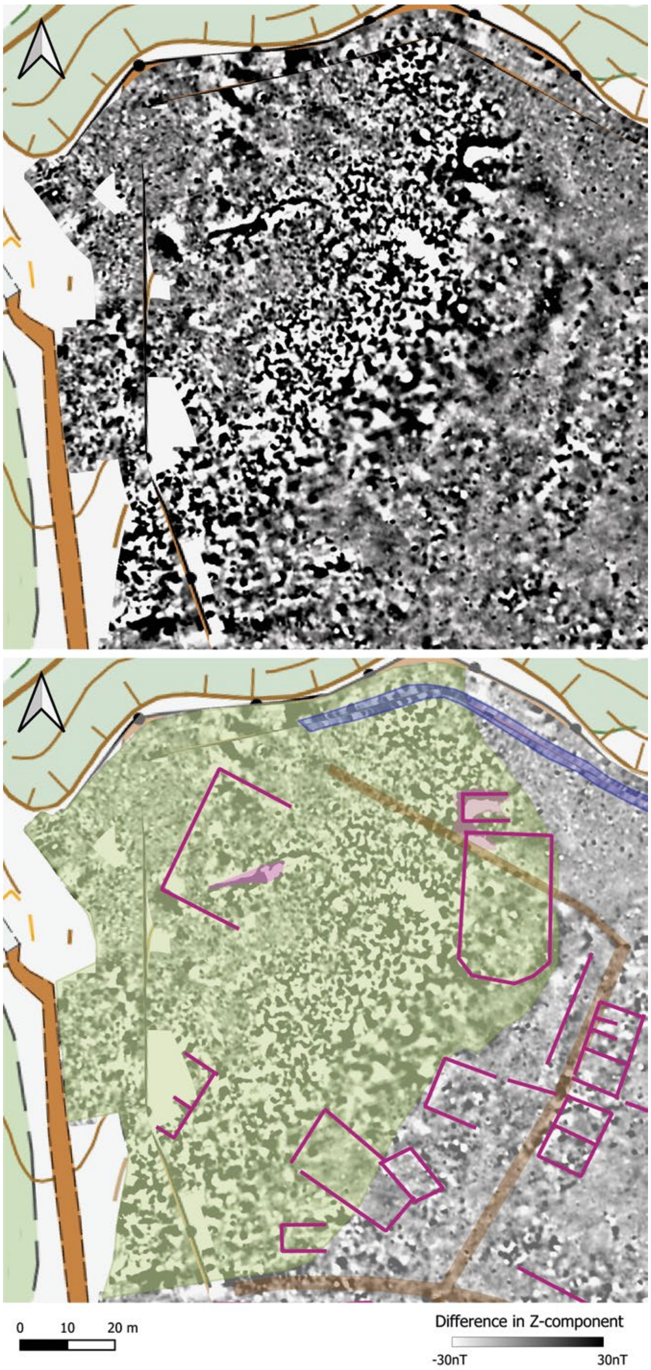
71 Marchetti et al. 2014, esp. 7 fig. 9.

Fig. 4: Vulci, scheme for the interpretation of non-archaeological anomalies

Colour	Characteristics of the anomaly	Description and possible cause
	Radial dipole anomaly with high amplitude; partly linear in the case of current paths along existing structures	**Lightning-induced** remanent magnetisation
	Single dipole anomaly of various shapes, mainly with very high amplitude	**Modern structures**, like metal fences, pipes, aligned stones at the surface, rails
	Extended positive and dipole anomalies with soft edges	**Geological formation**, rock and soil features: often associated with basalt, either bedrock or scattered stones

4

Fig. 5: Vulci, magnetic data showing scattered geological anomalies (above: magnetic data; below: magnetic data with interpretation)



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sively in the survey area. The anthropogenic depressions, which are clearly visible in part in aerial photographs[72], are formed into the tuff of the Sorano 2 formation. Below this formation, thick magmatic rock (tephrite) of up to 35 m occurs.

23 Extended anomalies with high intensities and a dipole character are mainly classified as *geological disturbances*. These can be related to rock and soil features and are often associated with basalt, either bedrock or eroded outcrops. Two extensive areas, one close to the northern gate (green in Fig. 5[73]) and the other at the western end of the plateau (the so-called acropolis) facing the river (Fig. 6), show these types of geological anomalies. Here, the layer of the Sorano 1 formation is probably eroded, and the high intensities are caused by the underlying tephrite. Within these areas it becomes difficult to recognize archaeological features. Furthermore, distinct, radial-shaped dipole anomalies with very high intensities are visible, caused by *lightning-induced* remanent magnetization (LIRM)[74], often following the shape of existing structures as lightning-current pathways (Fig. 7). Anomalies of *modern origin* usually manifest themselves in mostly regular dipole anomalies with a very high intensity (blue in Fig. 8) and are related to visible and known modern structures, i.e. the fences of the archaeological park or the railroad used by the lorries during the old excavations (Fig. 9).

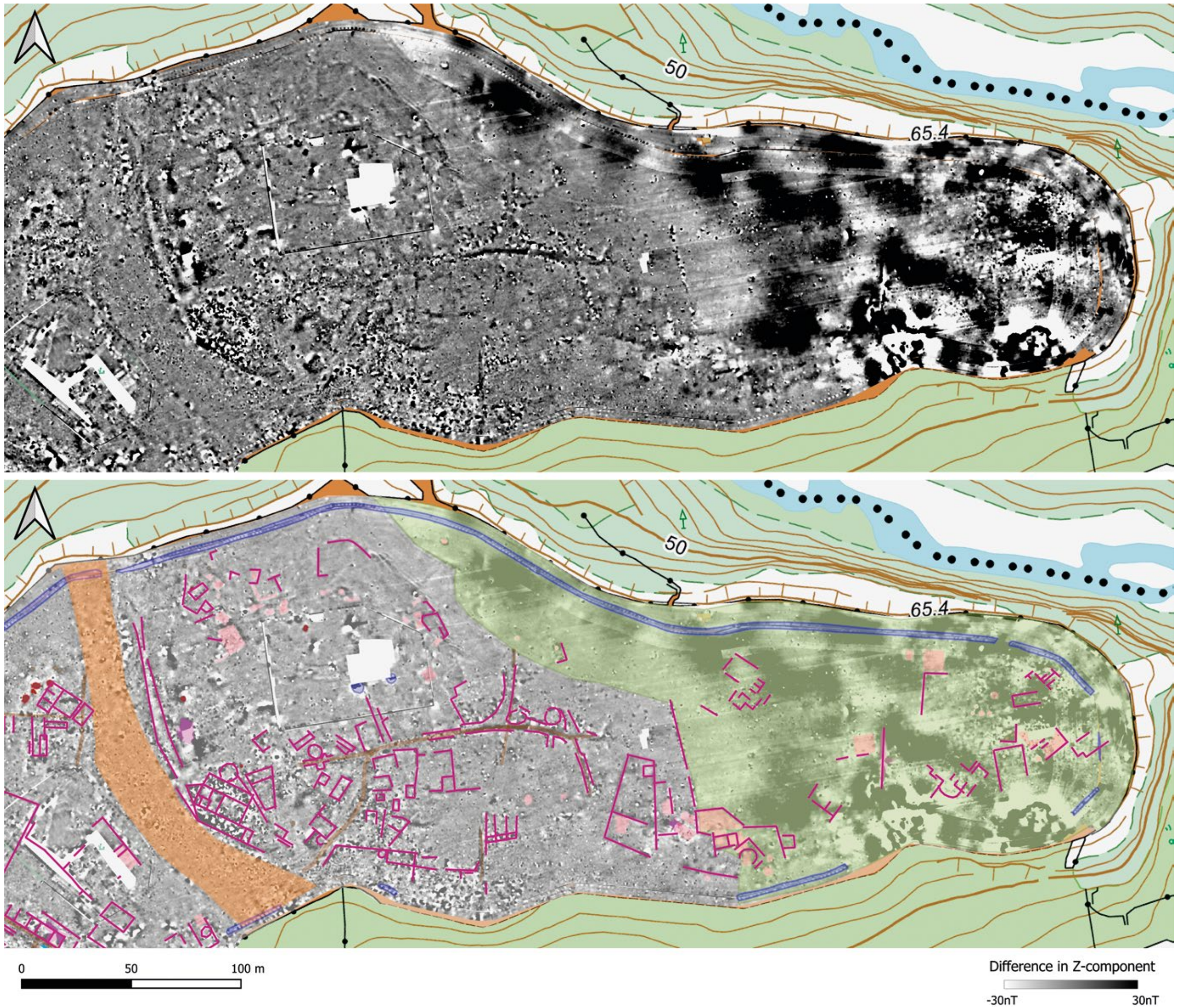
Archaeological Structures

24 The archaeological anomalies are divided into eight different types (Fig. 10). Round to oval anomalies with a diameter of around 0.5 m to 2.0 m and a predominantly positive intensity, but without a clearly delineated outline, are interpreted as *pit fillings* (brown in Fig. 11).

72 For example, in the photographs published in Pocobelli 2004, 139 fig. 15; 140 fig. 16. 17.

73 The positions of the individual, detailed images are marked in the general plan in Fig. 36.

74 Jones – Maki 2005; Maki 2005.



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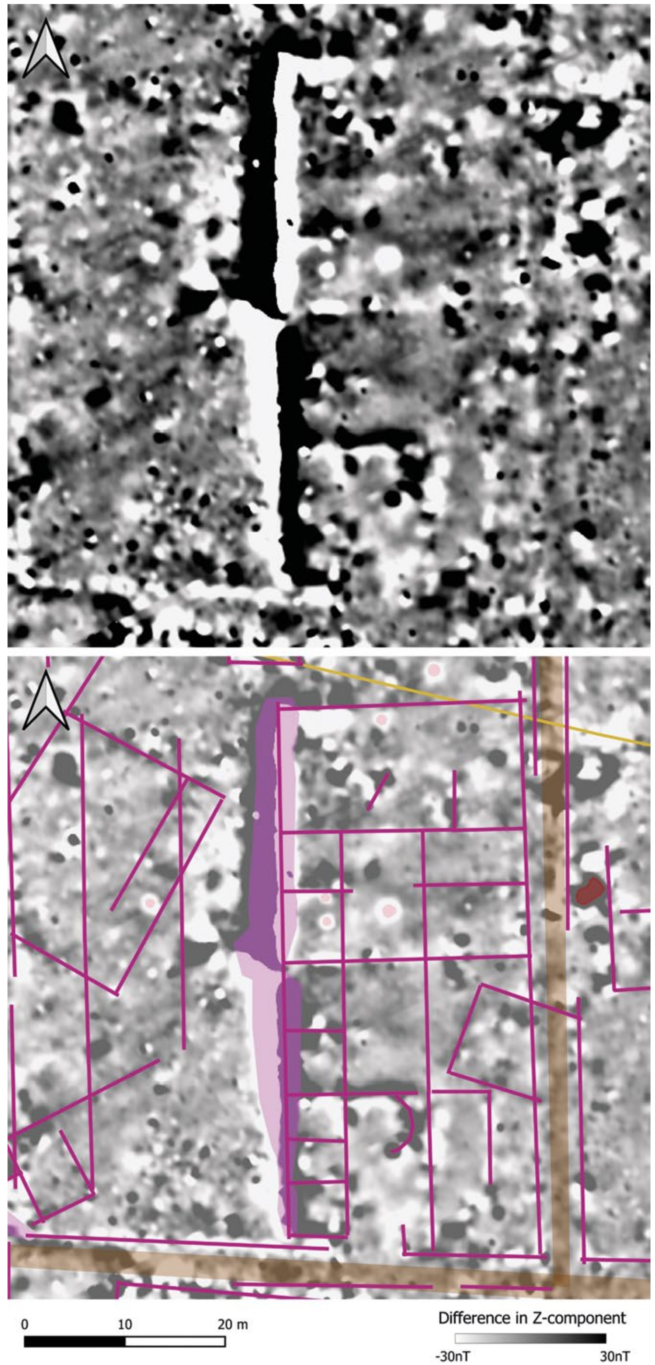

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Fig. 6: Vulci, the area of the so-called acropolis with different depressions or deepenings (above: magnetic data; below: magnetic data with interpretation)

Fig. 7: Vulci, example for enhanced magnetisation along a linear structure due to lightning (above: magnetic data; below: magnetic data with interpretation)

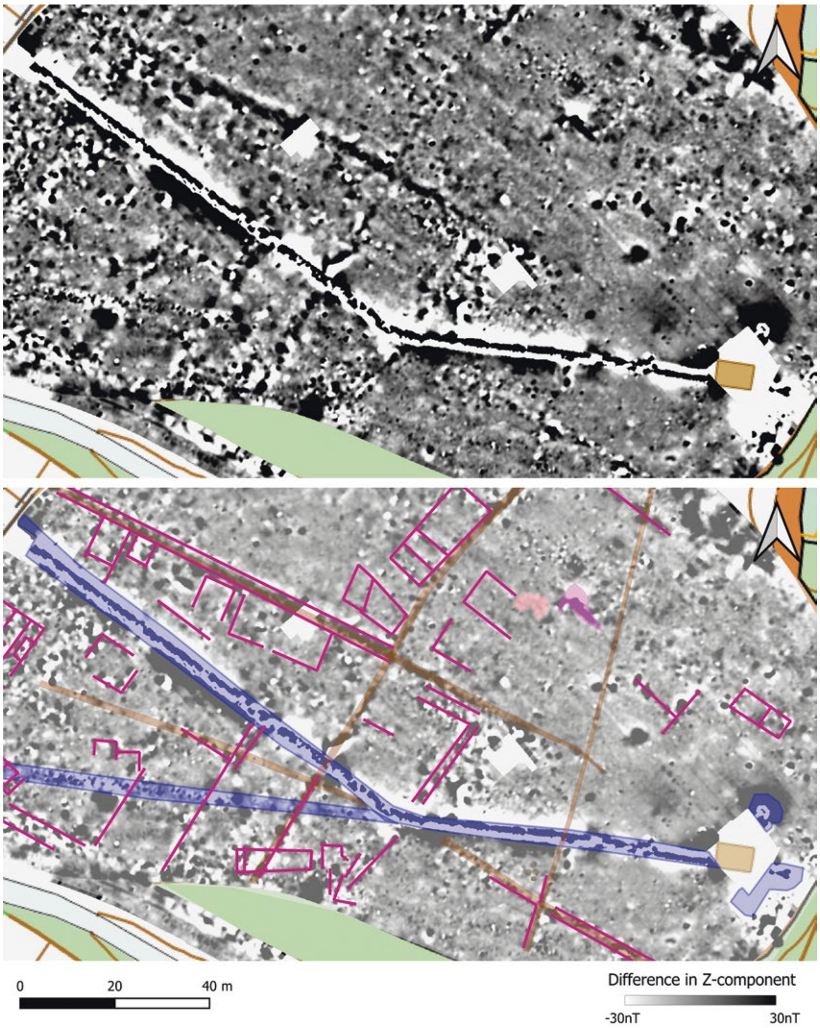

Fig. 8: Vulci, example for linear anomalies caused by modern structures (above: magnetic data; below: magnetic data with interpretation)

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Fig. 9: Vulci, the excavation from the 1950s (left) and the 1970s (right) with the railroad and the lorries

25 Round or rectangular negative anomalies indicate the removal of the tuff bedrock for *depressions* or *deepenings* like floors or cisterns (coral in Fig. 6 and Fig. 12, see below). Those with a rectangular shape probably served to level the subsoil and constituted the floor of individual rooms. A number of depressions in the central area lie directly next to one another (coral in Fig. 12). The resulting individual rooms vary

Colour	Characteristics of the anomaly	Description and possible cause
	Simple round to oval shape with a predominantly positive amplitude, but also negative amplitude	**Pit**: filling and pits, caused by the quarrying of tuff stone
	Extended linear shape with a slightly different amplitude from the surroundings	**Trench**: filling and/or colluvial infill in former ditches
	Linear form of positive or alternating positive and negative amplitudes	**Wall**: structure made of tuff or a mixed material - basalt, brick and limestone
	Simple to complex angular shape with a slightly negative amplitude or round with a strongly negative amplitude	**Deepening, floor, cistern**: caused by the removal of tuff stone
	Simple round or oval shape with a very high positive amplitude	**Furnace, fireplace, kiln**: filling of remanent material, such as burnt clay or slag
	Elongated linear shape with a slightly positive amplitude	**Pavement, path**: road paving and/or topsoil compaction
	Linear, sometimes curved shape with a slightly negative amplitude	**Canal, pipe**: deepening or canal lined with tuff blocks
	Elongated linear shape with a slightly negative amplitude, partly discontinuous	**Unclear**

10

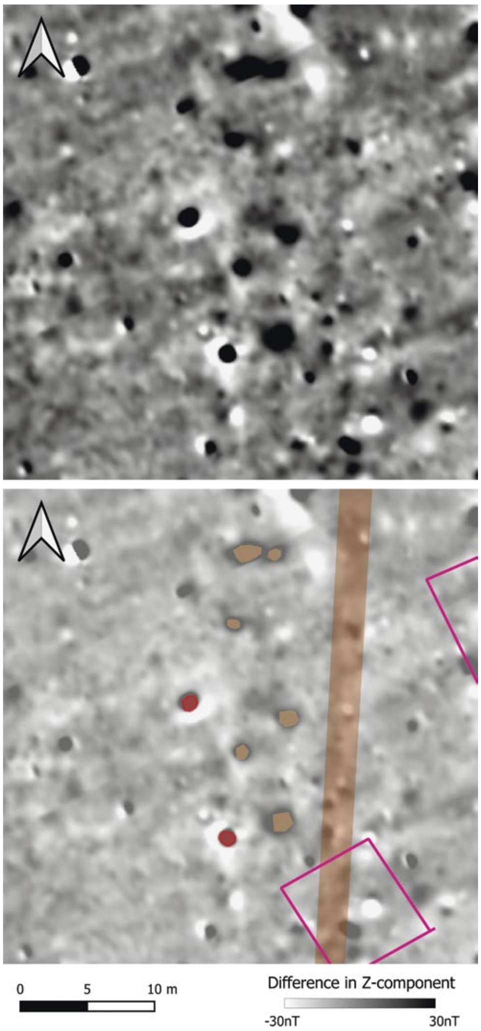
Fig. 10: Vulci, scheme for the interpretation of archaeological anomalies

from 12 m^2 to 42 m^2, but many may be even smaller, as the individual wall features suggest. Another concentration of rectangular deepenings is located east of the ditch on the so-called acropolis (Fig. 6). In this area lie several anomalies with strong negative intensities; those with a roundish shape are presumably cisterns (Fig. 6). Their diameter varies depending on the dynamics of the dataset. This cluster may be related to the nature of the soil, probably eroded to such an extent that no other layers or sediments remain on the surface, making the depressions particularly visible.

