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Articles

Montarice (Porto Recanati, MC, Italy): reconstructing long-term occupation history using legacy records and recent non-invasive data

Wieke de Neef

Wieke.de-neef@uni-bamberg.de – University of Bamberg (Germany),
Institute of Archaeology, Heritage Conservation Sciences, and Art History (IADK) /
Ghent University (Belgium), Department of Archaeology

Elisa Paolini

elisapaolini@cnr.it - Consiglio Nazionale delle Ricerche (Italy),
Institute of Cultural Heritage Sciences (CNR-ISPC) /
Sapienza Università di Roma (Italy), Department of the Sciences of Antiquity

Abstract

This paper discusses the challenges of integrating legacy and new research data in the study of the multiperiod settlement site of Montarice at Porto Recanati (Marche, Italy). The site was discovered in the early 1970s and has since seen a series of invasive and non-invasive fieldwork to document its occupation history. Until now the various data collected during these endeavors have not been integrated, and large parts of the legacy data remain unpublished. A new research collaboration between the Universities of Ghent (Belgium), Bamberg (Germany) and Sapienza – Roma (Italy), supported by the SABAP-Marche Sud, the Museo Nazionale delle Marche, and the municipality of Porto Recanati aims at collecting all available archaeological and archival records of Montarice. Our final goal is to reconstruct the long-term settlement history of this coastal hilltop, from the earliest Palaeolithic evidence to the site's final abandonment in the Middle Ages. The most intensive period of occupation was in the Middle and Recent Bronze Age, as is attested by surface material and the records of an unpublished excavation in the 1970s. Here we present a first outlook on this new project, highlighting the various datasets we work with and how they mutually inform each other. We also discuss the first results of our studies of the protohistoric settlement phases.

Keywords

Landscape archaeology, Holocene landscape formation, artefact survey, geophysical prospection, Bronze Age

1. Introduction

This paper discusses the potential of integrating legacy and new multidisciplinary research data in the study of the multiperiod settlement site of Montarice at Porto Recanati (Marche, Italy). The incorporation of analogue information from (unpublished) older fieldwork with new digital datasets is a nontrivial issue in archaeological studies. As archaeological data acquisition is becoming more and more digital, dealing with analogue plans, diaries, and documents requires reflection on how we transform them into formats that we can integrate with other, non-analogue data (Allison 2008; Richards-Rissetto - Landau 2019). These non-analogue forms may consist of 'natively digital' datasets (primary data that is collected in digital form, for instance GPS positioning or geophysical data), but also analogue items that have been processed with various software into a new, derived digital format (such as pottery distribution maps, or photogrammetry). Legacy archaeological datasets often remain 'shadow data' as long as they cannot be turned into useful evidence for current research questions and integrated with newer, digital data that is collected to answer them. Yet such unlocked data often includes important information that, if accessed, can broaden our understanding of past sites and landscapes. In an epistemic discussion of the potential of archaeological shadow data, Wylie (2017) points to the capacity of archaeologists to use and reuse extremely fragmented evidence in their interpretative models. She proposes three avenues in which such legacy or shadow data can be put to use: extracting new information from legacy materials (f.i. isotope analysis on previously excavated burials), recontextualizing data (f.i. re-considering standard typologies by incorporating legacy contexts), and experimental simulation using large, combined datasets. In a discussion of digitally-mediated practices in archaeology, Richards-Rissetto and Landau (2019) emphasize how such integration of analogue shadow data should start in the first place from reflexive thinking about our general data handling.

How do we put such epistemic considerations into practice in the study of a protohistoric settlement in Central Adriatic Italy? We have little guidance: case studies on combinations of analogue and digital datasets at relatively small, non-urban contexts remain rare, especially in Italy, where large, centralized settlements or urban centers remain at the center of archaeological enquiry (De Neef 2016; 2023). Most studies on the practical use of legacy 'shadow' data consider broad spatial and chronological contexts: regional archaeology projects which predominantly produce digital datasets analyzed in GIS environments (Witcher 2008; Vermeulen 2012; Brancato 2020), or targeted site studies where multiple invasive and non-invasive recording techniques have been applied. The latter usually focus on large, urban and/or monumental sites where non-invasive prospection and recording techniques provide a new spatial dimension for intra-site analysis (Venter *et al*. 2017; Hoffelinck - Vermeulen 2021). Montarice is an excellent representative of an underrepresented archaeological site type to discuss interpretative and epistemic aspects of the use of unpublished legacy excavation data from the 1970s in combination with non-invasive prospection datasets acquired after 2000. Regarding Richards-Rissetto and Landau's (2019) call for reflexive data handling, we found the key in being explicit about our research goals, and being pragmatic about the limitations of each of our digital and analogue datasets. Moreover, we found ways in which we could extract new information from the old data following Wylie's (2017) suggestions – in this case by putting Montarice in a wider environmental and economic framework of livestock management and mobility through zooarchaeological and isotope analysis of bone material.

At Montarice, we were confronted with the poor compatibility of our various datasets, but we also learned to apply Wylie's (2017) optimism about the evidence hidden in the legacy data. Merely reconstructing the original position of old excavation trenches proved insufficient to incorporate the trench plans and excavated materials with the spatial information from subsequent field walking, geophysical surveys, and aerial photography. We quickly realized the intrinsic level of uncertainty in the legacy data due to missing metadata: there is no accurate positioning; the excavation diaries, section plans, and level drawings are recorded in difficult handwriting; there is no record of material collection strategy or the rules according to which the excavation finds were ordered in three groups of diagnosticity ('selected' (*scelto*), 'also selected' (*anche scelto*), and 'not selected'). Making sense of the 1970s documentation required not just a simple transformation of material and paper information to accessible and quantifiable digital data in a database and GIS, but also an active translation and interpretation of excavation and recording choices. Thus, we did more than merely creating new digital versions of old analogue information ('digitization'): we actively transformed it into something we could use for our own purposes. This creation of new data by processing and interpreting analogue items is what Richards-Rissetto and Landau (2019) call 'datafication', thereby pointing out the need for archaeologists to reflect on the choices and documentation thereof when they undertake such transformations, creating new metadata in the process. In our case, this means that we had to be explicit about the contribution of an excavation conducted in the 1970s to our project to reconstruct long-term occupation of a relatively small, non-urban settlement and its direct surroundings. As we will discuss further below (section 4.6), this contribution can be divided in two main components: first, enhancing the chronological and functional detail of the main occupation phases; and second, providing a baseline to assess the impact of mechanized agriculture on the archaeological record since the 1970s. This second point helps us to reiterate our interpretations of the (near-)surface archaeology at Montarice by taking into account the progressive degradation of the site. Before we elaborate on our current project (sections 5 and 6 below), we first present the scholarly context (section 2), environmental background (section 3), and research history (section 4) of Montarice.

2. Montarice and the Potenza Valley Survey

Until today, the low hilltop plateau of Montarice (Fig. 1) is the most intensively studied pre-Roman site in the Potenza Valley Survey (PVS) of Ghent University (Belgium), but the site was known and investigated already in the 1970s. It is atypical in the PVS dataset: it is the only site with long-term (if not continuous) occupation between the Palaeolithic and the Middle Ages,

Figure 1 – The archaeological area of Montarice seen from the south, photographed from a small aircraft. The motorway separates Montarice (right) from the ridge of Colle Burchio (left). River Potenza is visible at the base of the hill, the town of Porto Recanati in the right. In the far distance is the Conero limestone massif, looking out over the Adriatic Sea (photograph Frank Vermeulen).

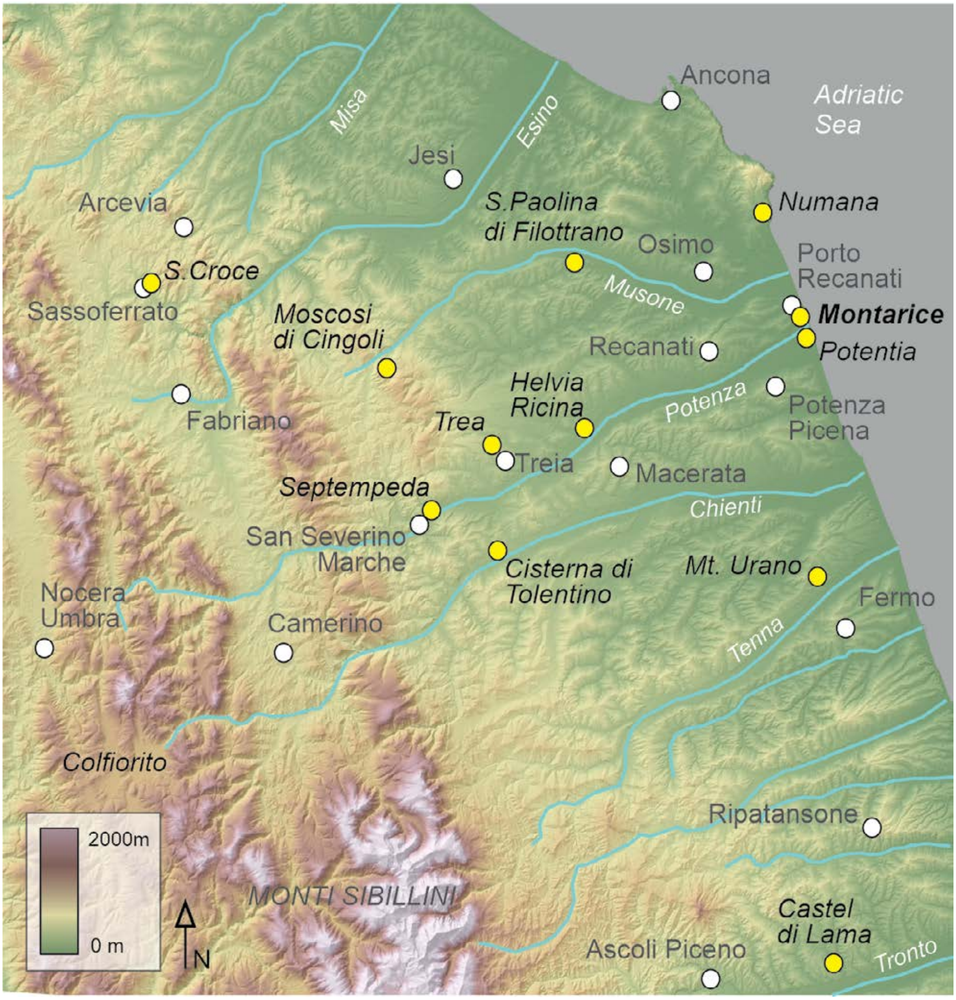

Figure 2 – Map of the central Marche region with the location of Montarice along the coast near Porto Recanati. Archaeological sites mentioned in the text are indicated with yellow dots; present-day towns with white dots.

with its zenith in the Bronze Age. Although the PVS had a diachronic approach and recorded remains from all periods, especially in later years the focus of the project gravitated towards the Roman periods and the Romanization processes in the centuries before the Roman conquest. Indeed, the non-invasive approach combining artefact surveys, aerial reconnaissance, and geophysical surveys proved very effective in mapping and analyzing the archaeological record from these phases, for instance in the detailed maps of the Roman towns of *Septempeda*, *Helvia Ricina*, and *Trea* (Vermeulen *et al.* 2017; see also Vermeulen - De Neef 2024). In later years the Ghent University research focused on the excavations and full mapping of the coastal colony of *Potentia* and its immediate surroundings. Despite this increasingly Roman focus, Montarice remained a key site in the PVS because of its location in the direct vicinity of *Potentia* (Fig. 2). As such it provides an ideal context to study the impact of Romanization and the foundation of the colony on indigenous settlement along the Adriatic coast.

The starting point for our current project is the non-invasive work conducted by the PVS and of a recent spin-off project on pre-Roman settlement in the Potenza Valley (Vermeulen *et al.* 2017; De Neef – Vermeulen 2018). Over the years these produced surface artefact distributions at various resolutions, geophysical data, geoarchaeological information, and aerial imagery that provide a good overview of the site's internal layout. Our current project unlocks the survey and artefact inventories of the 2002 Montarice surveys which were incorporated in a Dutch-language, unpublished PhD thesis (Boullart 2006) and only partly published in PVS output (Boullart 2003; Percossi *et al.* 2006; Vermeulen *et al.* 2017).

The PVS spin-off project 'Neighbours and Nobles' started with a re-study of the unpublished protohistoric material from Montarice (De Neef 2017), and from there expanded into a six-year landscape-archaeological study of Bronze and Iron Age settlement in the Potenza Valley and beyond through non-invasive prospection methods (De Neef - Vermeulen 2018). This included a complete re-survey (2019) of Montarice at a higher resolution to allow a better spatial integration of the surface distributions with the geophysical surveys and aerial imagery. In the course of the spin-off project the legacy data and find material from the first archaeological work at Montarice in the 1970s became available for study. This material of exceptional quality provides important clues on the subsistence economy, crafts, and exchange networks of the protohistoric community living on and around the hilltop.

Fifty years after its discovery and 20 years after the first artefact survey, we thus dispose of multiple datasets of varying resolutions which so far have not been integrated and studied as a whole. This is the task we now set ourselves. In this article we provide an overview of the available sources at our disposal and present the first results of the ongoing material studies of the Bronze Age occupation phases. First, we place Montarice in its landscape setting and discuss the formation processes that shaped the changing environment of the coastal zone (section 3). In section 4 we elaborate on the research history of the site, connecting the Ghent University non-invasive studies with the observations from the 1970s excavations and surface collections by Delia Lollini of the cultural heritage authorities (Soprintendenza Archeologica delle Marche). Then we move on to our current project, presenting our approach to the data processing and integration of the various datasets. The last part of this article presents the first results of the material studies (section 5) and an outlook to future work.

3. Landscape and archaeological setting

Montarice is a low plateau (ca. 54 m a.s.l.) situated on the outskirts of the present-day town of Porto Recanati (MC, Marche), at a distance of ca. 1 kilometer of the current Adriatic coastline (Fig. 3). It has relatively steep slopes to the north and south and a gentler descend towards the east. Its western connection to the adjacent Colle Burchio is cut by the Autostrada A14, the construction of which in the 1960s undoubtedly obliterated relevant archaeological evidence. The hill overlooks the coastal zone of river Potenza which runs directly to the south, and has wide views of the broad lower valley towards the opposite hill ridge of Potenza Picena and Monte dei Priori, where another Bronze Age site is located (Vermeulen *et al.* 2017: 207-208; Fig. 3). The alluvial coastal plain contains up to 40m of clastic sediments (Calderoni *et al.* 2007; Centamore 1986; Cilla and Dramis 1999). The remains of former beach ridges, running parallel to the present-day coastline, are buried under alluvial clay deposits. Previous coring

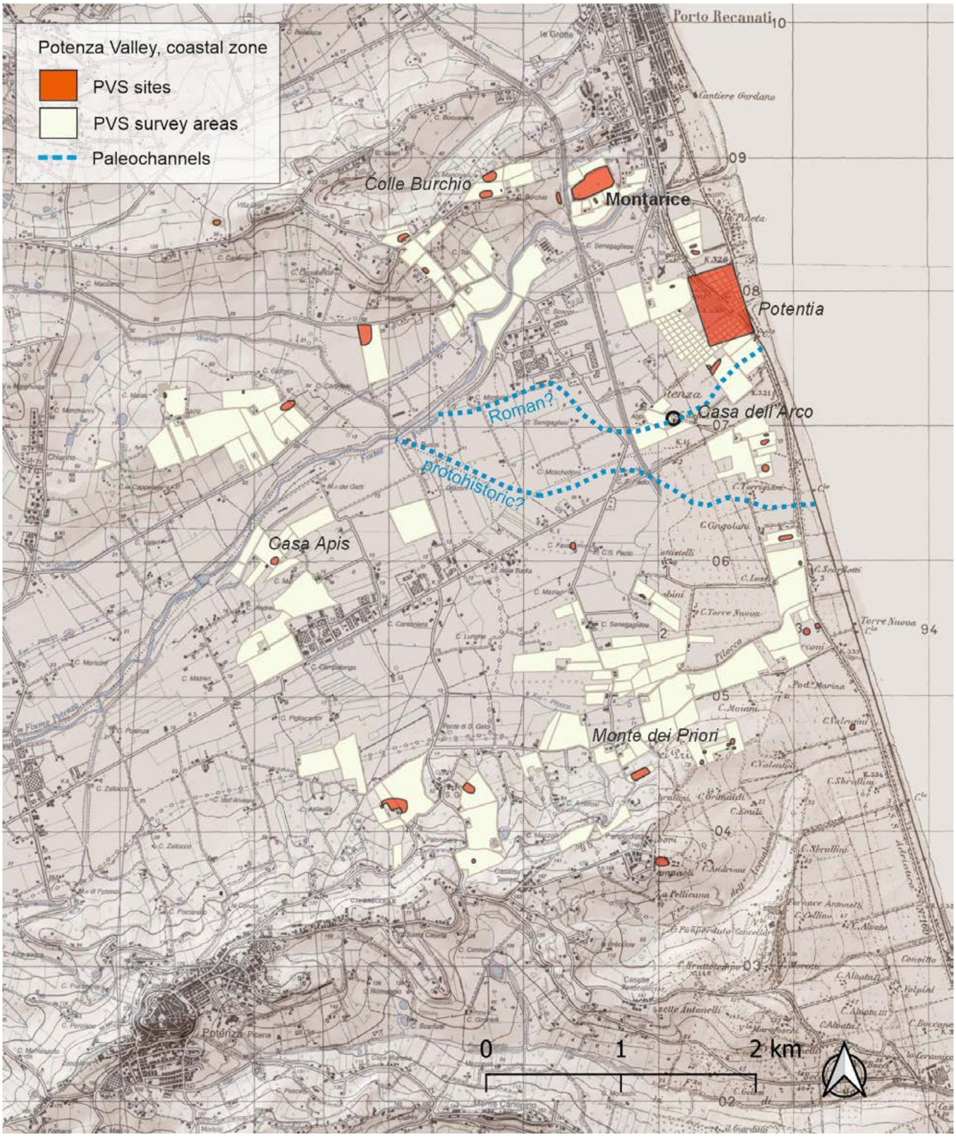

Figure 3 – The coastal zone of river Potenza. PVS sites and survey areas are indicated; hypothesized past courses of the Potenza are outlined by dashed lines (after Goethals et al. 2009). Background is the IGM 1:25.000 toporaphic map.

campaigns have established the presence of former coastal lagoons behind these beach ridges (see below; Goethals *et al.* 2009: 432).

Montarice is the easternmost part of a long ridge running towards the town of Recanati. It consists of upper Pliocene to lower Pleistocene blue clays and sandy clays of the *Formazione delle Argille Azzurre* (FAA) on top of which lower Pleistocene sandy clay, clayey loams and loamy sands of the Formazione di Fermo (FEM) are deposited (Taelman *et al.* 2017: 49). These dip towards the S-SE as the result of regional uplift. The top of the ridge consists of the remnants of lower Pleistocene marine terraces, with gravel deposits up to 15 m thick (Massari *et al.* 1986; Goethals *et al.* 2005: 41). Continuous agricultural activity has impacted on the soils formed in these terraces: only shallow soils are preserved on the highest, western part of Montarice where marine terrace gravels are actively being ploughed out. The ridge ends in an inactive cliff with abrasion platforms at the base (ca. 5-6 m a.s.l.), now in a densely built residential part of Porto Recanati.

The coastal landscape of Montarice has changed drastically during the Pleistocene and Holocene, influenced by natural processes such as climate changes, but also by (indirect) human impact. To understand the environmental setting of the hilltop during various archaeological phases, it is essential to briefly describe the long-term landscape formation processes. The present-day situation is the result of long-term fluvial and coastal aggradation, while the hilltop itself is impacted by agriculture and slope wash. River aggradation characterized the dry and cold Younger Dryas phase of the late Pleistocene, fueled by sediment transport related to slope erosion. The much denser vegetation during the warmer and humid phase of the Early Holocene Climate Optimum (until ca. 6000 BP) decreased the erosion processes and related sediment supply, which in turn resulted in river incision (Calderone *et al.* 2007; Cilla and Dramis 1999: 78). A climate transition to a colder and drier phase occurred between 6000-5000 BP and lasted until ca. 3500 BP, covering the period between the Late Neolithic and the Middle Bronze Age. As a result of the decreased vegetation cover in this colder phase, erosion and related river aggradation increased again. Around the same time, ca. 5000 BP, the sea level of the Adriatic reached its maximum (Elmi *et al.* 1994; Corregiari *et al.* 1996; Oldfield *et al.* 2003). The Adriatic coastline during this phase was of the Atlantic type, with steep cliffs alternated by river outlets. During the Chalcolithic and Early Bronze Age (ca. 5000-4000 BP) we may therefore imagine Montarice as a coastal cliff top directly on the coast. During this phase a beach ridge was formed at the river mouth just south of the hill. Geoarchaeological work by the PVS established that the ca. 300 m wide beach ridge is asymmetrical, with a steeper sea-ward slope and a gentler inland slope (Taelman *et al.* 2017: 57; fig. 36). OSL dates of auger samples place the formation of the beach ridge in the 4th millennium BCE, starting after 5040 ± 35 BP (3953-3713 cal BCE). This date marks the transition from marine sedimentation (heavy clays) to fluvial inputs (sandy loam), explained by a decelerating sea level rise combined with regional uplift (Goethals *et al.* 2009: 432). The top of the beach ridge was formed between 4.400 ± 500 BP and 3.500 ±400 BP-3.300 ± 500 BP. In 184 BCE the Roman town of *Potentia* was founded on top of this former beach ridge.

Despite a warmer period in the Middle and Late Bronze Age (ca. 3500-3000 BP), vegetation and forests did not recover but instead dramatically decreased (Giraudi 1998; Taelman *et al.* 2017: 46). An indirect indication is the lack of new travertine deposits in the Apennine inland during this phase (Cilla *et al.* 1994). Travertine deposits are a typical phenomenon of the central Adriatic Apennines during the early Holocene climatic optimum, when Mediterranean thermophile forest vegetation and thick brown-calcic soils lead to large amounts of CO_2 in the atmosphere. In summary, excess CO2 enters groundwater through precipitation, where it contributes to the dissolution of limestone and subsequently the deposition of travertine around natural springs. This process comes to a halt between 6000-3500 BP, indicating the onset of a colder, drier phase. The decline in travertine deposits in the entire central Adriatic Apennines suggests that this is part of a wider environmental development (Cilla – Dramis 1999: 81; Calderoni *et al.* 2007). The absence of new travertine formation after 3500 BP, during the

Middle and Late Bronze Age, indicates a lack of excess CO2 despite a warmer period favorable for plant growth. Although it is difficult to determine the extent of human impact on these processes, increased exploitation of woodlands and pastures in the Apennines may have been a decisive factor (Cilla *et al.* 1994). These anthropogenic alterations of the natural environment have been linked directly to vegetation changes and increased erosion in different parts of Italy (Sevink *et al.* 2019 for southern Italy; Magri – Sadori 1999; Ramrath *et al.* 2000; Sadori 2018 for the central Tyrrhenian). Similarly, mass sedimentation acceleration starting around 3600 BP is attested in sediment cores taken the central Adriatic, as a result of surface processes related to forest clearance and intensified cultivation in Adriatic Italy (Oldfield *et al.* 2003). A similar phase occurred in the Middle Ages (starting ca. 700 BP). The related sediment supply from slope processes in turn resulted in renewed alluvial deposits in the valley floors as well as coastal aggradation. This latter process reinforced the formation of beach ridges in front of the coastal cliffs, as well as the gradual transformation of the coastal lagoons behind the beach ridges into marshlands and/or seasonal wetlands. The beach ridges and the wetlands directly behind them will have been an important factor in the accessibility and mobility in the coastal zone during the Bronze Age, and may also have provided landing places for ships. This latter point is not trivial, since the coast of Marche has no natural harbors except for the sheltered bays on the Conero promontory near Ancona and Numana.

The lower course of the river Potenza changed considerably during the Holocene, gradually migrating from the south to the central part of the plain between the Bronze Age and the Middle Ages, and then abruptly to the north (Fig. 3). Currently the river runs between the Roman town *Potentia* and the foot of Montarice in the northern part of the coastal plain. This course is artificial and was created by cutting an upstream alluvial fan, sometime after 355 ± 30 BP (1453-1635 cal CE; Goethals *et al.* 2009; Taelman *et al.* 2017: 62). Older river courses in the southern part of the plain were reconstructed using aerial photography, geomorphological studies, hand augering and electric resistivity surveys. Two main paleochannels can be distinguished in the aerial imagery. The southernmost of these consists of a meandering gravel bed in a 10 m wide transition zone and sandy riverbanks of ca. 20-30 m wide. The top of the gravel bed was OSL-dated 3600 ± 400 BP and thus coincides with the Bronze Age occupation at Montarice and the beach ridge which was formed in the preceding centuries (possible paleochannel labelled ‘protohistoric’ in Fig. 3). The second paleochannel runs directly south of *Potentia* in the central part of the coastal plain. It is crossed by a Roman bridge which is preserved in the foundations of an 18th century CE farmstead at Casa dell’Arco, and must thus in any case have been present during the Roman occupation of *Potentia*. This may be the river *Flosis* which we know from Roman sources. 14C-dates from a core taken near this bridge show that the river remained open until the Middle Ages (top of the gravel bed dated 630 ± 25 BP /1288 - 1397 cal CE) and then started to migrate north (sandy riverbed deposits on top of the gravel bed dated 505 ± 25 BP / 1400-1445 cal CE). Clayey floodplain deposits dated 80 ± 25 BP (1692-1920 cal CE) indicate that the coastal plain was regularly flooded until the late 19th/early 20th century, gradually filling the wetlands behind the protohistoric beach ridge (Goethals *et al.* 2009: 436). The artificial post-medieval channel is visible in ancient maps, and originally ran through Porto Recanati (Corsi *et al.* 2009; labelled ‘post-medieval’ in Fig. 3). This major hydrological work is often placed in the context of increased population and land reclamation for agriculture (Cencini and Varani 1991; Nanni and Vivalda 1997; Goethals *et al.* 2009; Taelman *et al.* 2017).

Marine sediment data indicate a minor sedimentation peak around 2400 BP, in the later Piceni phase, but this is not related to heavy deforestation as seen in the Middle Bronze Age pollen record (Oldfield *et al.* 2003). In fact, there seems to be little change in, and direct human impact, on vegetation during the Piceni and Roman periods; an observation which is corroborated by pollen samples from Lago Mezzano in Central-Tyrrhenian Italy (Ramrath *et al.* 2000). The wetland environment of the Roman town of *Potentia* is reconstructed from pollen samples taken from stratigraphic contexts of the western gate, excavated by Ghent University between 2007 and 2010 (Taelman *et al.* 2017: 59). During the late Republican phase, the landscape was open with only limited evidence for deciduous (oak, elm, hornbeam, maple, hazel) and hygrophilous (poplar, willow, alder) trees. There are indications for brackish conditions related to marine ingressions in the presence of halophytic plants. Crop cultivation and horticulture is reflected in the presence of cereal, fruit and vegetable pollen. In the Imperial period, the plant economy changed to denser hygrophilous forest cover paired with an increase in grassland and a decrease in cereals, fruits, and vegetables. The presence of typical wetland herbaceous taxa such as reedmace and reed confirm the presence of the river and permanent water near the city. This open grassland situation with limited crop cultivation and hygrophilous trees continued into the Middle Ages, when a new heavy erosion phase occurs (visible in the marine sediment records).

4. Previous research

4.1 The Lollini excavations and surface collections, 1970s

The earliest research of Montarice was conducted in the 1970s. After a first report of archaeological remains by inhabitants of Porto Recanati, the inspector Delia Lollini of the Soprintendenza Archeologica delle Marche visited Montarice in December 1973 to take stock of the situation. In her site report she mentions to have seen lithic artefacts, Roman potsherds and protohistoric pottery with typical Apennine-style decorations along the southern side of the plateau. Of immediate urgency, however, was a recent trench excavated in preparation for construction work on the NW slope. In its sections Lollini observed a dark layer of ca. 80 cm thick and at least 1.50 m wide with abundant prehistoric pottery fragments. She also noted an Upper Palaeolithic pointed scraper on the surface in this area. Alarmed by the planned construction work, Lollini proceeded with a single rescue excavation campaign in October 1977 that helped to impose protective measures and safeguard the site. A strip of 18 m was investigated by cutting back the NW escarpment in spits of ca. 15-20 cm to a total depth of ca. 2 m below the break of slope (Fig. 4, left). Finds were collected for each spit in 2 x 2 m grid units.

Following the cleaning of the lowest level at the base of the escarpment (approximately 2 m below the top of the hill), several pits of varying size were found with diameters up to 35 cm in diameter (Fig. 4, right). These pits were recognizable by their greyish-colored filling compared to the brown color of the layer in which they were cut. The pits contained mainly small ceramic fragments, some with typical Apennine-style geometric decoration (MBA3, late 15th-late 14th century BCE), and some faunal remains. A possible alignment of these pits indicating their use as postholes for structures needs to be verified. There is indeed evidence for the presence of buildings: the finds include fragments of hut loam with twig impressions, also in the lowest levels. During the 1977 campaign, 82 crates of material were collected,

Figure 4 – The 1977 excavation on the north slope of Montarice. Left: the excavation of the escarpment in progress. Right: the lowest level of the trench; visible are postholes and a lowered basin. Photo reproduced under permission of the Soprintendenza Archeologia, Belle Arti e Paessaggio Marche Sud.

which are currently stored at the Museo Archeologico Nazionale delle Marche (Ancona). These contain artefacts from all phases of occupation of the site, from the Palaeolithic to the Middle Ages. The majority of finds are pottery fragments, but there are also lithic artefacts, metal and plaster fragments, and faunal remains.

A few years later, in August 1979, Lollini inspected an area directly downslope from her earlier excavations. These surface inspections took place after ploughing had exposed fresh archaeological material. She collected six more boxes of artefacts in which all the phases of occupation of the site are attested. No invasive work has been conducted at Montarice since the Lollini excavations; the hilltop obtained a protected archaeological status. A first overview of the materials recovered by Lollini is given below in section 5.

4.2 Aerial photography, 2000 - 2014

Between 2000 and 2014 the PVS acquired aerial photographs of Montarice during a series of observer-directed low-altitude flights with a small aircraft above the whole Potenza Valley (Vermeulen 2009; 2011). The early photographs were taken with an analogue 35 mm reflex camera; and from 2004 onwards with digital cameras. An important impulse for the PVS studies at Montarice were successful flights in 2001 and 2003, during which very clear cropmarks indicative of ancient structures were recorded (Vermeulen - Verhoeven 2004: 60, fig. 2; Vermeulen *et al.* 2005: 49-52; Vermeulen *et al.* 2017: 79). Subsequently, Montarice was monitored during annual flights until 2014, thus compiling a large dataset of aerial imagery documenting cultivation and soil regimes. From 2007 onwards the PVS experimented with a range of unmanned low-altitude aerial photography devices. The motivation for these experiments came from the wish to acquire both higher-resolution photos to identify smaller features, and imagery in the invisible near-ultraviolet and near-infrared domains. The early experiments included flying a Helikite, a 7m3 helium balloon with attached kite wings that

Figure 5 – Oblique aerial photograph taken from a small airplane in May 2005 from the west. The circular feature on the south slope can be seen in the cropmarks (photo Frank Vermeulen).

could carry a small remotely-controlled camera cradle and which could fly up to 250 m (Van Limbergen *et al.* 2017: 23; Verhoeven *et al.* 2009). The Helikite was also used at Montarice to obtain such additional imagery in the visible and invisible domains.

The multiple aerial photographs of Montarice allow to distinguish a range of anthropogenic traces, and to monitor their preservation and visibility across the years. One of the most conspicuous is a large curvilinear feature with positive cropmarks, indicating that this is a deposit with a high organic content (Fig. 5). It delineates the upper, western part of the plateau and is tentatively interpreted as an enclosure ditch. On either side of it are multiple cropmarks, both circular and rectangular. These too have positive signatures indicative of pits and lowered floor levels covered with organic material. The imagery taken in 2005 was of particular high quality and immediately demonstrated the value of aerial photography in the study of Montarice. Additional processing of the imagery was used for a first interpretation of functional zones at the site (Verhoeven *et al.* 2009). The cropmark features could not be dated by their morphology alone, but the subsequent artefact surveys of the early 2000s and the resurveys in 2019 provided additional chronological clues (see below).