26 Anomalies with an extended shape that has hardly any appreciable change in its intensity could be interpreted as *trenches* or *ditches*, as in the case of the wide ditch of the inner-urban fortification (the so-called agger), dividing the plateau at its narrowest point and characterized by the lack of any kind of structures (orange in Fig. 13). Since the filling probably consists of local sediment, the ditch is difficult to distinguish from its surroundings, particularly along the southern edge.

27 Linear anomalies with high intensities, which are either positive or negative or alternate between positive and negative, define individual *walls* or *wall courses* (pink in Fig. 14). We often register a strong bipolarity of individual anomalies, lined up in a row with an average diameter of approx. 0.7 m at a dynamic of ±30 nT. The variance in size of the individual anomalies enable conclusions to be drawn in relation to the thickness of the walls. Less visible, mostly negative linear anomalies can also be assumed to be walls. The polarity of the intensity is caused by the magnetic properties of the building material, which is presumed to be tuff. Linear, sometimes curved anomalies with a low negative intensity[75] are interpreted as stone-built *channels* or *water pipes* for the purposes of supply or drainage (light blue in Fig. 14 and Fig. 15). At a dynamic of ±30 nT, such an anomaly measures on average 0.7 m in width.

75 Also visible in some aerial photographs, see Pocobelli 2004, 140 fig. 16. 17.



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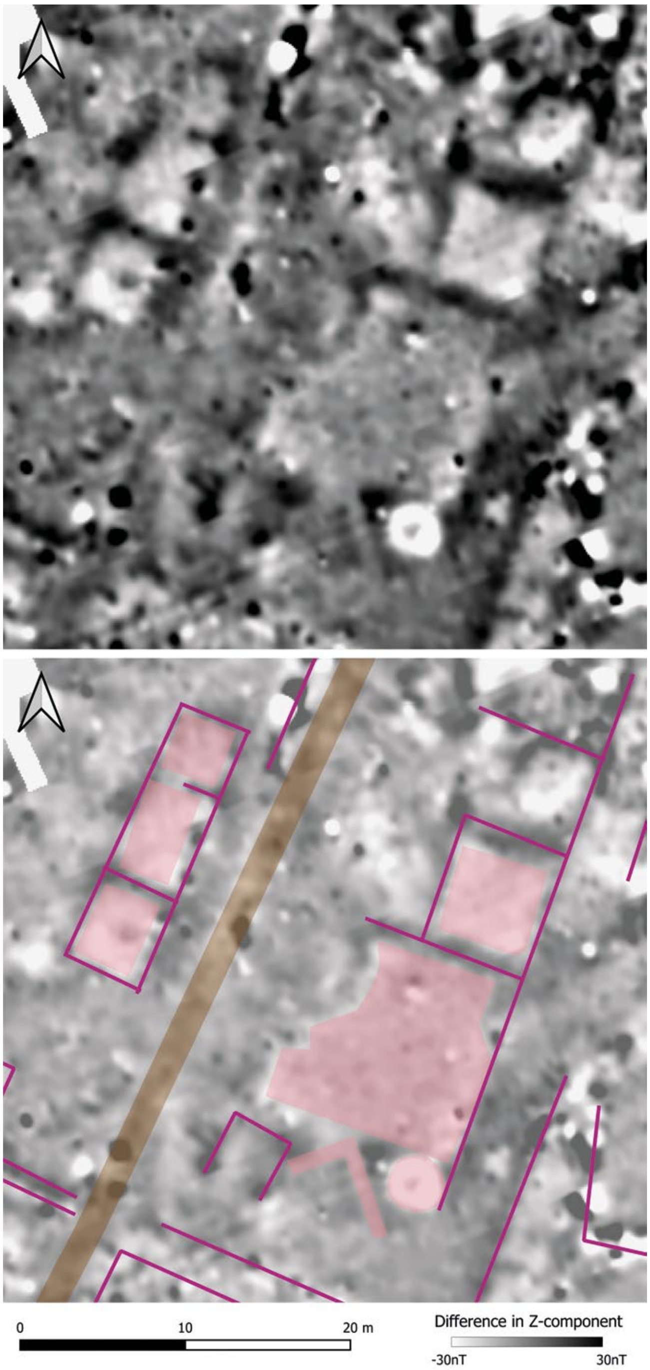

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Fig. 11: Vulci, example for single anomalies with varying pit fillings (above: magnetic data; below: magnetic data with interpretation)

Fig. 12: Vulci, example of rectangular and round anomalies classified as depressions or deepenings (above: magnetic data; below: magnetic data with interpretation)

28 Roundish to oval anomalies, with very high positive intensities, are usually caused by thermoremanent magnetization of material in the soil, as this occurs in pit fillings, e.g. with burnt clay as the residue of a furnace or in residues of slag in extraction pits. A series of such anomalies define at least four *kilns* located at 2.5 to 3.0 m next to one another (red in Fig. 16). On average, the anomalies measure around 4.2 m in length and around 1.7 m in width and are oriented from south-east to north-west. Other anomalies, visible near the north-west »kiln«, also show particularly high intensities. It is likely that this ensemble of anomalies reflects the remains of a workshop area. The immediate surroundings have an almost rectangular shape with a slightly negative intensity, which is likely to point to an enclosed structure.

29 Elongated linear anomalies with positive intensity, often accompanied on both sides by narrow, chain-like dipole anomalies with medium intensities (brown in

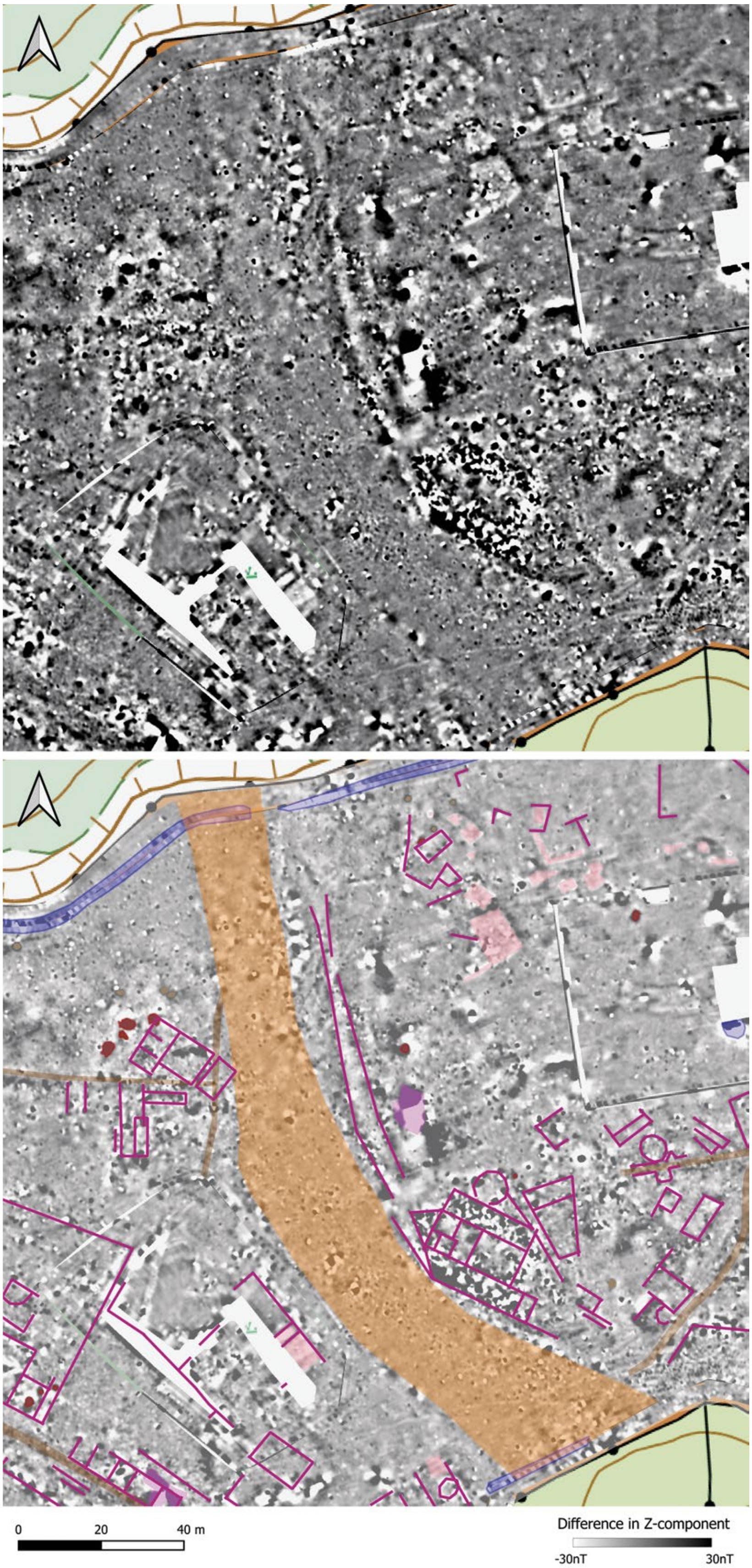

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Fig. 13: Vulci, detailed map of the ditch in front of the so-called acropolis (above: magnetic data; below: magnetic data with interpretation)

Fig. 17), are attributed to the compaction of the soil close to the surface, which is typical in the case of paths and may be interpreted as *road paving*, producing different magnetic signatures depending on the material used. The reconstruction of streets is based

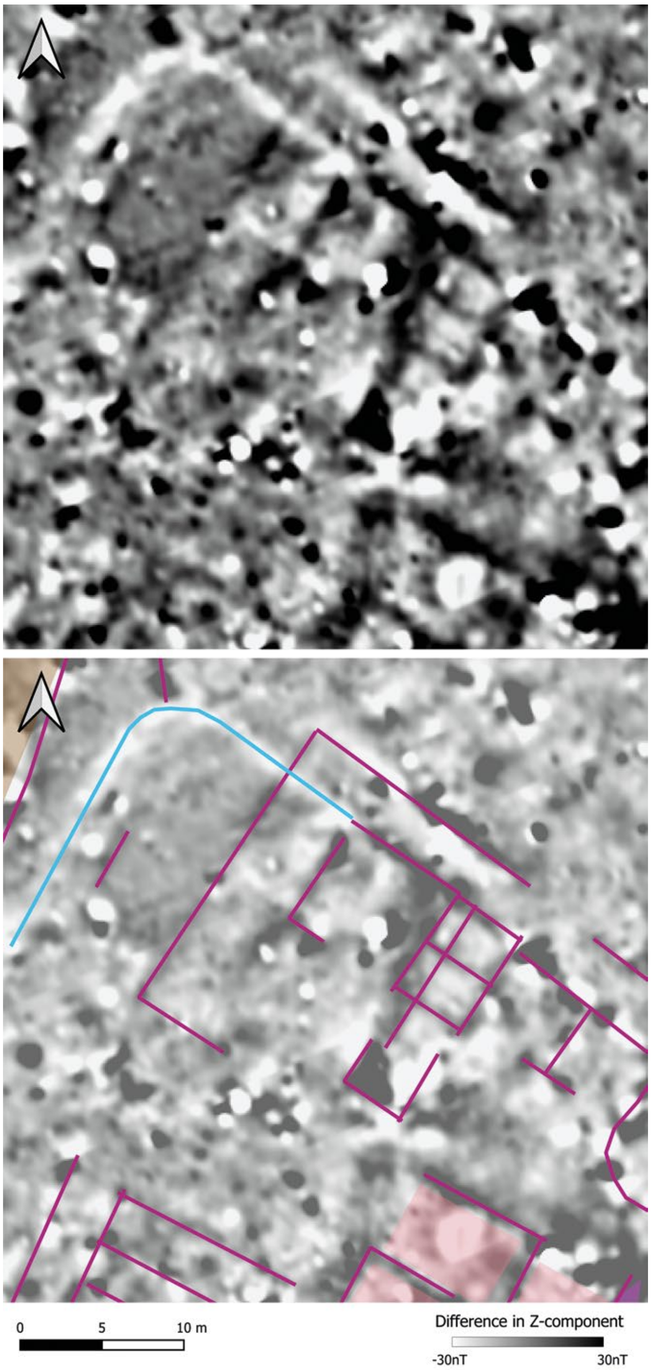

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Fig. 14: Vulci, example for anomalies interpreted as wall courses and channels (above: magnetic data; below: magnetic data with interpretation)

on different evidence in the magnetometer survey data: sometimes the streets themselves are relatively clear, sometimes they can be reconstructed based on accompanying walls or, in rare cases, channels; in other cases, such as the continuation of the so-called cardo, the data most certainly correspond to a paved street, providing comparisons for the signal of such anomalies.

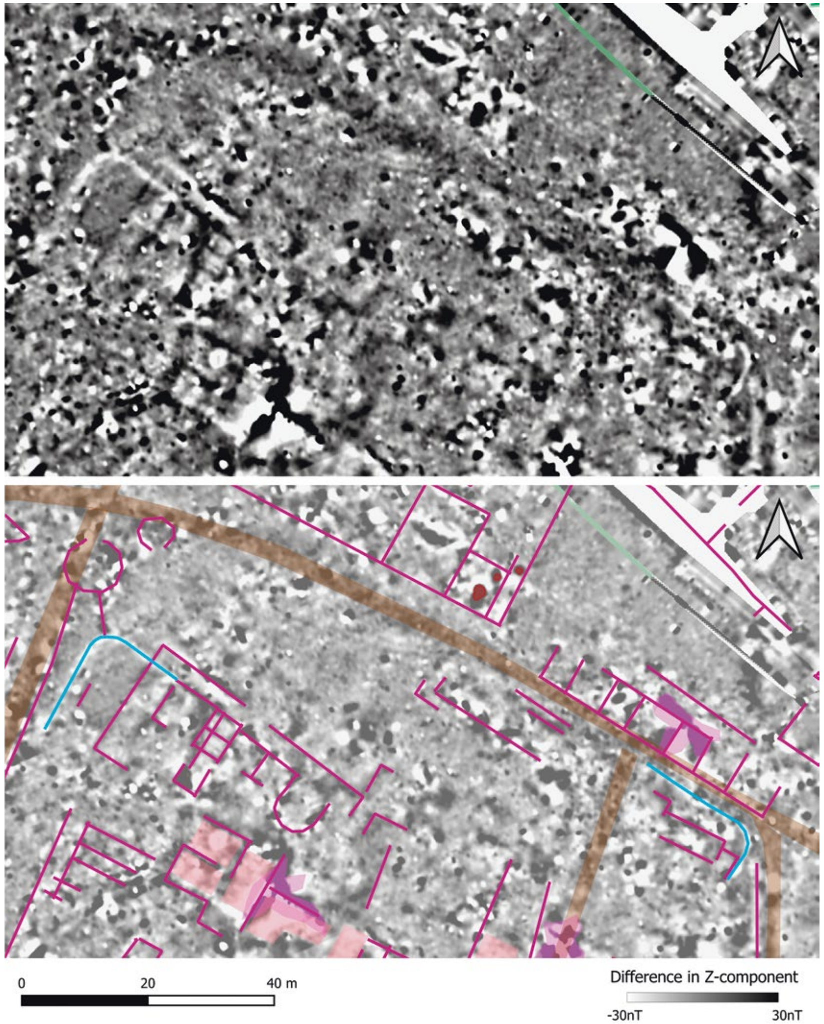
30 An additional category defines *unclear* anomalies that cannot be unequivocally classified into one of the described types. There are two marked anomalies, both located in the western area, north of the tempio grande (okra in Fig. 18). Both have an elongated shape, are not particularly wide (around 0.6 m), and show a slightly negative intensity. The western trace manifests itself as a series of adjacent, roundish, negative anomalies. The eastern trace varies and is more easily recognizable in the northern region. Interestingly, both do not follow any visible structures, neither buildings nor the existing road system. However, both anomalies run slightly parallel to one another from the north-west to the south-east at a length of 114 m and 160 m, respectively.

GPR1 – Testing the Potential of a Multi-Method Approach: GPR and Magnetometry in Comparison

31 We pursued several goals using the GPR survey: Firstly, to compare the results of GPR and magnetometry in an area where the results of the latter were not always clear. Secondly, we wished to assess the reliability of both methods for detecting streets and wall courses. GPR1 was positioned accordingly in an area in which a road course, flanked by wall structures, was recognized in the magnetometry (Fig. 19, left and central). As the road constitutes the potential northward extension of the so-called cardo, one of the main streets in Vulci, the area is of particular significance.

32 As seen in Fig. 20 a–e and Fig. 21 a–e, we obtained the best results up to a depth of 1.0 m. The interferences at the northern edge of the area can be attributed to a modern path. The antique road, however, which is clearly visible in the magnetometer data, appears in the GPR slices only through the accompanying linear structures, presumably walls, on both sides (Fig. 19, above right). These linear structures are best visible at depths between 0.6 and 1.0 m (Fig. 20 d–e and 21 d–e). In contrast, wall courses, which are not recognizable in the magnetic data or show only a very weak magnetic response, are distinctly visible in the GPR data and draw an intricate overlap of structures at different depths (compare Fig. 19 below). However, no coherent buildings or ground plans can be reconstructed. These features are best visible at depths of up to 0.8 m (Fig. 20 a–d and 21 a–d). It appears, therefore, that the road has, at some point, been superseded by higher lying structures.

33 It can be concluded that both methods have their own advantages but are best used together, as they complement each other in terms of resolution, dimension and



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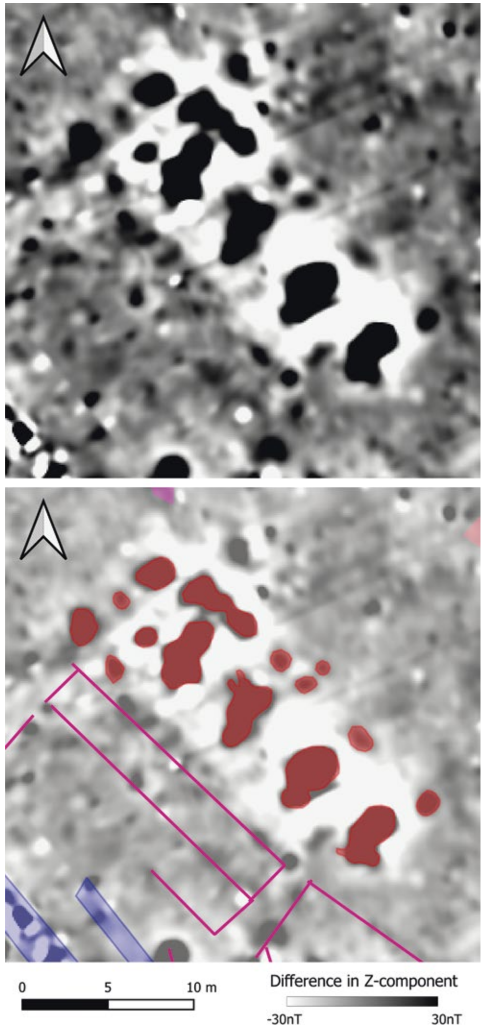

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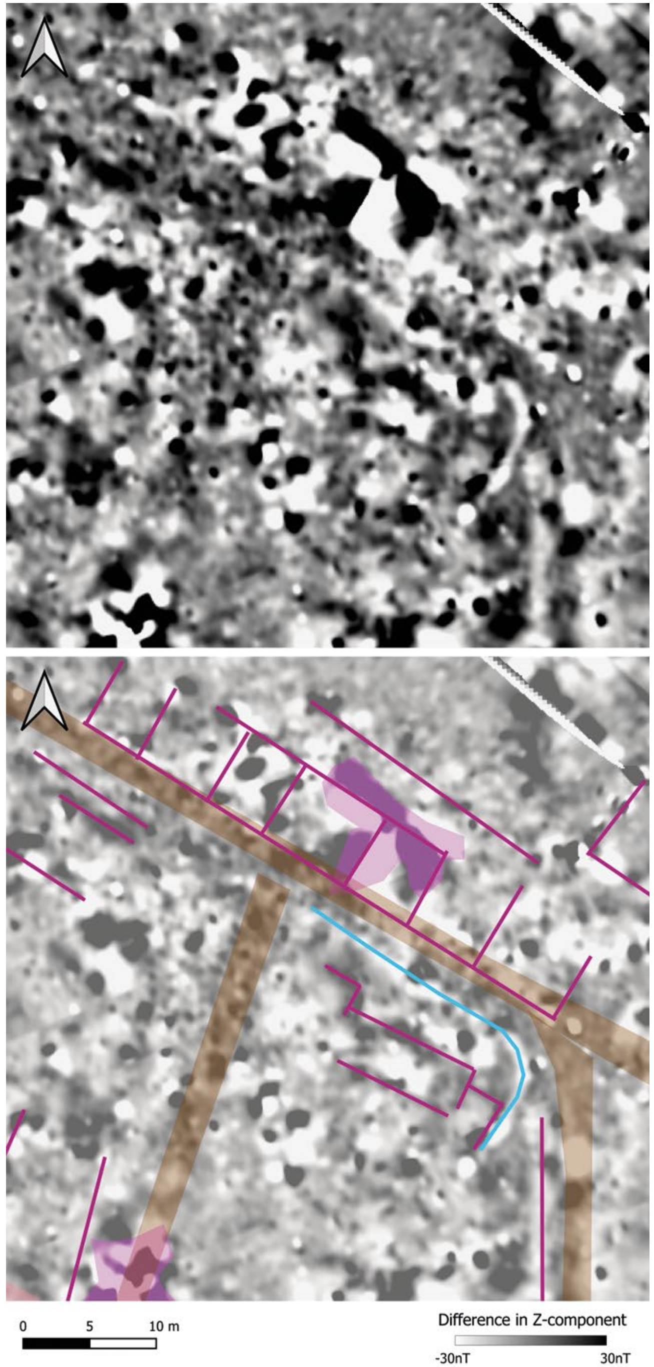

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Fig. 15: Vulci, example for anomalies interpreted as wall courses and channels (above: magnetic data; below: magnetic data with interpretation)

Fig. 16: Vulci, example for anomalies interpreted as kilns (above: magnetic data; below: magnetic data with interpretation)

Fig. 17: Vulci, example for anomalies interpreted as road paving (above: magnetic data; below: magnetic data with interpretation)

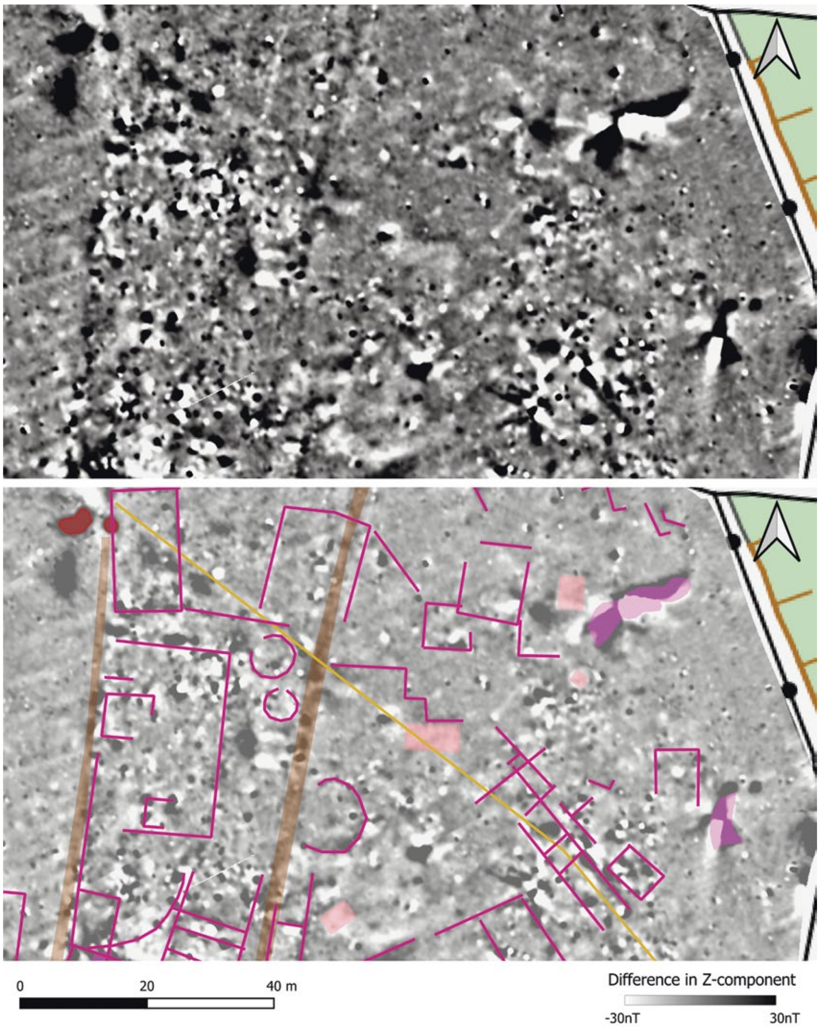

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Fig. 18: Vulci, the elongated unclear feature crossing urban structures in the western part of the plateau (above: magnetic data; below: magnetic data with interpretation)

material properties of the archaeological targets. Magnetometry is well suited to identify linear structures, such as roads, while GPR allows to identify (non-magnetic) walls and small-scale features.

GPR2 – A Combined Multi-Methods Approach: Magnetometry, GPR and Archaeological Excavation to Unlock the Newly Discovered Sacred District

34 GPR2 was defined to obtain a more detailed picture of the temple identified in the magnetometer data (Fig. 22) and, in particular, to determine the dimension of the walls and to define a promising area for archaeological excavation. Furthermore, as the orientation of the temple deviates from adjacent north-south oriented streets, we included the immediately adjoining areas in the GPR to better understand the local layout and organization of the urban space (Fig. 23). In 2021, we started an excavation at the north-east corner of the temple[76], which now allows for a further methodological comparison and anchors the geophysical prospection results to a stratigraphic sequence.

76 Franceschini – Pasieka 2022a; Franceschini – Pasieka 2022b. The excavation is ongoing; the second excavation campaign took place in summer 2022.

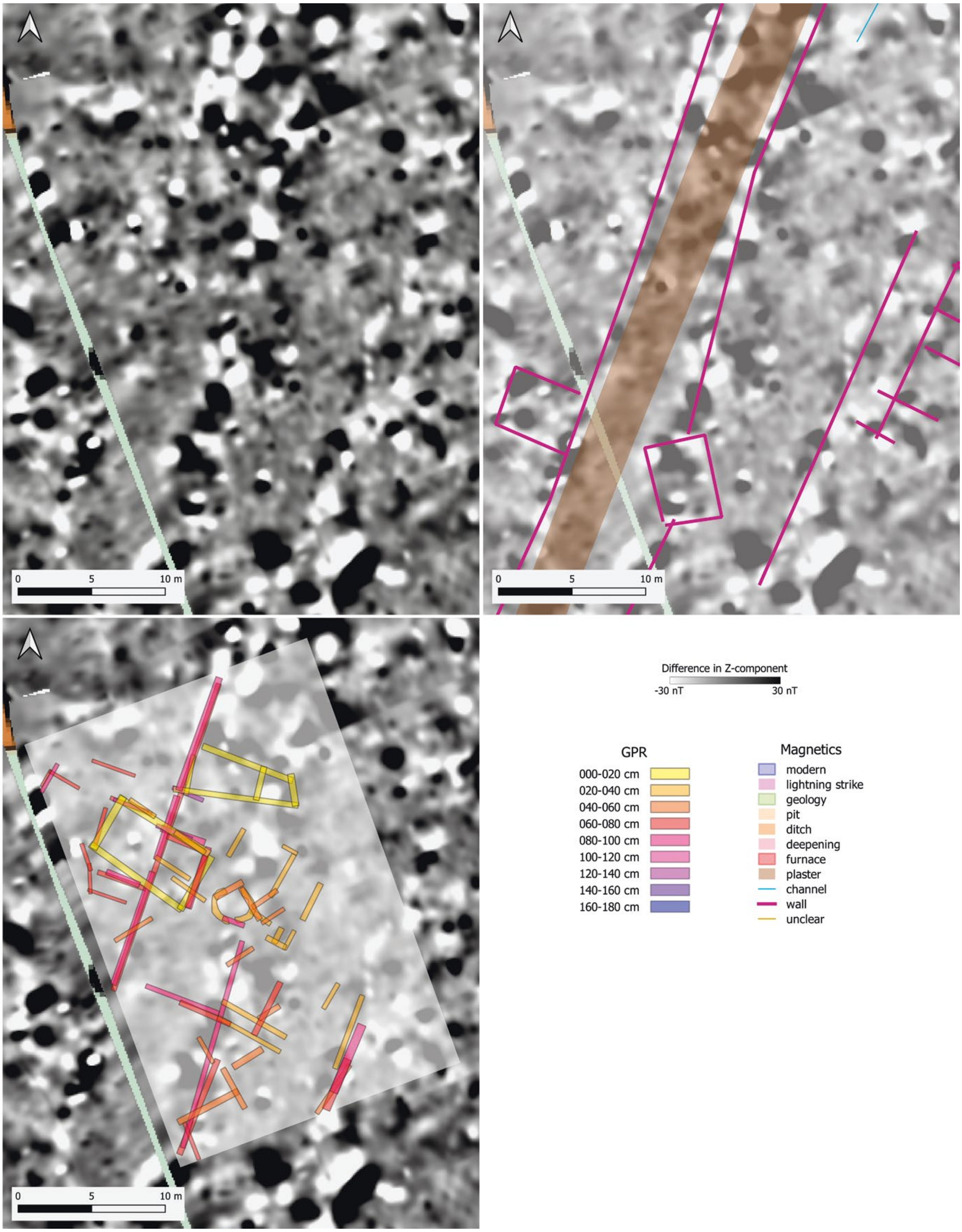

Fig. 19: Vulci, the survey area GPR1: magnetic data (above, on the right with interpretation) and in GPR interpretation (below)