4.3 Fieldwalking surveys, 2002

The hilltop is ploughed and cultivated to this day, causing progressive erosion, especially on the higher western part of the plateau. Archaeological artefacts from occupation deposits are therefore continuously mixed in the plough zone. The first systematic surface survey of the

Figure 6 – Left: distribution patterns of protohistoric impasto pottery and post-Iron Age artefacts of the 2002 surveys. Right: distribution of impasto and Roman building materials and common wares in the 2019 resurveys. The maps are north-oriented.

site was carried out in 2002, following on the 2001 aerial reconnaissance. The surface artefacts were collected in units of 30 x 30 m on the plateau, and larger units on the slopes (Fig. 6). The artefact distribution confirms Lollini's earliest observations that protohistoric and later occupation was not limited to the NW escarpment, but also occurred on the top plateau and partly on the southern slope. On the relatively flat top plateau the lateral displacement of artefacts is limited, although the ongoing ploughing will have resulted in the progressive mechanical wear and fragmentation of archaeological objects. Artefacts may have been transported further from their depositional origin on the northern and southern slopes, as indicated by their fragmentation and wear. The deposits from which these artefacts are eroding are still present, as was seen in aerial imagery and later also geophysical data.

Catharina Boullart's PhD and a preliminary re-study of the 2002 artefact distribution already suggested long-term occupation dynamics at Montarice (Boullart 2006; De Neef 2017), with phases of occasional prehistoric human presence and dense habitation (MBA-RBA) followed by low-density presence or perhaps even complete abandonment (Final Bronze Age-Early Iron Age), re-occupation (Picene Iron Age), and low-density presence again (Roman and medieval periods). The close study and publication of the PVS survey materials of Montarice are part of our current project, aiming at a higher resolution of chronological and functional detail. However, the main challenge of the 2002 materials is the low spatial resolution of the survey, which prevents us from making direct links with the results of the aerial and geophysical surveys (sections 4.2 and 4.4).

4.4 Geophysical prospection and coring, 2013

In July and October 2013, a magnetometer survey was conducted on the Montarice plateau and parts of its upper slopes (Vermeulen *et al*. 2017). A flexible cart array with seven Foerster FEREX 4.032 CON 650 fluxgate sensors was used to map the plateau and part of the north slope (Fig. 7). The results of the magnetometer survey are striking: apart from isolated disturbances caused by electricity poles at the plateau edges, the data reveal a large number

Figure 7 – The Eastern Atlas team conducts the magnetometer survey on Montarice, July 2013 (photo Burkart Ullrich).

of archaeologically relevant traces that seem to be little affected by later impact (Fig. 8). One of the most conspicuous magnetic features corresponds to the large semi-circular cropmark seen in the aerial imagery. It is ca. 4-5 m wide and has weakly positive magnetic amplitudes. The magnetic signature, size, and location of this anomaly underline the earlier interpretation of the cropmark feature as a large ditch that delimitates the upper zone of the plateau. In recent publications on the Montarice magnetometry, we explored possible approaches to estimate the labor effort needed for the construction of such large ditches, using an architectural energetics approach based on the geophysical properties of the anomaly (width, length, estimated depth based on magnetic amplitude; De Neef - Ullrich 2019; De Neef 2023).

We interpret single magnetic anomalies on both sides of the large curvilinear feature as traces of human occupation (Fig. 8, bottom). They include (semi-) rectangular features that may be traces of buildings, pit-like circular anomalies and clusters of traces that indicate activity zones. It is difficult to establish whether these traces belong to single or multiple occupation phases. The magnetometry dataset shows that the plateau was nearly completely occupied, in discrete clusters, although their contemporaneity is unclear. In 2019 a full high-resolution artefact re-survey of the entire plateau was conducted to collect more detailed information of occupation clusters and their temporal variation in relation to the geophysical features (see section 4.5 below).

A striking set of large curvilinear traces in the northern and eastern parts of the plateau were initially also interpreted as large man-made structures possibly related to demarcation and/or defense of the site (Fig. 8, bottom). However, their morphologies and magnetic signatures were different from the semi-circular features that we interpreted as a ditch: all of them have weak dipole characteristics. The results of an electrical resistivity tomography profile laid out

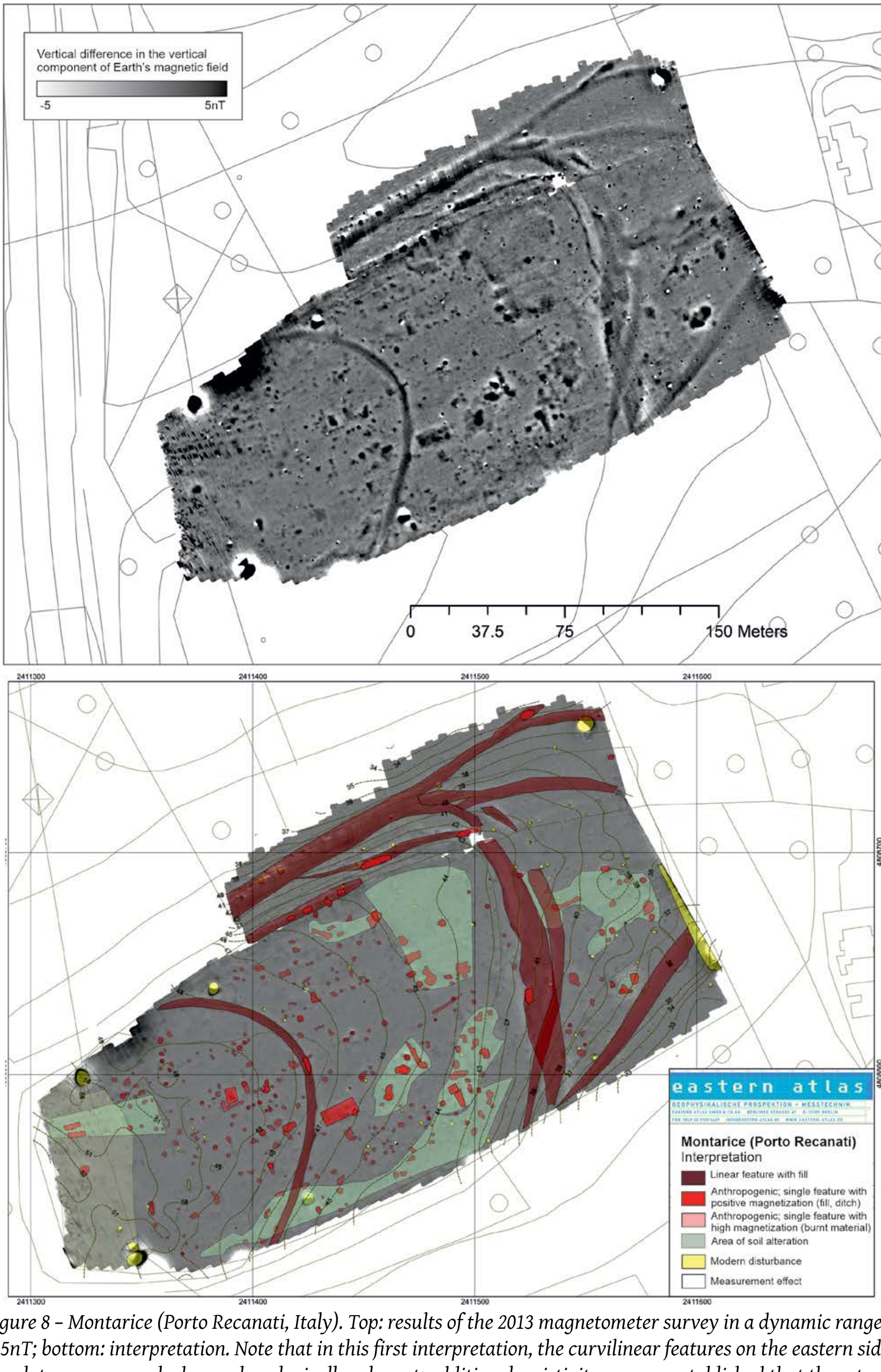

Figure 8 – Montarice (Porto Recanati, Italy). Top: results of the 2013 magnetometer survey in a dynamic range of +/-5nT; bottom: interpretation. Note that in this first interpretation, the curvilinear features on the eastern side of the plateau were marked as archaeologically relevant; additional resistivity surveys established that these traces are natural conglomerate outcrops (data and interpretation Eastern Atlas). The maps are north-oriented.

Figure 9 – Intensive re-survey at Montarice, September 2019. Left: view towards the SE at the border of the top plateau, overlooking river Potenza and the coastal zone. Right: survey of the zone with the soil discoloration on the south slope, related to the circular cropmark feature seen in the aerial imagery.

across one of them showed that this indeed is not a ditch, but an outcropping conglomerate bank causing a significant magnetic contrast with the overlying and surrounding soils. This was confirmed by targeted coring. Still, such natural phenomena may have been intentionally incorporated in the site's architecture.

4.5 Re-surveys, 2019

A complete re-survey of the plateau and parts of the north and south slope was conducted after ploughing in September 2019 (Fig. 9). Aim of the survey was to obtain an artefact distribution map at a higher resolution than the 2002 one, to establish spatial associations between the surface record and the subsurface features identified in the magnetometer data (Fig. 10). The survey was conducted in 20x20 m units. Walkers typically walked at 5 m interval (surface coverage 40%), but collection was intensified if a concentration of material was encountered (total sample, 100%). All materials were collected per unit except for bulky building materials (cobbles, tiles, etc), which were recorded but left in the field. Special finds and remarkable surface features, such as a cobble concentration, were recorded by GPS. Some artefact concentrations can be related to magnetic features, but further research (coring, test pitting) is needed to confirm the spatial and chronological associations.

We also investigated two areas of interest on the slopes of the plateau. On the southern slope a circular feature had been observed in aerial photos (Verhoeven *et al.* 2017); we suspected that this may be an eroding funerary monument (Fig. 9, right). On the north slope, a dark patch of soil in the vicinity of Lollini's 1977 excavation was investigated.

The feature on the **southern slope** was first investigated in three 15 x 20 m units (4001-4003), with 3 walkers walking at 5 m interval. The quality and density of material was so high that we subsequently intensified the artefact collection: the area with the most finds was surveyed in 6 units of 10 x 10 m at 100% coverage (units 4004-4009). Two grey patches at the western border of the artefact concentration were investigated separately as we suspected they may be related to discrete ash deposits (units 4010-4011). The extent of colored patches of soil were recorded by GPS.

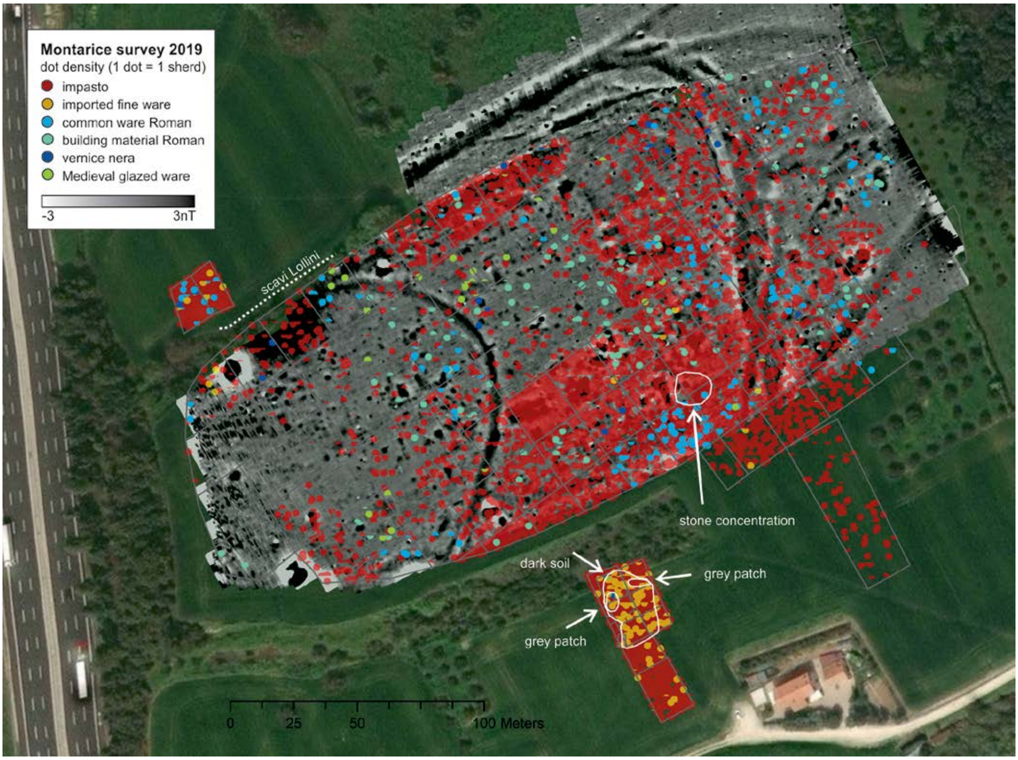

Figure 10 – Dot density distribution map of the 2019 resurvey. 1 dot = 1 sherd. The map is North-oriented.

The circular feature seems to be related to a funerary context, considering the number of fine wares including a miniature impasto pot. The extent of the material concentration matches the circular feature seen in the aerial imagery. Two occupation phases can be distinguished: a Bronze Age phase with materials dating to the MBA3-RBA; and an Iron Age Piceni phase with fine wares (Attic imports, Italo-geometric wares) and *bucchero* pottery. Storage and coarse wares, animal bone, shells, and building material were also collected. Pending further study of the assemblages and invasive research, we think it is likely that an older Bronze Age (habitation) phase was covered by an Orientalizing Piceni burial.

Of special interest are the artefacts collected in unit 4005. Here a miniature impasto pot, a ceramic and a stone loom weight and a fragment of a bowl were collected, painted import wares, a fragment of an oven floor, pieces of burnt hut loam and a pebble floor. The cemented pebble floor may be part of the Piceni burial. There were no metal finds but the location may already have been searched by metal detectorists.

The brown patch on the **northern slope** was investigated in two 10 x 20 m units, with walkers walking at 5 m interval (coverage 40%). The abundance of pottery indicates that the brown patch is related to an eroding protohistoric occupation area. Most pottery consists of plain medium- and thick-walled impasto pottery, but there are also a few fragments of (painted) fine ware. This is in line with the finds done by Lollini in this area in 1977 and 1979.

4.6 Current studies

The aim of our current research is to reconstruct Montarice's occupation history by piecing together the various invasive and non-invasive datasets collected over the years. The greatest challenge is the recovery and translation of unpublished legacy data, establishing the exact locations of surface collections and excavation pits from the 1970s, and their spatial integration with the more recent investigations. As we will show below, the unpublished but well-preserved excavation materials provide us with two crucial pieces of the puzzle which are difficult to extract from the ploughed and weathered surface materials: first, a high chronological resolution, and second, technological and functional information that allows us to place Montarice in wider (supra-)regional socio-cultural frameworks during the Bronze Age. Moreover, they provide us with faunal remains and sensitive materials such as bone and bronze.

Regarding the issue of reflexive data handling (section 1) in the integration of analogue (excavation documentation), digitized (fieldwalking distribution maps, aerial imagery and terrain models, geoarchaeological observations), and natively digital datasets (geophysics), we were confronted with the problem of transforming the 1970s information into something we could use to our purposes. This implied that we had to create new metadata for our translations of Lollini's poorly legible diaries, drawings, and photographs, starting from the information we hoped to extract. First of all, we aimed at a degree of certainty about the positioning of the trenches. This was especially of interest for a small trench on the top plateau visible in one of the photographs, which we hoped to associate with cropmarks or magnetometry features as a degree for the site's preservation or degradation. This proved to be impossible due to the limited dimensions of the trench, but also the inherent ambiguity in the interpretation of the non-invasive prospection data. Another issue was establishing the selection criteria for the find materials in three categories: 'selected' (*scelto*), 'also selected' (*anche scelto*), and 'not selected'. This was important to determine which excavation spits are securely dated to the Bronze Age, and thus suitable for the zooarchaeological study and the selection of bone samples for the isotopic analysis. Although Lollini's diary is not outspoken on this topic, the large amounts of non-diagnostic wall fragments (the 'not selected' category) suggest that most material was taken. However, while counting and documenting the unwashed finds in these crates, we realized that Lollini had not been all too selective: there were many natural stones that had apparently been mistaken for pottery. Ultimately, we realized that the quality of her 'selected' and 'also selected' finds groups are the key to integration with the finds repertoire from the field surveys in the 2000s. Lollini's finds provide us with a narrow chronological framework for the protohistoric occupation and later phases, but also about pottery production and (supra-)regional contacts. Moreover, the 1970s surface and near-surface finds give us a baseline for the preservation of archaeological deposits at and near the ploughzone. The pottery fragmentation rates in the surface collections of the 2000s and 2019 illustrate the progressive degradation of the site.

Preliminary analysis of the diagnostic finds of the 1977 Lollini excavations (2800 fragments) shows that 92% can be dated to the Bronze Age, in specific to the last phase of the Middle Bronze Age (MBA3; late 15th-late 14th century BCE) and, to a lesser extent, to the Recent Bronze Age (RBA, *c.* late 14th-mid 12th century BCE). Materials from these two Bronze Age phases are present in all the investigated levels, but become exclusive in the lowest levels of the excavation spits (VII to X). These levels do not yield any historic pottery. To date, diagnostic material from the different phases has been selected and photographed, and drawing is in progress. The faunal finds from the lowest levels, VII-X, are the subject of archaeozoological investigations for the determination of attested species and the selection of samples for isotopic analyses aimed at the study of animal mobility in the Bronze Age[1]. The material collected on the surface in 1979 is also being studied, while the analysis of the finds collected during the Potenza Valley Surveys in 2001 and 2002 and during the 2019 reconnaissance has almost been completed.

In the next section, we present the first results of the ceramic studies of the Bronze Age materials from the Lollini excavations and the PVS surveys.

5. The main occupation phases of Montarice: MBA and RBA

Most of the material found at Montarice consists of Bronze Age pottery and, specifically, of the so-called Apennine *facies* (MBA3, late 15th-late 14th century BC) and, to a lesser extent, to the Sub-Apennine *facies* (RBA, late 14th-mid 12th century BC). To date all decorated fragments of the Apennine *facies* from the 1977 excavation and the surveys carried out since the 2000s have been photographed and, in part, drawn. Drawings are made of fragments with legible decorations, or where at least a distinction can be made between angular and curvilinear motifs. The fragments with such Apennine decorations amount to 576, the total number of recorded decoration motifs is higher (640 decorations) as it is quite common that several parts of the same vase are decorated with different decorations (usually the inner part of the rim and the upper and lower walls).

Pottery datable to the RBA phase is abundant, but less than the MBA3 material. The finds from this phase are characterized above all by the presence of upstanding handles with cylindrical ends (cilindro-rette), or with zoomorphic elements such as horns and bird-shaped *protome*. These typical RBA elements are, unfortunately, always found without the vessel on which they were originally set (generally open forms such as bowls and cups). The documentation of the RBA material is still in progress.

5.1 The decorated pottery of the Apennine facies (MBA3)

Here we present the very first results from the study of the Apennine phase sherds, which were part of a recently concluded PhD project at Sapienza University of Rome (Paolini 2023). The most characteristic element of the Apennine *facies* is a particularly rich apparatus of geometric decorations, mostly realized through incision, impression and carving. This is the first aspect of Italian Bronze Age material culture distributed over a wide area, between Romagna and northern Apulia and, on the Tyrrhenian side, between central Tuscany and northern Calabria. Regional peculiarities are present both in terms of the decorations (Macchiarola 1987: 151-157, fig. 69) and the pottery shapes (Poggiani Keller 1995: 359; Macchiarola 1995: 441-457, tab. 2). However, there exists an underlying homogeneity that indicates a broad sharing of morphological and decorative models between the different communities of the peninsula.

[1] The zooarchaeological study was conducted by dr. Elena Maini within the PRIN project 2020EP24PP 'HERDS: Animal Husbandry and its Economic Role in the Development of Central Mediterranean Protohistoric', based at Sapienza University of Rome.

At Montarice, the typical angular and curvilinear decorations are present, both without backgrounds (henceforth 'smooth') and filled with impressed dots and incised hatches ('fillers'). Montarice is part of Macchiarola's 'Middle Adriatic group', which has a high number of exclusive decorative motifs (Macchiarola 1987: 151-152, Figs 69-70) that are also attested on our site.

An analysis of the relationship between the vessels' shape and the decorations shows that open forms with an articulated profile have the most decorations at Montarice (97% of recognizable shapes). Carinated cups and bowls are by far the most decorated (77%) compared to the cups and bowls with a rounded profile (27%). On closed forms decoration is only present on neck vases (*vasi a collo*). There are also numerous fragments of decorated grip elements, such as handles and knobs, most of which can be associated with open forms.

Seventy percent of the decorations are made with the incision technique; in 15% of the cases combined with the technique of impression. Carving is present on 7% of the sherds and is mostly used to outline opposing rows of triangular elements on the inner surface of rims and, to a lesser extent, for lines in angular or curvilinear motifs. Of particular interest is the presence of wide and deep incisions and another technique that produces an effect similar to a wheel profile, the so-called 'roller' technique (*a rotella*: Baldelli *et al.* 2005: 555. Lucentini 2005: 608; Figs 11.8-9, 12.6). This technique occurs mostly in Adriatic Italy. In Marche, this technique is also known from the sites of Castel di Lama (AP; Lucentini 2005, fig. 5. 1-3, 5), San Giovanni di Monte Urano (FM; Baldelli, Damiani 2005, fig. 1. 2-3), Cisterna di Tolentino (MC; Percossi, Pignocchi, Sabbatini 2005, fig. 1.16), Campeté (MC)[2], Santa Paolina di Filottrano (AN; Rellini 1932, tab. III.1-2), and Pieve Torina (MC; Rellini 1932, fig. 28).

The decorative motifs at Montarice are mostly without filling elements such as dots or lines (70% of the fragments). Dense dots (3%) are scarce compared to the single row of dots (16%), such as, for example, in the materials from Santa Paolina di Filottrano (AN; Rellini 1932; Macchiarola 1987) and Monte Santa Croce di Sassoferrato (Lollini 1957). Hatching is well documented (9%), especially in the version in which vertical or horizontal strokes are grouped together and separated by free spaces (Figs 11.1, 12.2-3). Two rare types of fillers have been identified at Montarice: the undulating row of dots (Fig. 12.2) and the row of carved squares alternating with free spaces (Fig. 12.1). The former is found on a significant number of fragments in the Abruzzo site of Coccioli (TE; Macchiarola 1987, e.g. tab. 18.3) and probably on a fragment from Monte Ingino (PG)[3]. The second type is mostly associated with ribbons or straight bands, while it rarely occurs with curvilinear motifs such as spirals. Beyond Montarice, curvilinear figures filled by carved squares are found in a few other contexts, all located on the Adriatic side of the Italian peninsula: Santa Paolina di Filottrano (AN; Rellini 1932, tab. II.3), Castel Trosino (AP; Polletti 2000, fig. 21) and Grotta a Male (AQ; Pannuti 1969, figg. 11.6; 14.4).

Curvilinear decorative motifs are the most frequently attested at Montarice (55% of the studied decorations). Dominant is the spiral motif made with a linear incision or with a ribbon without fillers (Macchiarola 1987, fig. 7. 25, 29a; Fig. 11.4), followed by the incised 'running dogs' (*cani correnti*) motif, which are also mostly smooth (Figs 11.3, 12.4) or filled with a single

[2] Materials exhibited at the State Archaeological Museum of Cingoli.
[3] Malone, Stoddart 1994, fig. 4.17.29, although on this fragment there is a double row of dots.

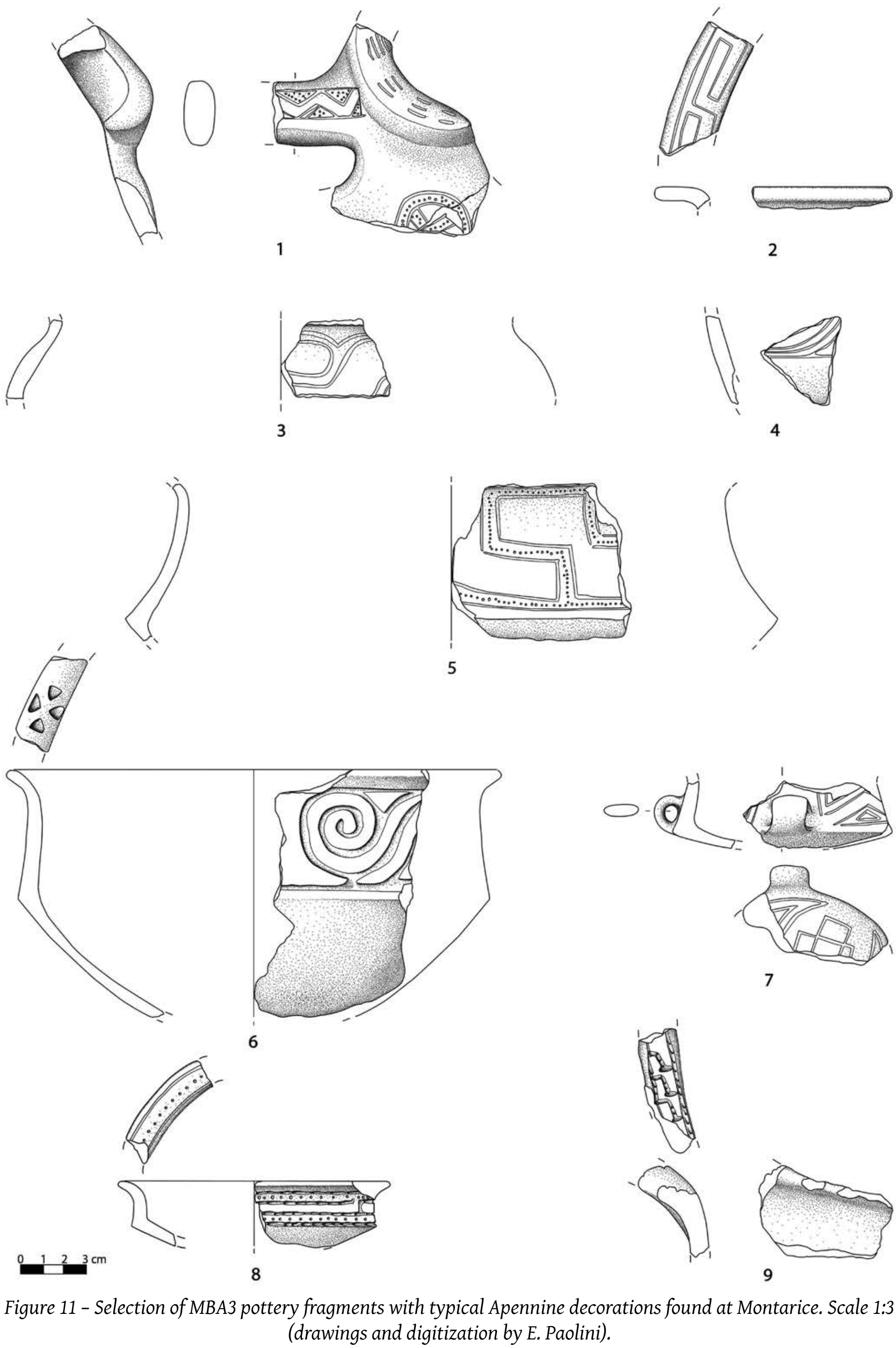

Figure 11 – Selection of MBA3 pottery fragments with typical Apennine decorations found at Montarice. Scale 1:3 (drawings and digitization by E. Paolini).

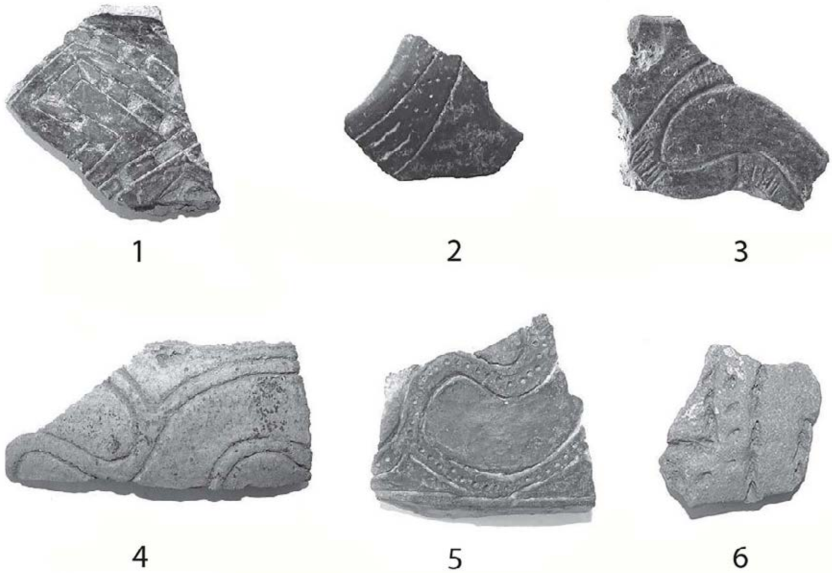

Figure 12 – Selection of MBA3 pottery fragments with typical Apennine decorations found at Montarice. N. 1 scale 1:3, ns. 2-5 scale 1:2, n. 6 scale 1:1 (photos by W. de Neef).

row of dots (Fig. 12.5) (Macchiarola 1987, fig. 9. 44a-b). Among the angular motifs, meandering motifs predominate. Frequent is the continuous straight meander motif, made by incision and without fillers (Macchiarola 1987, fig. 10. 56, 57; Fig. 11.2) and, above all, the 'inverted z' motif (*zeta rovesciata*), also made by incision, with the z-shaped elements linked and smooth. Less well attested is the version with the z-shaped elements divided by a row of dots (Fig. 11.5) (Macchiarola 1987, fig. 11. 78, 80b).

Macchiarola (1987) and Baldelli *et alii* (2005) proposed a distinction between an earlier and a later phase of the MBA3 on the basis of the geometric decorations. Decorations from Montarice belong to both of these sub-phases. To the early sub-phase belong the filling-free motifs with concatenated lozenges (Baldelli *et al.* 2005, fig. 6.13 bis; Macchiarola 1987, fig. 27.125), concentric lozenges (Baldelli *et al.* 2005, fig. 6.16; Macchiarola 1987, fig. 28.151) and crosses with concave arms (Baldelli *et al.* 2005, fig. 6.17 Macchiarola 1987, fig. 24.15a) (Fig. 11.7, bottom). To the late sub-phase belongs the technique that produces a 'wheel' effect. At Montarice this is used to create 'inverted Z' motifs, with the Z-shaped elements concatenated and without fillers (Fig. 11.9); simple rectilinear ribbons arranged in several registers, often decorating the inner surface of the edges; curvilinear figures, most probably spirals. Other elements that can be dated to the later period are the opposing 'v-figures' without fillers[4]; the oblique false meander motif with carved triangular elements in the resulting spaces[5]; and, finally, carved spiral motifs[6] (Fig. 11.6).

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4 Baldelli *et al.* 2005, fig. 7.39; Macchiarola 1987, fig. 34.93, a motif attributed by the author to Apennine 1 and/or 2.
5 Baldelli *et al.* 2005, fig. 7.39; Macchiarola 1987, fig. 33. 101b, attributed by the author to the Apennine 1-2.
6 Baldelli *et al.* 2005: 555, in the case of Montarice these are carved spirals with no carved elements in the resulting spaces; Macchiarola 1987, fig. 29.29f.

Although both sub-phases of MBA3 are attested, the more recent one seems to dominate. This chronological detail is an important preliminary result of our present studies, which was obtained mainly thanks to the availability of the numerous and better-preserved materials from the Lollini excavation. Further study on the associations between decoration and pottery shape will allow to verify the chronological considerations outlined above. Furthermore, comparisons with other Apennine contexts in central and southern Italy are expected to place Montarice within Bronze Age networks of contact and exchange. For now, we can place our site in a wider regional network where specific decoration motifs and techniques were shared. In our current project, the integration of the legacy data with more recent survey data and the detailed study of the pottery thus allows us to reconstruct a more detailed and complete chronological and cultural framework.

6. Reconstructing the long-term occupation of Montarice

The long research history of Montarice poses specific challenges for the study and interpretation of its archaeological context. We have very useful non-invasive prospection data from aerial imagery and magnetometry, yet these are difficult to associate spatially and chronologically with the artefact distributions from the relatively low resolution early PVS surveys. The 2019 re-surveys added the required spatial detail, but were affected by the progressive fragmentation and erosion of the archaeological topsoil record by intensive agriculture. As a result, we can map the distributions of broad material categories such as protohistoric impasto pottery, Roman common wares, and building materials, but we lack the chronological detail to distinguish shorter-term changes in occupation.

Here the newly accessible documentation and finds from unpublished legacy excavations provide a crucial key. The close inspection of the materials from the 1970s excavations confirm that the main occupation occurred in the final phase of the MBA3 and the early phase of the RBA, a period of ca. 200 years. In the Final Bronze Age and Early Iron Age, Montarice seems to be abandoned almost completely, coinciding with a wider trend in Marche and the Adriatic which is often associated with a radical change in social, economic, and political structures (Baldelli *et al.* 2005; De Neef 2017). In the subsequent Piceni and Roman phases, the plateau seems to be occupied at a lower density centred on single habitation foci. One of these Roman foci could successfully be associated with a geophysical anomaly through the high-resolution 2019 surveys, while the majority of geophysical features is situated within the general protohistoric impasto carpet. The combined surface collections thus suggest that most of the aerial and geophysical features belong to the MBA3-early RBA window.

This relatively short period falls at the end of a relatively cold period during which the beach ridges formed at the mouth of river Potenza (see section 3 above), making the previous Atlantic-type coastline more accessible and perhaps even allowing for the first time the beach landing of ships. The landscape processes allowing this new coastal connectivity can therefore be linked to the intensive Bronze Age occupation of the hilltop. This is not an isolated case: Montarice's twin site Monte dei Priori, overlooking the southern part of the Potenza delta, dates to the same period, although it was not as densely settled. The Bronze Age colonization of the coastal zone also coincides with the period of intense deforestation and erosion as reconstructed by the offshore Adriatic sediment columns and peninsular pollen records (see section 3 above). We can tentatively associate this with demographic growth and an increased pressure on the landscape to sustain larger populations.

The maritime connections continue after a period of near-abandonment at the end of the Bronze Age and beginning of the Iron Age. The Piceni Iron Age inhabitants of Montarice had access to Greek fine wares, which we find both on the plateau, in the circular feature on the south slope, and in the excavated levels on the north slope. Whether the Piceni community controlled the import of these wares themselves, through a harbour in the Potenza delta, or whether they obtained them from another trade node such as Numana, is still to be resolved.

At the same time, our new material studies underline the peninsular connections of the protohistoric community at Montarice. During the MBA3 they knew and used the same decorative techniques and motifs attested in contemporary sites in central and southern Italy, combined with some specific aspects that are characteristic exclusively of (central-) Adriatic contexts. Interestingly, in the RBA we also have indications for 'hybrid' pottery forms that combine elements from the Adriatic groups with those in the Po basin, which suggest more long-distance connections. These peninsular networks also provide a supra-regional framework for the ebb-and-flow dynamics of protohistoric occupation at Montarice. The abandonment during the Final Bronze Age mirrors a period of profound social, economic, and political change in the Po basin, the Adriatic, and in the wider Mediterranean.

We still have little guidance on the transition from the Bronze Age to the Iron Age, resulting in a chronological gap of ca. 300 years. Montarice seems to have been almost completely abandoned during this period, but possibly this is also an effect of the poor visibility of Early Iron Age shapes and fabrics in the survey pottery. Yet this fits a wider peninsular phenomenon of radical social upheaval and a move into the mountainous inland after the collapse of the coastal network and the Terramare system in the Po basin (Cardarelli 2009).

Similar to other sites in the Potenza valley such as Monte Franco (De Neef 2020), Montarice is reoccupied in the Piceni period, albeit at a seemingly much lower intensity than during the Bronze Age. Both the 1977 Lollini excavations and the PVS surveys show high-quality material from this period, but other than that we have little evidence of an intensively inhabited permanent settlement. The circular traces on the south slope seem to belong to an isolated Piceni tomb that reoccupied an older MBA-RBA context; the pottery from the excavations on the north slopes stem from mixed stratigraphic contexts that indicate that they rolled off the summit plateau. This, in turn, is consistent with the present archaeological record of the Marche: still few Piceni habitation contexts are known and investigated, let alone using geophysical methods. We therefore still have little indications for what a Piceni settlement would look like in a magnetometer dataset. Moreover, it may be possible that a small Piceni settlement on the highest part of the plateau is completely destroyed by ploughing.

The Roman conquest had profound effects on the social, political, economic, and settlement structure in the Potenza delta, but apparently little impact on vegetation regimes and erosion susceptibility. The colony of *Potentia* on the former beach ridge led to urban development in the alluvial plain. At the same time, Montarice remained inhabited on a very limited scale. With the 2019 survey, we were able to identify one of these small-scale habitation foci, and connect it with traces from the aerial imagery and geophysical surveys. It is interesting to note that the offshore sediment cores indicate a low peak in sedimentation at the end of the Piceni period and shortly before the Roman conquest, around 2400 BP (Oldfield et al 2003; section 3 above). However, this peak is not linked to a substantial change in vegetation, which suggests that agricultural strategies and cultivation intensity in Adriatic Italy did not vary much between the Piceni and Roman periods. Such changes occurred only much later, around 700 BP, possibly linked to increased coastal activity. The post-medieval artificial redirection of the river may only have become possible, and perhaps necessary, by the progressive aggradation of the coastline in conjunction with medieval erosion processes.

7. Conclusions and outlook

Montarice is a textbook case of successful non-invasive studies on a multi-period settlement site, yet there are several challenges to the integration and interpretation of the resulting datasets. The primary challenge is to establish spatial, chronological, and functional associations between geophysical and aerial traces, and the archaeological surface record. A re-study of the 2002 survey materials combined with a high-resolution re-survey in 2019 resolved some of the spatial links and identified small-scale single-period activity foci that remained under the radar in 2002. However, while the spatial resolution of the 2019 survey is high, its chronological resolution is limited: due to the progressive degradation of materials in the ploughzone, the artefacts collected in 2019 have much fewer diagnostic features than the 2002 surveys. We have worked around this using the newly available finds from the 1977 excavation as a chronological baseline, at least for the protohistoric phase. These stratigraphic finds inform us about the pottery fabrics and shapes used at Montarice, and give us a narrower chronological arc for the main Bronze Age occupation phase. In the next phase of our project, we plan a systematic study of the impasto fabrics, aiming to discover further spatial, functional, and chronological trends in the protohistoric settlement. Together with a detailed analysis of the 1977 excavation, these new material studies will be the basis for a volume dedicated to Bronze Age Montarice (De Neef & Paolini in prep.).

A second, related challenge is to unravel the long-term occupation dynamics of Montarice using the ploughzone assemblages. While the excavation provides guidance for further classification of the protohistoric impasto carpet, the materials from other periods are more generic and provide fewer dating clues. Here, too, the advanced mechanical wear of the ploughzone materials is hampering the identification of pottery types with abraded surface treatments (e.g., *vernice nera*) or painted decorations (Italo-geometric wares, Attic imports). As such, low-density occupation phases remain difficult to grasp, including the Bronze Age-Iron Age transition, the Piceni phases, and the post-antique period. However, the circular feature on the south slope provided well-preserved, datable Piceni materials that entered the ploughzone as recent as 2019 or shortly before. Monitoring the site and keeping an eye on possible newly exposed archaeological deposits is therefore imperative to advance our understanding of the material record, especially of the lesser-known phases. For the Roman phases, we dispose of a high-resolution comparative dataset: the excavation materials from the Ghent excavations at *Potentia*. The studies of the Roman materials from Montarice using the *Potentia* parallels are ongoing by Anna Gamberini and Emanuela Grassetti, and will be included in an upcoming volume about settlement development in the Potenza delta between the Bronze Age and the Roman period (Vermeulen - De Neef (eds.), in prep.).

Looking beyond Montarice, we realize the unique character of our site. Despite the many open questions, the amount and quality of information on the spatial organization and material culture is exceptional and has few parallels in other long-term and/or pre-Roman sites in Adriatic Italy. Placing Montarice in a wider cultural, historical, and environmental context requires more (non-invasive) work on similar sites, which remain underrepresented in current archaeological scholarship. At the same time, we emphasize the need for reflection on the handling of different datasets and the integration of legacy, analogue datasets with modern digital recording methods in archaeology. Reflecting on the legacy of the Potenza Valley Survey and looking towards a follow-up project, we think that the Marche has an enormous potential for the advancement of such studies.

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Legacy GIS data integration and non-invasive survey for the study of the archaeological landscape of Atella (Caserta, Campania, Italy)

Rodolfo Brancato

rodolfo.brancato@unina.it – Università degli studi di Napoli Federico II

Stephen Kay

s.kay@bsrome.it– British School at Rome

Abstract

This paper presents results from a GIS-based approach applied in the archaeological study of Atella (Campania, Italy). The project integrates both new and legacy data using GIS technology, including a geophysical survey conducted at Sant'Arpino in 2006, and analyzes both field and proximal sensing data. The study, part of the Atella Archaeological Excavation Project led by University of Naples, aims to understand the city's urban topography. It emphasizes the integration of various methods considering complexity, cost and data visualization challenges related to the archaeological surface record.

Keywords

Ancient topography, Roman Campania, Legacy data integration, GIS application, non-invasive methods, geophysics

1. Introduction

This paper presents the results of a GIS-based integrated approach applied by the archaeological project for the urban area of Roman Atella (Campania, Italy) based on 1) the integration of new and legacy data through the use of a GIS platform; 2) a geophysical magnetometry survey undertaken at Sant'Arpino (Caserta); 3) field and proximally sensed data analysis (Fig. 1). It describes the different survey methodologies applied and presents the results with an interpretation and discussion. The research is part of the Atella Archaeological Excavation Project (MIC | MIC_SABAP-CE | 26/06/2024 | 0013094-A) which aims to investigate the buried remains of the Campanian city in order to understand its urban topography through an integrated approach, combining the digitization of legacy data and its integration with survey data (Fig. 2). The project was instigated by the Department of Humanities Studies of University of Naples with the Soprintendenza Archeologia, Belle Arti e Paesaggio (hereafter SABAP) di Caserta and SABAP Area Metropolitana di Napoli to establish a digital and open access archaeological map of the remains of the ancient city and its ager.

The geology of the area is of volcanic origin, situated to the north of Mount Vesuvius and the caldera of Campi Flegrei. Eruptions from these locations deposited volcanic material through pyroclastic flows across the Campanian plain. In this region, partially molten lapilli (ranging from 2 to 64 mm) fused into solid layers, cooling after each volcanic episode and creating stratified layers of tuff. The deposits surrounding the site were laid down during the historic

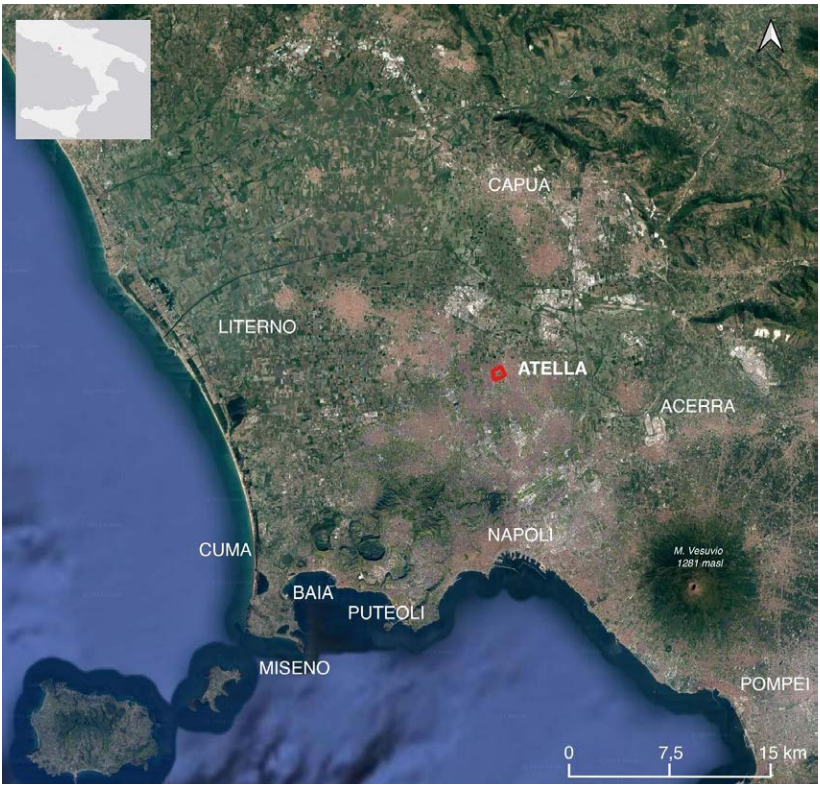

Figure 1 – The location of Atella in the Campania region (southern Italy) on satellite imagery (Google Earth 2024) (R. Brancato).

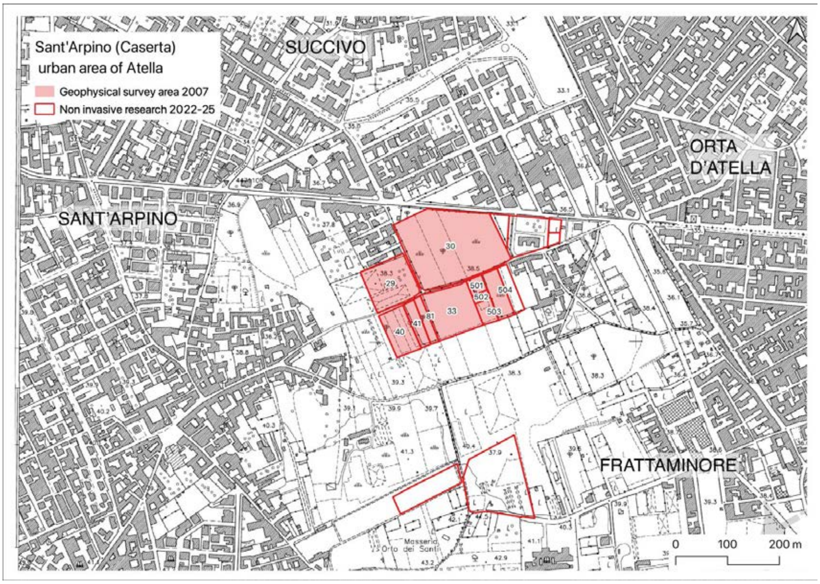

Figure 2 – Area divisions of the archaeological site of Atella (scale 1:10.000) with indication of the contemporary municipalities (R. Brancato).

Figure 3 – Sant'Arpino (Caserta) and the study area in foreground (L. Ceruleo).

period (since approximately AD 79) and overlay earlier Pleistocene geologies (cf. Di Vito *et al.* 2021).

The modern town of Sant'Arpino is situated ca. 23 km to the south of Caserta and 30 km north of Naples, between the towns of Orta di Atella and Frattaminore, and joins with the town of Succivo: the archaeological area extends into the overlapping outskirts of these towns (Fig. 3). The research area (5 hectares) extends into Sant'Arpino, divided by Via Luigi Compagnone, a road identified as the main *decumanus* of the Roman town (Bencivenga Trillmich 1984, with references). This sector of the site, the core of the archaeological park established in 2010, is currently partly used for the cultivation of wheat; the rest of the area, part of which was excavated by SABAP over a two-year period (2010-11), is covered by dense vegetation.

2. Archaeological setting

The location of Atella, an Oscan city which in antiquity gained fame through the "*fabulae Atellanae*", has been known at least since the mid-18th century (cf. De Muro 1840; Beloch 1890; De Caro 2012; Laforgia 2007; 2014) (Fig. 4). At the beginning of the 20th century, the urban perimeter of the city was defined by Castaldi (1908). The archaeological map is an valuable representation of the site made when the main urban infrastructure (roads and city walls) were still visible (Fig. 5). Archaeological evidence suggests the city's origins can be traced back to the end of the 5th century BC, and its urban development traced to throughout the 4th century BC (De Caro 2012, 87). Allied with Capua in response to the Roman expansion in the Campanian plain, after their defeat in 338 BC, Atella became a *municipium*, holding the status of *civitas sine suffragio* (Festus, 50.126). In 211 BC, the city lost autonomy and citizenship after siding with Hannibal in 216 BC (Laforgia 2007, 18). By the 1st century BC, Cicero's writings indicate that Atella was recognized as a *municipium* with jurisdiction over an *ager vectigalis* (Cic., fam., 8.7). By the first half of the 1st century AD, Atella was likely equipped with the set of

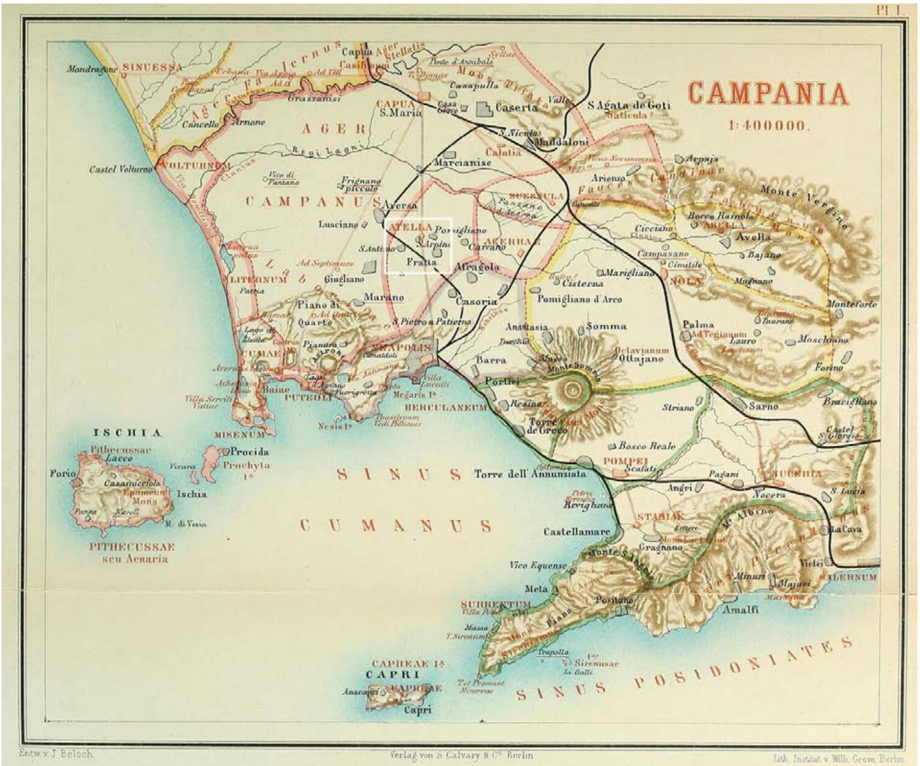

Figure 4 – Atella in the context of ancient Campania (J. Beloch, 1890).

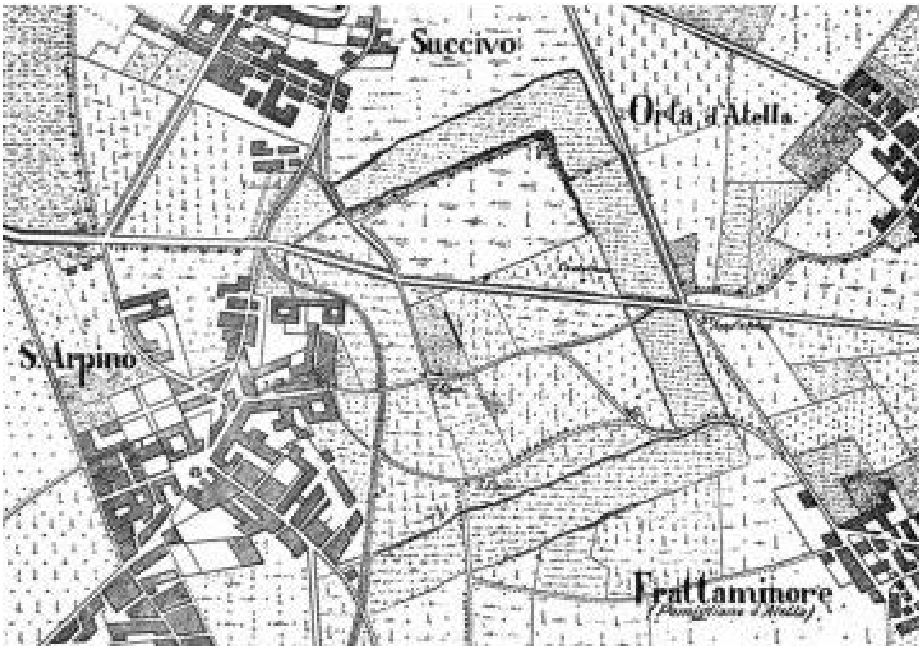

Figure 5 – Archaeological plan of Atella proposed by Castaldi (1908).

public buildings typical of a Roman city: a theatre must indeed have been a significant feature at the birthplace of the Atellan farces, although it is never mentioned by ancient sources; however, there is a reference to an amphitheatre by Suetonius (Tiberius, 3.75.3), in connection with the populace's wish to burn the body of Tiberius, who died in Misenum (AD 37). In Late Antiquity, the city was destroyed by a fire (late 4th-early 5th century AD) but continued to prosper as an episcopal seat until at least the 7th century AD (cf. De Caro 2012, 88). During the Roman period, Atella was connected to the major cities of Campania through a series of roads, whose topography is strictly linked to the centuriation of the alluvial plain (Quilici Gigli 2002; 2005). Several elements remain allowing a discussion of the chronological evolution of Atella's rural landscape and its relationship with the *Ager Campanus* following research conducted in the Acerra area (Giampaola 1997; 2002).

Nevertheless, the general urban evolution of Atella remains still largely undefined. The trapezoidal layout of the city is marked by large tuff block fortifications and a wide ditch, which date to the mid-4th to early 3rd century BC (Elia 1959; Johannowsky 1970, 1976; cf. Bencivenga Trillmich 1984, 6, n. 11). The city's internal layout included a network of streets, among them three roads, one *cardo* and three *decumani*, as well as several narrower streets with a NW-SE orientation, differing from the *Ager Campanus* alignment (cf. Monaco 2004, fig. 7). The space between the *decumani,* of approximately 180m, features Roman measurements and above all a module of 60 repeated three times, perhaps a layout for scamna (Rescigno and Senatore 2010). The most visible remaining Roman building of Atella is the "Castellone", part of the *frigidarium* of a monumental bath complex adorned with painted stuccos from the early 2nd century AD. Notable discoveries within the area also include 1st to 2nd century BC private houses with a peristyle (Johannowsky 1966, 1967; Matarese *et al.* 2023) (Fig. 6). Excavations of a bath complex were conducted between 2009-10 in an area probably close to that investigated in 1967, whose exact location is still uncertain. The structures correspond to only part of the entire complex, extending over an area of 1170 m2, along a NE/SW axis along. The bath may be referred to the canonical sequence which provided for the passage from cold rooms to gradually heated ones (De Caro 2012, 96). An analysis of the building technique and the stratigraphic data allowed the identification of three main phases, from the Republican to the Imperial period, with subsequent use up to the 5th century AD and an eventual abandonment between the 6th and early 7th centuries AD (cf. Arenella *et al.* 2015). Funerary contexts identified south of the city walls currently constitute the most significant archaeological evidence of the city's life (Guzzo 2016, with references). Archaeological investigations have also brought to light tombs from the pre-Roman phase, some dating between the late 5th and early 4th centuries BC; however, most data pertain to the large necropolis of the 4th century BC (Bencivenga Trillmich 1984). Systematic archaeological investigations, conducted by SABAP between 1995-97 at Frattaminore (Orto dei Santi), revealed a sector of the southeastern necropolis: seventy-six tombs dating between the 1st and 4th centuries AD with differing orientations were investigated, although a majority were E-W oriented, consistent with the road axis that crossed the investigated area (De Caro, Guzzo, Tocco 1997, 815).

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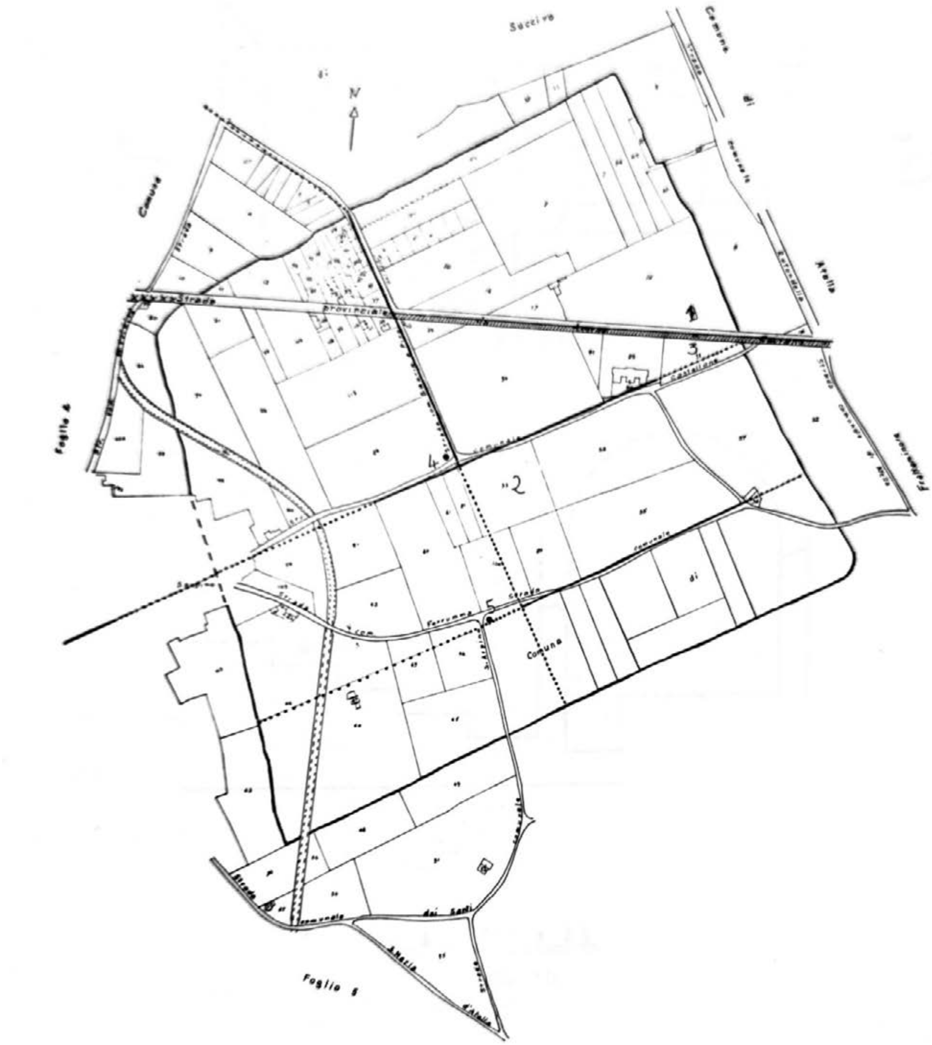

Figure 6 – The archaeological plan of Atella proposed by Bencivenga Trillmich (1984).

3. Research strategy and methods

The topographical integration of legacy data into archaeological mapping has been a widely discussed topic in archaeology over the past decades (cf. Brancato 2019, with references). The time-consuming interpretative process can no longer fully exploit the potential of purely non-invasive investigations by analyzing only surface records. As recently proposed by Launaro *et al.* (2023), the solution to this may lie in the combined application of both traditional and innovative topographic and archaeological methods, including field surveys, remote and proximal sensing, and large-scale geophysical prospection (cf. Scardozzi, Saponara, Masini 2007; Campana 2018). Indeed, the GIS platform is not just an ideal set for the digital palimpsest for this data visualization but also a dynamic environment that allows both new and legacy

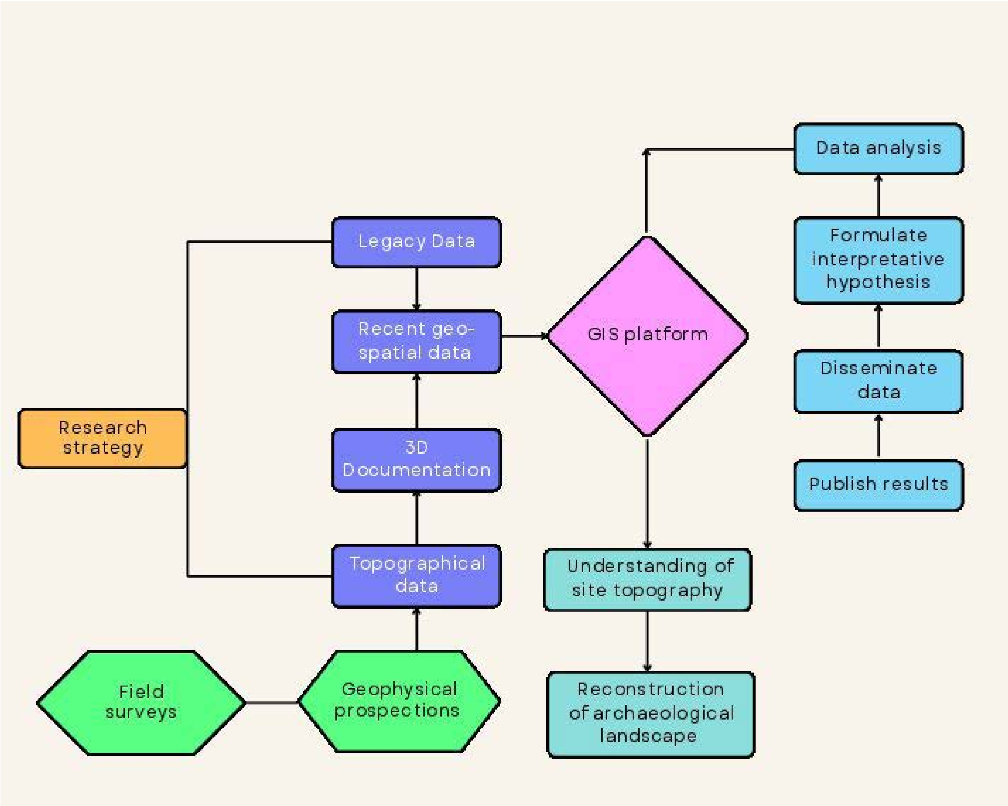

Figure 7 – A workflow diagram of the Atella Archaeological Project: 1) research design and planning; 2) legacy data digitization; 3) 3D geodata production; 4) heterogeneous data GIS integration; 5) GIS analysis for interpretative hypotheses; 6) ground truth results check; 7) curate, archive, and disseminate the data; 8) publish results (T. Tescione).

data to interact with each other (Bogdani 2019, with references). This approach is used for the reconstruction of the archaeological landscape of Atella, where 2D and 3D geospatial and archaeological documentation interact within the project's geodatabase (Fig. 7).

As part of the project, archaeological legacy data from the 19th and 20th centuries were collected, in order to identify the provenience of excavated materials and improve the documentation of architectural elements at Atella. The digital data integration workflow defined for the project is a multilayered process that aims to enhance the archaeological investigation for understanding the site's ancient urban layout, without the need for direct excavation (Abate *et al.* 2023; Dorninger and Nothegger 2012; Wang and Hu 2014; Tanasi *et al.* 2023). Therefore, together with the non-intrusive methods, the approach conforms to the so-called "Archaeology of Archaeology", which was initially proposed by Murray and Spriggs Field (2017). This approach views a site as a laboratory where prolonged archaeological investigation produces data and knowledge while leaving physical evidence on the site.

The archival research carried out so far has generated a large amount of data (both raster and vector) on the dispersed archaeological heritage of Atella. The heterogeneous datasets serve as layers in the GIS platform, enabling geodata to interact with one another. These datasets are based on:

1. cartographic data from archives;
2. published reports of archaeological excavations and survey projects;
3. topographical data from the fieldwork undertaken for the georeferencing of legacy data in points 1 and 2;
4. topographical data from the geophysical prospection with the use of Ground Control Points (GCPs) measured with a GPS;
5. remotely sensed data, including satellite imagery, low-altitude historical photographs from Royal Air Force (RAF), Military Aeronautics (AM), Istituto Geografico Militare (IGM); Italian National Geoportal, Bing Maps, Google Earth, LiDAR (TLS);
6. Proximally sensed data, including UAV imagery, DTM models obtained through aerial Structure from Motion (SfM), multispectral imagery, etc.
7. Excavation data.

The multi-temporal raster dataset helps mitigate the biases that archaeological surveys might face when relying on a single method. As with other Mediterranean regions, in the second half of the 20th century Campania was heavily modified by large infrastructure and building expansion, and many archaeological elements of the landscape have therefore been erased (Fig. 8). For example, the analysis of historical aerial photographs (Guaitoli 2003), compared to satellite images, in the case of Atella constitutes an essential asset of the research aimed at reconstructing the urban form of the city and its territory (Carfora 2011; cf. Quilici Gigli 2005). However, a biased analysis can arise from the randomness and seasonality of traces, which often have a short duration; indeed, for remotely and proximally sensed data, images taken in different years and at different times of the year, increase the chances of detecting traces of buried archaeological features (cf. Brancato, Barone, and Scardozzi 2023 for more). The diachronic analysis of these images is facilitated by their georeferencing and integration into GIS platforms, which create a virtual environment where remotely sensed data is combined with archaeological and geophysical data.