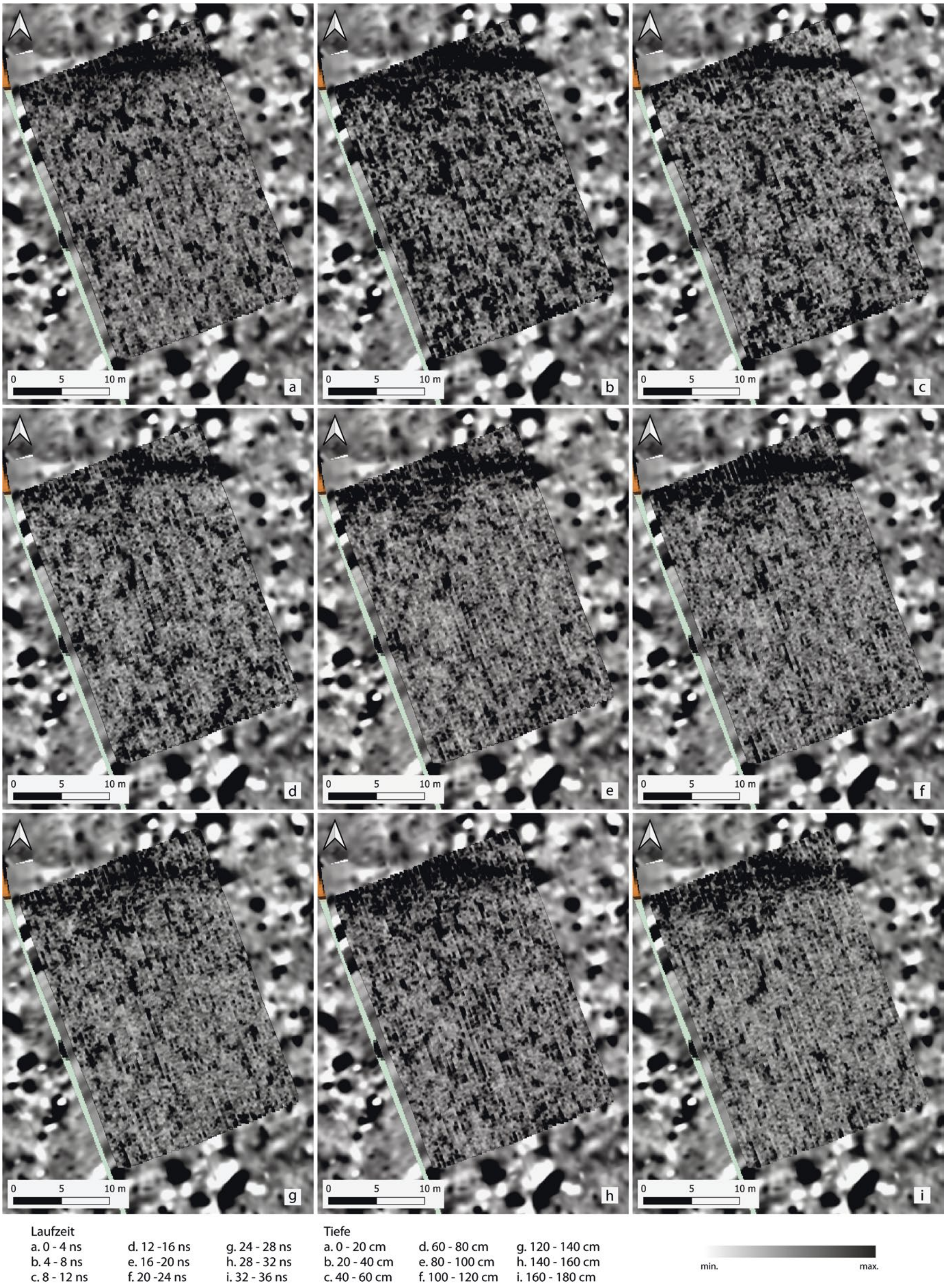

Fig. 20: Vulci, time slices for GPR1

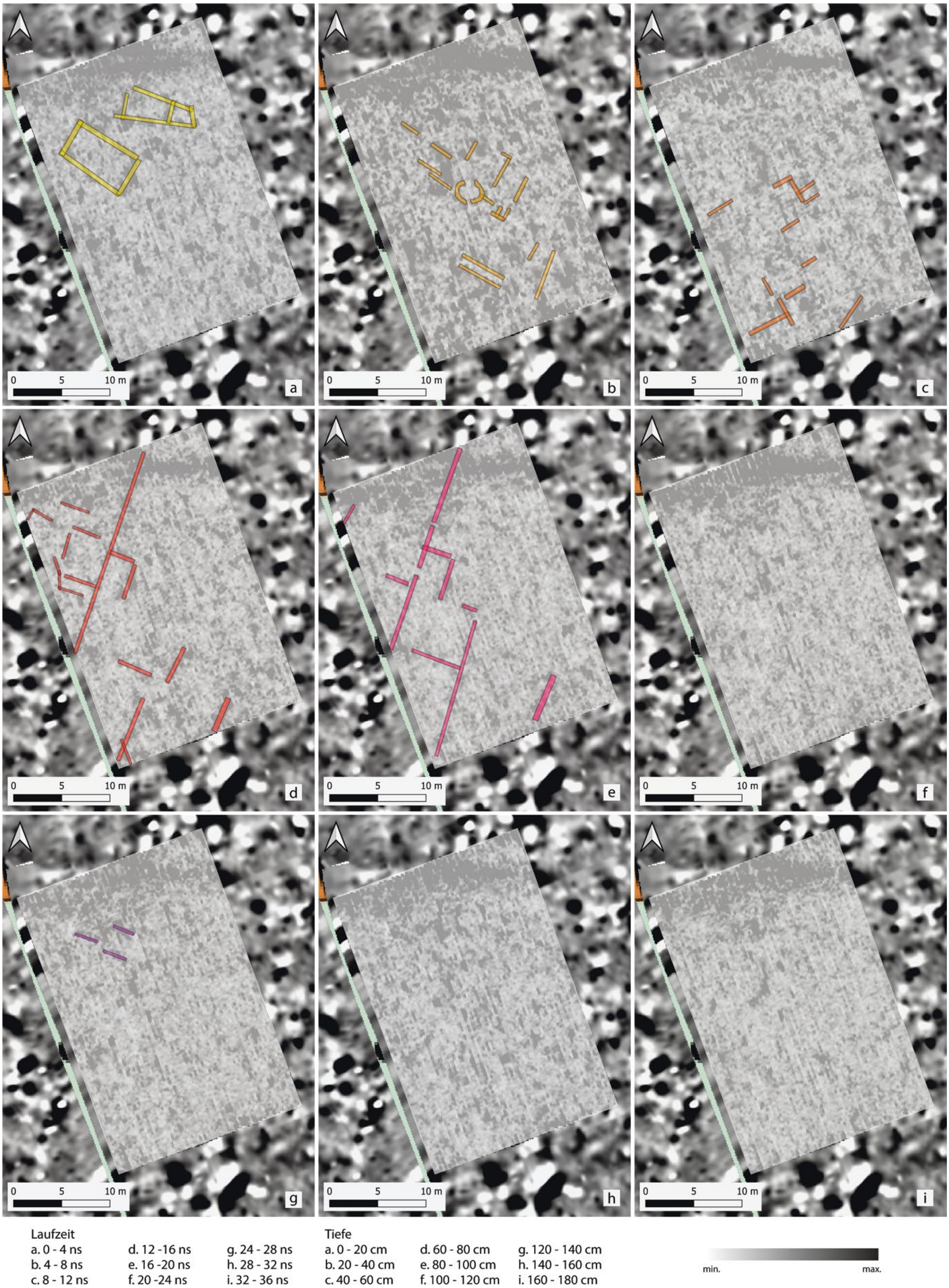

Fig. 21: Vulci, time slices with interpretation for GPR1

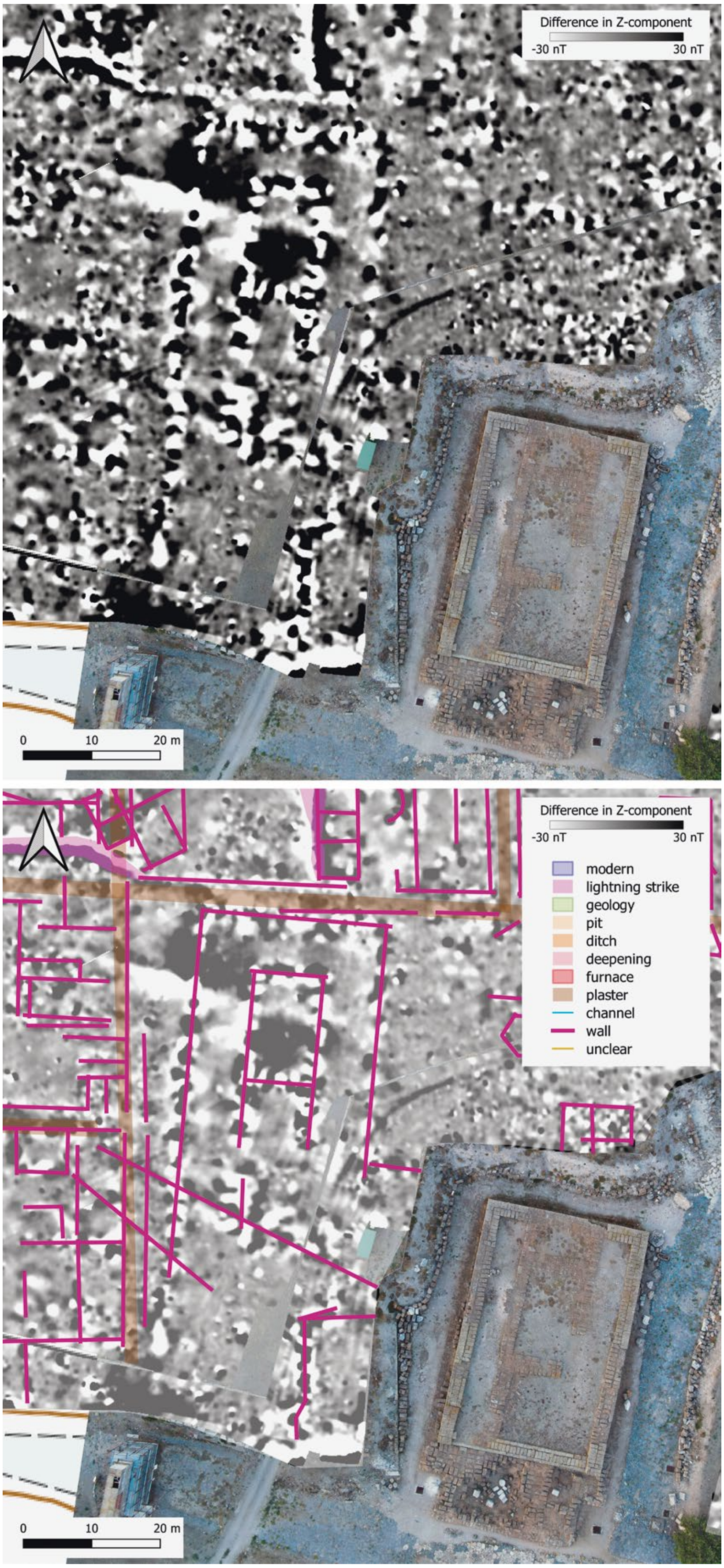

Fig. 22: Vulci, magnetometer data (above) with interpretation (below) for the area of the sacred district (GPR2)

Interpretation of Magnetometer Survey

35 Around 20 m north-west of the tempio grande, the magnetometer survey revealed a huge building structure, the plan of which clearly corresponds to a temple: a rectangular cella with pronaos and antae walls is enclosed by three walls to the north, west and east sides; a south wall is not clearly delineated in the data (Fig. 22). The walls of the outer building measure around 40 m by 27 m; the temple is almost north-south oriented and is rotated by 3° to the west.

36 The intensities of the magnetic anomalies in the southern part of the area are smaller compared to the other sides. An elongated dipole chain seems to continue along the western external wall of the temple; it is not directly connected with it but probably belongs to a group of similar traces to the west. In the south-east corner of the survey area, a strong dipole anomaly points to another wall of around 11.5 m in length, which is in an exact north-south alignment and is intersected at both ends by further walls.

Interpretation of Ground Penetrating Radar

37 The GPR data provide information up to a depth of 1.8 m; up to 0.2 m, no coherent structures are recognizable (Fig. 24 a and 25 a). At 0.2–0.4 m (Fig. 24 b and 25 b), more features with high reflection amplitudes are visible in the picture, however, it is still difficult to recognize archaeological features. The eastern part of the surveyed area is dominated by anomalies, which can be assigned to the modern road. At a depth of 0.4 to 0.6 m (Fig. 24 c and 25 c), parts of a smaller building, probably also a temple or, in general, a public building, can be identified in the south-east. Two parallel walls can be traced for approximately 9.9 m in length. Roundish features indicate the likely position of pillars or columns. At a depth interval of 1.0 to 1.2 m, these three anomalies, with a diameter of 2.0 m, become clearer and indicate a regular distance of ca. 2 m.

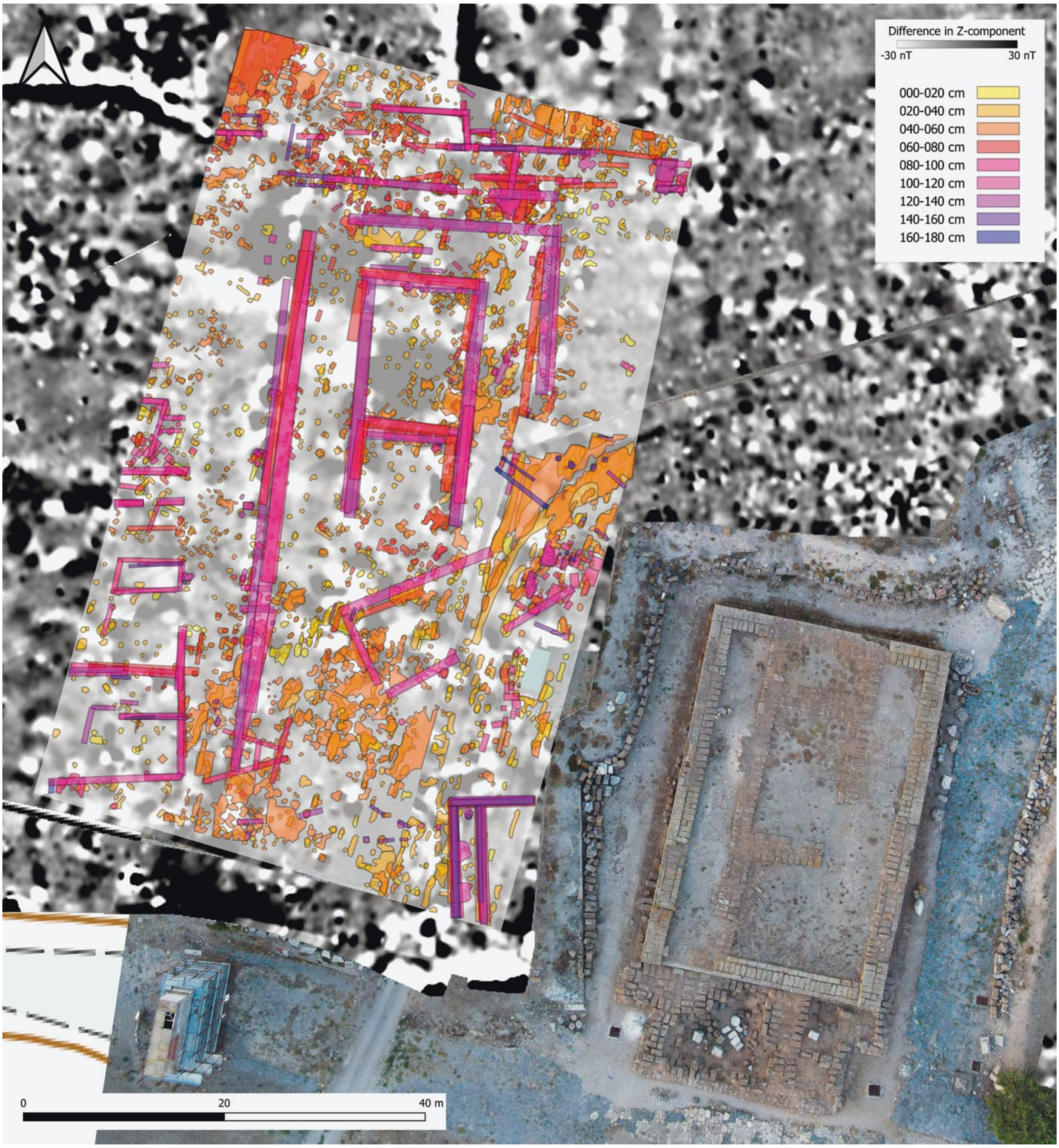

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Fig. 23: Vulci, interpretation of GPR data for the area of the sacred district (GPR2)

38 In the very northern part of the surveyed area and north of the newly discovered temple, several features, parallel to one other and to the northern wall of the new temple, appear clearly at a depth of 0.6 to 0.8 m (Fig. 24 d and 25 d) and can be followed to a depth of at least 1.2 to 1.4 m below the actual surface. These can possibly be associated with a street or accompanying walls, respectively, or channels.