Indeed, topographic surveys in the field are also required to record relevant information concerning the site's archaeological potential. The ground surface may contain important information about the nature of an archaeological site, either related to the potential existence of structures buried beneath the soil (Bowden 1999) or to the taphonomic processes associated with its origin (Quilici Gigli 2002). This is the case of Atella, whose Roman urban grid partially survived embedded in the contemporary landscape. However, radical changes also occurred in its topography which have a great influence on determining the nature of features to be checked through a non-invasive survey (Fig. 9). Therefore, the first step is the detailed topographic survey of the site for recording elevations and relevant points along known breaks in slope; on the basis of these fixed GCPs, corresponding to locations on the digital map, the second step is the creation – in the GIS - of a grid of the entire area. Geodata at different scales are collected to generate three-dimensional and two-dimensional models. This process, which uses Structure from Motion (SfM), enables the extraction of orthophotos and sections from the resulting Digital Elevation Models (DEMs) (cf. Bezzi *et al.* 2010; Naso *et al.* 2024). Extensive and intensive topographical surveys, geophysical prospections, surface sherd collection, pedological soil sampling, and test trench excavations are crucial in the project's

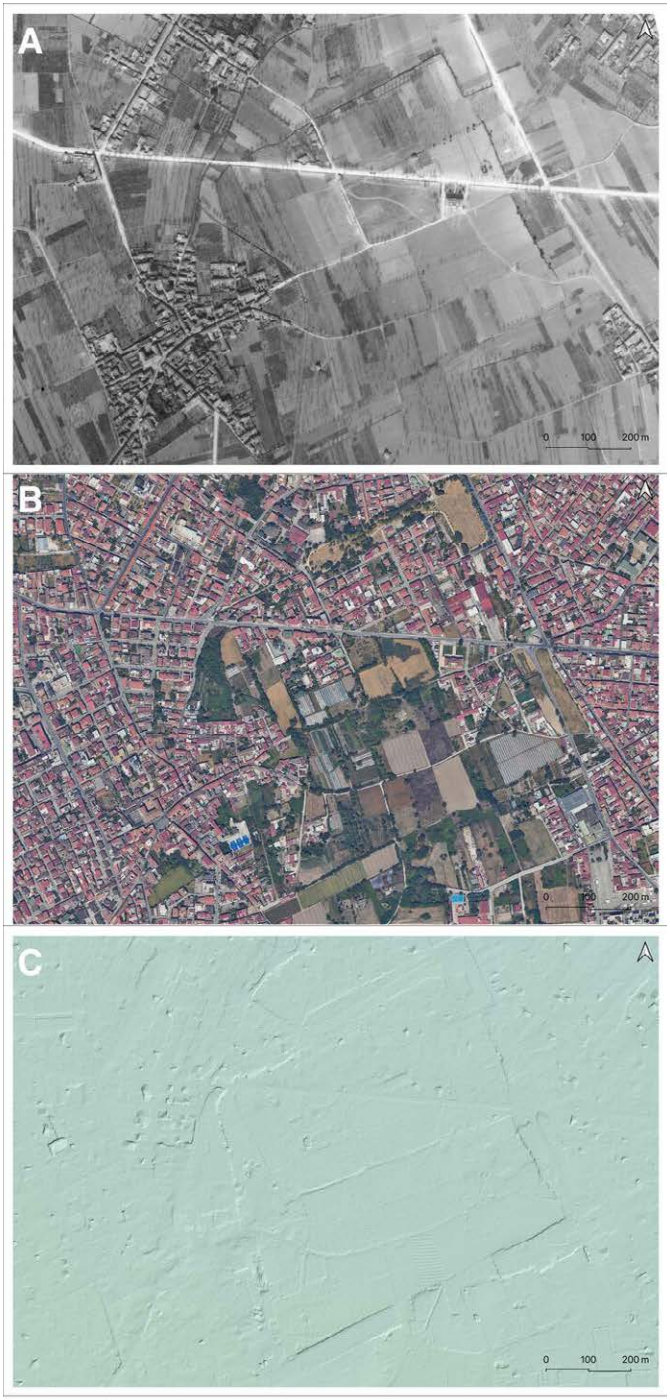

Figure 8 – Atella (A) georeferenced aerial photograph (RAF 1945); (B) satellite imagery (Google Earth 2024); (C) DTM with a 1 m ground resolution derived from LiDAR scanning acquired by the Ministry of the Environment of Italy (R. Brancato).

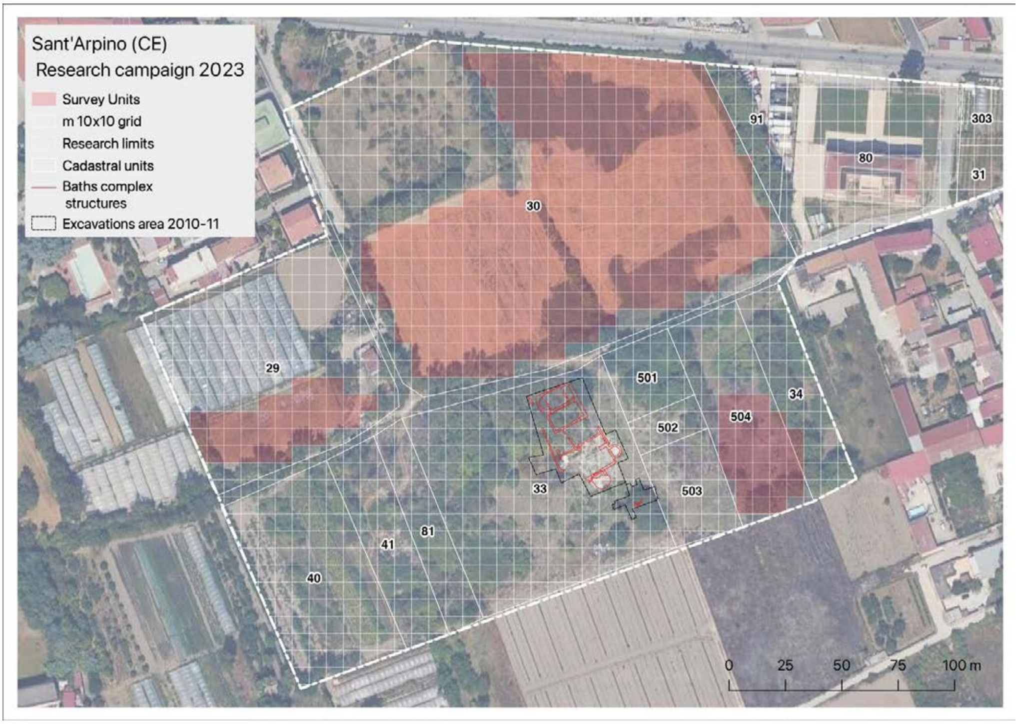

Figure 9 – Project research area with indication of the grid (10 by 10 m) and cadastral units (R. Brancato).

strategy. However, it is necessary that the execution plans and the results are designed to align with the same grid system.

R.B.

4. Geophysical prospection

A number of different geophysical survey techniques can be applied by archaeologists to record the remains of sub-surface archaeological structures. The most commonly applied geophysical techniques include magnetometry and Ground-Penetrating Radar (GPR) (Gaffney *et al.* 2003; Jol 2009). The choice of prospecting methods is determined on the basis of the extent and nature of presumed subsurface archaeological structures, remains and features (for the methods cf. Non-Intrusive Methodologies for Large Area Urban Research) and the local soil morphology and geology. Magnetometry survey is generally chosen as a relatively time-saving[1] and efficient extensive survey technique (Gaffney *et al.* 1991: 6), suitable for detecting minor changes in the earths magnetic field, and is therefore particularly suitable for locating kilns, hearths, ovens, ditches and walls, especially where ceramic material or tufa have been used in construction (Gaffney *et al.* 1991: 6; Scollar *et al.* 1990: 362) and is therefore particularly suitable for the investigation of a Roman town (Kay et al 2023). In areas of modern disturbance

[1] The magnetometry survey at Atella was conducted in 2006 when the technique was the most widely used due to its efficiency in covering large areas. More recently, towed multi-channel GPR configurations have enabled similarly sized areas to be investigated.

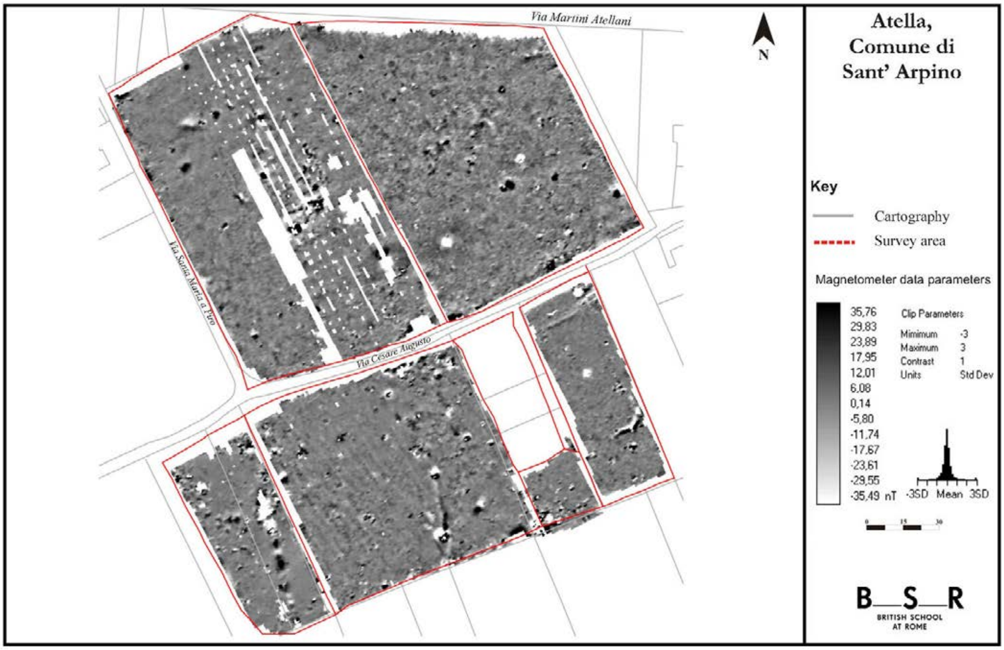

Figure 10 – Magnetometry survey results (S. Kay).

however, the technique is limited due to disturbance by modern ferrous material. GPR is a high-resolution geophysical technique traditionally employed in archaeology for the detailed investigation of restricted areas (Jol 2009). This method utilizes electromagnetic waves to detect and map subsurface features and anomalies. Measuring the strength and time delay of the responses it is possible to estimate the depth of the sub-surface features. Recent work has demonstrated the value of GPR for the investigation of Roman urban sites: since 2015, the GPR has been used on a large scale to generate high-resolution datasets of two greenfield sites in Lazio, Falerii Novi and Interamna Lirenas. Although such rapid data collection allows the mapping of entire Roman towns at an unprecedented level of detail, interpretation of these datasets still largely relies on expert visual interpretation and the manual digitization of anomalies.The magnetometry survey at Atella, undertaken by the BSR, was conducted in 2006 since when there have been significant developments in terms of sample resolution and efficiency with the advent of multi-sensor cart configurations (Fig. 10).

The decision to use magnetometry was guided by the previous successful application of this technique by teams from the BSR and University of Southampton at the nearby Roman towns of Teano (Hay *et al*. 2006) and Calatia (cf. Campana 2021). At Atella, an area of approximately 4 hectares was investigated. The presence of a high quantity of metal, such as that used in fences, pipelines and greenhouses may have had the effect of masking the more subtle magnetic fields of archaeological features (cf. Geoscan Research 1996).

The geophysical survey used grids of 30m by 30m, which were set out using a Total Station. In optimal conditions the grids would be oriented to ensure that the survey crossed the line of potential archaeological features at a 30° angle; however, the significant restrictions imposed by the vegetation across the site meant that the survey grid was established in an approximate north - south direction, in line with the majority of the vegetation. The geophysics was spatially located through a topographical survey for accurately mapping the geophysical survey with the available cartography. The magnetometer survey was undertaken using a Geoscan Research FM36 Fluxgate Gradiometer. Readings were taken at 0.5m intervals along traverses every 1m. An automatic encoder trigger was used to take the readings, allowing the survey to take place more rapidly in areas relatively free of obstructions. However, in the areas of dense vegetation, in particular area 30 (Fig. 14), it was necessary to use the manual logger to collect the readings.

The geophysical survey at the site of Atella presented a series of problems for the magnetometer survey, and these are reflected in the results (Fig. 11-12). The modern interference caused by metallic fences, discarded material and overgrown vegetation has the effect of potentially concealing archaeological features which have a weaker magnetic field. However, the background geology of the site, whilst undoubtedly contributing to the masking of some features due to its volcanic nature, was generally quiet which has aided in identifying some archaeological features. Therefore, the survey successfully located features related to aspects of the urban topography of the ancient Roman city.

In the northern part of the survey, to the south of Via Martiri Atellani, several positive anomalies were recorded which would appear to relate to a series of walls (M1, Fig. 11). Whilst there are no clearly distinguishable rooms visible, it would appear that the walls relate to a building. Further northwards were located a further series of positive linear anomalies (M2, Fig. 11) which can be interpreted as walls. Whilst it is not possible to identify precise function, it should be noted that the anomalies lie on the same alignment as those to the south [M1] as well as those further to the north (M4, Fig. 11). Furthermore, the orientation of these features also appears to correspond to the known direction of the main *cardo* and *decumanus* of the city. As with the general layout of the site, illustrated by Bencivenga Trillmich (1984), the features are orientated on a northwesterly southeasterly axis, parallel and horizontal to the known urban plan (Fig. 6). To the east, fewer archaeological anomalies were identified, possibly due to the effect of data collection in high vegetation. However, traces of some positive and negative features were recorded by the survey (M3, Fig. 11). The features show clear right angles, a strong indication of the presence of buried walls.

In the western sector of area 30 a series of archaeological features were identified (M5, M6 and M7, Fig. 11). The positive anomaly (M5, Fig. 11) towards the southern end of area 30 is slightly masked by the presence of modern rubbish towards the centre. However, this appears to be the location of a sizable structure; the complete feature is roughly oval in shape and measures approximately 18 m in length by 12m. Within the general feature there appear to be some radiating anomalies, however the effect of the modern debris has masked many of the more ephemeral features.

A further series of archaeological anomalies as well as some general linear features, both positive and negative were recorded in the middle of the study area. The features have been distorted by the interruption caused by the vegetation but appear to lie on a similar orientation to those identified in the eastern part end of the field (M14, Fig. 11). Further northwards lies an area of modern disturbance (M7, Fig. 11) whose recorded readings were

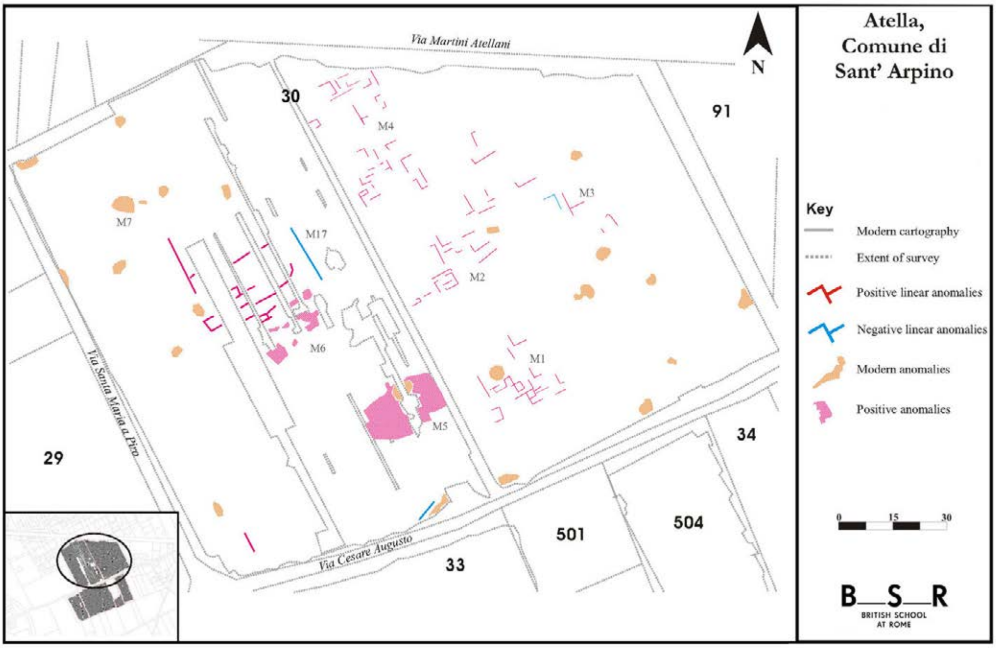

Figure 11 – Interpretation of northern area of magnetometry data (S. Kay).

however significantly lower than those expected of modern debris. It is possible that this is the location of an earlier investigation that apparently located the presence of a buried tomb.

The western section of the southern field corresponds to the area where Johannowsky conducted an excavation in the mid 1960's and discovered a private building, as well as part of a bath complex. The survey was successful in mapping a number of these walls (M9, Fig. 12), however it is clear that not all were detected by the magnetometry. The excavated area was likely to have been backfilled after the excavation or covered over a period of time (§ Discussion). This modern disturbance may have masked some of the weaker archaeological features. However, some of the features recorded appear to correspond to those seen by Johannowsky, in particular the apsidal feature which would appear to correspond to a part of the bath complex (M9, Fig. 12).

Towards the northern edge of the survey in area 33 were recorded a further series of positive linear anomalies (M10, Fig. 12). These features would appear to be on the same alignment as the general urban grid. Also apparent in this area are a series of faint negative modern anomalies that run in an approximate northsouth direction. These are modern traces of the polytunnels constructed from metal support arcs which were removed the day before the area was surveyed and therefore reflect the depressions left in the soil by the space between the tunnels.

To the southern end of the survey area, still within a central area of the city, were recorded a series of positive anomalies (M11 in Fig. 12) which appear to correspond to archaeological features. In particular, clearly evident is a further apsidal feature, associated to a series of

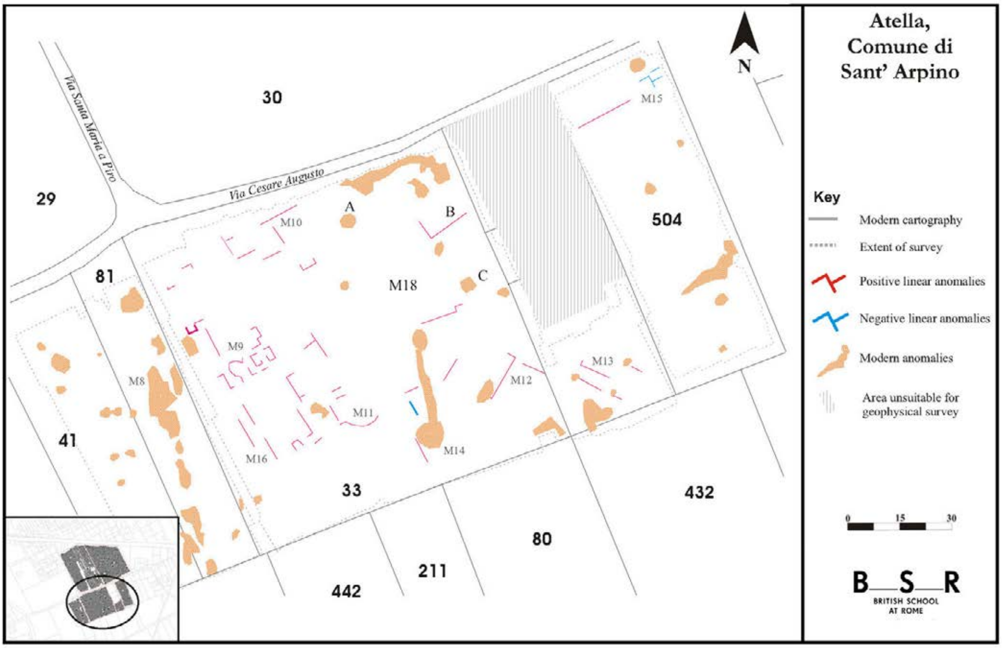

Figure 12 – Interpretation of southern area of magnetometry data (S. Kay).

interlinking walls. The features recorded to the east of this area, beyond the area seemingly investigated by Johannowsky, lie a series of features (M12 – M13 in Fig. 12) on a different alignment to the others (M9 – M11 in Fig. 12). Whilst it is not possible to identify the function of these features, it is possible that these may relate to a different phase of activity on the site.

Within area 504 several features were identified, both positive and negative (M15, Fig. 12) as well as several modern anomalies. These appear on the same alignment as those further to the west and lie parallel to the *decumanus*, approximately 5–10 m to its south.

The modern disturbance across the site presented some problems for the magnetometer survey and the subsequent interpretation of the results. However, there is clearly evidence for a series of buried structures across the survey area, which when combined, begin to form a picture of the urban layout of the town.

The northern area of the survey (Fig. 11) illustrates the complexity of the underlying archaeology, in particular (M4, Fig. 11) which recorded a range of different features. Furthermore, several different features lay on a differing orientation to the other identified positive anomalies, which may therefore indicate a different phase of activity on the site (M13, Fig. 12).

In conclusion, the magnetometry successfully mapped a series of structures and anomalies that would appear to be associated with the ancient town. The majority of these features appear to lie either parallel or perpendicular to the known road system within the city, and thus conforming to the presumed settlement layout. Despite the aforementioned problems

Figure 13 – Aerial view of the 2023 survey area (cadastral unit 30) covered by earlier magnetometry survey (L. Ceruleo).

(i.e. interference by highly magnetic structures and debris, as well as the overgrown vegetation), the survey did successful identify a range of features which will help to broaden the knowledge of the plan of this ancient city.

S.K.

5. 2023 field survey and proximal sensing application

The archaeological research project at the site began in June 2022 with a field survey of the area. Through the integrated use of a Total Station Leica TS03 5'' R500 and a GPS Antenna Leica Zeno FLX100, elevations and relevant points along were measured. The grids (10 by 10 m) created in the GIS platform in WGS 84 UTM Zone 33N (EPSG 32632) - was transposed to the field with a series of fixed GCPs corresponding to locations on the digital map (cf. Brancato *et al*. 2023).

The site's geomorphology is characterized by a wide, flat terrace elevated on the Campanian plain, formed by a sequence of volcanic soils and tufa, upon which the urban landscape of Atella was shaped (cf. Di Vito *et al*. 2021). However, in the last century, the agrarian landscape, still testified in a 19th century description of the area (e.g. Beloch 1890 and Castaldi 1908), was re-shaped by the urban expansion, which dramatically intensified in the entire area after the Second World War (Fig. 8). Other recent changes could clearly be deduced also from a comparison between historical cartography and the remotely sensed data. Due to the urban expansion that has occurred at the archaeological site, mainly in its northern sector, coupled with the dense vegetation coverage which affect the central and southern parts, a survey approach was imperative for undertaking the planned activities (Fig. 13).

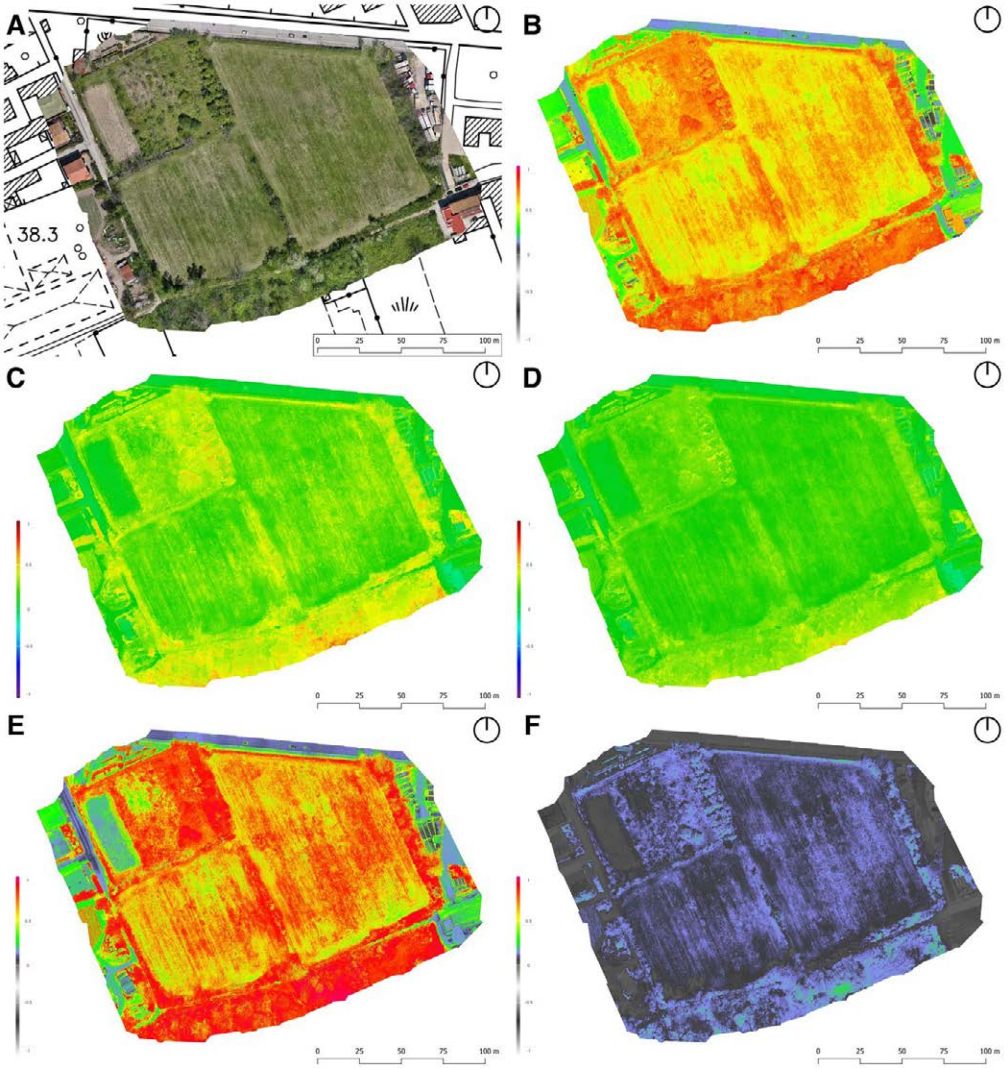

Figure 14 – Orthophoto of the 2023 survey area comparing the panchromatic image (A, RGB) with the multispectral indices: B) GNDVI, C) LCI, D) NDRE, E) NDVI, F) OSAVI (R. Brancato. G. Luongo, V. Mirto).

In 2022-23, a topographical survey was conducted of the entire area (5 hectares): 1) instrument relief survey; 2) field survey; 3) close-range remote sensing and proximally sensed data, using a drone equipped with RGB and multispectral cameras[2] (Fig. 14). Instrumental surveying was applied to capture key topographic points essential for the multiscale cartographic documentation of the site. The instrumental survey was established using a closed-type topographic polygon, a choice made despite visibility challenges caused by the dense vegetation in the southern sectors of the site (nos. 40, 41, 81, 33, 501-3 in Fig. 9). The measurements were designed to produce high-resolution digital cartography for the entire

[2] The DJI Mavic 3 is a drone equipped with a two-in-one system which integrates a multispectral camera featuring four 5 MP lens, and an RGB camera equipped with a 4/3-in CMOS and a 20 MP image sensor.

site (geometric model) and to provide a topographical platform for 3D models, addressing the needs of research, conservation, and enhancement within cultural heritage studies (cf. Lock 2003; Moscati 2009; Ferdani *et al.* 2019). The 3D spatial data, derived from SfM processing created with Agisoft Metashape, were integrated in Leica Cyclone (cf. Brancato in Naso *et al.* 2023): this was possible through the identification of GCPs utilized for the placement of a total station and measured with a GNSS antenna. Based on the same GCPs, through the "Georeferencing" plugin available in the cartographic software QGIS, each raster file was a layer of the GIS platform and used for the creation of vectors.

Commenced in 2022 and still ongoing, the intensive and systematic surface survey (60 hectares) was based on the10m by 10m grid plotted in the GIS: teams using portable GIS on tablets (QFields software) surveyed the squares arranged in transects with a constant distance (2 m) (Fig. 9). In agreement with the SABAP, a total collection of visible archaeological artifacts on the surface was undertaken. Although preliminary, the survey of the central area has yielded significant results: material found in the topographical unit (UT) 30, which had the best visibility since it was surveyed immediately after ploughing, ranges from the Republican period to the modern age, with interesting evidence for the early medieval period (Fig. 15).

The aerial survey of the central area (6.7 hectares) was carried out through the systematic use of a drone (Fig. 16). The obtained proximally sensed data were used for the creation of an ultra-high-definition digital model (1.2 cm per pixel), from which it is possible to extract not only orthophoto plans but also an updated topographic base with 10 cm contour lines. Thanks to the combined application of RGB and multispectral cameras, the orthophoto plans can be analyzed sequentially to check the topographic consistency of cropmarks visible in the cultivated sector of the archaeological part; in the southern sector, the dense tree vegetation and the greenhouses prevent the use of the multispectral sensor. However, good results were obtained from the aerial survey conducted in early May 2024 over the central area (2.5 hectares) north of Via Martiri Atellani, when the grain was almost at the end of its growth cycle (n. 30 in Fig. 9). Here, intricate chromatic anomalies are visible, some of which are likely related to buried buildings, at least in the case of a long linear feature (M1 in Fig. 16 B).

6. Discussion

The visible archaeological structures, together with the data from the magnetometry and the remotely to proximally sensed data, may help in the reconstruction of the urban plan of Atella. Only two flights were undertaken in 1943 and 1945 by the RAF on this area: however, in the frames, traces of a large rectangular anomaly, about 52m wide and elongated in a NW-SE direction for about 113m, is clearly visible in the 1945 aerial photograph (flight 930 of March 10, 1945; strip: 3402; frame: 3073) and in the VB by IGM (1954) (Fig. 17) (cf. Brancato, Barone Scardozzi 2023). This is in the central area of the ancient town, near the place where the main *cardo* and *decumanus* likely intersect: with an orientation consistent with that of the urban layout, the anomaly may refer to the perimeter of a large building or perhaps a large paved open space. Moreover, also a chromatic anomaly could be substantiated by a structure which was plotted in the archaeological map published by Castaldi (Fig. 5, n. 3). Indeed, based on the GIS, this anomaly should be in area 30 and may correspond to a wall (5 m) (Castaldi 1908, fig. 1, n. 8). Its description consists of height measurements relative to the ground level (maximum height: 2.13 m) with *opus latericium* superimposed on a structure in *opus reticulatum*) (Castaldi

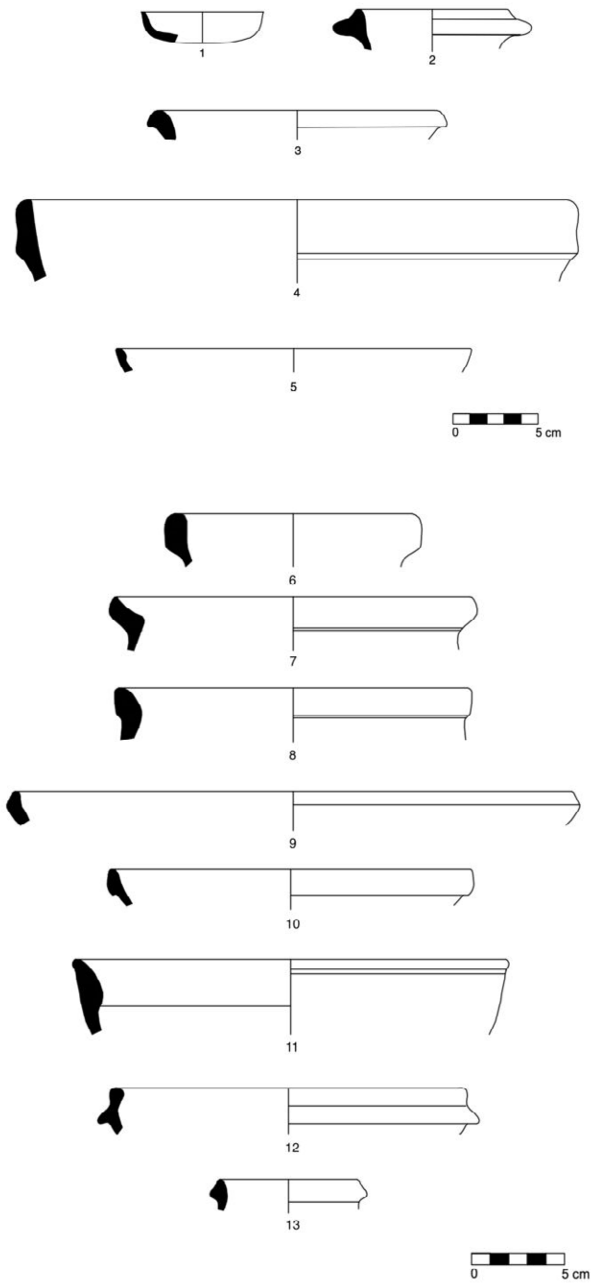

Figure 15 – 2023 survey area (cadastral unit 30), ceramic sherds dating from the mid-Republican to early Imperial period: black-glazed ware (nos. 1-2), common ware (nos. 3-4), African cooking ware (no. 5). Late Antiquity: painted ware (nos. 6-8), African red slip ware (nos. 9-10), common ware (nos. 11-13) (E. Canciello, T. Tescione)

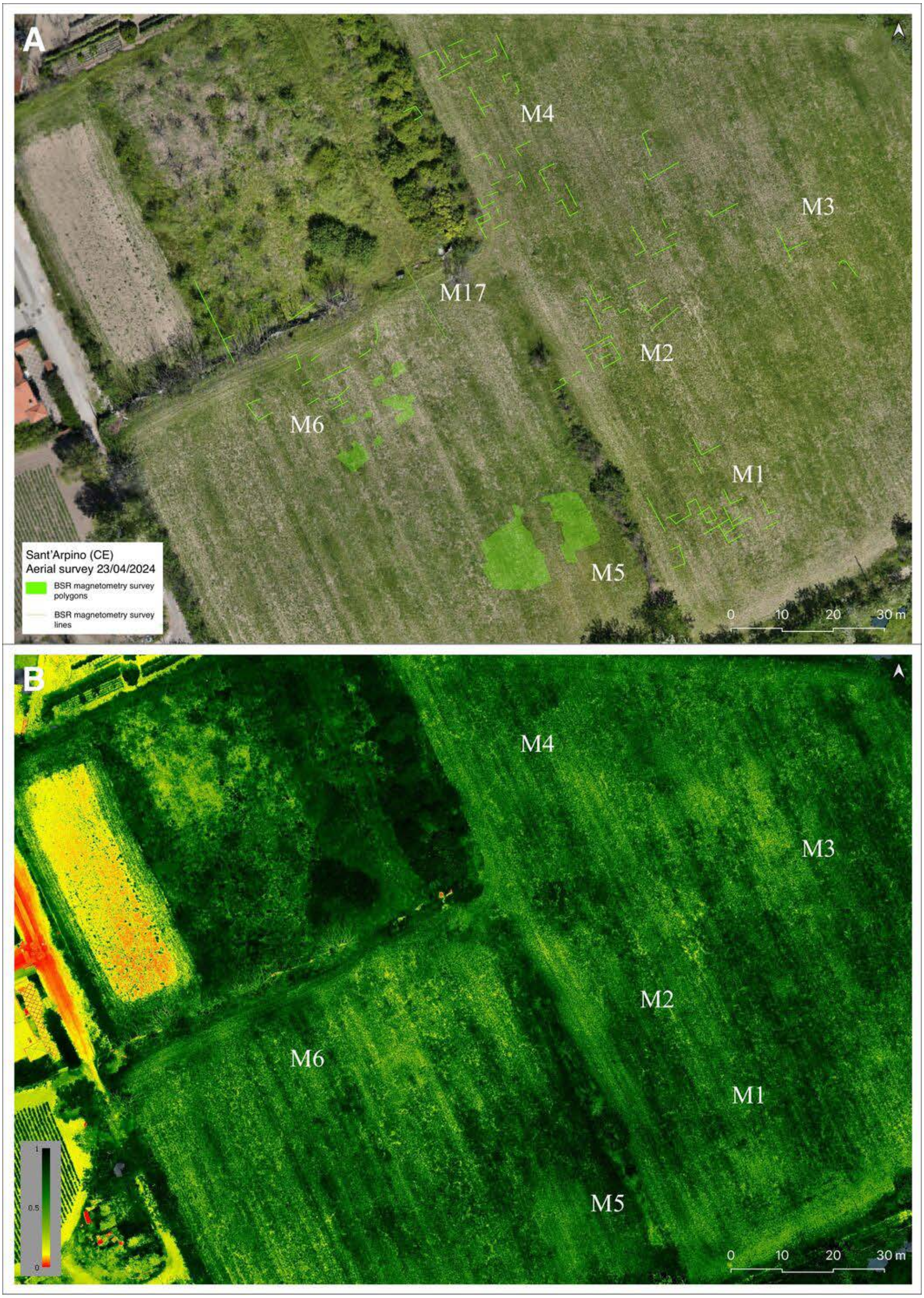

Figure 16 – 2023 survey area (cadastral unit 30), panchromatic and NDVI orthophoto plan annotated with the results of the magnetometry survey (R. Brancato, G. Luongo).

Figure 17 – The chromatic anomaly west of the 2023 survey area (cadastral unit 30) (A. RAF 1945; B. VB IGM 1954; C. Satellite imagery (Google Earth 2024) (R. Brancato).

Figure 18 – The excavated bath complex at the end of 2011 excavation campaign led by SABAP (L. Lombardi).

1908, 81): the level of detail may allow for the hypothesis that the structure could be attributed to a multi-phase construction, perhaps a monumental portico located on the eastern side of the forum. The west sector of the field was covered by the magnetometry survey conducted in 2007, and aerial survey with multispectral sensor in 2023. The positive anomalies M5 and M6 from magnetometry can be compared with proximally sensed data (Fig. 16). Indeed, in both panchromatic and multispectral aerial footage filtered with the NDVI index, significant anomalies are visible that are consistent with those identified by geophysical surveys and, in some cases, comparable to buried buildings (cf. Agapiou *et al.* 2012).

The results from the magnetometry survey conducted in 2006 can be compared also with the structures brought to light in the 2010-11 excavations. Indeed, the placement of the excavation was likely based on visible wall crests on the surface (38.68 m a.s.l.), without necessarily considering the results of the magnetic survey (Fig. 18). Specifically, in that sector,

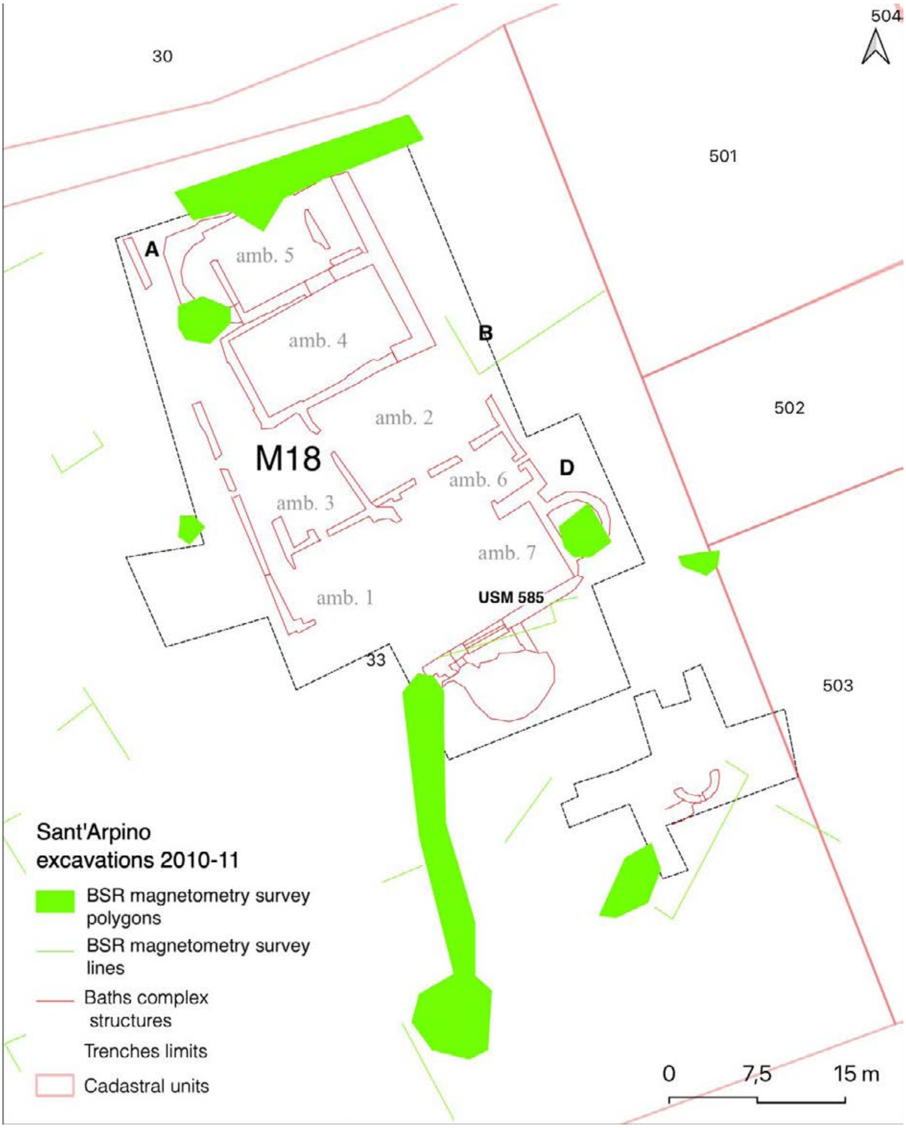

Figure 19 – The bath complex plan compared with the magnetometry results (R. Brancato).

a series of anomalies emerged, particularly two linear features with an east-west orientation and small areas of higher readings, identified as potentially modern fills. Therefore, it is of particular interest to note that M18 (Fig. 19) constituted the bulk of a significantly thick wall partition (USM 585, 37.86 m a.s.l.), attributable to the south perimeter wall (cf. Figs 12 and 19). The lack of visibility of anomalies related to structures buried deeper than 0.82 meters from the ground level is certainly significant in light of the excavation results; the areas identified as modern anomalies are likely related to the fills of the pools of the frigidarium (C in Fig. 19) and the calidarium (A in Fig. 19).

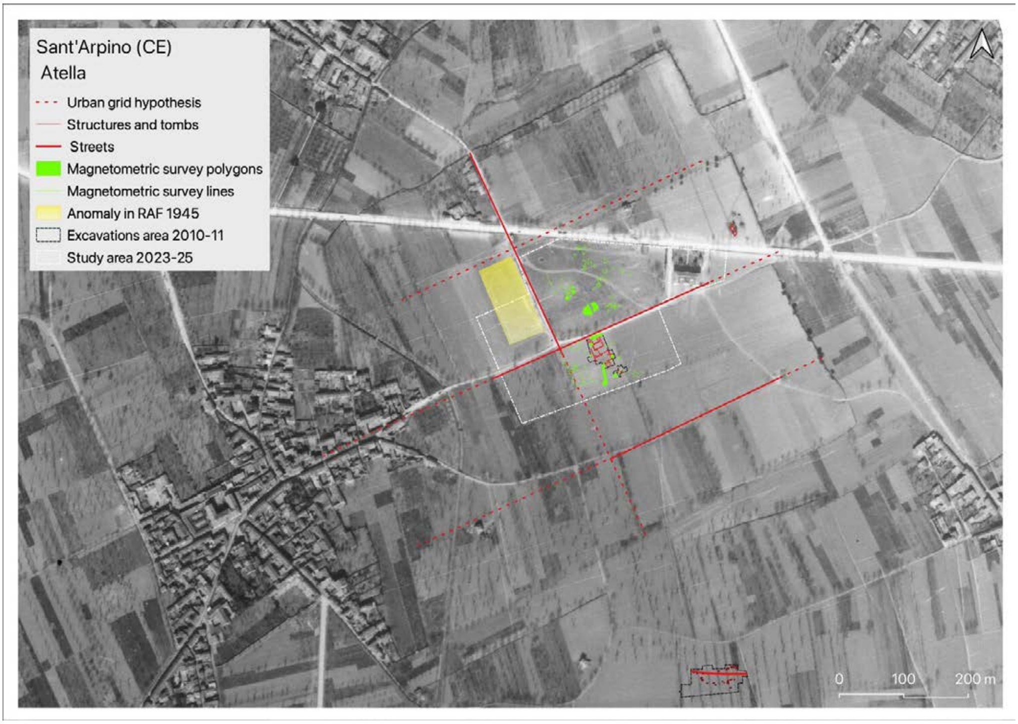

Figure 20 – The palimpsest of heterogeneous geodata from the Atella Archaeological Project overlaid on the 1945 aerial photograph (RAF), georeferenced in GIS (R. Brancato).

This case emphasizes the importance of integrating different archaeological methodological approaches, particularly between geophysical surveys, like magnetometry, and traditional archaeological excavations. The cited example highlights how, in some cases, decisions regarding the location of excavations can be influenced by surface observations, such as visible wall tops, without adequately referencing data provided by pre-excavation geophysical surveys. This may lead to underestimating or even overlooking crucial information about the presence of structures buried at greater depths. The mention of linear anomalies with an E-W orientation and small pockets of higher readings interpreted as modern fill illustrates the complexity of interpreting geophysical data and the need for careful integrated analysis to distinguish between ancient structures and more recent interventions. Moreover, the discovery of a significantly thick partition wall and the potential identification of structures from the thermal complex underscore how geophysical surveys can provide valuable information to guide and optimize archaeological excavations. The use of GIS technologies for overlaying and analyzing geophysical data with excavation results and other ground investigations allows for a deeper understanding of the archaeological site and facilitates the reconstruction of ancient structural complexes. In this specific case, the confirmation through GPR survey of the presence of buried structures at a certain depth adds another layer of information, supporting the hypothesis of structures belonging to the thermal complex and potentially indicating new areas of interest for future investigations.

R.B.

7. Conclusion

In summary, the multidisciplinary approach not only improves the precision and effectiveness of archaeological research but also opens new perspectives on understanding ancient urban sites, allowing for more informed hypotheses on their spatial and functional organization. The workflow applied in the first steps of the Atella Archaeological project, integrating data from different scales, sources and technologies, including aerial photography, satellite imagery, geophysical prospection and field survey aims to provide a detailed understanding of the archaeology topography of the site (Fig. 20). The connection between the thermal complex investigated in 2010-11 by SABAP and the forum, as suggested by Camodeca (2021) through an insightful analysis of the epigraphic material, is a hypothesis now supported also by the integrated reading of legacy geodata and remotely sensed images. Indeed, the digital topographic palimpsest, inferred from the informed layering of anomalies derived from geophysical prospection and the recovery of topographical evidence from digitized and georeferenced legacy data, allows for the hypothesis that the project's focus area is the central part of Atella, where the main public buildings were located (Gros, Torelli 1988). Future research on such a crucial sector of the ancient city may not only provide significant insights into the urban planning and architectural development of Atella through the centuries, but it can also highlight the importance of integrating various methodologies in archaeological research. Indeed, the combination of extensive geophysical surveys and photointerpretation may offer a glimpse into the spatial and functional topographical organization of a Roman town, as outlined in the discussion of the 2006 magnetometry survey results. Through an integrated approach, hypotheses about the urban layout and functional areas of ancient urban centers are possible, but they must be substantiated. In the case of the Atella Archaeological Project, the planned targeted excavations in the next years (2024-26) will clarify the stratigraphic relationships between the elements of the digital GIS palimpsest.

R.B., S.K.

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Landscapes of mobility: the results of the Roca Archaeological Survey (Part II)

Francesco Iacono
francesco.iacono5@unibo.it – Dipartimento di Storia Culture Civiltà, Università di Bologna
Luca Alessandri
luca.alessandri@uniroma1.it – Dipartimento di Scienze dell'Antichità, Università La Sapienza di Roma
Alessandro Quercia
alessandro.quercia@cultura.gov.it – Soprintendenza archeologia, belle arti e paesaggio per la città metropolitana di Torino
Guven Gumgum
guvengumgum@gmail.com – Dipartimento di Studi Umanistici, Università di Bari
Eda Kulja
edakulja@gmail.com – Independent scholar
Francesca Porta
francesca.porta5@unibo.it – Dipartimento di Storia Culture Civiltà, Università di Bologna
Angela Falezza
angela.falezza@merton.ox.ac.uk – Dipartimento di Storia Culture Civiltà, Università di Bologna; Merton College, University of Oxford
Giovanna Agostini
giovanna.agostini3@unibo.it – Dipartimento di Storia Culture Civiltà, Università di Bologna
Alessandra Salvin
alessandra.salvin@gmail.com – IIMAS - The International Institute for Mesopotamian Area Studies

Abstract
The Roca Archaeological Survey has produced a wealth of new data on the landscape frequentation of the important settlement of Roca Vecchia, one of the most important hubs in the central Mediterranean from later prehistory until medieval times.

This paper presents the results obtained from the analysis of the data from the ancient to the late medieval period, as a continuation of what has been published in part I in the previous volume of GROMA (Iacono *et al.* 2024), trying to highlight how the specific features of a mobility hub like Roca Vecchia influenced occupation trends through time.

Keywords
Central mediterranean, Survey, Prehistory, Classical, medieval/post-medieval

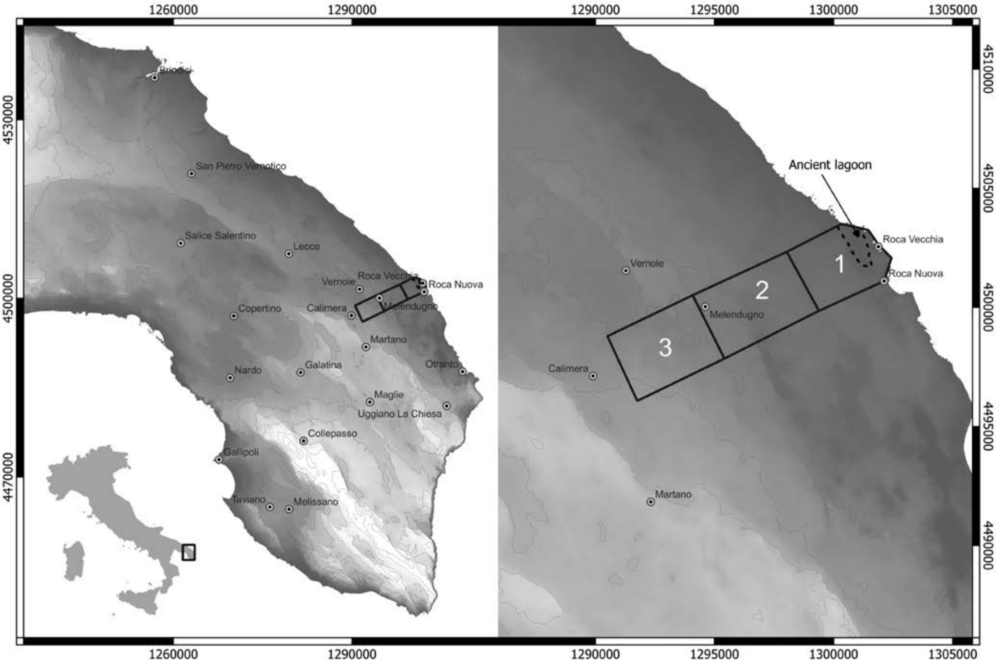

Figure 1 – Main area of the Roca Archaeological Survey (after Iacono et al. 2020).

Roca Vecchia: a Mediterranean hub through history

The archaeological site of Roca Vecchia is located on the Adriatic coast in southeastern Italy (Fig. 1). The site has been one of the most important mobility and interaction hubs in the central Mediterranean Sea since later prehistory, when it was at the core of connections with Aegean palaces. It later developed through ancient times as important cave-sanctuary and, in the Medieval Age, it became a military citadel.

The main objectives and methodology of the Roca Archaeological Survey[1] were outlined in Part I of this article, published in Groma 8 (Iacono *et al.* 2024), along with the preliminary results related to the Prehistoric phases of the site. This paper will focus on the Ancient to post-medieval / Early Modern macro-periods (Table 1), trying to highlight how the specific features of a mobility hub like Roca Vecchia influenced occupation through time.

Extensive connections during the Archaic and Hellenistic period are witnessed not only by imported materials recovered at the site, as well as at its necropoleis (Giannotta 1996; Auriemma 2004), but also in the nearby Grotta della Poesia, whose walls are covered by numerous inscriptions in three different languages: Messapian, Greek and Latin (Pagliara 1987, see also Auriemma 2004). Finally, the late-medieval and post-medieval phases are best

[1] The Roca Archaeological Survey was funded by the project "Landscape of Mobility and Memory" (Progetto Montalcini 1910) and AlmaScavi - University of Bologna. Permits were granted by the Superintendence ABAP for the provinces of Brindisi and Lecce. Our most sincere thanks go to this Institution for the precious collaboration over the years, as well as to the many students that took part in the survey.

Table 1 – Diachronic developments at Roca Vecchia (dates BCE in the table are only grossly approximate and do not take into account different opinions in chronological assessment of main developments such as the beginning of the Iron Age (on which see Bartoloni & Delpino 2005 or Picht & Nijoboer 2018)

Period	**Roca**	**Approx. years**
Archaic / Classical	– New moat – First dedication inscriptions found on the walls of *Grotta della Poesia* – Tombs	600–400 BCE
Late Classical / Early Hellenistic	– New fortifications in large stone blocks – Large residential quarters – Numerous necropolis areas	400–200 BCE
Romano-Late antiquity	– No archaeological evidence from the Roman period at Roca, but there is a settlement nucleus on the southwestern gate of the Hellenistic walls – *Grotta della Poesia* continues to be frequented until this period	200 BCE–600 CE
Medieval	– Remains of the small religious building – 7th–8th century CE necropolis near the north gate of the Hellenistic walls	600–1300 CE
Late medieval – post medieval / Early Modern	– Foundation of the late medieval citadel, which was abandoned around 1550 with the rise of the Renaissance village of *Roca Nuova* in the hinterland. Toward the end of this period, connections were established with the Ottoman area to the east	1300–1550 CE

represented in the architectural remains currently visible on the ground, which have allowed an accurate reconstruction of this historical phase of the settlement (Güll 2008). Beyond the evidence from the main settlement, forcibly abandoned in favour of an inland new village around the late 16th century CE, for a long time the hinterland of Roca saw also other forms of mobility. These can certainly be recognised in the medieval and post-medieval periods when the entire eastern Salento experienced the arrival and settlement of people who spoke the Griko language (a form of Greek attested in various parts of Southern Italy, see Pellegrino 2021) and who had considerable religious, cultural and economic ties with the world on the other side of the Adriatic Sea (i.e. Greece and the Balkans).

After the abandonment of the main medieval citadel, not much is known about Roca. Between the 1200s and 1800s the lagoon environmental conditions worsened considerably, creating relevant economic issues in the area as reported by local historical sources (Carrozzo 2019). At some point after this period, the village of Roca "Li posti" was established although this remained very small (it had only 21 inhabitants up until 2001). In the 1950s, a summer camp/

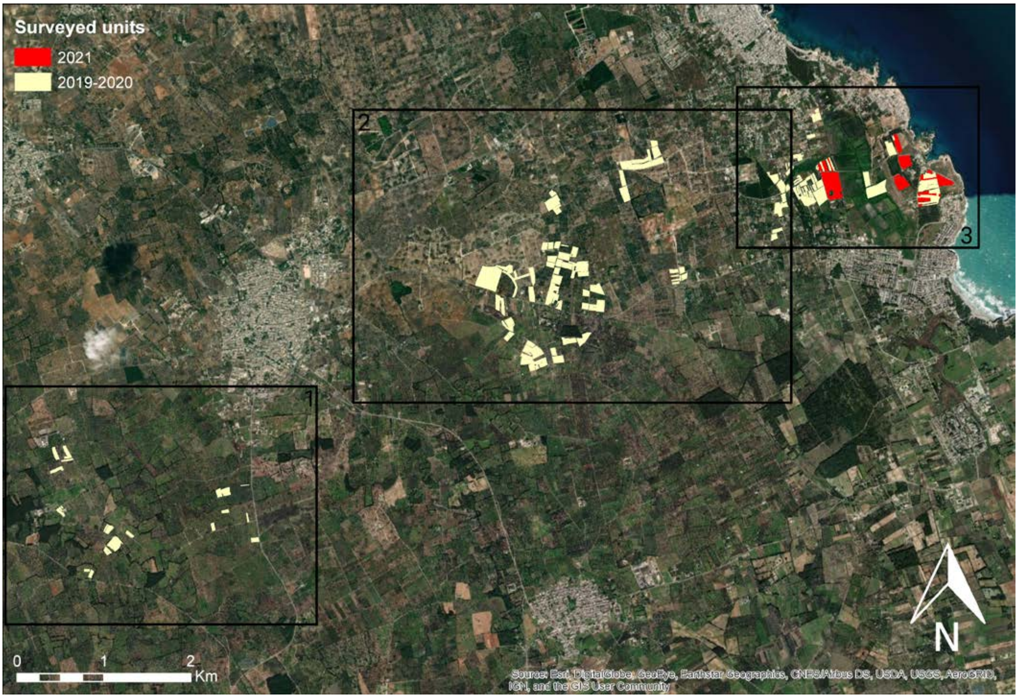

Figure 2 – Surveyed units in the Roca Archaeological Survey according to date (Iacono et al. 2024).

leisure facility was established by the local church, later reused in the 1990s to guest migrants coming from Albania in the first main immigration flow occurring in Europe in the aftermath of the fall of the Eastern Bloc (Farina and Iacono 2024). More recently, the wider area has been at the centre of a very intense social and political conflict between local communities and large-scale development, following the decision to route the large pipeline bringing to Europe Azerbaijani gas (the trans-Adriatic pipeline) through this region.

The Landscape of Roca Vecchia through time

A discussion on the field methods and quantification practices employed for material collection was presented in the previous part of this article (Fig. 2, Iacono *et al.* 2024). Here, we will focus only on the data pertaining to periods ranging from Antiquity to post-medieval times (Table 1).

From the Archaic period to Late Antiquity

After the Iron Age, for which there is scarce evidence (for the few well-explored contexts dating to this period from the main site, see Corretti *et al.* 2017), more substantial information on the human presence at the site can be found from the 4th century BCE onward. The settlement's extension included the area of the promontory where the prehistoric occupation was concentrated. This area is provided with fortification walls that describe an open polygon approximately 1550 m in length, with two entrances: the North and West Gates. Two ditches run parallel to it, whose cuts are evident along the cliff (Rizzo 2006; De Giosa 2011).

Fortification walls display several phases of construction and appear to have been interrupted simultaneously in all sectors. Their chronology, spanning from the second half of the 4th to the beginning of the 2nd century BCE, could be estimated thanks to the discovery of a tomb below the foundation level (De Giosa 2011). At this point, Roca Vecchia is a Hellenistic town, and the surface record poses no little interpretative issues (Bintliff 2012, and more generally Vermuelen *et al.* 2012). The quantity of materials has expanded tenfold, particularly in the area immediately to the south of the Bronze Age fortification. Moreover, the presence of formal burial areas and structural remains, excavated by Mario Bernardini in the 1940s and 1950s (Bernardini 1956; Giannotta 1995, 1996), further complicates the analysis.

Six architectural elements dating to this broad chronological horizon have been identified in the surroundings of the wall circuit, namely a keystone, a base element, a *cornice,* the fragment of a threshold, and some slabs. These could have been part of the nearby monumental necropolis complex. All analysed pieces are made of fine-grained tuff, probably from quarry deposits near the Roca area.

The *cornice* (Fig. 3) probably belonged to a prestigious monumental tomb comparable to others already identified in the area (Lamboley 1988). Comparative analysis with other findings from the area will help to determine if these are local artefacts, and therefore is they were produced by local workers or whether they were imported. It is possible to roughly date the architectural elements to a broad chronological period from the second half of the 4th to the beginning of the 2nd century BCE.

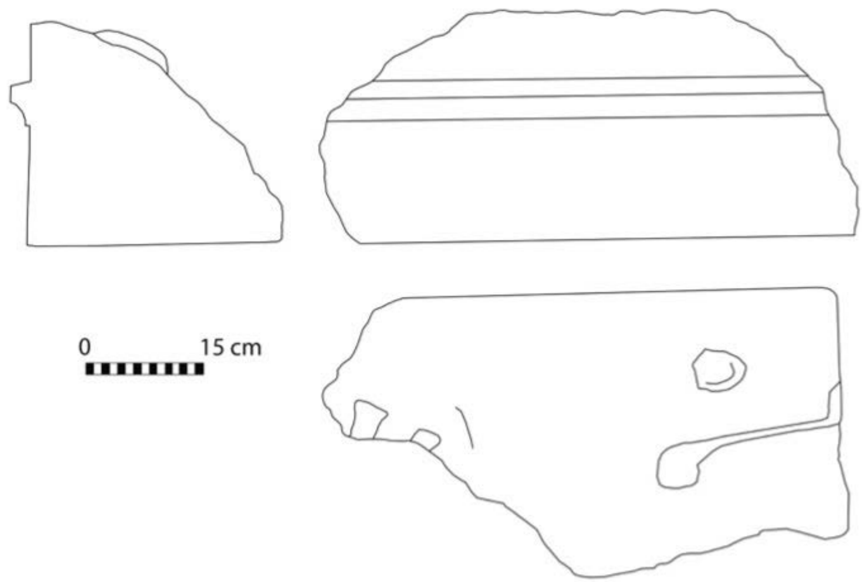

Figure 3 – Stone cornice from the ancient town (drawing by the author)

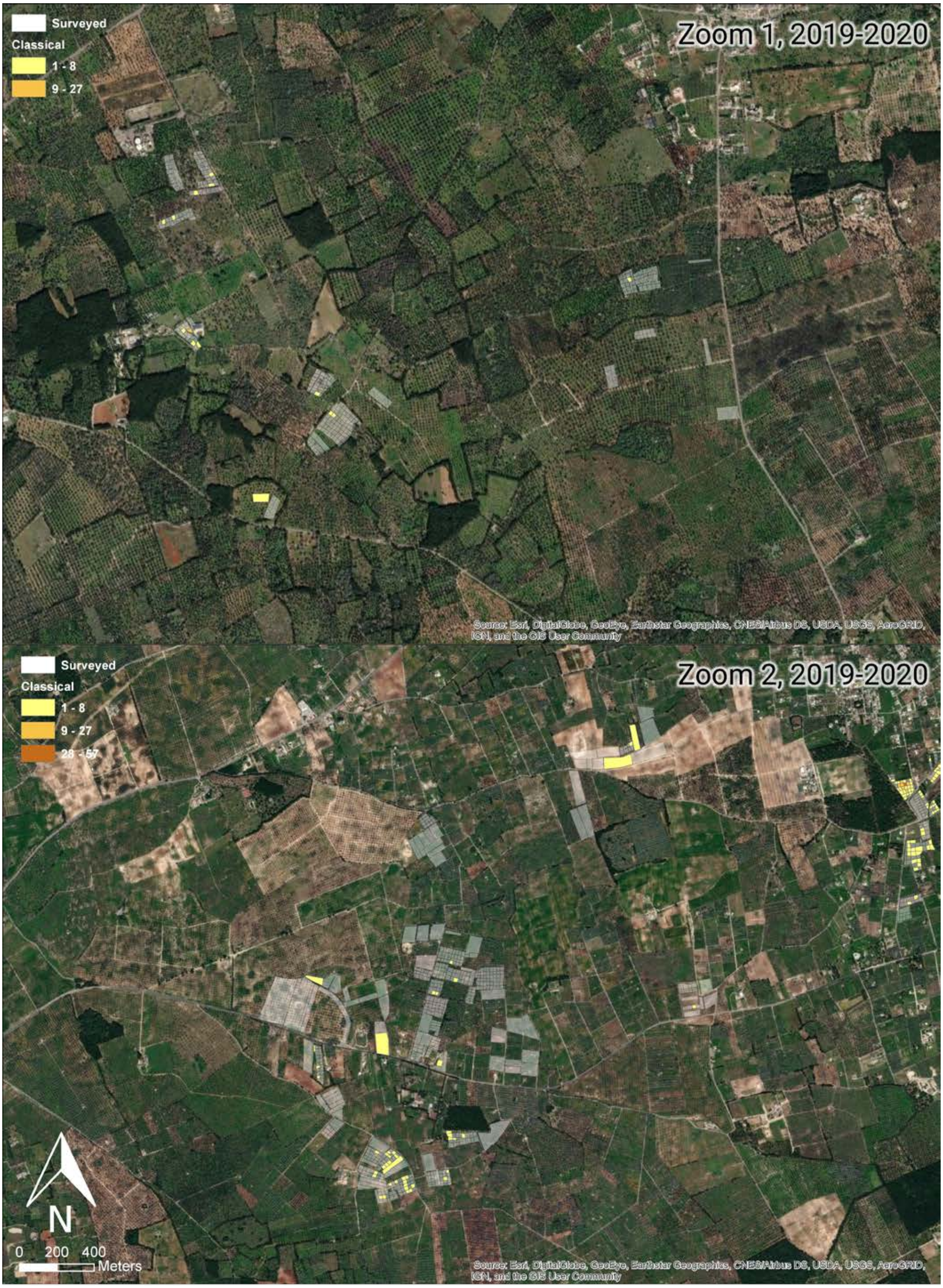

Figure 4 – Distribution of ancient material in the areas 1-2 of Fig. 2

As for the internal organisation of the settlement, the remains of a rectangular structure were found in the central sector of the promontory, which retains part of the foundations, several blocks, and a limestone floor (Pagliara 2001). Immediately to the north and south of the building, along its shorter sides, two roadbeds - used for at least a century – have been identified. Structures and tombs belonging to the same chronological horizon have also been uncovered along the southern side of the inlet opposite the Sanctuary of the Madonna di Roca and to the SW of the Grotta della Poesia, SE of the promontory (Pagliara *et al.* 2009). In this area, excavations have revealed a complex urban layout, including the terminal part of a moat dug into the bedrock dating to the Late Archaic phase (late 6th century BCE). Running parallel to this moat there was a straight road axis, on the sides of which a series of rectangular rooms and enclosures were located. From the same road, two additional orthogonal paths departed northward, and between them another series of rooms and structures were found. Finally, in the same sector, 22 pits and tombs dug in the bedrock were brought to light (De Giosa 2011).