39 The ground-plan of the temple is distinctly visible at a depth of between 0.6 m and 1.4 m (Fig. 24 d–g and 25 d–g). It is indeed striking that the temple is barely discernible and that the podium walls are distinctly narrower than in the magnetometry. Other structures to the south and most clearly visible at a depth of between 0.6 and 1.2 m (Fig. 24 d–f and 25 d–f) are unlikely to be aligned with the temple: several walls in the

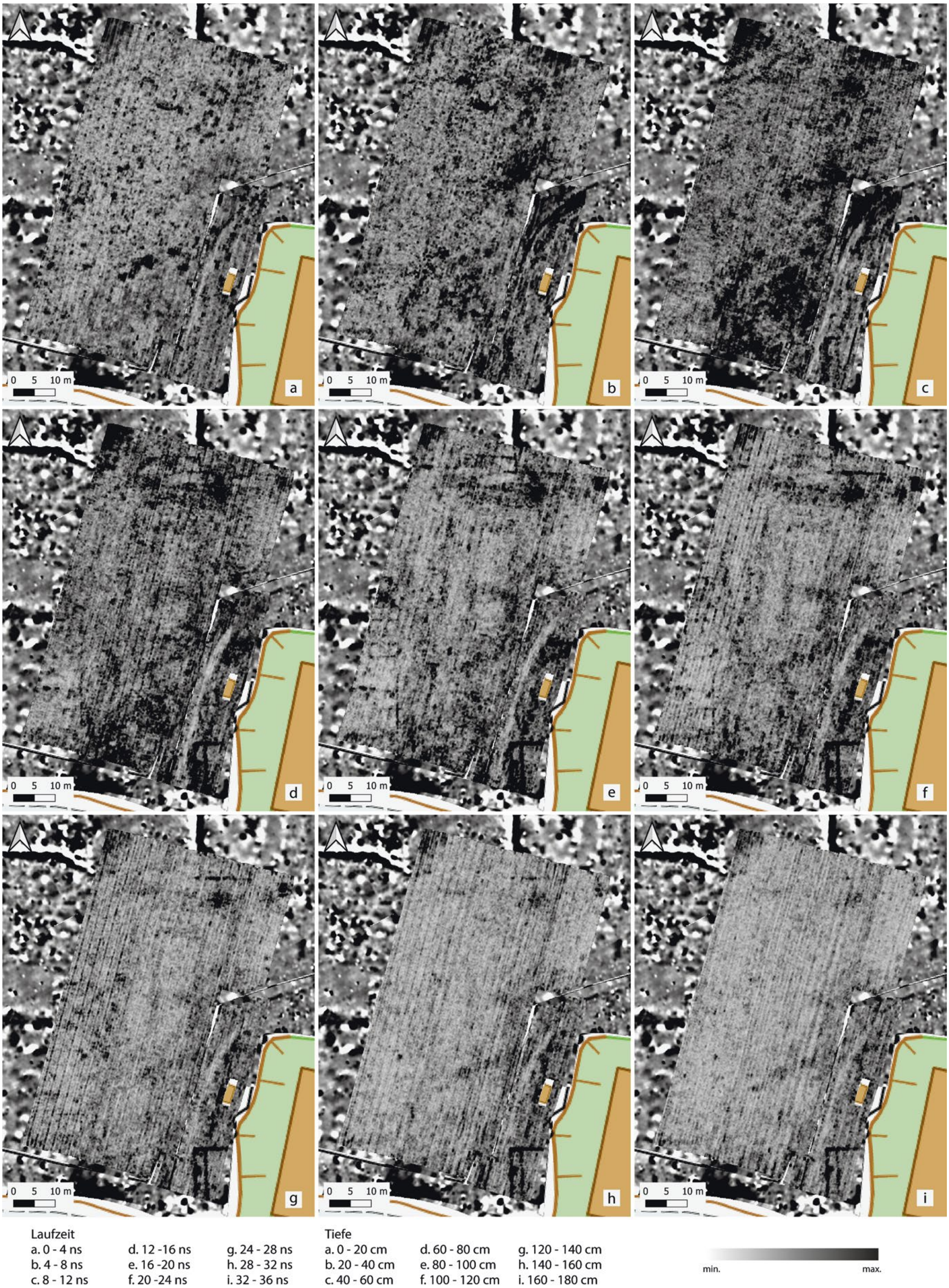

Fig. 24: Vulci, time slices for the area of the sacred district (GPR2)

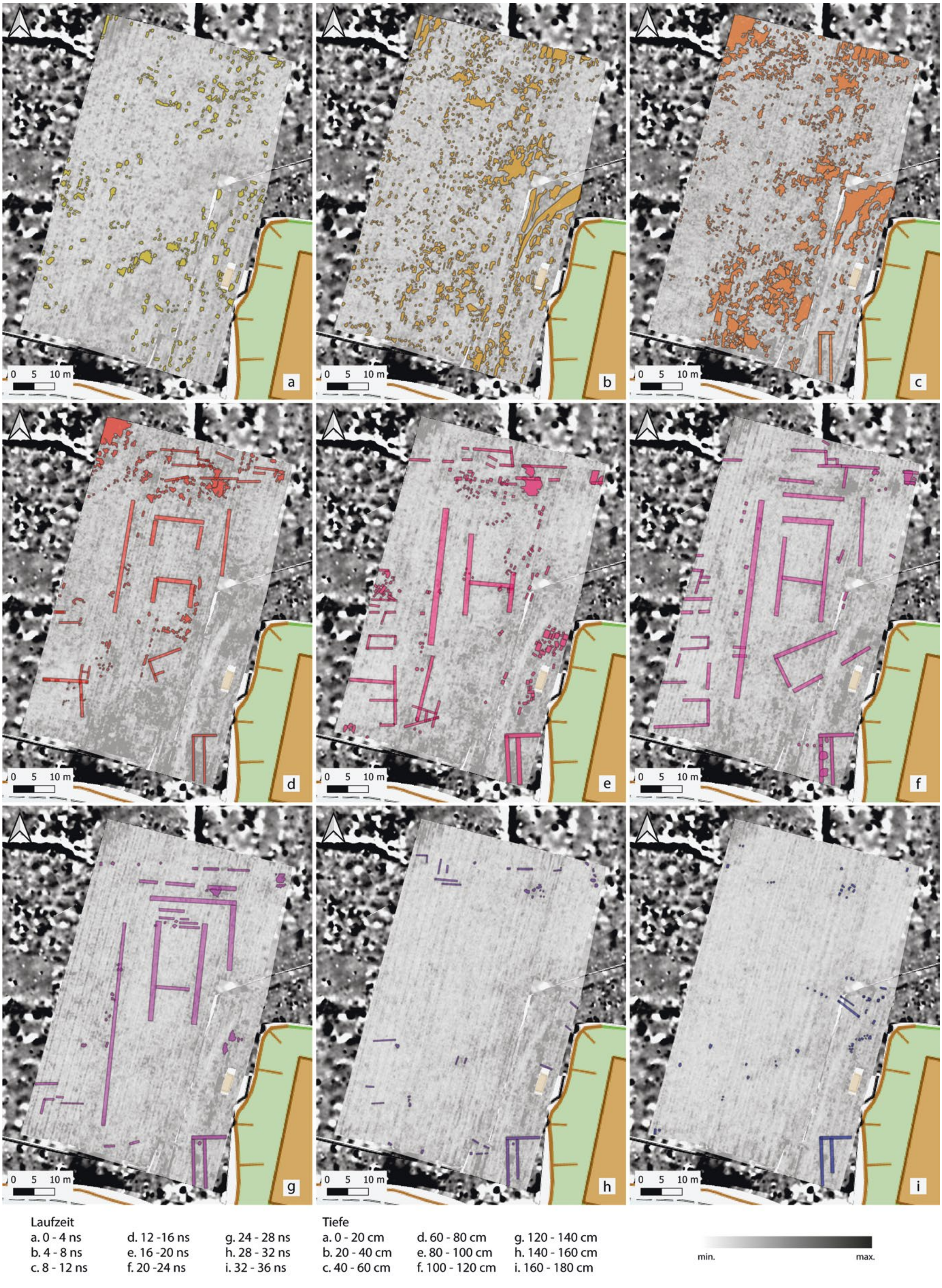

Fig. 25: Vulci, time slices with interpretation for the area of the sacred district (GPR2)

south-western part of the survey area probably form part of a built-up area, along with regular buildings north of the so-called decumanus, which stretches to the city walls to the west[77]; these are also related to a street running north-south and clearly visible in the magnetometer survey data. To the east, we wished to highlight, amongst other interesting magnetic anomalies, two parallel features, oriented south-west – north-east, between the cella of the new temple and the smaller public building.

Archaeological Excavations 2021 and 2022

40 The first two excavation campaigns in the north-east corner of the new temple in 2021 and 2022 have confirmed the results of the magnetometry and the GPR of a monumental foundation wall, both in the cella and at the peristasis, in varying states of preservation[78] (Fig. 26).

41 It was possible to stratigraphically distinguish different areas in our trench: inside the cella and between the foundation wall of the cella and the outer peristasis wall, we found the original, mostly undisturbed filling of the construction layers of the late 6th/early 5th century B.C., thus confirming, for now, the constructive coherence and synchronicity of both walls[79], with the caveat that the excavation between the cella wall and the peristasis wall have not yet been completed. The foundation walls of the cella are extremely well preserved. They were found 0.2 m below the current surface, at an elevation of 72.15 m, and are preserved up to 2.5 m at the deepest point, considerably better than the results of the GPR had suggested. The wall consists of a huge tuff ashlar structure of 1.8 m in width, which is conserved up to five courses high.

42 The area of the peristasis wall, by contrast, is exhibited through various spoliation and destruction layers, which, as far as one can determine at present, seem to date to the Early Imperial period. The tuff stones of the upper courses have mostly been robbed, therefore, the coherent sections of the wall only appear between ca. 1 and 1.4 m below the highest point of the cella wall at 71.12 and 70.76 m, respectively. The peristasis wall measures approximately 3 m in width and is covered with a row of runners made from nenfro. The results of the excavation so far indicate that the GPR does not display the full width of the peristasis wall, which holds true in particular for the northern portion, whereby the data of the magnetometry correspond closely with the real width of the walls.

43 In the area of the road, we have to distinguish between the eastern and the western half. In the western half, we found a compact horizon of clayey soil, which could cautiously be interpreted either as a walking surface or as a preparation layer. This presumed road was defunctionalized by a north-west – south-east running cut, which was filled in the east with several layers dating back to the late 1st or 2nd century A.D.[80]. Over the entire length of the northern edge of our trench we found a structure of tiles, stones, and mortar, which delineates the road to the north.

Comparison of Results

44 At first glance and contrary to earlier attempts in other areas at Vulci[81], the temple layout appears clearer in the magnetic data than in the GPR time slices. Wall features stand out clearly and the strength and polarity of the anomalies provide important information, e.g. the thickness and material properties of the walls (Fig. 22), which point to the different types of targeting subsurface objects, using the wave propagation

77 See Moretti Sgubini 2008, 171–175; Moretti Sgubini 2017b, 66–74.

78 Franceschini – Pasieka 2022a; Franceschini – Pasieka 2022b.

79 Franceschini – Pasieka 2022a, 59 f.; Franceschini – Pasieka 2022b, 141 f.

80 Franceschini – Pasieka 2022a, 58 f.; Franceschini – Pasieka 2022b, 140 f.

81 For example, see the results in McCusker – Forte 2017; Forte et al. 2020; Forte et al. 2022, 5.

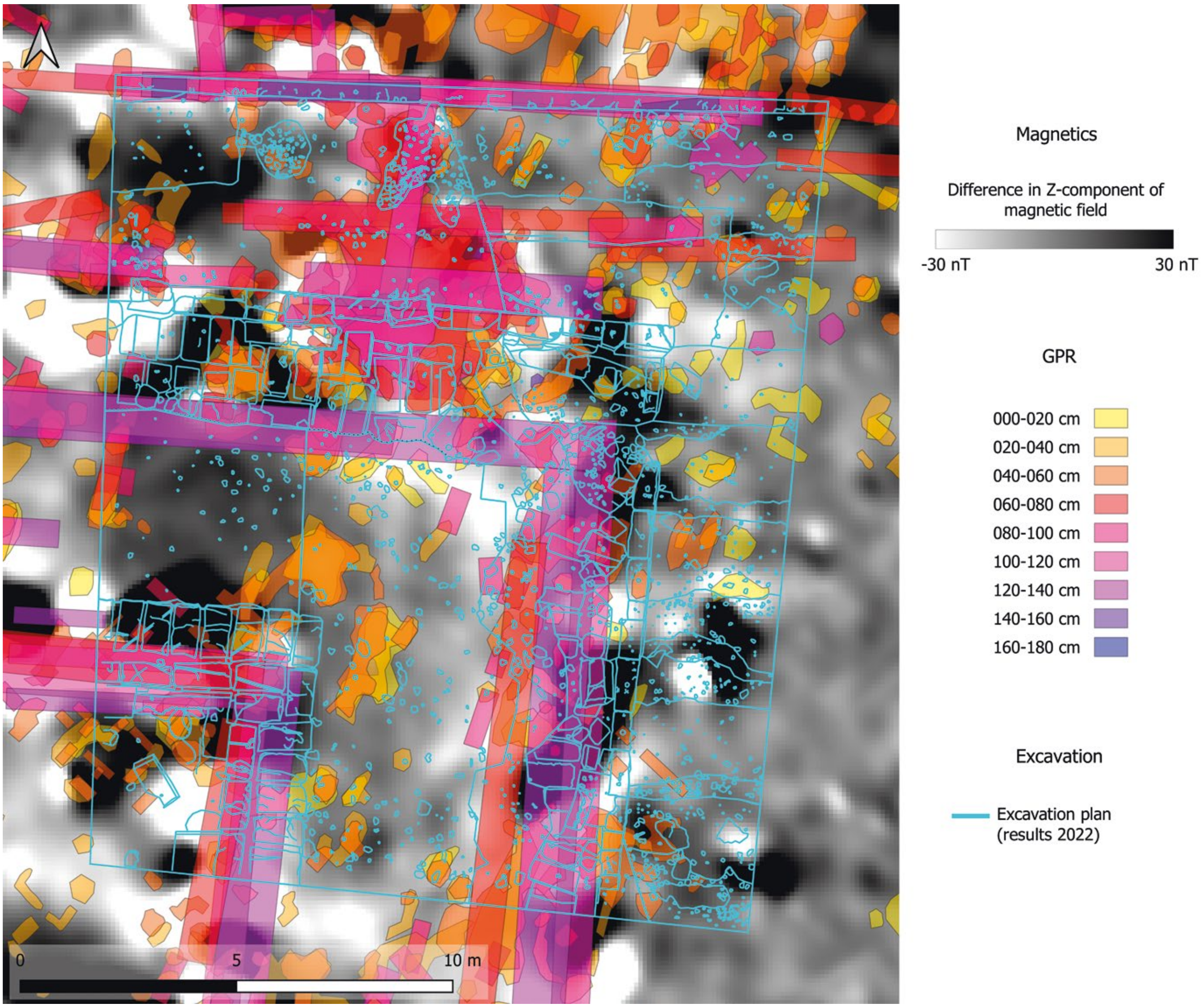

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Fig. 26: Vulci, detailed map showing results of excavations 2021 and 2022 at the new temple compared to the magnetometer and GPR data

method, GPR and potentially magnetic field surveys. In some areas, however, the results complement one another. Whereas the magnetometer survey data show superimposed buildings in the south and south-west of the area (Fig. 22), the GPR results are more detailed (Fig. 23). A group of magnetic dipole anomalies, south of the temple, appear in the magnetic data and are slightly washed out compared to the clearly defined temple walls. Overlapping structures and disturbances, probably caused by more recent construction activity, influenced the signal. Certain other features, such as the internal structure of the smaller cult or public building to the south, remain largely invisible in the magnetic data, which point to the type of stone used, likely to be limestone. In contrast, a relatively detailed ground-plan appears in the GPR data: the internal parallel wall, three roundish pilaster or column foundations made of caementicium – as evidenced by the partly excavated eastern wall – and the northern wall. The different signals in the GPR and magnetometer data could be explained by the use of various building materials with different physical properties, which is substantiated by the ongoing excavation. This confirmed that the magnetometry can very well detect tuff stones, particularly as the foundation walls of both the podium and the cella were encountered at the location indicated (Fig. 26). The GPR provides slightly different structural information: one cannot trace the borders to the north and to the south exactly, while the blocks of the cella and the eastern wall appear in the same position as on the excavation and with approximately the same thickness. Significantly, the foundations in the north show a different picture, maybe because the spoliation layers alter the responsiveness of the tuff blocks (Fig. 26). An amorph anomaly in the north-eastern part of the GPR area, which is discernible at a depth of between 0.4 and 1.0 m (Fig. 24 c–e and 25 c–e) turned out to be a pit of the spoliation of the presumed peristasis wall of the new temple, filled with a considerable number of roof tiles and stones[82]. The structure which accompanies the putative road to the north is also clearly visible in the GPR (Fig. 26). A slight diagonal anomaly, between a depth of 0.6 and 1.0 m (Fig. 24 d–e and 25 d–e), can now be better understood in light of the excavation: it appears to follow the diagonal line of antique cuts through the road and the eastern part of the podium[83]. Moreover, the blocks of the foundation wall of the cella already appear at a depth of 0.2/0.3 m from the present ground level and continue up to a depth of 2.5 m, hence sooner and deeper than the GPR detected them, since the temple appears clearly at a depth of ca. 0.6 m and seems to disappear at a depth of 1.4 m in the data. This will allow for the future calibration of the applied techniques, and highlights the possibilities and limitations of certain geophysical methods under the specific survey conditions in ancient Vulci.

45 Overall, we obtained a higher spatial resolution of the building structures and detailed depth information with GPR. Moreover, features detectable by the magnetometry could be identified, which could point to additional buildings (i.e. the rectangular structure in front of the temple in Fig. 23). The archaeological excavation was not only able to date the structures, but also made significant adjustments to the archaeological interpretation of the geophysical data. The potential of the combination of different non-invasive and invasive methods must, therefore, be emphasized.

Unlocking the Hidden Cityscape of Vulci: An Archaeological Interpretation

46 The results of the extensive geophysical surveys (Fig. 3) have successfully revealed a whole new map of the northern area of the city (Fig. 27) as a complex palimpsest, in which all time phases can be viewed side by side at the same level. It was possible to recognize different functional areas and to address their reciprocal relationship, thus obtaining a more complete vision of the cityscape of Vulci. In the following, we will briefly discuss the main functional areas that can be identified from the magnetometry.

The Fortification System

47 The so-called agger that separates the so-called acropolis from the rest of the city and which is visible both in the terrain and in the aerial photographs[84] emerges in the magnetic map as a broad strip, largely free of anomalies and structures, and measuring approx. 20 m at the narrowest point and 40 m at the widest; a slight depression and a relatively steep increase correspond to this anomaly in the terrain (orange in Fig. 13 and Fig. 28). At the crest line of this increase, two parallel linear structures are visible that can most likely be interpreted as walls (pink in Fig. 13 and Fig. 28), but we don't see here the classical picture of two walls containing an agger. By contrast, the geophysical data of the agger from Gabii show two walls, one sub and the other super aggerem, accompanying the ditch respectively ditches[85] in a different position, leaving

82 The strata US18, US22, US58, US66 and US90; see Franceschini – Pasieka 2022b, 141.

83 The cuts US34 and US43; see Franceschini – Pasieka 2022b, 140.

84 Pocobelli 2003, 152 fig. 274. 275; Pocobelli 2004, 139 fig. 15; 140 fig. 17; Pocobelli 2010/2011, 118 fig. 2.

85 See Helas 2010, 252 f. with fig. 5. 6. 8; Helas et al. 2019.

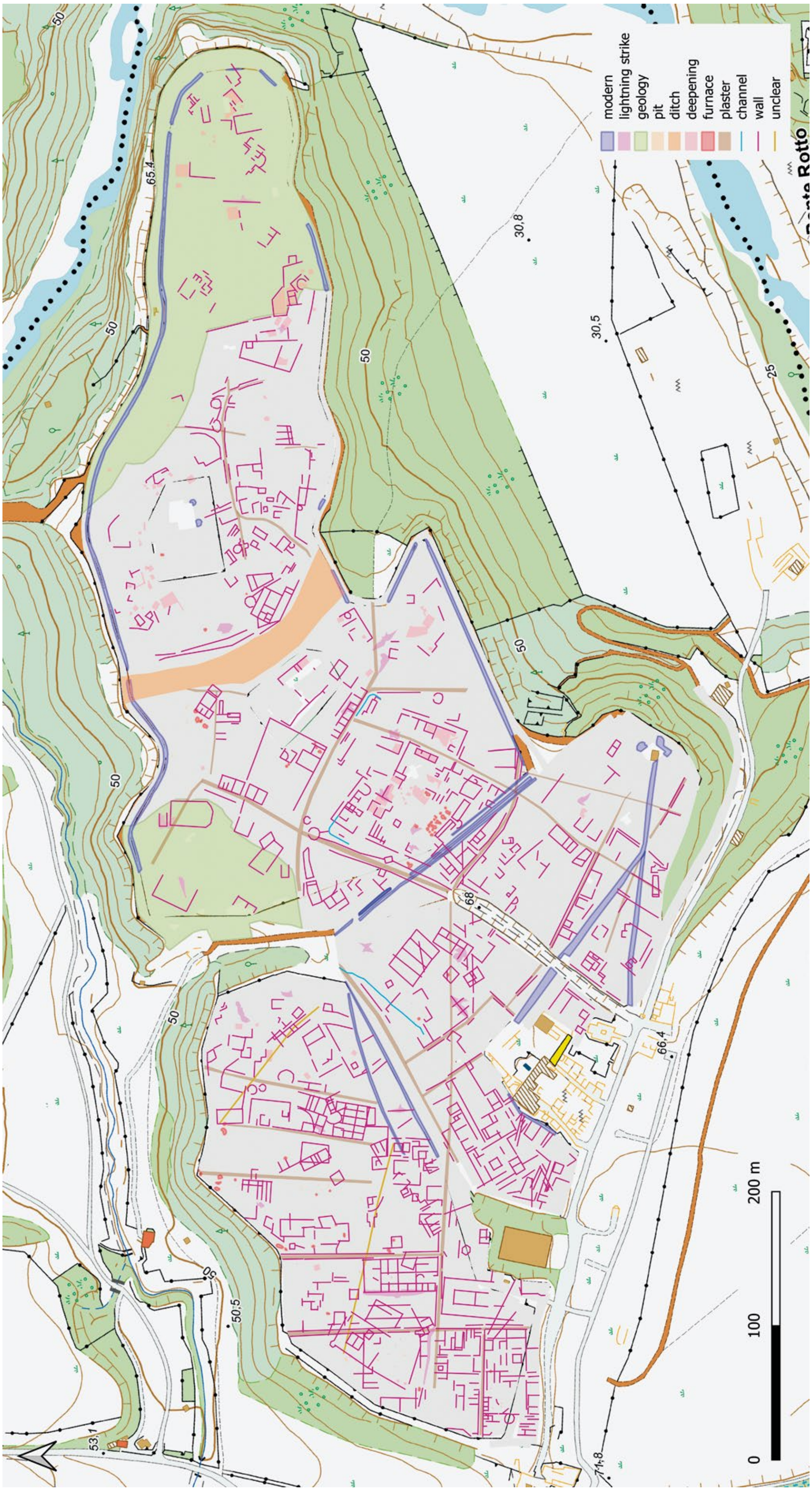

Fig. 27: Vulci, interpretation of the magnetometry survey data

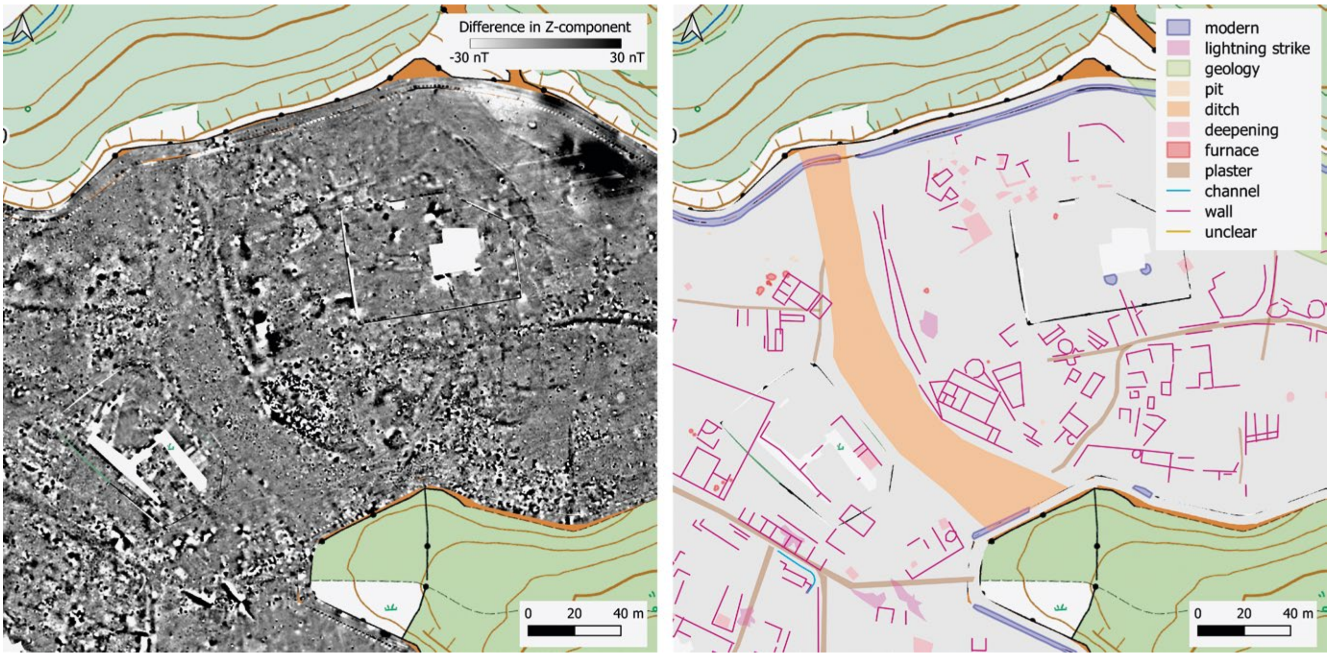

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Fig. 28: Vulci, detailed map of the main ditch (left: magnetic data; right: interpretation)

our data open for further interpretation. The situation also seems to differ from that at the western gate, where Moretti Sgubini dates a first agger to the middle/second half of the 8th century B.C.[86]. Still, the question remains whether this fortification benefitted from the geological margin or if it is wholly or partially man-made[87]. Acqua Acetosa and its defensive systems of the Final Bronze Age and Early Iron Age seem to be the closest parallel for our situation[88]. Some of the anomalies in the area of the access to the acropolis, which opens into the central artery of the acropolis, can perhaps be interpreted as a monumentalized or at least a densely build-up entrance or maybe as a bastion[89].

Road Networks

48 The road network shows the complex, diachronic palimpsest and development of the city structure which highlights the historical depth of Vulci[90]. Different responses of streets in the magnetometer data could reflect various construction techniques and eventually correspond to different phases[91]. The gates and the excavated street sections provide good references for the interpretation, just like the results of other recent geophysical studies[92]. Thanks to the overlapping of buildings and streets at certain crucial points (highlighted in orange in Fig. 29), at least two distinct road systems can be recognized, suggesting different phases in the structure of the city. This, in turn, has far-reaching consequences for our ideas of social organization.

86 Moretti Sgubini 2006, 333. 341.

87 The question also remains in Gabii, see Helas 2010, 251.

88 See Bedini 2016.

89 Courtyard gates or walls accompanying the road are found in Vulci and secondary settlements in the territory of Vulci, such as Rofalco or Ghiaccio Forte, in early Hellenistic times; for a survey of the late 4th/early 3rd century B.C. fortifications of Vulci, Rofalco und Ghiaccio Forte, see Cerasuolo 2019.

90 Pocobelli 2003, 149 fig. 269; Pocobelli 2004, 131 fig. 5; 134 fig. 8.

91 See above the interpretative framework § 27. Moreover, Renato Bartoccini speaks of two phases of the roads he excavated, both of the decumanus (the road collapsed due to poor weather conditions, uncovering another road with a canalization system; Bartoccini 1960, 11 f.) and of the street to the north gate (Bartoccini 1960, 18).

92 See Kay et al. 2021a, 85 fig. 3; Sabatini et al. 2021a, 355 fig. 2; Forte et al. 2020.

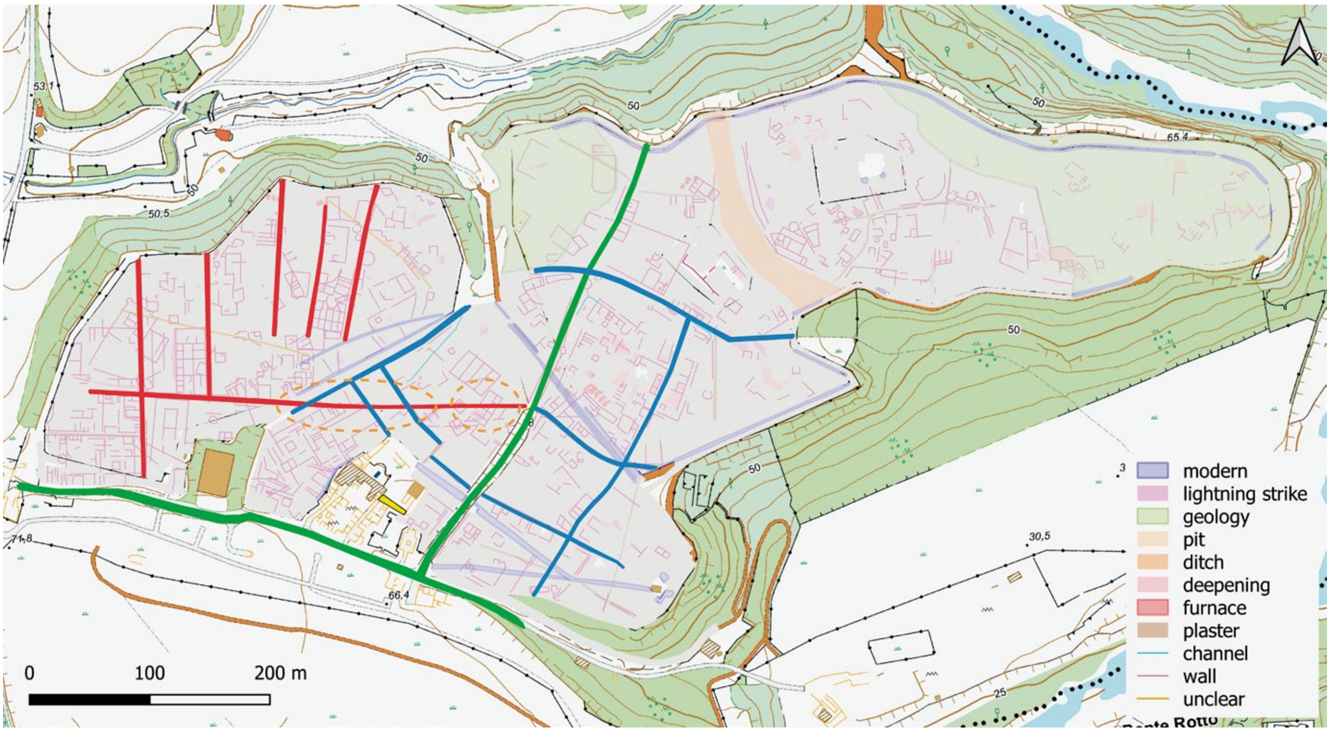

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Fig. 29: Vulci, the different phases of the street systems (green: constant; red: older; blue: later)

Fig. 30: Vulci, GNSS survey to mark remains of local opus caementicium and the intersection with another road recognised in the magnetometry

50 The streets to the west of the so-called cardo of the second (and presumably) later system (blue in Fig. 29) overlap the major east-west street of the first system. This second system is centred around the so-called cardo with another main north-east – south-west street to its east and a street connecting the tempio grande with the so-called cardo and the northern gates to its west. These three streets are interconnected with secondary collector roads which are, at least in one instance, visible at the excavated section of the cardo (Fig. 30). This system seems to be related to structures that resemble rather large units, organized around various courtyards (e.g. atria, peristyles) and mir-

93 The central section of this road coincides with the modern park route. However, it is a perfect extension of the road from the east, in a non-disturbed area of the park, and can also be seen in aerial photographs before the park was established (see Pocobelli 2003, 148 fig. 268). This seems to confirm with relative certainty that it is an ancient route. The street was already reconstructed by Adameşteanu in this form in his first draft of a city plan (see Adameşteanu 1964, 71; see also Finocchi 1970, 43 fig. 3 a) but excluded in later reconstructions (for example in Pocobelli 2003, 149 fig. 269; Pocobelli 2004, 132 fig. 6; 134 fig. 8).

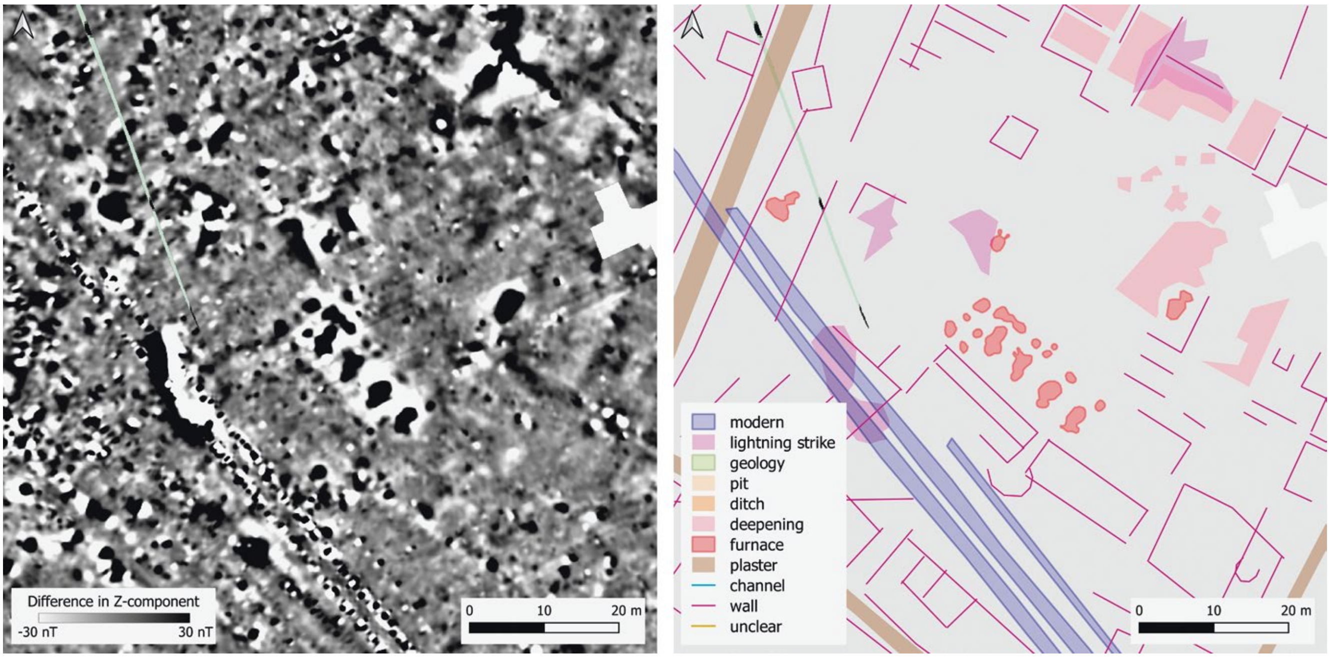

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Fig. 31: Vulci, detail of the production area with magnetic anomalies interpreted as kilns (left: magnetic data; right: interpretation)

roring in some cases the plan of Roman domus, which will be discussed later. The main axes, especially the so-called decumanus and cardo, follow the course of the terrain and connect the natural accesses to the plateau[94]. They do not seem to have changed over time since they match both systems, thus representing the more stable elements of the urban road system, linking the city with the outside (green in Fig. 29).