A subsample of the material culture collected during the 2020 survey (Fig. 4, 5) has been analysed and is predominantly composed of non-diagnostic finds or finds with broad date ranges, which hinder precise chronological interpretation. Some ceramic classes, such as plain and cooking wares, are particularly difficult to assign to specific chronological phases. In this section, we primarily discuss finds recovered in the immediate surroundings of the main site (Fig. 5).

The Archaic and early Classical phases (second half of the 8th to the early 5th century BCE) at Roca Vecchia are documented by limited diagnostic finds, including fine wares, trade amphorae, and local matt painted pottery (18 certain finds and 11 dubious ones). Among the Archaic fine pottery, a wall fragment of a so-called *filetti* cup, characterised by a grey fabric, could be tentatively considered one of the earliest examples. Also, a rim of B2 type cup, widely attested in colonial and indigenous contexts of south Italy in the 6th century BCE, is noteworthy. A single fragment of Black-Figure Greek pottery was uncovered during the survey. Other finds, such as black gloss and slipped pottery - primarily *lekanai* - could hypothetically be associated with this period based on the features of their fabric (e.g., 'sandwich' type or gray) and surface treatment. At present, we do not have enough evidence to determine whether such early materials represent Greek imports from 'colonial' regions, though they undoubtedly testify to mobility typical of the mid-first millennium BCE in Southern Italy.

Trade amphorae are represented by very few fragments associated with Greek imports commonly documented in Archaic South Apulia, such as a toe and a handle consistent with a Corinthian Amphora A, and a toe belonging to a Corinthian B (Koehler 1981).

The evidence datable with certainty to the full 5th century BCE is very scarce. A fragment of red-figure *stamnos* and an almond-type rim belonging to a plain basin (see parallels in Villing and Pemberton 2010, 576, Fig. 9 nos. 15-16) can be tentatively associated to this phase.

Much more documented is the evidence for the Hellenistic period (at least 84 fragments), proving a more intense presence in the area from the 4th to the 2nd century BCE. Black gloss wares, either produced locally or in the nearby Greek *poleis* of Metaponto and Taras, are documented by a broad variety of drinking vessels, namely *skyphoi* (type Morel 4375b 1, 4373), one-handled and handleless cups (type Morel 2942), concave-convex type, small cups (Morel

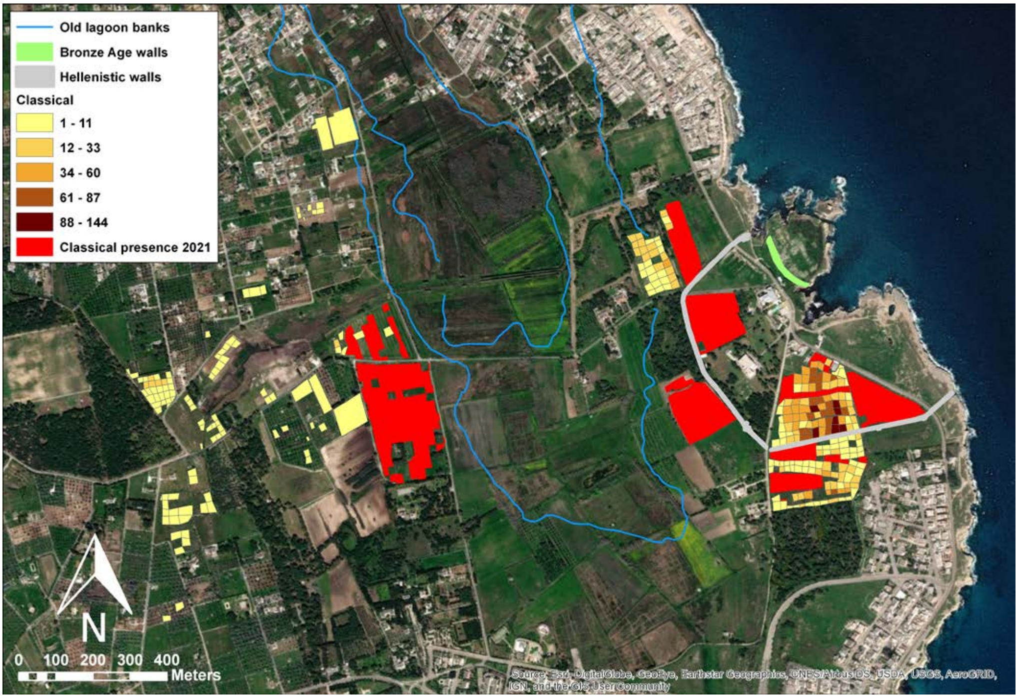

Figure 5 – Distribution of ancient material in the area 3 of Fig. 2

2400, 2430), *kantharoi* (Morel type 3164 a 1), shallow bowls (Morel type 2273-2274-2276), and plates (Morel type 1313-1315)[2]. A single fragment of Hellenistic Red-Figure pottery produced in the colonial area occurred with certainty. Among other fine wares, there is an abundance of wall, bases, and handles fragments from kraters, basins, and plates belonging to the Hellenistic Messapian painted pottery, characterised by a brown or red coat and stripes. The presence of other local fine pottery productions, like the Grey Gloss Ware and the High Fired Ware group (HFWG) is also documented by a few finds.

Fragments of plain wares, associated primarily with the same forms attested in painted wares and related to household contexts, are also numerous. Some of these could also come from tombs grave goods. Additionally, eight fragments of cooking wares are also related to domestic contexts and consistent with shapes and types commonly attested in the Hellenistic sites in Messapia, predominantly *chytrai*, lids (to a lesser extent), as well as a *lopas*.

The so-called 'Graeco-Italic' and 'mushroom-rimmed' amphorae (at least 19 items) are the most common types found among transport vessels. These amphorae were very popular in the Mediterranean area from the end of the 5th/early 4th century BCE onward with different production centres located in the Aegean area and in Southern Italy (Vandermersch 1994; Lawall 2004). Less frequently attested are other types of Hellenistic amphorae, including a fragment of late Punic Maña C, few fragments belonging to late Roman Republican amphorae

[2] for Morel types see Morel 1981.

Lamboglia 2 (see Bruno 1995), and a toe from a probable 'Brindisi' type amphora (Sciallano and Sibella 1991).

From the 1st century BCE onwards, through the entire Roman period, there is a drastic decrease in the number of finds. Only four fragments of fine pottery certainly belonging to this phase have been collected during the survey; a foot of Eastern Sigillata A (forma 23, 2nd c. BCE–10 CE; *Atlante II*, 24, pl. 3, no. 14), a wall of African Sigillata C dated to 4th century CE (type Hayes 62 A or B; *Atlante I*, pl. 26, no. 15), a fragment of African Sigillata D of 5th century CE, and a wall of thin-walled pottery. The number of Roman transport amphorae is equally modest (10 fragments, only two of them attributable with confidence), and most of them consistent with African production, although some could be associated with the earlier late Punic productions.

Likewise, the evidence for the Late Roman phase is scant, consisting in only a fragment of a transport amphora of dubious provenance (possibly Africa or from the Aegean area) and a rim of bowl/lid belonging to a cooking ware type generically attested in the Mediterranean between the 5th and the 7th century CE.

This picture confirms what was already known from the excavation at the main site, indicating that Roca was abandoned and seems to have remained uninhabited throughout the entire period of Roman occupation in Salento (Auriemma 2004, 199). It was only in the Middle Ages that the site resumed occupation.

Medieval and post-medieval times

The material dating to the medieval and post-medieval periods consists of fragmentary finds, many of which presents challenges in typological identification. Its distribution is somewhat more evenly widespread when compared to earlier periods (Fig. 6, 7), possibly due to the presence of the early modern settlement of Roca Nuova in the deep hinterland of Roca Vecchia, at least from the mid-late 16th century CE (see Fig. 6).

The history of Roca Vecchia in the Byzantine period remains to be defined. The only available evidence comes from numismatic sources, with the discovery of a bronze *folle* coined between the 10th and the first half of the 12th century CE (Auriemma and De Gasperi 2003, 78).

Some amphora fragments with thick walls and fabric rich in white or black inclusions, likely micaceous, could be attributed to an early medieval period. The existence of a small church with burials near the north gate, still unpublished but attributed to the early medieval period, further supports the idea that the site was already frequented during this period.

Regarding the data collected through the survey, most of the materials consist of tile fragments that can generally be attributed to the medieval and post-medieval periods. These are difficult to date precisely, though published data from the late medieval occupation of Roca Vecchia provide a chronology ranging between 14th and 16th centuries.

This material is composed of mainly locally produced ceramics circulating in the area during the medieval and post-medieval period, although imported materials are also attested,

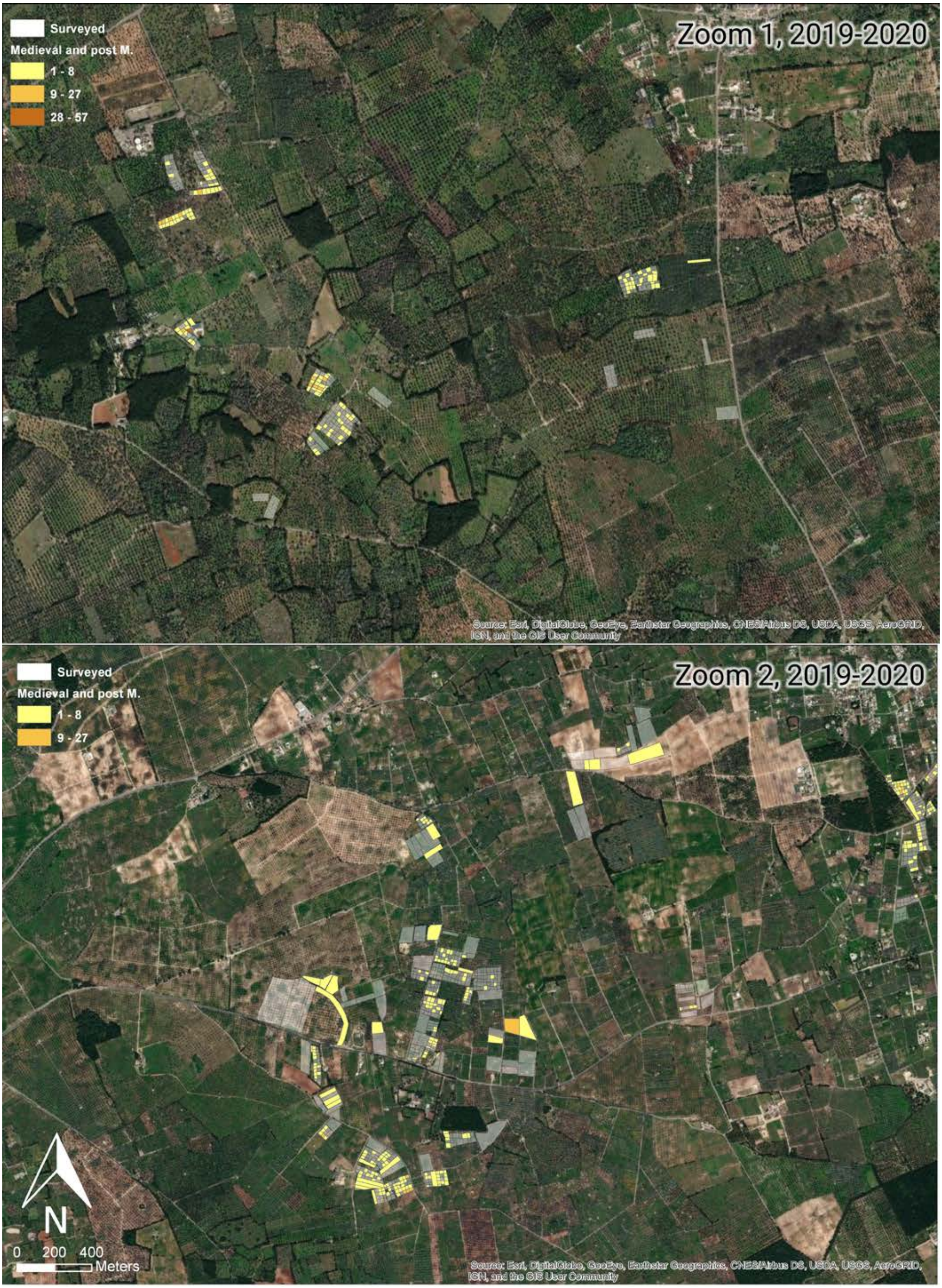

Figure 6 – Distribution of medieval and post-medieval material in the areas 1-2 of Fig. 2

Figure 7 – Graffita *pottery*

highlighting the importance of Roca as a trade hub in the southern Adriatic area during this time. Among these finds, some fragments of *graffita* (Fig. 7) dating probably to the second half of the 16th century CE seem to have been imported from various regions of northern Italy, suggesting previously unrecognized forms of long-range mobility. The ceramic material is dominated by depurated, unpainted, everyday pottery, with some shreds painted in narrow bands. These artefacts are characterised by highly depurated clays and are uncoated, intended for the storage of solid or liquid food (in the case of closed shapes) and for the preparation of raw food (in the case of open shapes). Among the diagnostic fragments, one is a rim of a large open shape container (basin) characterised by a short jutting brim with a triangular cross-section, widespread in the period between the 14th and 16th centuries CE (Güll 2008, 405-407; Kulja 2013, 155-157).

Oval-section handles and ribbon handles of large containers with a truncated cone or globular profile have been identified. These were widely attested throughout the Middle Ages, with a particular high incidence in the late medieval phase, especially at sites in the Salento hinterland, namely Apigliano, Quattro Macine, Cutrofiano, Lecce and Muro Leccese (Caprino 2017, Tagliente 2007). These materials provide evidence for the existence of medium-scale market exchange and the associated forms of mobility.

There is a rather limited number of fragments related to cooking ware, both with or without lead-based glaze. Despite the high fragmentation, it was nevertheless possible to recognise closed shapes referable to pots with a globular shiny glazing (preserved to varying degree) body and two close vertical handles. The presence of the glazing serves as a reliable chronological marker considering that this technique does not appear to be attested in contexts predating the 14th century CE (Caprino 2006; Güll 2008; Kulja 2013; Kulja 2015).

Polychrome glazed pottery is attested by very few fragments. Of particular interest is a jug with a decoration consisting of brown and red parallel strokes, a motif widely documented

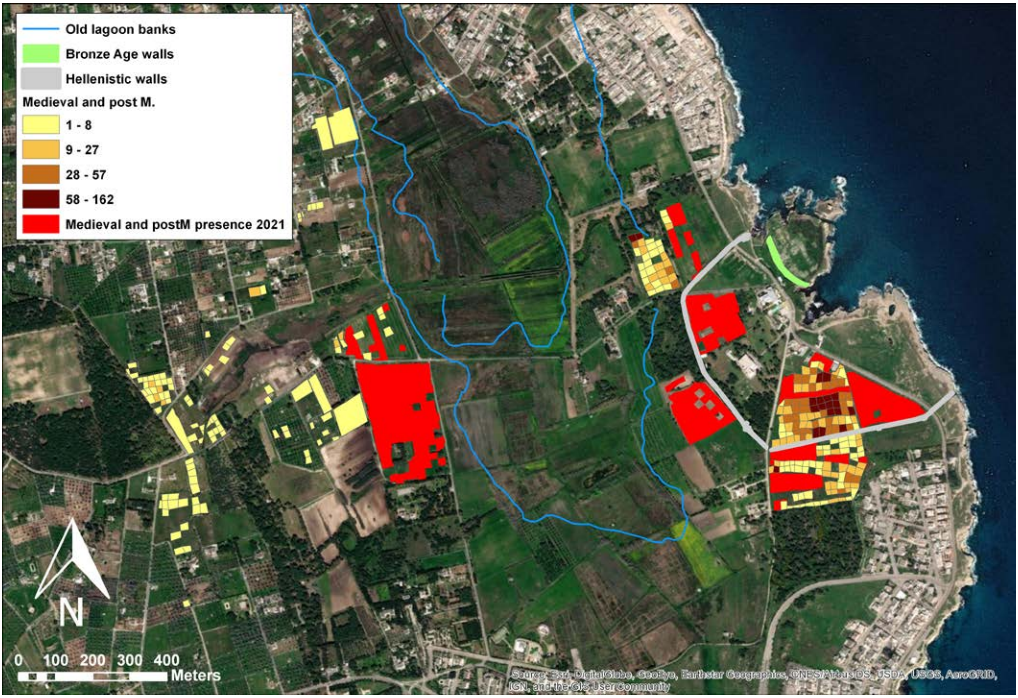

Figure 8 – Distribution of medieval and post-medieval material in the area 3 of Fig. 2

both in Roca Vecchia and inland sites, and dated to the 14th century (Fig. 8; Güll 2008, 394-397; Tinelli 2012; Kulja 2013; Kulja 2015).

The assemblage also includes fragments of tobacco pipes, objects of Ottoman tradition that are frequently found in both urban and rural contexts of the modern age throughout Apulia. Their presence suggests the cultural significance and influence of interactions with the Eastern side of the Adriatic - then part of the Ottoman empire – and the possible impact on market exchanges and personal mobility. The two fragments recovered are both pertinent to plain pipes and can be classified as Type 1, thus characterised by a clear distinction between the burner and the short pipe (Bruno 2015; Kulja 2016).

Mobility in the long term at Roca Vecchia

Moving to historical times, we start to glimpse the image of a Hellenistic city at Roca Vecchia, whose functioning relied on both short- and long-range mobility. As far as the short-range is concerned, it is reasonable to assume daily movements toward fields for agricultural activities essential to sustaining a nucleated settlement. It is no coincidence that the imposing ancient fortifications were suitably equipped with gates – some more monumental than others – designed to facilitate such movement (De Giosa 2011). Conversely, long-range mobility involving both relocation of individuals and commercial trade is evidenced by the circulation of imported material from nearby Greek colonies and other Mediterranean regions, as well as by the epigraphic inscriptions in multiple languages inside Grotta della Poesia (Pagliara 1987). Despite the continued use of Grotta della Poesia, the Roman period appears to mark a potential hiatus in the occupation of the site and a shift in settlement patterns, with people leaving Roca to relocate toward the surroundings north and south areas. A previously fertile landscape is now apparently abandoned (Auriemma 2004, 199).

Following Roman times, evidence of mobility within the landscape is rather scarce up to late medieval times. However, coin finds and the presence of a Byzantine cult building at the main site certainly tells us of eastward connections, which undoubtedly involved human mobility as well (Auriemma and De Gasperi 2003; De Pascalis 2004). When the Norman city was founded in later medieval times, it is possible to suggest that this involved the relocation of the population who occupied the area until its eventual abandonment (De Pascalis 2004; Güll 2008). Material remains datable to the modern period attest to the prosperity of regional market exchanges linking Roca Vecchia to nearby production centres as well as to more remote regions, such as northern Italy and the Ottoman Empire. The latter connection also facilitated the gradual diffusion of cultural practices, including tobacco smoking, toward Western Europe.

Conclusions

A long-term analysis of mobility patterns at Roca Vecchia provides broader insights into the interaction between human landscapes and mobility from Prehistory to modern times. As discussed in Part I of this contribution, the analysis of surface finds attests to a transition from localised Prehistoric mobility to increasingly larger settlements, indicating that by the end of the Bronze Age these communities were more "urbanised" than previously assumed (Iacono *et al.* 2024).

As we transition into historical times, the evidence of mobility in the landscape become even more pronounced, as examined in this paper. The presence of materials from different Mediterranean regions suggests long-distance exchanges, while short-range mobility may be reflected in settlement nucleation and the gradual expansion of the site's boundaries. However, given the scarcity of topographical data for the Iron Age, assessing the continuity between the site's extent in the Bronze Age and its size in Classical times remains challenging.

The expansion of settlements and their associated networks was not a linear process. The apparent decline in occupation and mobility at Roca Vecchia during the Roman period suggests that such trends could undergo significant disruption or even reversals, whether temporary or permanent. Further research is required to better understand the impact of these changing dynamics within the Tamari basin (Fig. 5).

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LiDAR data visualization techniques for archaeological research. The case study of the medieval site of Torre Palazzo (Benevento, Italy)

Antonio Corbo

antonio.corbo@uniroma1.it – Sapienza Università di Roma

Abstract

LiDAR (Light Detection and Ranging) technology offers a non-invasive approach to remote sensing, crucial in archaeological studies. This article explores its application in investigating medieval castle settlements, in a hilly site covered by vegetation. Using LiDAR carried out by the Italian Ministry of the Environment (MATTM) the study aims to enhance visibility and interpret archaeological features through filtering, classification and visualization algorithms. Additionally, it evaluates the historical-topographic potential of LiDAR data obtained via aerial surveys (Airborne Laser Scanning - ALS). Results demonstrate the effectiveness of this type of data in detecting microtopographical features, aiding in the interpretation of archaeological elements. However, limitations in spatial resolution pose challenges, particularly for smaller archaeological remains. Nonetheless, the study showcases the extraction of key features of the medieval site of Torre Palazzo, illustrating LiDAR's utility in reconstructing structures and identifying constituent elements.

Keywords

LiDAR, LiDAR-Derived Models, remote sensing visualization techniques, archaeological prospection

Introduction

LiDAR (Light Detection and Ranging or Laser Imaging Detection and Ranging) is a remote sensing technique that uses laser pulses to determine the distance of an object. The measurement of the time taken for thousands of emitted light pulses to return to the scanner provides useful information to calculate the distance from the measured object, generating a three-dimensional point cloud (Opitz 2013, 16-17; Lasaponara and Masini 2009, 80; Lasaponara *et al.* 2010, 155-157; Masini, Coluzzi, and Lasaponara 2011, 263-265; Masini and Lasaponara 2013, 663-664).

Over the years, this technology found several applications in the archaeological field, for some essential reasons. Primarily, any survey processed with this technique is independent of the atmospheric and lighting conditions of the treated scene, overcoming significant limitations inherent in other remote sensing methods. Furthermore, the use of this sensor mounted on a UAV (Unmanned Aerial Vehicle) allows to obtain a high point density, necessary for the detailed restitution of the mapped area with a high spatial resolution that can reach even one or two centimetres. Finally, the ability of the various laser pulses to obtain data through small openings in the vegetation makes it relatively easy to investigate vast areas otherwise hidden by forest cover. It is, in fact, possible to filter, through different algorithms, the point clouds obtained to remove vegetation to highlight the shadow site, whose interpretation is useful to reveal partially buried archaeological emergencies (Sithole and Vosselman 2005, 67-70; Meng, Currit, and Zhao 2010, 840-850; Suleymanoglu and Soycan 2019, 398-400; Buján, Cordero, and

Miranda 2020, 155-156; Doneus, Mandlburger, and Doneus 2020, 95-100; Lozić and Štular 2021, 37-40).

In particular, this specific characteristic determined a widespread use of the LiDAR data in the study of medieval castles settlements located in hilly or mountainous areas, whose subsequent abandonment, which occurred over the centuries, has determined an abundant growth of trees. In such contexts, where a stratigraphic excavation would encounter significant difficulties and likewise a survey would be strongly limited by poor visibility, LiDAR represents a valid solution for the investigation of archaeological marks. The studies based on the use of LiDAR in this field are increasingly numerous and widespread worldwide, which constitutes a continuous stimulus for the development of research and processing and visualization techniques (Bernardini and Vinci 2020; Risbøl *et al.* 2020; Menéndez Blanco *et al.* 2020; Stereńczak *et al.* 2020; Crabb *et al.* 2022; 2023; Pețan and Hegyi 2023; Vinci *et al.* 2024).

This paper aims to experiment the use of LiDAR images through a sample case chosen for its characteristics. It is currently abandoned and located in the municipality of Torrecuso (Benevento, Italy), in a low hill area covered by a forest. The area where the site is located is characterised by a tree cover of deciduous oaks and dense undergrowth composed of foliage and various vegetation, which limits visibility and hinders archaeological interpretation. For these reasons, therefore, the area is suitable for the use of LiDAR data and the derived models generated by visualization algorithms, whose interpretation could provide essential information for the identification of shadow site useful for determining the shape of castle. From a methodological point of view, the target is to present the different visualization analyses carried out on the DTM (Digital Terrain Model), aimed at improving visibility and facilitating the interpretation of the archaeological marks and of the geomorphological features.

Furthermore, this study aims to evaluate the potential in the historical-topographic field of a specific set of LiDAR data, produced from an authorised aerial survey by law no. 179/2002 (art. 27) and carried out by the Italian Ministry of the Environment (*Ministero dell'ambiente e della tutela del territorio e del mare*, MATTM) in agreement with the Ministry of Defense and the Presidency of the Council of Ministers - Department of Civil Protection, as part of the PST-A project (Extraordinary Plan for Environmental Remote Sensing) (Gazzetta Ufficiale n. 189 del 13 agosto 2002. Legge 31 Luglio 2002, n. 179, Disposizioni in materia ambientale, art. 27) and available: http://www.pcn.minambiente.it/viewer/.

In Italy, archaeological research based on this specific Airborne Laser Scanning (ALS) dataset is still limited (Fontana 2022; 2024, Corbo 2024). Nevertheless, the availability of such data, largely stemming from periodic surveys promoted by governmental agencies for environmental monitoring and land management, offers highly promising research opportunities. The potential of ALS has already been widely tested in several European countries, such as in the United Kingdom (Challis 2006; Crutchley 2006; Devereux *et al.* 2005; Challis, Forlin, and Kincey 2011; Johnson and Ouimet 2014; Crabb *et al.* 2023); in The Netherlands (Van Zijverden and Laan 2003); in Germany (Sittler 2004; Sittler, Siwe, and Gültlinger 2005; Sittler *et al.* 2007); in France (Mayoral *et al.* 2017); in Spain (Cerrillo-Cuenca and Bueno-Ramírez 2019; Cerrillo-Cuenca and López-López 2020); in Norway (Risbøl, Gjertsen, and Skare 2004); in America (A. F. Chase *et al.* 2011; 2012; A. Chase *et al.* 2014; Golden *et al.* 2016; A. F. Chase and Chase 2017). For a general overview of this topic, see (Vinci *et al.* 2024).

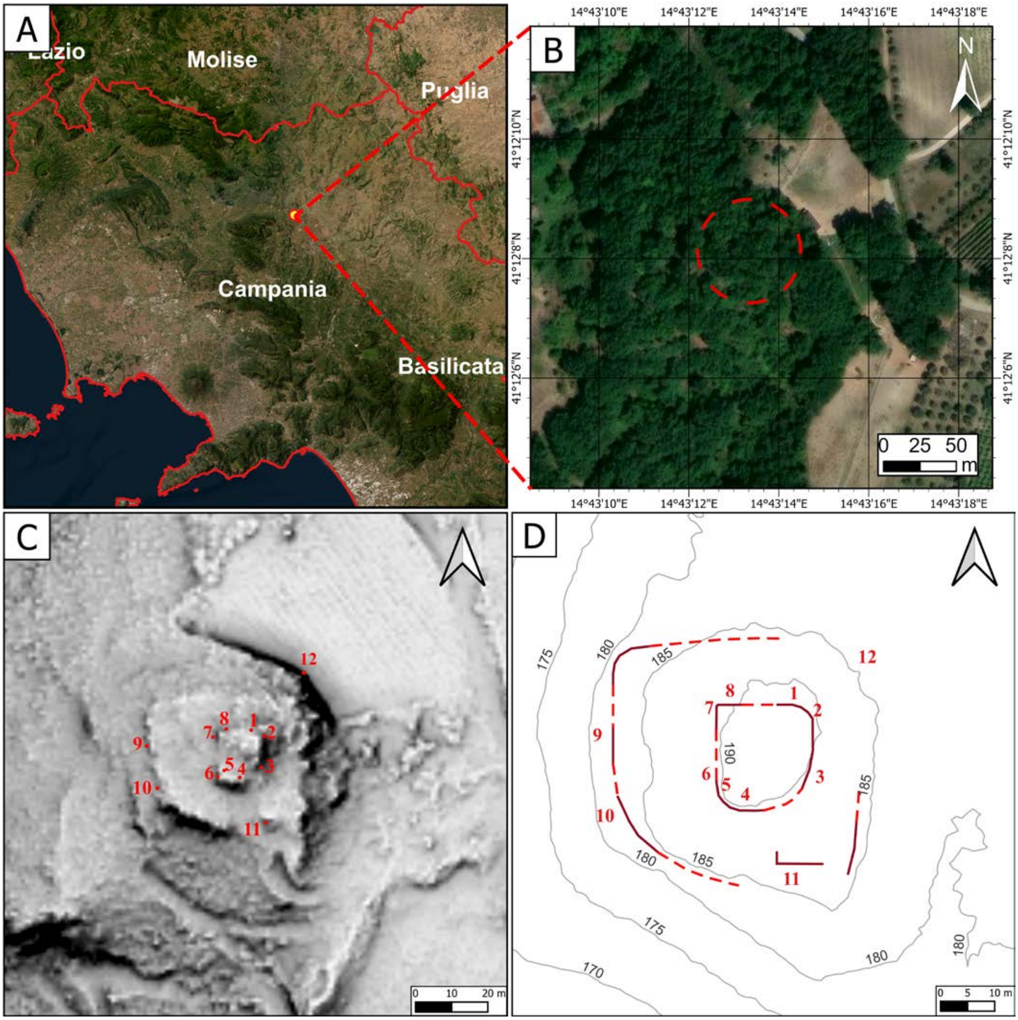

Figure 1. A-B. Topographic overview of the study area; C. Orthophoto with the investigated area delimited in red; D. Visualization for Archaeological Topography (VAT) map with numerical indication of the plots where field inspections were carried out and mapping of the archaeological elements based on the indications obtained from all the derived models created. (nn. 1-3=figure 6; nn. 4-6=figure 7; nn. 7-10 8=figure 8; n. 11=figure 9. A; n. 12=figure 10.)

The final phase of the research also included topographical survey, which is necessary in any case for direct verification of the identified proxies (walls, roads, rocks) and confirmation of the archaeological characteristics of the site.

Historical and archaeological setting

The target of the research is the medieval Campanian castle of Torre Palazzo, located on the top of a modest hill (200 m above sea level), which rises to the southeast of a deep valley excavated by the Reventa stream and to the west of a bend in the Calore river, where the same stream flows; the site is located at a nodal point between the Benevento plain and the Telesina valley, in an area marked by the middle and lower course of the Calore river (Queirazza *et al.* 1990, 169; Renda 2010, 110; 2020, 51)[1]. Currently, the remains of the castrum are part of a fraction of the municipality of Torrecuso, in the province of Benevento (Fig. 1.A-B).