51 Although overlapping roads and structures allow to establish a relative chronology, any attempt to precisely date the road systems without stratigraphic data presents in most cases methodological problems[95].

The Production Areas

52 To the north of the so-called cardo (Fig. 16. 31) and on the north-western borders of the plateau (Fig. 27), several kilns can clearly be recognized, based on their shape and size[96]: a round main part corresponds to the combustion and firing chamber, a smaller rectangular part to the stoking chamber. The kilns are clustered in certain areas and the four, east of the so-called cardo, are clearly lined up in a row; other kilns are present in their vicinity (Fig. 31). These kilns can be linked with large-scale manufacturing inside the city walls[97]. To date, only one kiln from the Campanari excavation, which can no longer be located[98], was identified in the city area; other productive areas

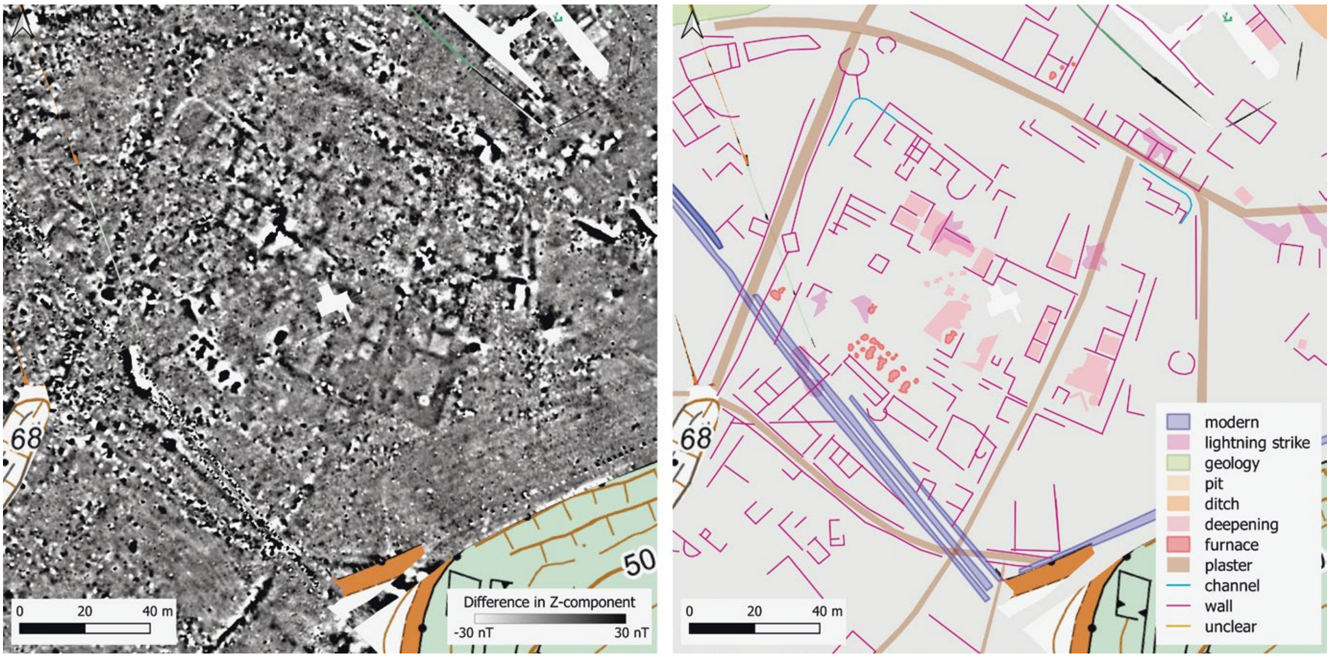
94 They are also visible in aerial photographs, see Pocobelli 2003, 148 fig. 268. See details of the road system around Vulci in Pocobelli 2007; Pocobelli 2010/2011.

95 An attempt to date part of the city based only on the orientation of streets and buildings in Forte et al. 2022, 6. 12–15; 16 fig. 14 is highly speculative and mostly unfounded.

96 Similar anomalies can be found, for example, in the results of the magnetics in Selinunt (Bentz 2019, 161 fig. 18), and were confirmed by excavations (Bentz 2019; Bentz 2020 with further bibliography), but also in Verulamium (Lockyear – Shlasko 2017, 18 f. fig. 9D).

97 Whereas some kilns are clearly recognizable as pottery kilns, others may have been used for metal production.

98 Campanari 1836a, 58; Buranelli 1991, 250; Carosi et al. 2017, 277 f.; they could be related to those described by Ferraguti 1937, 107.



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are archaeologically documented in the area of the porta est[99] and ovest[100], north of the city[101], as well as in the Fiora plain[102]. These various known production areas date from the 6th to the 1st century B.C.

Fig. 32: Vulci, the residential area in the north-eastern part of the plateau (left: magnetic data; right: interpretation)

Residential Areas

53 The results of the magnetometry show an intense and dense settlement for the entire area[103], although it cannot be determined whether all buildings existed simultaneously. Only on the so-called acropolis is the picture less clear, due to the impact of geological formation on the magnetic data. It is possible to recognize structures carved into the natural ground[104], often accompanied by walls and clustered in the central part of the area and on the so-called acropolis (Fig. 6. 12. 32). Magnetic anomalies which resemble rows of single stones, mostly following the sides of the streets appear to be connected to these features and could be interpreted as water or drainage channels[105] (light blue in Fig. 14, 15 and 32).

54 In other areas of the plateau, chains of dipole anomalies can be addressed as walls[106] (Fig. 33). The rather unclear image, showing positive and negative anomalies around the second, blue road system (Fig. 29) could be associated with the construction technique: collapsed terracotta roofs or walls, either of different building materials with

99 Carosi et al. 2017, 283 f.

100 Carosi et al. 2017, 279–282.

101 Carosi et al. 2017, 278.

102 Carosi et al. 2017, 284–287.

103 Particularly in contrast to earlier reconstructions, see, e.g. Pocobelli 2004, 132–134 fig. 6–8.

104 See above § 25. These structures were also clearly visible in aerial photos (see Pocobelli 2003, 150 fig. 272; 152 fig. 274. 275; Pocobelli 2004, 139 fig. 15; 140 fig. 16. 17; Pocobelli 2010/2011, 118 fig. 2) and resemble certain rock-cut dwellings or probably underground chambers from Sorrina Nova, revealed in the magnetometry (see Mastroianni 2014, esp. 1523 fig. 4. 5).

105 For findings and features related to water channels in different parts of the plateau, see Bendinelli 1921, 352 f.; Papi 2000, 116–119; Moretti Sgubini 2006, 341; Carosi et al. 2017, 283; Moretti Sgubini 2017b, 74 f. note 38.

106 See above § 27.

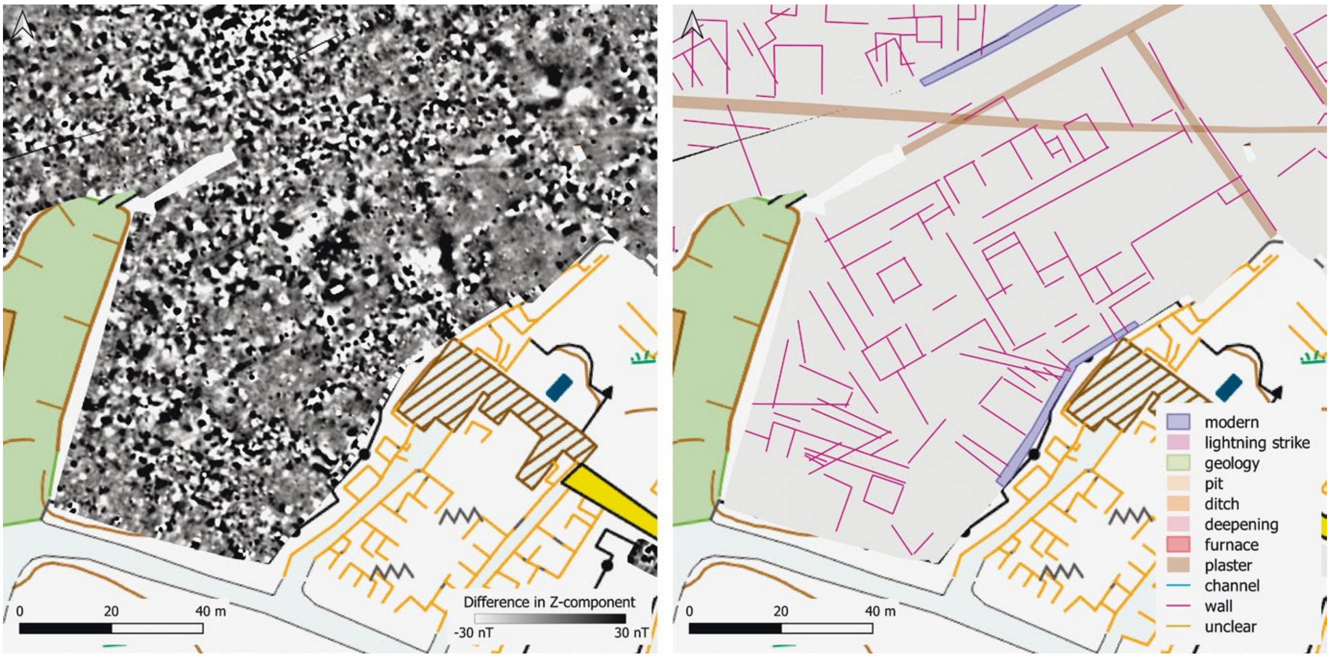

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Fig. 33: Vulci, details of possible roman domus (left: magnetic data; right: interpretation)

different magnetic properties, e.g. a mixture of basalt, limestone and tuff, as seen in the local opus caementicium (Fig. 30) or the use of bricks, both pointing to a Roman date, which is also confirmed by surface finds and the layout of the buildings, often larger units organized around courtyards. The excavations along the so-called decumanus and cardo, e.g. the domus del criptoportico (2nd/1st century B.C. with renovations in the Julio-Claudian period[107]) and GPR measurements to the west of the domus del criptoportico and between the cardo and the edge of the plateau seem to corroborate this impression. In the latter case, the GPR measurements of the BSR, University of Gothenburg and the Swedish Institute of Classical Studies in Rome showed several buildings with orientations and groundplans consistent with a Roman occupation[108]. Between the tempio grande and the domus del criptoportico Maurizio Forte and his team interpret an impluvium, and to the east, less evident, a peristyle[109]. It could be that the settlement activity was probably concentrated in this area at the time, although not exclusively.

55 Some walls overlap one another and the road system, linked to the east-west street, which runs parallel with the so-called decumanus (belonging to the red system; Fig. 29); this street – with due caution – could, therefore, have preceded the building and been obliterated by it.

56 In the western area of the plateau (in particular, north-west of the new temple and south-east of the porta nord) or at the highest point of the so-called acropolis, certain anomalies point to small buildings, which are more difficult to categorize (Fig. 34) and which were not visible in aerial photography[110]. Some of them do not seem to fit in a coherent system and are concentrated in different clusters, mostly around elevated positions, thus, they eventually represent a peculiar, fragmented occupation of selected areas of the plateau, in phases not directly connected with one of the two proposed street systems. Others seem oriented to the red street system.

107 Paglieri 1959.

108 Kay et al. 2021a; Sabatini et al. 2021a; Sabatini et al. 2021b.

109 See Forte et al. 2020, 20 f. fig. 1.4–1.7; 28 fig. 1.13; Forte et al. 2022, 8 fig. 6; 9 fig. 7; 11 f.; 15 fig. 13.

110 See, for example, Pocobelli 2003, 154 fig. 179; Pocobelli 2004, 135 fig. 8; Pocobelli 2010/2011, 122 fig. 6, where only the structure directly behind the new temple is clearly visible.

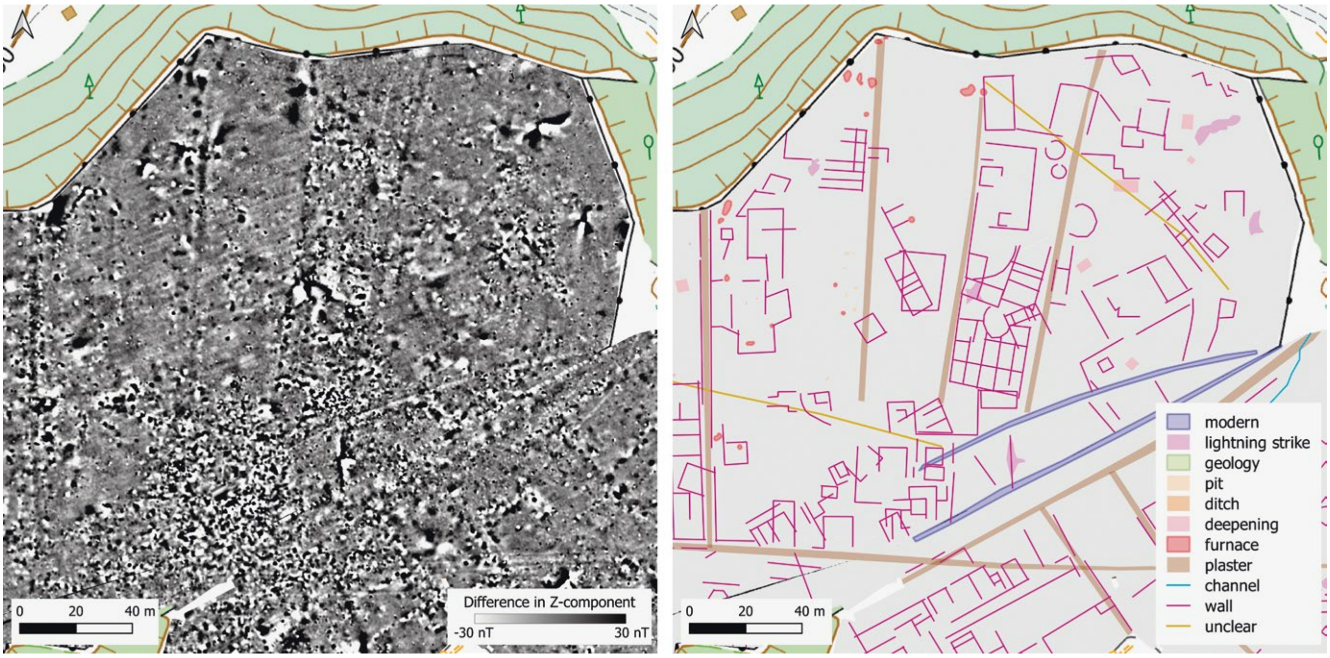

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Fig. 34: Vulci, the residential area in the western part of the plateau (left: magnetic data; right: interpretation)

The Sacred District

57 West of the tempio grande, a new temple, measuring circa 40 m × 27 m[111], as well as another public or sacred building[112] (22 m × 13 m) to its south were discovered (Fig. 22. 23). The three buildings seem to have formed a »sacred district« immediately north of the so-called decumanus (Fig. 22. 23. 35). Both the new temple and the smaller building at the decumanus can be observed in the GPR[113], showing considerable preservation and thus the possibility of encountering intact archaeological stratigraphy. This and the preservation of the temple to a depth of 2.5 m were, indeed, confirmed during the excavations of 2021 and 2022[114].

58 Although the newly discovered temple is oriented towards the decumanus, it does not connect to it and has a different orientation from the other sacred buildings. It is relatively striking that all three buildings of the sacred district are oriented differently, and it seems that the two monumental temples, in particular, do not fit well into the surrounding street system. The comparison with Veii or Tarquinia[115], where the monumental structures are likewise not always aligned with one other and/or with the street grid, suggests that the different orientations could be shaped by other ritual or functional needs or that the different directions are dependent on the successive rebuilding phases of the city.

111 We do not wish to get into the debate here as to whether the tempio grande could be the temple excavated by Campanari (see Moretti Sgubini 1997, 163 with note 77, who is opposed to this theory and Buranelli 1991, 238–250 who is in favour of it; see a reassessment of the Campanari excavations in Franceschini – Pasieka 2021, 355–361). However, we would like to dispel the argument that the new temple could be the Tempio Campanari. On the one hand, the dimensions calculated so far do not match those given by Campanari, namely, 150 × 90 Roman palms or those calculated by Buranelli 1991, 242 (44.35 m × 27.2 m) and by Moretti Sgubini 1997, 163 note 77 (33.50 m × 20.55 m). On the other hand, during the first excavation campaign in the summer of 2021, we discovered an intact ancient stratigraphy and nothing that would indicate 19th century excavations; see Franceschini – Pasieka 2022a; Franceschini – Pasieka 2022b. Thus, it can be safely assumed that the new temple has not been previously excavated.

112 Even if part of the smaller building is visible in the section of the excavation trench of the tempio grande, this has until now been ignored, but for a brief mention in Bartoccini 1963, 9.

113 See above § 37–39.

114 See above § 40–43.

115 For Veii, see Campana 2019, 31 pl. 3; for Tarquinia, see Bagnasco Gianni et al. 2018b, 299–303. 336 f. fig. 16. 18.

Fig. 35: Vulci, the proposed reconstruction of the sacred district with aerial photos of the area and of the excavation trench 2021–2022

35

59 The basic structure of the new temple can be compared, both in terms of plan and proportions, with some well-known temples from other Etruscan cities and points to the architectural form of Graeco-italic peripteroi. These include the neighbouring tempio grande, reconstructed by Giuseppe Sassatelli and Elisabetta Govi as a tetrastyle peripteros with six columns at the sides and five columns at the back[116], which, according to some architectural terracottas found nearby during its excavation, has a first phase in the late 6th century B.C.[117]. Furthermore, the temple of Tinia in Marzabotto and temple B in Pyrgi are suitable comparisons, although smaller. Both are peripteral buildings: the Tinia temple dates from the early 5th century B.C.[118]; temple B at Pyrgi from the late 6th century B.C.[119]. After the preliminary analysis of the excavation data, the new temple would also date to the end of the 6th or beginning of the 5th century B.C.[120].

60 While the new, late archaic temple was spoliated in the Early Imperial Era, the small public or sacred building to its south corroborates with a presumed Augustean phase of the tempio grande[121], a continuation of this sacred quarter in the late Republic

116 Sassatelli – Govi 2005, 31 f. fig. 16. In contrast, Giovanni Colonna had reconstructed the temple with two rows of columns in the front in the 1980s, see Moretti Sgubini – Colonna 1985, 79.

117 Moretti Sgubini 1997, 154–161; Moretti Sgubini – Ricciardi 2001b, 180 f.

118 In addition, structures from the last decades of the 6th century B.C. have been found under the temple; see Sassatelli – Govi 2005, 33 f.; Sassatelli – Govi 2010, 32 f.

119 Colonna 1985b, 128.

120 Franceschini – Pasieka 2022a, 59 f.; Franceschini – Pasieka 2022b, 141 f.

121 Moretti Sgubini – Colonna 1985, 78; Buranelli 1991, 246; Moretti Sgubini 1997, 151–153.

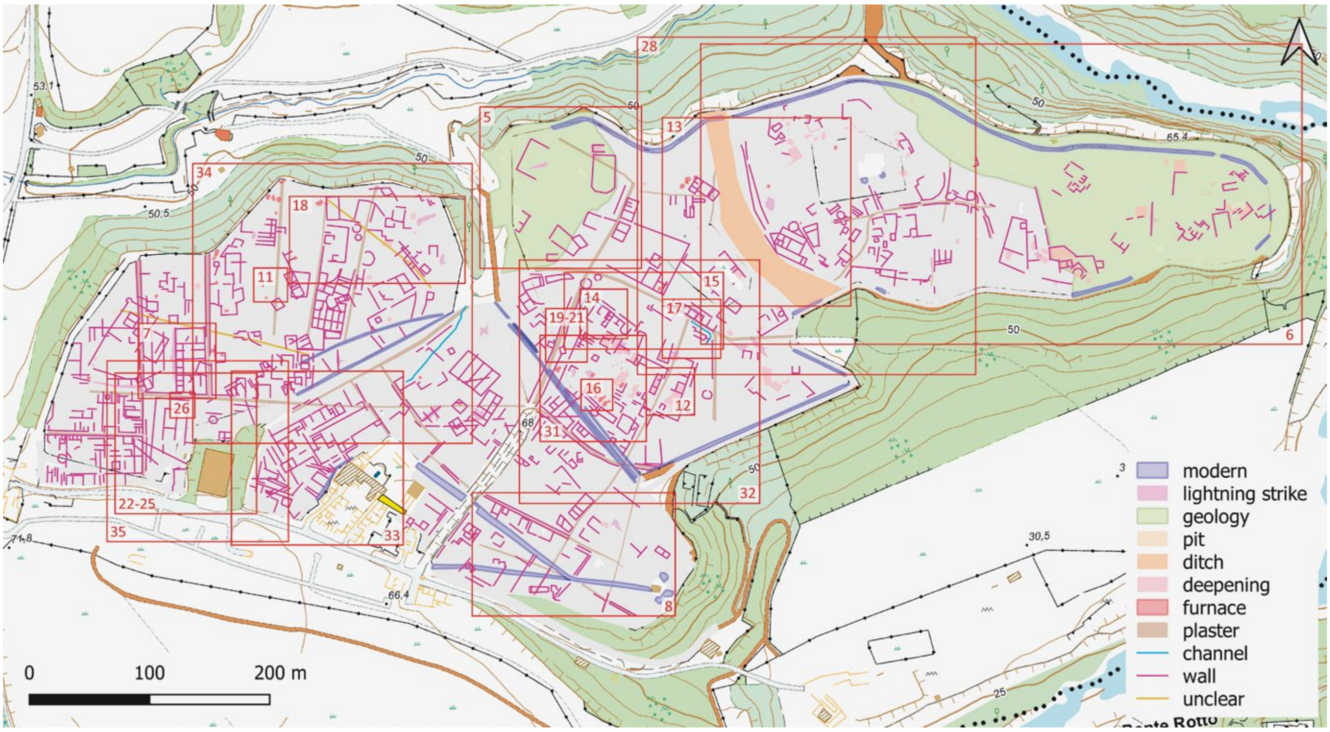

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Fig. 36: Vulci, positions of the individual figures in the general plan

and Imperial period. The visible part of the east side of the building shows masonry and pillars of opus caementicium, covered with limestone ashlars, which indicate a late Republican or Imperial date. The west and north wall, as well as the west pillars of this building, stand out very clearly from a geophysical perspective (Fig. 22. 23). This suggests a rather hypothetical reconstruction of a small peripteros sine postico, which suggestively recalls the model of a small temple from the votive deposit of the porta nord – without suggesting an identification –, with angular columns on the façade and half-columns on the walls, dating back to the 2nd century B.C.[122].

Reassessing the Cityscape of Vulci: New Perspectives on Etruscan Urbanism

61 The results of the geophysical surveys not only changed our ideas of the cityscape of Vulci, but also contributed to a better comprehension of Etruscan urbanism in general, particularly with regard to the internal organization of the city and to the significance and layout of sacred spaces. We gained, for the first time, a detailed georeferenced plan of Vulci's northern area, which differs significantly from former attempts[123] and which allowed us to define various functional spaces (Fig. 36).

122 For the model: Staccioli 1985. A quotation from Bartoccini (Bartoccini 1960, 20) regarding the three models from the deposit: »I tre pezzi ci danno quasi l'idea di edifici di una probabile piazza di Vulci (tav. XII, 4), dominata dal tempio a cella unica inquadrato da due portici, giacché di un secondo simile al primo si è recuperata una sola fiancata, unico elemento superstite. Tengo a dire che non si tratterebbe di una mia arbitraria supposizione, giacché un complesso di questo genere ha quasi un riscontro a Fiesole, ove quegli scavi hanno rimesso in discussione la questione del tempio a triplice cella, finora ritenuto tipico degli Etruschi«.

123 Contrary to the aforementioned plan elaborated by Pocobelli using aerial photographs (Pocobelli 2003, 149 fig. 269; Pocobelli 2004, 134 fig. 8) or the plan, in which Forte combined his prospection results (which are mostly based on the same old aerial photos and on GPR surveys combined with a few additions from multispectral images) with those of Pocobelli (Forte et al. 2022, 10 fig. 8; 16 fig. 14). Due to difficulties in georeferencing old aerial photos, the orientation and structure of most archaeological evidence differ significantly from our plan.

62 The main streets, especially the so-called decumanus and cardo, follow the terrain and, above all, connect the natural approaches to the plateau; they do not seem to have changed over time (in green in Fig. 29). Although a certain regularity can be observed in the streets, which is mainly reminiscent of a herringbone pattern, the streets nevertheless do not have a strict orthogonality. This peculiarity seems to be rather typical of Etruscan and Italic settlements and can be compared with the situation in Veii[124] and Tarquinia[125]. In Gabii, the central axis follows the morphology of the volcanic crater of Lago Castiglione and creates a quasi-orthogonal raster with the secondary streets, which was developed ex-novo at the end of the 5th century B.C. and then renewed several times[126]. In Tarquinia, preliminary excavation results indicate that the street system was laid out in the late 6th or early 5th century B.C.[127]. A fundamental redesign with the creation of an orthogonal street network can be traced in Veii in the area of Piazza d'Armi around the middle of the 7th century B.C.[128]. These examples suggest a reorganization that has radically changed the perception and division of the physical space of the cities and their street system. It is not yet possible to date the red system in Vulci and although it appears to respect both temples, further excavations will clarify whether it could possibly belong to a wider phenomenon of monumentalization of urban spaces in central Italy in the late Archaic period. One could, however, relate these interventions to demographic or social changes[129] and it will be one of the goals of this project to define the challenges or transformations that led to a particular urban solution and to the reshaping of the street grid.

63 The sacral topography of Vulci is strongly connected to traffic routes, both in and outside of the city, and to the gates[130]. Important sacred spaces intra muros are, to name just a few: the votive deposit at the porta nord[131], the sacello di Ercole[132] and the new sacred district, which can all be found along the main urban streets. Both monumental, late archaic temples are oriented towards the so-called decumanus and occupy a central elevated position, facing south and ideally towards the sea (even if it was not visible from the temples). Their monumental silhouette may have dominated the cityscape of Vulci and have significantly shaped the visual and ritual perception of the city – also from a diachronic perspective. Current evidence suggests that both temples were erected at roughly the same time in the Late Archaic period[133]. In Roman times, the smaller cult building in the south was added to the ensemble, an Augustean renewal has been assumed for the tempio grande[134] and at some point, in the Early Imperial Era, at the latest, the »new« temple fell into ruin.

64 The discovery of a new temple next to the tempio grande hints at a complex ritual landscape (Fig. 35). Adding a new urban temple to the core of the cityscape of Vulci is reminiscent of other sacred districts with two adjacent temples in Etruscan cities, such as those in Volterra[135] and Pyrgi[136] or the sanctuary of S. Antonio in Cerveteri[137]

124 See Campana 2019, tab. 1–3.

125 See Bagnasco Gianni et al. 2018a; Bagnasco Gianni et al. 2018b, 336 f. fig. 16. 18; Bagnasco Gianni et al. 2021, 185 fig. 13.6.

126 See Mogetta et al. 2019, 1 f. fig. 1, 4. 5; Johnston – Mogetta 2020, 92–94.

127 Marzullo 2018, 79 f.

128 Acconcia 2012, 15 f.

129 Bianchi 2017, 47 f.

130 Moretti Sgubini – Ricciardi 2001b; Moretti Sgubini et al. 2005.

131 Pautasso 1994; Moretti Sgubini – Ricciardi 2001b, 179. 182.

132 Bartoccini 1961, 265.

133 See § 41. 59.

134 Moretti Sgubini – Colonna 1985, 78; Buranelli 1991, 246; Moretti Sgubini 1997, 151–153.

135 Colonna 1985a; Bonamici et al. 2017 (with further bibliography).

136 Colonna 1985b; Colonna 2000; Baglione 2013; Baglione et al. 2017; Michetti 2021, 78–84 (with further bibliography).

137 Maggiani – Rizzo 2001; Maggiani 2008; Grummond 2021, 156 f. (with further bibliography).

or in Marzabotto[138]. These contexts show a diversified architectural spectrum which, nevertheless, share certain characteristics. The temples have, for example, the same orientation towards the sea or a main street (Fig. 35), thus underlining the relationship between sacral areas and traffic routes and in so doing, structuring both urban and rural spaces. Both temples in Caere date to the late 6th/early 5th century B.C.[139], the temple of Tinia and Uni in Marzabotto were built just a few decades apart, around the end of the 6th/beginning of the 5th century B.C.[140], while the temples of Pyrgi and Volterra were planned in a different time period[141], yet still respect the plan and the orientation of the former constructions. As in the other examples, it seems plausible that the two monumental temples of Vulci were coeval and dedicated to different gods. This ensured the religious representation of a larger part of the population, thus preserving social differences and preferences, creating a sense of inclusion for the wider public and contributing to social cohesion.

Conclusive Remarks

65 Through a multidisciplinary approach and the use of state-of-the-art geophysical prospection techniques, it was possible to propose a new reconstruction of the cityscape of Vulci, covering the entire urban area north of the so-called decumanus and providing a glimpse into the city's complex palimpsest, which spans more than 1,500 years.

37

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66 The use of two complementary methods, magnetometry (Fig. 37) and GPR (Fig. 38) in Vulci can be confirmed as thoroughly successful, providing evidence of several structures and functional areas and, in some cases, proposing a provisional chronological sequence of roads and structures and evaluating the way in which they interact and relate to one another. It was possible to identify part of the defensive system, as well as residential and productive areas. Most interesting, however, is the new sacred district that emerges near the tempio grande, where another monumental temple and

Fig. 37: Vulci, The multi-channel magnetometer system LEA MAX

Fig. 38: The pulseEKKO Spider GPR system

138 Sassatelli – Govi 2005; Govi 2018, 615–622 (with further bibliography).

139 Temple A – which also has an earlier phase dating back to the first half of the 6th century B.C. – dates to the late 6th and early 5th century B.C. (Grummond 2021, 156 f.), as well as temple B (Izzet 1999/2000, 144–146).

140 Govi 2018, 616 f.

141 For Pyrgi, see Colonna 1985b, 128 f.; Baglione et al. 2017; Michetti 2021, 78–94; for Volterra, see Bonamici et al. 2017, 55 f. 58 f.

a smaller building occupy such a prominent place in the centre of the city. Thus, we had to change our picture of the spatial organization of spaces, physically divided and organized via street systems, and were also able to highlight how functional clusters can be integrated and interwoven into an urban system. The combination of the two geophysical methods, together with archaeological excavations, is especially effective, revealing complementary features. While the use of large-scale magnetometry made it possible to trace the urban structure of the northern area of Vulci, the GPR made additional structures visible and showed a high level of detail. Furthermore, the discovery of hitherto unknown monumental buildings and the detection of various functional areas indicate the potential of breaking away from the small-scale, site-oriented approach, and the value of using geophysical survey technologies to identify larger areas or even whole cities.

67 The excavation of the temple confirmed the results of geophysics, laid the foundation for a further systematic refinement of geophysical technologies, and connected the spatial layout with its diachronic development. The integrated use of non- or minimally invasive methods, as well as targeted excavations, which are also planned for the future, promise to decisively enrich our picture of the ever-changing cityscape of Vulci. The aim must be to obtain a picture of a versatile city in which different functional areas are intertwined, are related to larger archaeological and historical developments, and evolve over the centuries as breathing organs of the city structure.

Acknowledgements

68 Our first and heartfelt thanks go to Simona Carosi and Carlo Casi and to the institutions they represent – the Soprintendenza Archeologia, Belle Arti e Paesaggio per la provincia di Viterbo e per l'Etruria meridionale and Fondazione Vulci, Parco Archeologico e Naturalistico di Vulci, respectively – for believing in the project from the very beginning, and for their tireless and constant support. Gratitude is owed, moreover, to the Fritz Thyssen Stiftung which generously funded the project over the years (Az. 20.19.0.028AA and Az. 20.21.0.0055AA) making both the geophysical prospections and the first excavation campaign possible; similarly the Gerda Henkel Stiftung generously supported our second excavation campaign 2022 (AZ 20/V/22). We wish to thank the departments of Archaeology of the Universities of Mainz and Freiburg for their help and support; in particular, we would like to thank the Top-level Research Area 40,000 Years of Human Challenges: Perception, Conceptualization and Coping in Premodern Societies of the JGU Mainz and the members of the Thematic Area 3 – Urban Agglomerations for the support, the stimulating inputs and fruitful discussions. For the helpful discussion regarding the defensive system, we warmly thank Sophie Helas. A warm and fond thank-you goes to the staff of the archaeological park for their invaluable support. Heartfelt thanks also go to the other members of the Eastern Atlas team, who undertook the survey in September 2020: Annika Fediuk, Ronald Freibothe and Henning Zoellner. Last but not least we wish to warmly thank our team, who have enriched the first two of many future excavation seasons: Melina Angermeier, Manuela Battaglia, Julian Brosius, Julius Bussilliat, Quirin Eimer, Cai Ellrich, Roland Frank, Jessica Hahn, Eliza Hernández Osorno, Felicitas Kandler, Maki Müller-Quade, Katharina Oppelland, Laura Rausch, Thomas Schmidt, Laura Schmitt, Philipp Schug, Nadja Schulz and Alexandra Wiesbeck-Klein.

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METADATA

Titel/*Title*: The Hidden Cityscape of Vulci. Geophysical Prospections Providing New Data on Etruscan Urbanism

Band/*Issue*: AA 2023/1

Bitte zitieren Sie diesen Beitrag folgenderweise/*Please cite the article as follows*: M. Franceschini – P. P. Pasieka – J. Meyer – B. Ullrich, The Hidden Cityscape of Vulci. Geophysical Prospections Providing New Data on Etruscan Urbanism, AA 2023/1, § 1–68, https://doi.org/10.34780/m6af-c144

Online veröffentlicht am/*Online published on*: 15.11.2023

DOI: https://doi.org/10.34780/m6af-c144

Schlagwörter/*Keywords*: classical archaeology, urban archaeology, Italy, Etruria, Vulci, geophysical prospection, urbanism

Bibliographischer Datensatz/*Bibliographic reference*: https://zenon.dainst.org/Record/003050322