During the Middle Ages, following the defeat of the Lombards by the Normans, the area, which initially fell within the jurisdiction of the Beneventan principality, was divided. The administration of the new rulers provided for a territorial division into counties: more or less extensive district circles that made up the conquered region (Figliuolo 1991, 41, 53-56; Cuozzo 2006, 285-302; J.-M. Martin 2006, 303-332). During the 12th century, the lower Calore valley, which fell within the southeastern part of the Telesino district, was administered, on behalf of Rainulfo, by some feudal lords who had obtained a portion of the territory (Tescione 1975, 9-10; Cielo 1995, 137)[2]. The birth of the fief, while representing an element of institutional novelty within the territory of the county, did not, however, upset its previous territorial arrangements; among these, we know the fief of Ugo Infante II, who administered the barony *de Fenuculo*. The territory of the new fief had as a reference point the *Fenuculus* castel, from which the barony probably takes its name, and a series of *territoria* grouped together to constitute the new institutional reality. Documentary information about the barony is rather scarce, but in a *cartula oblationis et confirmationis* dated May 1112, its extension and from how many and which castles it was composed are indirectly described (J.-M. Martin *et al.* 2015, 1576-1578). The document is drawn up by the will of Lord Ugo Infante, who carries out the wishes of his late father, his namesake, lord of *Castello Potonis* (Castelpoto, BN), who died before he himself could make the donation effective. In the *oblatio*, as mentioned, reference is made to the territories of the castellum of *Toro Helicuso* and *Turri Palatii* (both in the current municipality of Torrecuso, BN) and to the territory of the *castellum* once called *Caprarica*. The *territoria* therefore extended into the lower valley of the Calore river with the castles of Castelpoto, *Fenuculus* castel, Torrecuso, Paupisi, and Torre Palazzo, and into the Beneventan countryside with the *castrum Caprarica*. As we read in the 1112 document, the foundation of the castle of Torre Palazzo is certainly to be placed in a period prior, presumably between the 11th and the very early years of the 12th century (Jahn 1989 363-366; G. A. Loud 1991, 364-373; 2000, 256; Canosa 2015, 79), in concomitance with the birth of the fief of Ugo Infante, and would represent the desire for military reorganisation and greater territorial control over the barony (Figliuolo 1991, 55-57). In fact, the determining role of castles in the definition of medieval rural landscapes must be considered, as they, with their strong centralising function, contributed to the formation and consolidation of new demographic nuclei (J.-M. Martin 1993, 301-324; Toubert 1995, 300-315; Settia 1999; Carocci 2010, 265; Rao 2015, 138-141; Augenti 2016, 158-159).

In the *Chronicon Beneventanum*, the castle of Torre Palazzo is mentioned in 1128 during event for retaliation for events that occurred the previous year (D'Angelo 1998). In that year, Ugo Infante, a feudal lord of Count Rainulfo, openly supported his opponent Ruggero II. This provoked the reaction of the count himself who, together with Prince Capuano Roberto and Pope Honorius II, besieged and captured, "*with a large army*", the castle of Torre Palazzo, forcing Ugo Infante to swear loyalty to Rainulfo (D'Angelo 1998, 100-101).

[1] The area is locally known by the microtoponyms 'Castello', 'Castellone', 'I palazzi'.

[2] Founded shortly after 1062 and administered by Rainulfo I, then, in 1087 to Roberto I and later, in 1116 to Rainulfo II.

Between the 12th and 13th centuries, the barony *de Fenuculo* lived a period of relative prosperity, if compared to other centers in the lower Calore valley. In fact, the *Catalogus Baronum*, from which the patrimonial consistency of the fief administered by Tommaso *de Fenuculo*, royal judge, can be perceived, records the presence of two *milites* for the castle of Torre Palazzo and a total of thirty-five knights and twenty-five sergents (Jamison 1972, 176-177; Cuozzo 1984, 278-279).

The place occupied by the *castrum* originally take on a primary role in the capillary control system of the territory, which was completed during the Norman period in the 12th century. Indeed, the castle of Torre Palazzo, located between the Telesina valley (northwest) and Benevento (southeast), dominated the underlying Reventa stream and its natural crossing (ford) or artificial crossing (bridge) (Maio 1995, 21; Cielo 2011, 92; Maio 2012, 77). The area of relevance of the fortified site also extended to the nearby road axis that connected the ancient city of Telese to Benevento (*Telesia-Beneventum*) (Lonardo and Di Cecio 2020, 735). In addition, visibility analysis shows how it was in direct visual connection with the *Fenuculus* castel (directional center of the aforementioned barony *de Fenuculo*), founded a few hundred meters away, on the other side of the Calore river, to control the bridge and the road below. Probably the two castles played a key role in controlling the access routes to the Beneventan plain on one side and to the Telesina valley on the other and were functional to the collection of taxes on *pedatico*, which represented a substantial income for the economic assets of a lord or feudal lord.

Surface surveys carried out in the surrounding of area near the castle seem to testify to the formation, over the years, of a *territorium castri*: many ceramic fragments have been found a few meters east and north of the site, which attest to a chronological range between the late 8th and early 9th centuries and the 14th century.

Description of data

The LiDAR data used, as previously mentioned, are an integral part of the PST-A project, which envisaged the creation of a high-precision Environmental Remote Sensing Plan, aimed at verifying and monitoring areas with high hydrogeological risk (Costabile, Cocco, and Petriglia 2013, 491-494). The main purpose of the project is to monitor hydrography and land management in order to control areas at risk of flooding risk and contain the socio-economic impact of tragic events. Subsequently, the use of the data has been extended to all issues concerning areas of environmental interest.

The first phase of the PST-A was implemented between 2008 and 2009, and flights to acquire LiDAR images were carried out on the main river basins and coastal areas of Italian soil. Between 2010 and 2011, the previously established database was integrated with new acquisitions, and at the same time, the open-source GIS software AdB-Toolbox was developed, equipped with specific tools dedicated to the management and processing of LiDAR data and their derivatives.

The survey carried out has an altimetric accuracy corresponding to +/- 1s (root mean square error), with an error lower than ± 15 cm, while the planimetric accuracy is (2s), i.e., the error is contained within ± 30 cm, allowing for a rather faithful representation of the morphology of the surveyed territory (Conte, Bonofiglio, and Petriglia 2016, 58-61). The data thus obtained are Digital Terrain Models (DTM) and Surfaces (DSM) with a high level of detail corresponding to two series, one with a resolution of 1x1 m and the other with a resolution of 2x2 m.

Although the original purposes of the project were environmental protection and monitoring, LiDAR data with cells of 1x1 m could be also optimal for identifying archaeological features hidden by tree cover.

Methodology of analysis and visualization techniques

The DTM processed by MATTM presents many distortions due to the filtering algorithms used, which is why it is not useful for archaeological interpretation. Consequently, the point cloud was processed using the LasTools software, trying out different filtering and classification parameters (Lasground and Lasheight classify) to obtain the DTM (las2dem) free of vegetation and the most suitable for archaeological prospection (Fontana 2022).

A series of algorithms were executed with the input of the Digital Terrain Model (DTM) and the filtered point cloud (Fig. 2.A), which produced models with specific visualization characteristics essential for interpreting the archaeological microtopography. For this phase, ArcGIS Pro 3.0.1 and RVT 2.2.1 (Relief Visualization Toolbox) software were used. The objective of developing RVT was to consolidate the greatest number of visualization algorithms in a single software package (Kokalj *et al.* 2016).

The following analyses were carried out: *Hillshade* (HS); *Multi Hillshade* (Multi-HS); *Principal Component Analysis* (PCA); *Slope*; *Simple Local Relief Model* (SLRM); *Local Relief Model* (LRM); *Sky View Factor* (SVF); *Anisotropic Sky View Factor* (ASVF); *Openness Positive* (OP) and *Openness Negative* (ON); *Sky Illumination Model* (SIM); *Local Dominance* (LD) and *Visualization Archaeological Topography* (VAT). This number of visualization algorithms was chosen because it was observed that no single technique is able to sufficiently highlight all the archaeological features. Instead, a comprehensive and articulated comparison of multiple elaborations is needed.

The data produced was then imported and analysed in GIS system. Subsequently, structures and shadow marks of archaeological interest were manually traced to understand the overlap between automatically obtained features and those optically detected. The following are essential descriptions of the visualization techniques performed and the derived models with the utilised parameters.

The *Hillshade* (HS) is one of the most commonly used techniques for providing an intuitive visualization of topography (Horn 1981, 14-47; Blinn 1977, 192-198; Batson, Edwards, and Eliason 1975, 401-408; Yoëli 1965, 141-148). It consists to illuminate a surface with a direct light source having fixed azimuth and elevation angles for the entire area. Low elevation angles are useful in relatively flat contexts, where the general topography is characterised by slight changes in elevation (Kokalj and Hesse 2017, 16). In the case of Torre Palazzo, after numerous elaborations with different parameters, we chosed to calculate the HS with an elevation angle of 45° and an azimuth of 315, using RVT. The main limitation of HS is hiding archaeological evidence oriented in the same direction as the light beam. Furthermore, especially in hilly areas of medium and high slope, HS produces results in which the illuminated sides are

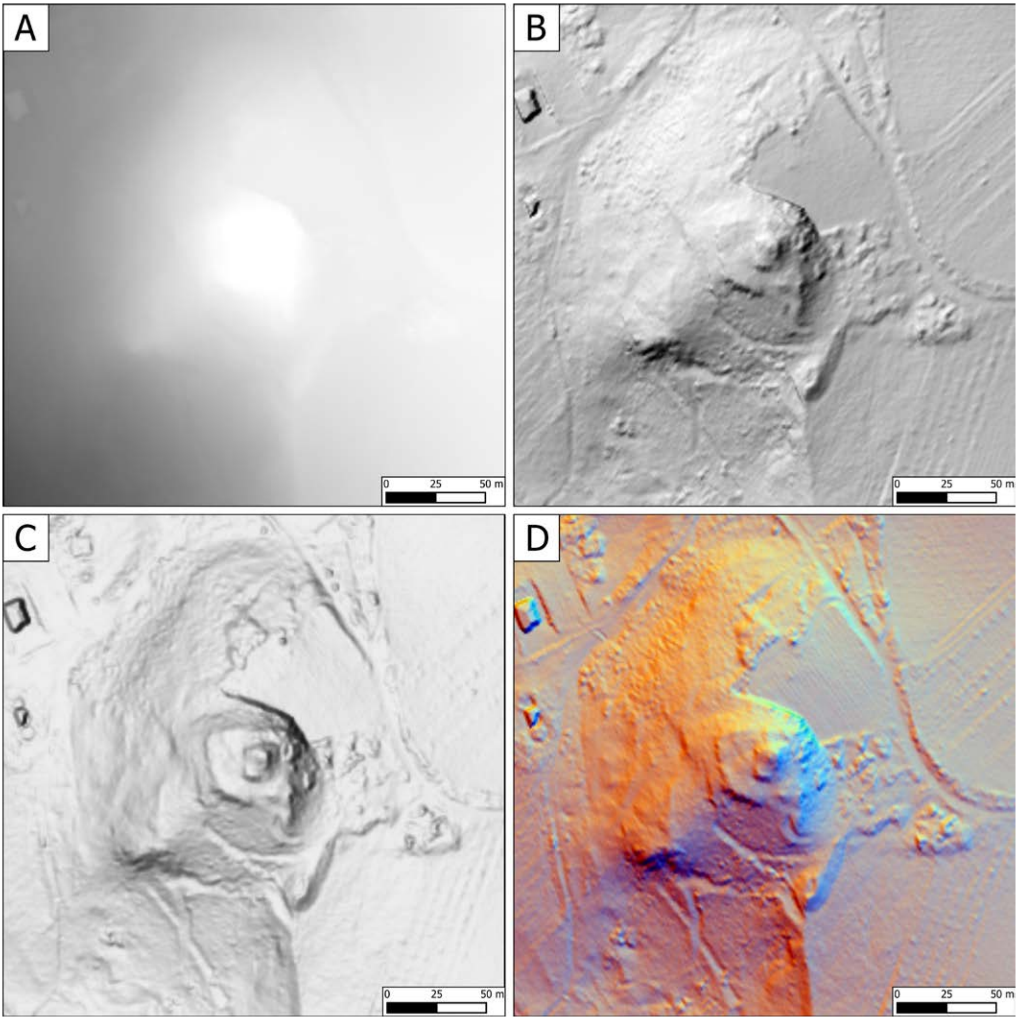

Figure 2. A. DTM processed with LAStools; B. HS processed in RVT; C. Mutli-HS processed with the Hillshade function (Multidirectional) tool di ArcGIS Pro; D. Multi-HS processed in RVT.

overexposed, while the details of the terrain on the non-illuminated sides are in shadow. A solution proposed by some scholars is to produce multiple HS with different parameters and then compare the results however, this investigative methodology is difficult to apply in the case of multiple archaeological elements close to each other and with different orientations (Crutchley 2006, 251-257; Kokalj, Zakšek, and Oštir 2011, 263-273; Hanus 2012, 233-248; Forlin 2012, 252; Hutson 2015, 259; Devereux, Amable, and Crow 2008, 471-472), and moreover, this practice does not allow for easy interpretation when working on a large area (Crutchley 2006, 23) (Fig. 2.B).

Other valid solutions consist of processing *Multidirectional Hillshade* and *Principal Component Analysis*. With the Multi-HS algorithm executed with both RVT and ArcGIS Pro tools, leaving the parameters of 45° elevation angle and 315 azimuth unchanged, the light coming from multiple sources is combined for better terrain visualization. The Multi-HS executed with ArcGIS Pro is in grayscale and calculates shading from six different directions, resulting in a more realistic image with balanced overexposed and underexposed areas (Fig. 2.C**)**. On the other hand, the Multi-HS generated with RVT is viewable as a multiband false-color (RGB) image, but lacks the balance between areas of strong light and shadow, which is useful for archaeological interpretation (Fig. 2.D).

The second case, PCA, consists of a multivariate statistical transformation procedure that combines multiple information into a single raster file, facilitating interpretation of the surveyed area (Zavyalov *et al*. 2009, 55-66; Mather and Koch 2022). The primary function of PCA Hillshading is to group a considerable number of images with limited loss of information since these are typically contained in the first three components, speeding up the interpretation phase considerably (Kokalj and Hesse 2017, 17; Forlin 2012, 257-258) (Fig. 3.A).

Slope Analysis (Slope) was also executed with RVT. Slope give a very plastic representation of morphology and highlights changes in the elevations of a particular area; typically, slope calculation is based on a data structure with cells containing altimetric information, evaluating the variation in altitude between a cell and its eight adjacent cells assigns a statistical parameter (Podobnikar 2012, 788; Prufer, Thompson, and Kennett 2015, 9; Larsen *et al*. 2017, 7-12). Consequently, slope analysis, which returns an output file with average value, could result in a general leveling of the terrain, negatively influencing micro-morphology interpretation (Colecchia and Forlin 2013, 43). Nevertheless, its use is still widespread for predictive models and site location (Opreanu and Lăzărescu 2014, 76). The output file generated is in grayscale but has been reclassified with a color map from green to red to facilitate understanding of terrain elevations (Fig. 3.B). However, the disadvantage of Slope is that positive/convex features (e.g. embankments) and negative/concave features (e.g. ditches) are presented in the same colour, irrespective of rise or fall.

The *Local Relief Model* (LRM) is a technique that involves filtering the terrain surface to expose only the archaeological features, removing large-scale morphological elements and enhancing small-scale ones, independent of the lighting conditions. The method generally followed was developed by Hesse in a 2010 paper (Hesse 2010). It is a rather simple workflow but involves several steps: applying a low-pass filter to the original DTM, subtracting the smoothed DTM from the original one to preserve only the topographic features at a small scale, applying the "Contour" function, extracting the actual elevation from the original DTM with the "Extract by mask" tool, converting the resulting elevation raster into elevation points with "Raster to Point", creating a new DTM from the elevation points ("Create TIN" and "TIN to raster function"), and finally subtracting the resulting DTM from the original with the "Minus" function. LRM has excellent potential when used on terrains with gentle and gradual slopes but works less well, producing distortions, where the terrain is steeper, just like the case studied (Kokalj and Hesse 2017, 21). For the case study of Torre Palazzo, the *Local Relief Model* tool, proposed by Novák and updated to the latest version (Novák 2014), integrated into ArcGIS was used, significantly simplifying the workflow and automatically creating LRM by adjusting only a few parameters (input DEM cell size and the type of low-pass filter to be used). The processing proposed for this study did not involve any changes to the default settings. In addition, the *Simple Local Relief Model* (SLRM) integrated into the RVT software was also performed. This is a simplified process in which the trend is calculated from a mean filter,

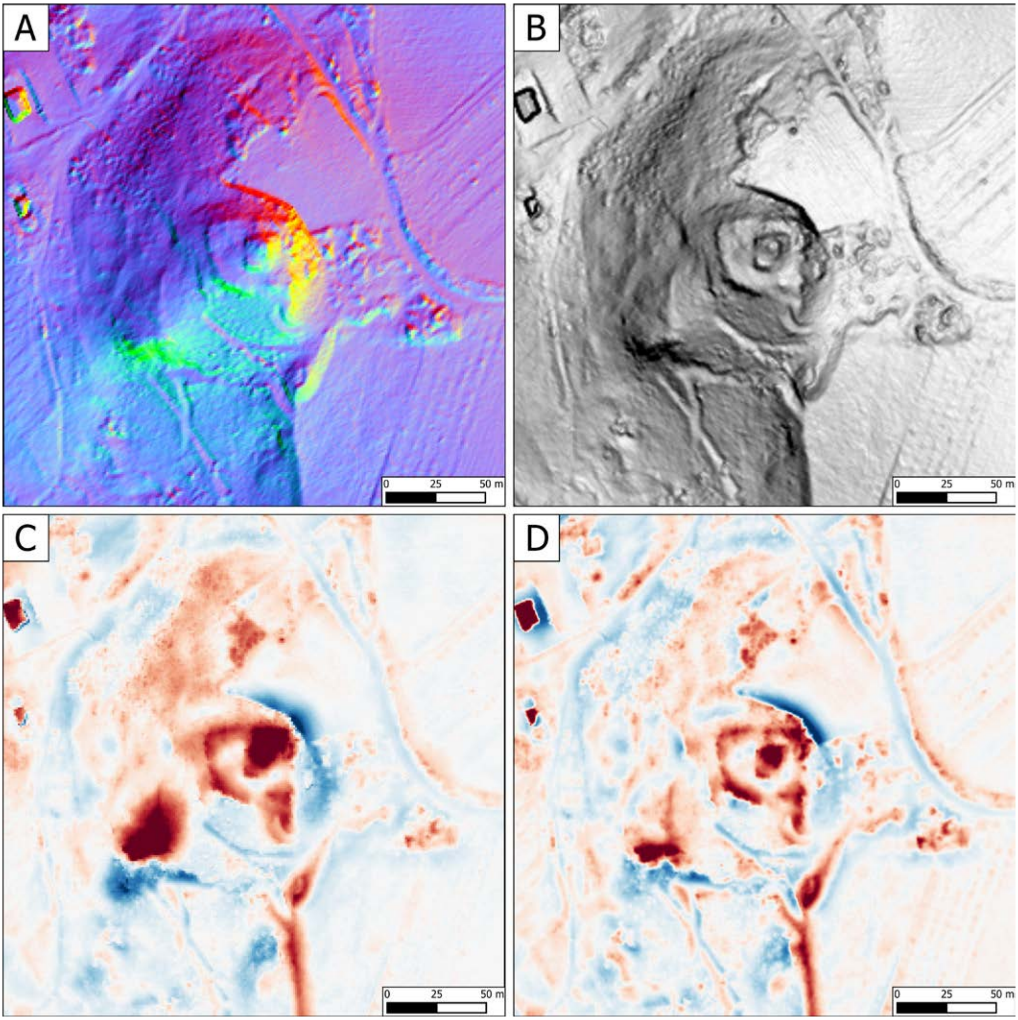

Figure 3. A. PCA processed in RVT; B. SP processed in RVT; C. SLRM processed in RVT; D. LRM processed with the Local Relief Model tool in ArcGIS Pro.

and a trend-removed model is produced directly by subtracting the filtered model from the original one. The only parameter to be set is the radius for trend evaluation, which in this case was set to 10 m. The two results intentionally processed with different parameters show some differences due to the trend evaluation radius and the type/size of the low-pass filter kernel, which determines the spatial scale of the features highlighted in LRM. Indeed, in SLRM, the reliefs are highlighted with greater precision and detail (Fig. 3.C-D).

Sky View Factor (SVF) algorithm is also useful for overcoming the problems caused by the direction of the light beam in the HS. In fact, through a geophysical parameter, SVF measures the portion of the sky visible from a certain point. It is based on diffuse illumination and returns the scene illuminated by an artificial light coming from the celestial hemisphere (Kokalj, Zakšek, and Oštir 2011, 263-273; Zakšek, Oštir, and Kokalj 2011, 398-415; Kidd and

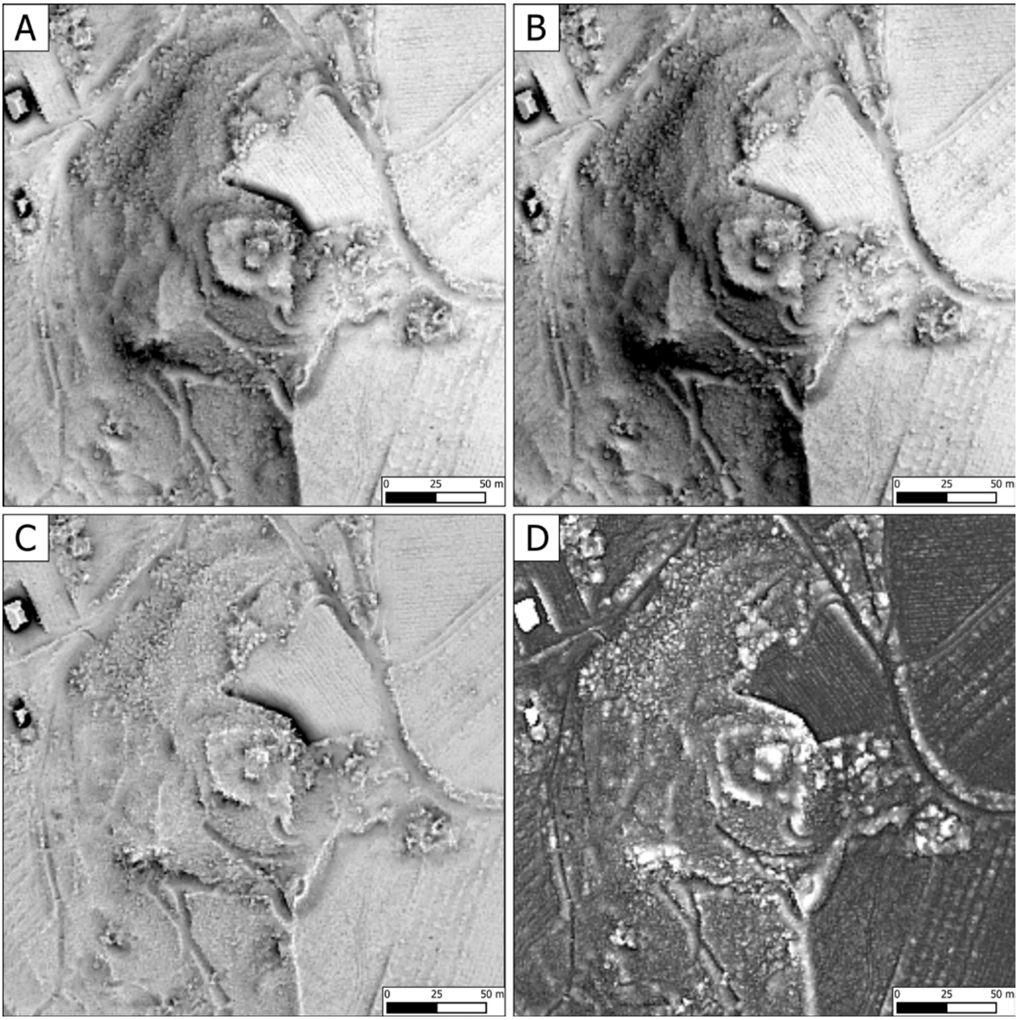

Figure 4. A. SVF processed in RVT; B. ASVF processed in RVT; C. OP processed in RVT; D. ON processed in RVT.

Chapman 2012, 3640-3652). As a result, a ridge appears brighter than the bottom of a valley, because the angle that measures the portion of sky visible from a relief is always greater than that of a valley bottom. Therefore, SVF is particularly effective when applied to hilly or steep areas (Forlin 2012, 262). The calculation of SVF depends on the horizon search radius: the larger the radius, the more general the results, therefore, a small search radius between 5 and 10 meters is necessary for interpreting archaeological features (Colecchia and Forlin 2013, 48-49). Several software programs provide SVF, such as ENVI, LiVT, RVT, and SAGA GIS, however, the latter produces output with highly saturated areas, which is not very useful for details in valleys (Kokalj and Hesse 2017, 22; Magnini, Bettineschi, and De Guio 2017, 213). To enhance the micromorphology of Torre Palazzo, the algorithm integrated in RVT was chosen to use because, unlike that in SAGA GIS, it allows for noise reduction (Level of noise removal: low, medium, or high) in the data, so that the relevant characteristics are more clearly visible. The raster obtained from SVF has values ranging from 0, when sky visibility is obscured, to

1, when visibility is total. For better visualization, the minimum and maximum values of the histogram can be adjusted (Danese *et al.* 2022, 1593). The parameters we used were a search radius of 5 meters and low noise reduction (Fig. 4.A).

For the processing of the *Anisotropic Sky View Factor* (ASVF), the RVT algorithm was preferred over SAGA GIS for the same reasons. ASVF does not consider a uniformly lit sky like the SVF, but depends on the azimuth and distance from the light source; therefore, it is similar to HS, but produces sharper images and small features are enhanced even on flat areas (Zakšek *et al.* 2012, 285-299). ASVF in RVT assumes some parameters to be adjusted such as the level (low or high), and the direction of anisotropy by setting the azimuth; in the following study, a low anisotropic level and an azimuth of 315° was used (Fig. 4.B).

Openness is a visualization mode of topography that expresses the positive or negative domain of a particular area (Yokoyama, Shirasawa, and Pike 2002, 257). To determine the openness value, all pixels of a raster are calculated from eight fixed viewpoints (N, NE, E, SE, S, SO, O, NO) with different zenith or nadir angles within a specified search radius. *Openness Positive* (OP) considers a perspective above the DEM surface (convex shapes), equal to the average value of zenith angles, and *Openness Negative* (ON), below the DEM surface (concave shapes), equal to the average value of all nadir angles (Doneus 2013, 6428-6429; Danese *et al.* 2022, 1592). The main difference with SVF is that Openness considers the entire sphere, not just the celestial hemisphere, so the maximum value can exceed 90°, and the output is a flat image, that is more difficult to interpret, but the local terrain features are more pronounced (Zakšek, Oštir, and Kokalj 2011, 403-404; Kokalj and Hesse 2017, 27; Masini *et al.* 2018, 10). The processing of PO and NO was carried out using RVT software, with the same SVF values (Fig. 4.C-D).

Local Dominance (LD) determines how much each pixel “dominates” locally what surrounds it: the brightness of each pixel corresponds to the average angle at which an observer looks at the surrounding surface (Kokalj and Hesse 2017, 25; Hesse 2016, 116). LD is very useful for highlighting features in flat or slightly inclined areas, for these reasons it did not produce excellent results, having been used on a hilly terrain with the Southeast slope characterised by a steep incline. In RVT, the parameters to be adjusted concern the minimum and maximum radius within which to consider the calculation; for the case of Torre Palazzo, the values were set at 5-5 m (Fig. 5.A).

The *Sky Illumination Model* (SIM) consists of a uniformly distributed light source that illuminates a surface (Kennelly and Stewart 2006, 21-36). In RVT, the overcast and uniform parameters are implemented, as both neglect shading effects. Overcast was chosen for the Torre Palazzo study, which produced a plastic and three-dimensional-looking raster where the micromorphology is well highlighted. The number of sampling points was left at 250, while the maximum shadow modeling distance was lowered to 50 (Challis, Forlin, and Kincey 2011, 281; Kennelly and Stewart 2014, 384-406) (Fig. 5.B).

Visualization for Archaeological Topography (VAT), is a visualization technique created for archaeological purposes and implemented in RVT (Kokalj and Somrak 2019; Verbovšek, Popit, and Kokalj 2019, 2951-2953). It consists of the fusion of several images with the aim of improving the visibility of small topographic features. The combination involves the HS or Multi HS (viewable in RGB, equally the final product will be viewable in false colours) as a base

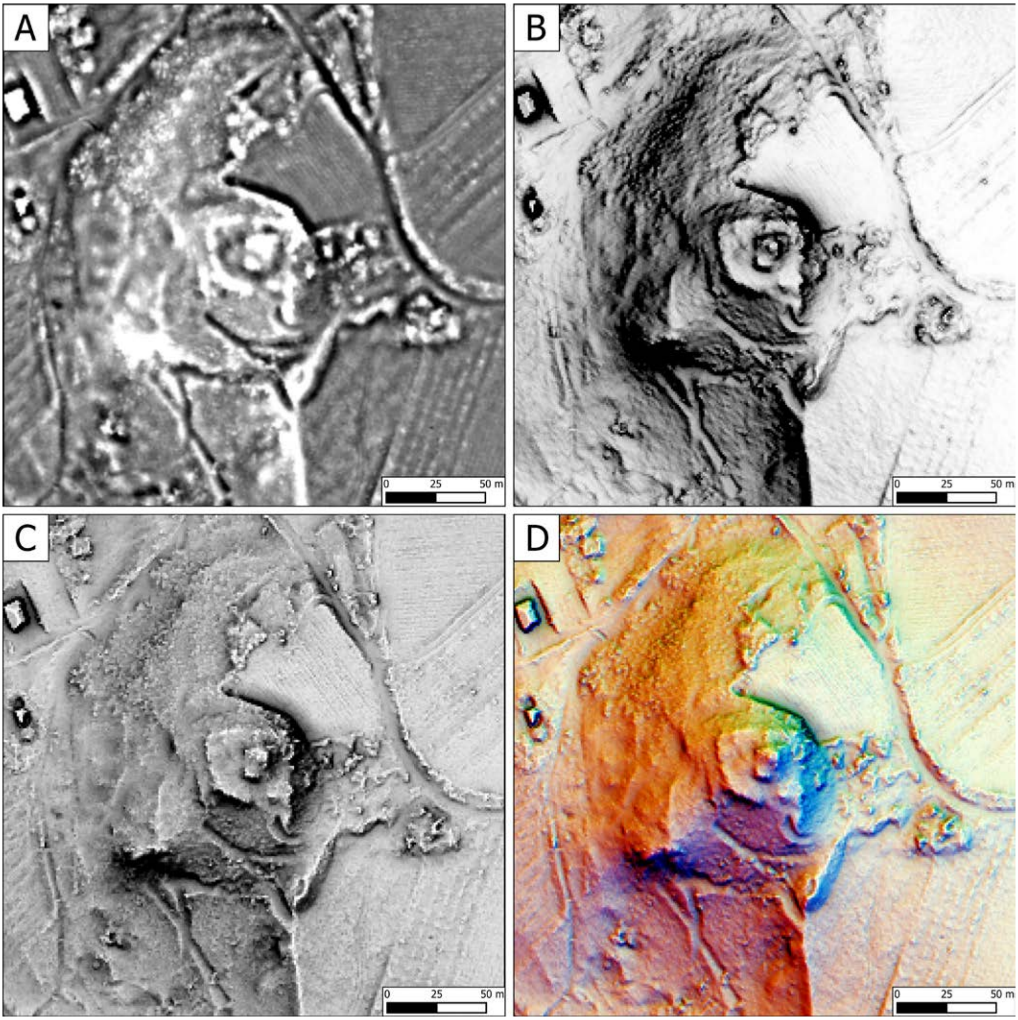

Figure 5. A. LD processed in RVT; B. SIM processed in RVT; C. VAT with HS as firs layer; D. VAT with Multi-HS as firs layer.

layer to which the Slope is added with the aim of conferring greater three-dimensionality (the blending mode is luminosity, with opacity at 50% and the min and max values are between 0 and 60 since the area of interest is on very steep terrain). Next, Openness Positive (OP) is added in overlay as the third layer, with 50% opacity and 70-95 as min and max values. The last layer in multiply mode with 25% opacity was SVF, with 0.60-1 min and max; these two are important for emphasising small-scale structures and are also complementary in that OP shows depressions as dark and exposed area as bright, as opposed to SVF (Fontana 2022) (Fig. 5.C-D).

Results and discussion

The comparative analysis of DTM visualization elaborations streamlined the processes of knowledge of the medieval site of Torre Palazzo, highlighting some significant marks of micro-topographic reliefs linked to archaeological and geomorphological elements of the area (Fig. 1.C-D).

Thanks to subsequent autopsy investigations, it was possible to recognise the emphasised elements detected by visualization analyses and subsequently attribute them to the archaeological features present in the area. However, the presence of deciduous oak trees and the abundant underbrush composed of foliage, but also brambles, represented, in some cases, an insurmountable obstacle for the investigation of archaeological elements that are currently mostly covered. In any case, the data from derived models have allowed the identification of large stretches of masonry structures, highlighting the iconographic articulation of a castle-tower (definition also based on Norman era documents). From the verification in situ of such data, it seems possible to identify the central nucleus of a fortified structure, perhaps a keep (Fig. 6.A-B), positioned in the northern corner of a small polygonal-shaped wall enclosure

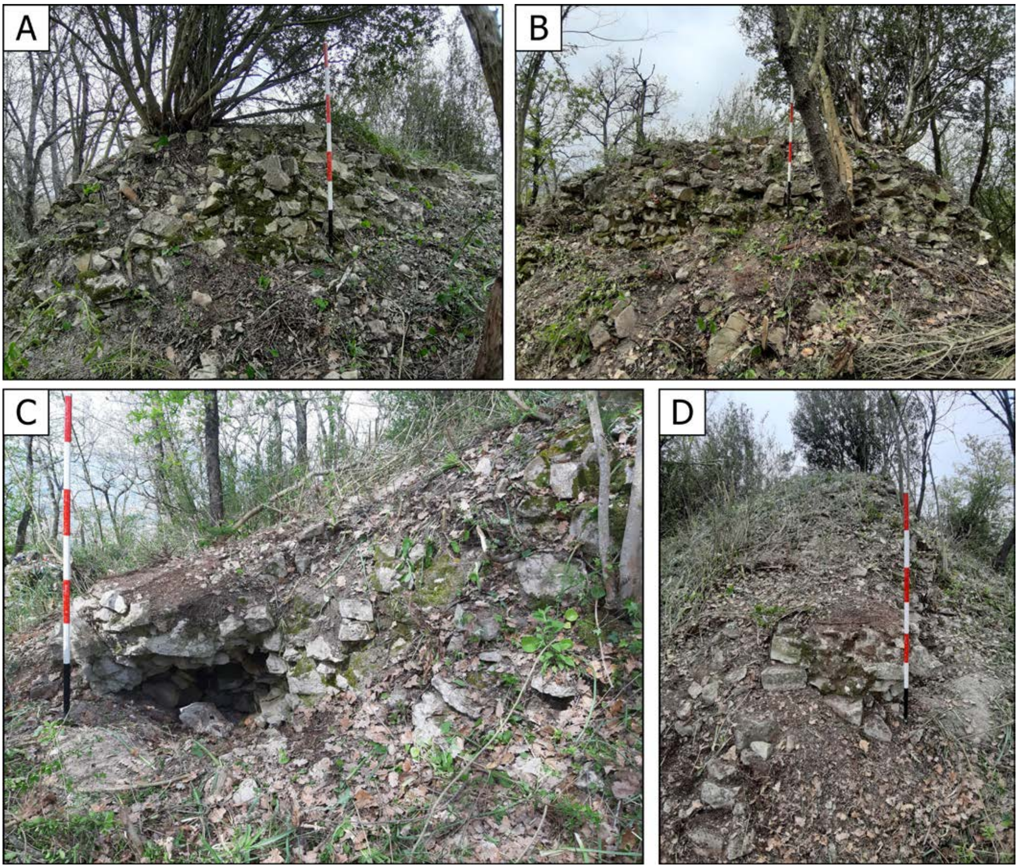

Figure 6. North angle of the inner wall: A. North wall; B. North-west wall. West corner of the inner wall: C. South-west wall (collapse); D. South-west wall (pictured from the south).

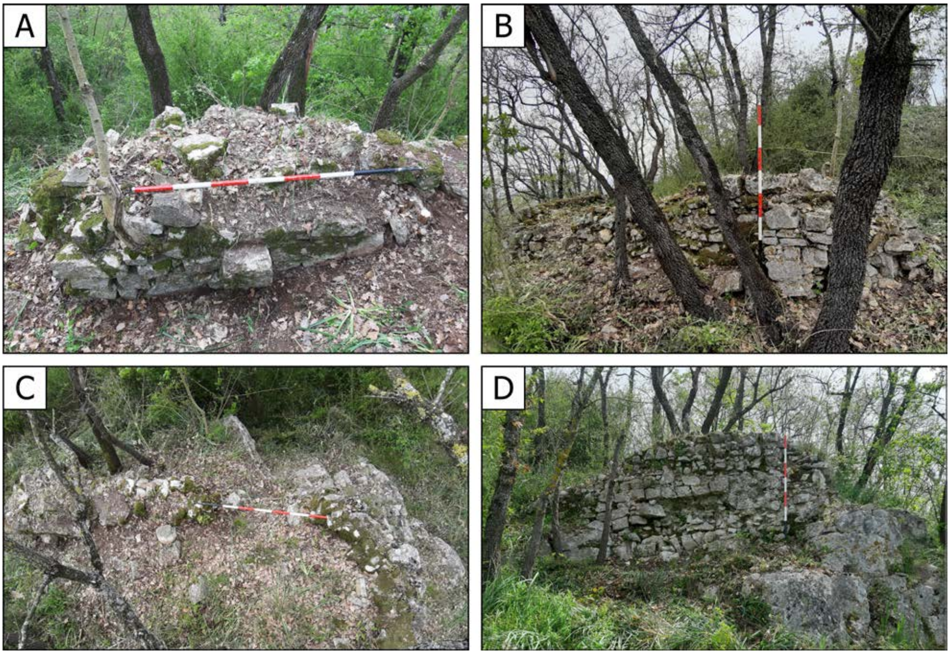

Figure 7. South south-west of the inner wall: A. Inner side of the south wall; B. External side of the south wall; C. Corner of the south south-east wall; D. External side of the south-east wall.

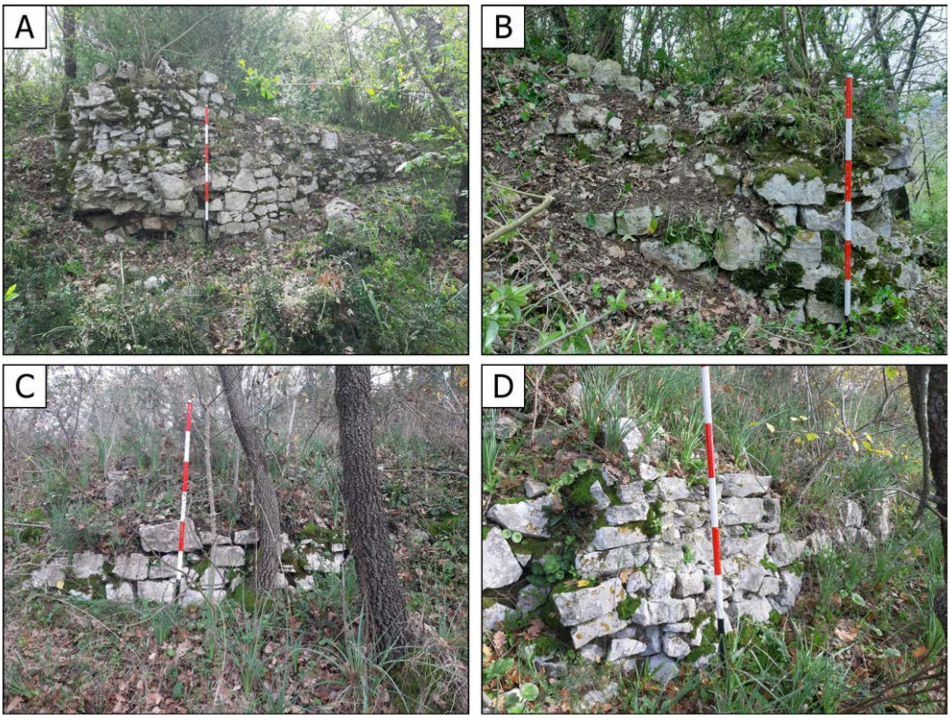

Figure 8. North-east corner of the inner wall: A. North-east wall; B. North wall. C-D. Remains of the external wall.

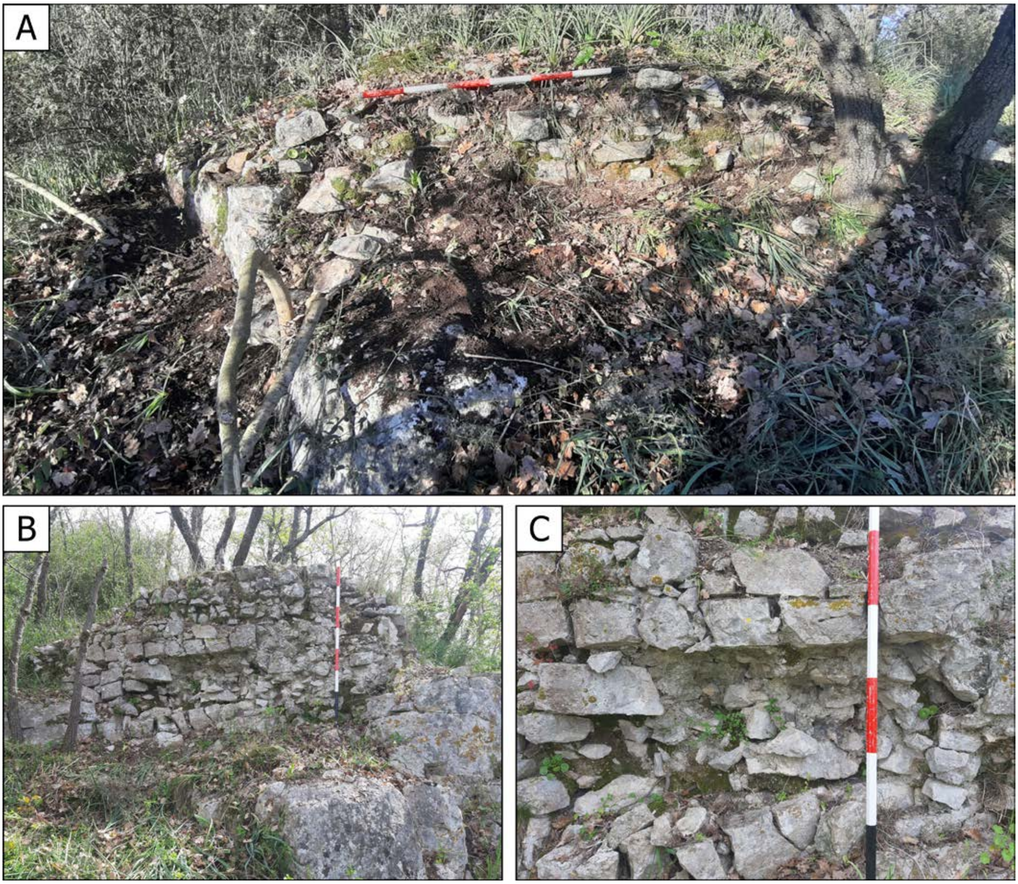

Figure 9. A. Remains of a wall partition, located to the south. B. External side of the south-east wall; C. Detail of the internal core.

(Fig. 6.C-D; Fig. 7; Fig. 8.A-B). The latter is slightly shifted against the northern portion of the curtain wall of a second outer circuit, which adapts to the rocky conformation of the soil and extends southeast, following the natural orography of the place (Fig. 8.C-D; Fig. 9.A). Only the eastern section and part of the western section of this second wall enclosure have been traced; the rest appears collapsed or inaccessible, unlike the inner enclosure, which appears more preserved.

The masonry technique consists of *opus incertum* and in *opus caementicium*, with abundant mortar, blocks, and shards of stonework (Crova 2005, 87-89, 94-95, 104-106; Frisetti 2020, 164-165). The curtain walls feature a limestone apparatus composed of rough-hewn blocks, sometimes also coarsely and summarily worked with imperfectly squared cuts and varying dimensions, arranged in a cursive manner, as perceived from the irregular courses with stone flakes closing the cavities (Crova 2005, 124-127) (Fig. 9.C). In some parts of the internal wall circuit the foundations are visible and are with direct attachment to the limestone rock (Fig. 9.B). Furthermore, it is to be hypothesised that there is a concrete possibility of

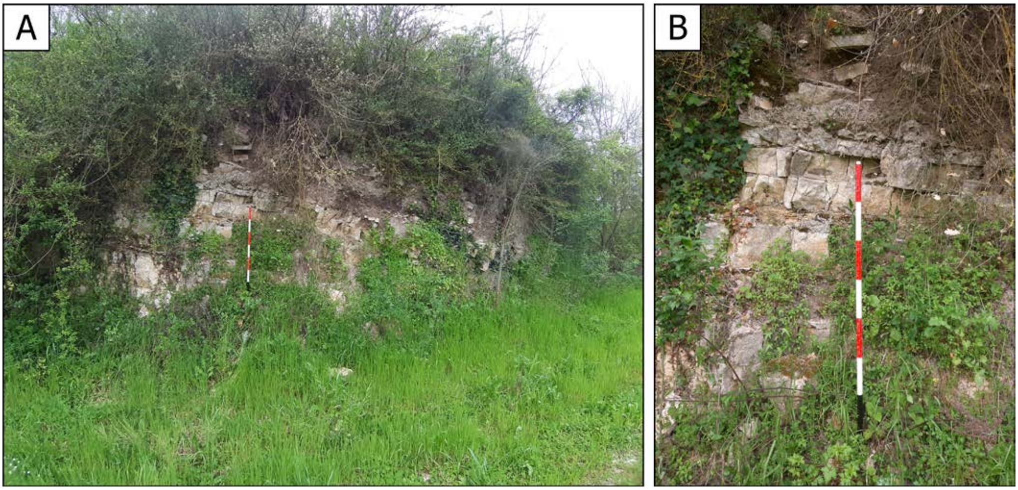

Figure 10. A. Northern side of the hill; B. Detail of northern side of the hill.

using diversified materials, not only stone but also wood, now disappeared, which certainly constituted a fundamental component in Norman constructions (Coppola 2015, 191-194).

The type of keep with a double wall circuit, internal and external, was functional for the defense and control of a certain area with significantly reduced construction costs and times, just like the case in question. The castrum of Torre Palazzo, due to its building technique, seems to represent an example of Norman military architecture referring to the 12th century, strongly serialised and elementary (Coppola 2005, 40). These characteristics find parallels with contemporary nearby settlements, such as the Torre Palazzo castle and the Ferrarisi tower, indicating a common building strategy and territorial arrangement in the analysed context (Lonardo and Di Cecio 2020, 784-785) Furthermore, it certainly played a relevant role within the barony *de Fenuculo*, being located in a strategic position to control the road network and the underlying crossing over the Reventa stream. In fact, following the Norman conquest, castles and fortified towers became typical elements of the countryside of the Calore valley and were used to control the territory. The real advantage is the speed with which they are erected and, in addition, they offer protection and security to all those living nearby.

In general, however, the results obtained from the processing of derived models appear quite satisfactory, limited only by the definition of the 1x1 m cells of the input DTM, and led to the detailed detection of surface relief and elevation variations related to both geomorphological and archaeological features. Most of the findings show elements attributable to the remains of a castle-tower, with an outer wall and a second internal one. Other marks are recognisable to the south, such as paths and roads or other less-deep micro-reliefs located to the right of the site, which could refer to potential structures or habitation buildings. The interpretation of these marks is less clear due to poor visibility, but the hypothesis of the presence of a settlement is certainly justified by the large amount of medieval pottery found in the surrounding ploughed lands and by the reading of medieval documents, especially the one from 1221 previously considered. In any case, the visualization techniques that contain the most detail are SVF, ASVF, OP and HS-VAT, which overcome the limitations due to illumination direction typical of HS or Multi-HS (Crabb *et al.* 2023, 6-7). Concerning the external wall circuit, a small interruption of the defensive structure can be traced, possibly due to a collapse (remains of small and medium-sized rough-hewn blocks were found in large quantities all along the western hillside). On the south side of the west wall, the collapse can be precisely identified (Fig. 1.C-D, n. 3; Fig. 6.C-D), which is not sufficiently represented in other visualization techniques. In addition, can be seen very precisely the pseudo-curvilinear course of the south south-west corner (Fig. 1.C-D, nn. 5-6; Fig. 7.C), that is directly on the rock, marked by a darker tone. Similarly, the contrast between black and lighter pixels helps to clearly highlight the north-east corner (Fig. 1.C-D, nn. 7-8; Fig. 8.A-B). It is possible to identify the remains of another wall section to the south; also built on the rock (Fig. 1.C-D, n. 11; Fig. 9.A), but whose function can only be defined with certainty after an excavation. It is likely that between the first and second walled circuit there were buildings or accessory structures made of perishable material (e.g. wood) and therefore no longer preserved, in fact, a mild slope, which could indicate the presence of buried structures, can be seen especially in the Slope, but also in the Multi-HS, MultiHS-VAT, SIM, LD. Finally, on the northern aspect of the hill a sheer rock face is observable (Fig. 10, n. 12). The morphological characteristics appear consistent with an artificial cut undertaken to enhance the settlement's defensive potential and to increase the difficulty of access to the most exposed section of the defensive circuit. The shaping of the rock (red calcareous flysch), cut at the base of the walls, may also have permitted the in situ extraction of building material for the castle. The extraction of material in situ, where feasible, was a common practice dictated by temporal constraints; it also allowed the procurement and on-site working of stone at relatively low cost (Coppola 2015, 149–150).

Conclusion

The great potential of airborne LiDAR sensors (ALS) to emit multiple laser pulses and record more than a single return is crucial for the investigation of high-altitude or mid-hill sites. For this case, only two return signals (First and Last) were recorded, nonetheless under certain conditions of arboreal vegetation (as for the site investigated, that is characterised by small and medium-sized oaks) the laser can pass through the canopy gap and return a sufficient number of points to be able to process the DTM.

The results obtained show how this type of data can be used for the detection and interpretation of microtopographical features of an archaeological nature. In fact, the MATTM's LiDAR was fundamental for the study of the medieval site of Torre Palazzo (for which few written sources are available), overcoming the limitations of optical sensors (such as aerial and satellite images and survey methodologies based on photogrammetry and aerophotointerpretation). The processing of the different visualisation algorithms, integrated and compared in order to obtain maximum information, also made it possible to identify the most useful analyses (Slope, SVF, ASVF, OP and VAT) for identifying surface discontinuities and emphasising traces and anomalies, which were then interpreted as pertaining to archaeological elements of the Torre Palazzo castle. Field verification of the obtained results through on-site surveys is crucial for attributing with certainty the highlighted marks to anthropic elements. Furthermore, it is important to set, where possible, the various parameters of the algorithms according to the specific characteristics of the terrain to be examined and empirically evaluate those parameters that seem to be most suitable to output derived models capable of maximise archaeological features.

The difficulty highlighted is the scale ratio, in fact that does not exceed 100 square meters overall. In fact, LiDAR data with 1x1 m cells only allow for the detection of elements of a meter or more and do not record other small height differences that smaller archaeological remains may produce. However, the present work, despite these limitations of spatial resolution, shows how it was possible to extract the main archaeological features of the Torre Palazzo fortification, allowing a hypothetical reconstruction of the structure's form and the identification of its constituent elements.

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Contribution to the Archaeological Map of Umbria (CAU): a diachronic analysis of the territory to the northeast of the city of Perugia, Upper Tiber Valley, Umbria

Alessia Mandorlo

alessia.mandorlo@unisalento.it – University of Salento

Abstract

This paper summarises the results obtained between 2020 and 2022 during the topographic study carried out in the northeastern sector of Perugia as part of my master's thesis at the University of Siena. The study involved the collection of published documentation followed by field-survey activities using Mobile GIS (QField) and aerial survey with UAVs. The data collected were managed and processed in a GIS environment, thus contributing to the analysis of the high archaeological potential of this territory and its settlement dynamics as well as past human-environment interactions, in a long-term perspective. The collected data also contributed to the expansion of the Archaeological Map of Umbria (CAU).

Keywords

Landscape archaeology, Upper Tiber Valley, landscape survey, rural settlement, *longue durée*

Introduction

The study of the selected area, located between Solfagnano and Villa Pitignano (Perugia), is characterised by the integration of relatively recent technologies into the traditional methodology of topographic survey (Cambi and Terrenato, 1994). This contribution is intended as a preliminary study, given the intrinsic complexity of territorial research. The aim was to highlight the archaeological value of a lesser-known landscape[1] by analysing the territory's high archaeological potential, settlement dynamics, and past human-environment interactions. By its own nature, this territory acts as a connective space between different cultural spheres of the region, thanks to the Tiber River flowing through it.

The study area

The geographical area here examined (ca. 40km^2) is located within the northeast sector of the territory of Perugia and along the *Upper Tiber Valley*, between the Umbrian Valley to the southeast and the Middle Tiber Valley South to the southwest (Fig. 1). The boundaries of the area selected for this study were identified by considering the modern administrative limits of the municipality, the geomorphological features of the territory, and the course of the Tiber River (Kolendo 1969; Cifani 2003, 23). The territorial context examined here is linked to a broader landscape framework that characterises the north and central Umbrian and southeastern Tuscan landscape adjacent to the central hilly belt and the mountainous areas.

[1] To the present day, there are no known surveys and project works published on central Umbria.

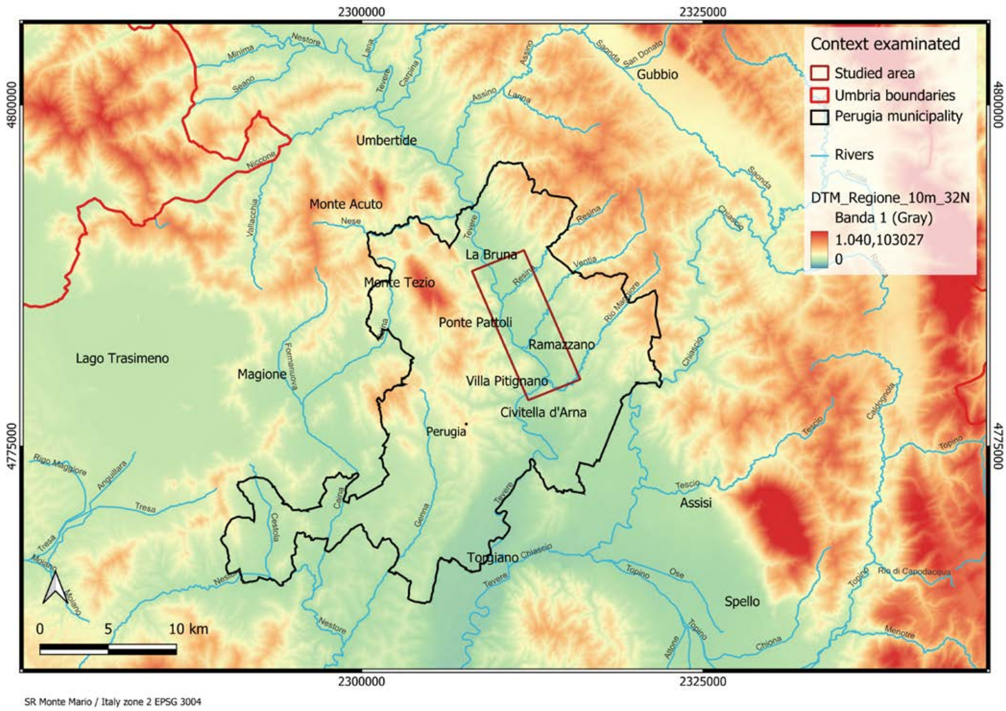

Figure 1 – The area selected for this study in the central western sector of Umbria.

In general, this territory is a typical example of the physical landscape of northern Umbria, and it is characterised by narrow plains with recent or ancient alluvial features and hilly stratifications. The geological history of the territory – which is related to the more complex geological evolution of the region itself – has contributed to the development of a uniform and homogeneous geomorphological conformation (Gregori 2006).

Method

The method adopted in this study is based on a plurality of theoretical and practical elements, paying particular attention to the different scales of detail (Campana 2015; Campana 2018). The approach is structured in three tasks. The first task involved the preliminary study of environmental, geographical, geological and geomorphological features, as well as the collection of published historical, historiographical and archaeological documentation. The second task involved data collection and its organisation in the GIS database (QGIS), thus creating graphic and tabular datasets (Campana and Forte 2017). Preliminary analyses include the identification and interpretation of anomalies through satellite images and orthophotos. Fieldwork activities were carried out using Unmanned Aerial Vehicles (UAVs) and a mobile GIS, i.e. QField for geo-referencing data collection in real-time (Montagnetti and Guarino 2020; Mandorlo 2024). During the summer season, in June and September 2021, aerial reconnaissance was performed using a UAV (Mavic 2 Pro DJI). The application of UAV made it possible to generate 3D models, orthophotos and Digital Elevation Models (DEMs), and later, to interpret the anomalies highlighted (Mandorlo 2024, 6-7; Fig. 2).

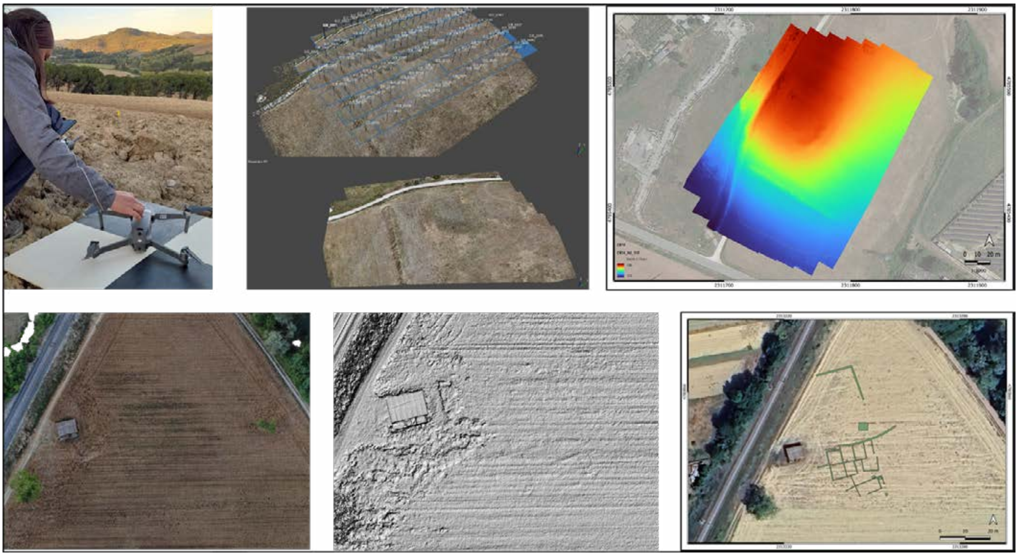

Figure 2 – Some examples of UAV survey: 3D models, Orthophotos, DEM and one example of anomalies' interpretation.

QField was used to geo-reference both internal ("intra-site") and external ("off-site") material concentrations (Belvedere 2010, 33), and for the data related to areas where the collected fragments may be considered as indicators of past human activities in the territory, the so-called "background noise" (Cirelli 2006, 170-172; Attema *et al.* 2020) (Fig. 3a-b). The survey activity was intensive but not repetitive, with few instances of repeated reconnaissance. Intra-site and off-site fragments played a key role in comparing correlations between off-site and *holes,* which is crucial for understanding the analytical framework (Cirelli 2006, 171). QField was used to create virtual grids at fixed intervals. These grids (5x5 m) were inspected by teams of 4-5 people per shift in order to achieve systematic area coverage. When considerable material concentrations were identified, grids were resized for more detailed sampling down to 2x2 m. For low-density concentrations, individual material fragments where recorded as points, while for large concentrations with high volume and density of fragments, sampling strategies were used. The sampling process was influenced by various factors including time and resource constraints as well as the proven effectiveness of the sampling methods in some studies (Terrenato 2000; Cirelli, 2006). Thanks to the *tracking* function offered by QField, it is possible to clearly define the boundaries of single concentrations.

The geomorphological features of these areas, mostly characterised by alluvial and colluvial deposits, display a coherent archaeological pattern influenced by shared agricultural practices (Saggioro 2003, 533). Intensive ploughing in these zones has led to the destruction of buried archaeological remains. The low plain areas with thick alluvial deposits have better preserved the archaeological record. Approximately 18% of the area (46 km²) was unsuitable for investigation due to residential, industrial and infrastructural coverage and 23% is forest covered (Fig. 4a); the remaining area consists of 42% ploughed fields, 9% overgrown areas, and 8% permanent crop (59% of 46 km²). About 10 km² of the remaining area was surveyed (Fig. 4b) between October 2020 and September/October 2021.

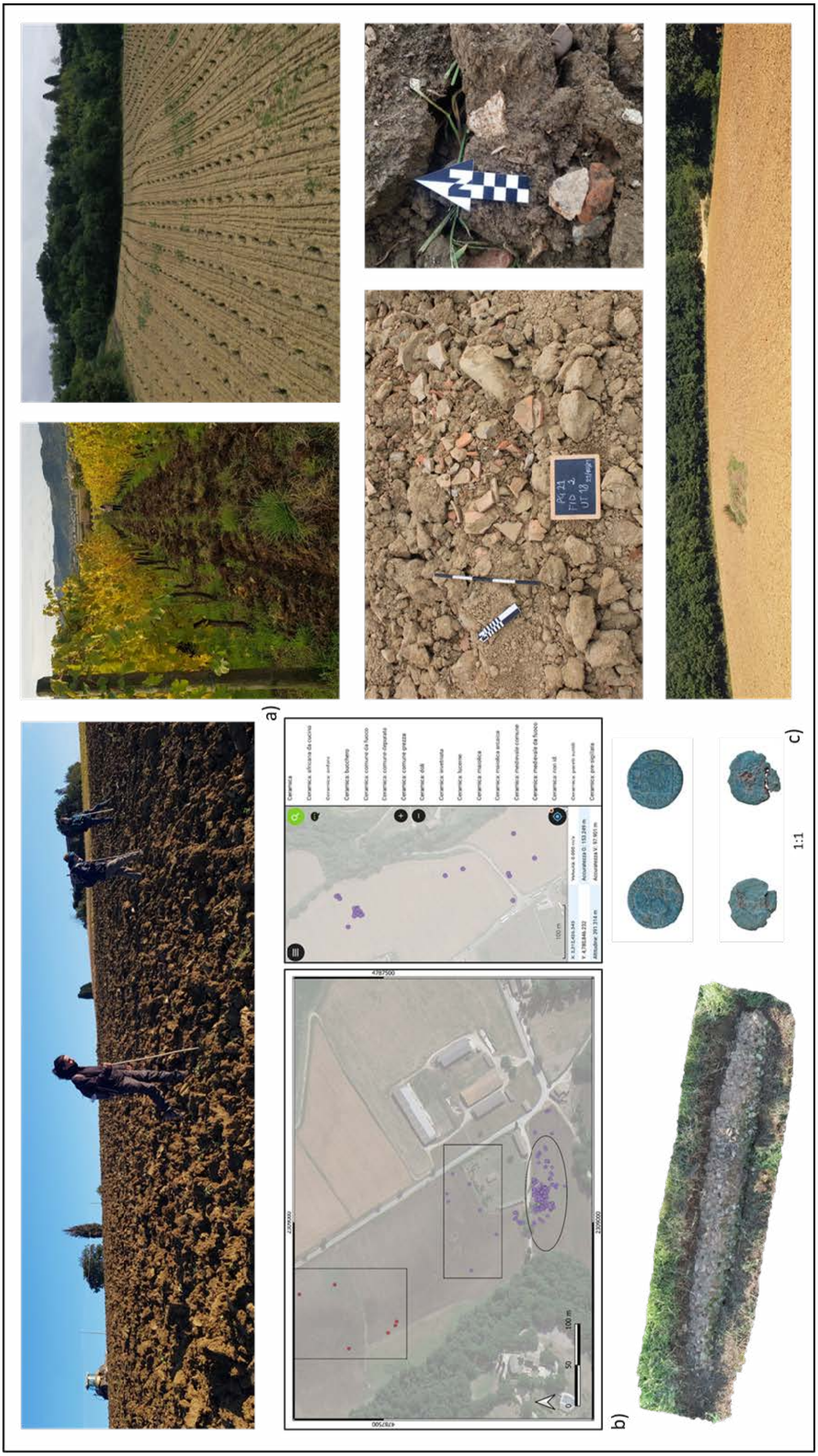

Figure 3 – Some examples of fieldwork activities: a) the pictures above and on the right show the land visibility of the surface and the status of the materials discovered; b) geo-referencing data collection in real-time with QField and an example of 3D model from survey activities; c) Late Antique coins discovered during the survey activities.

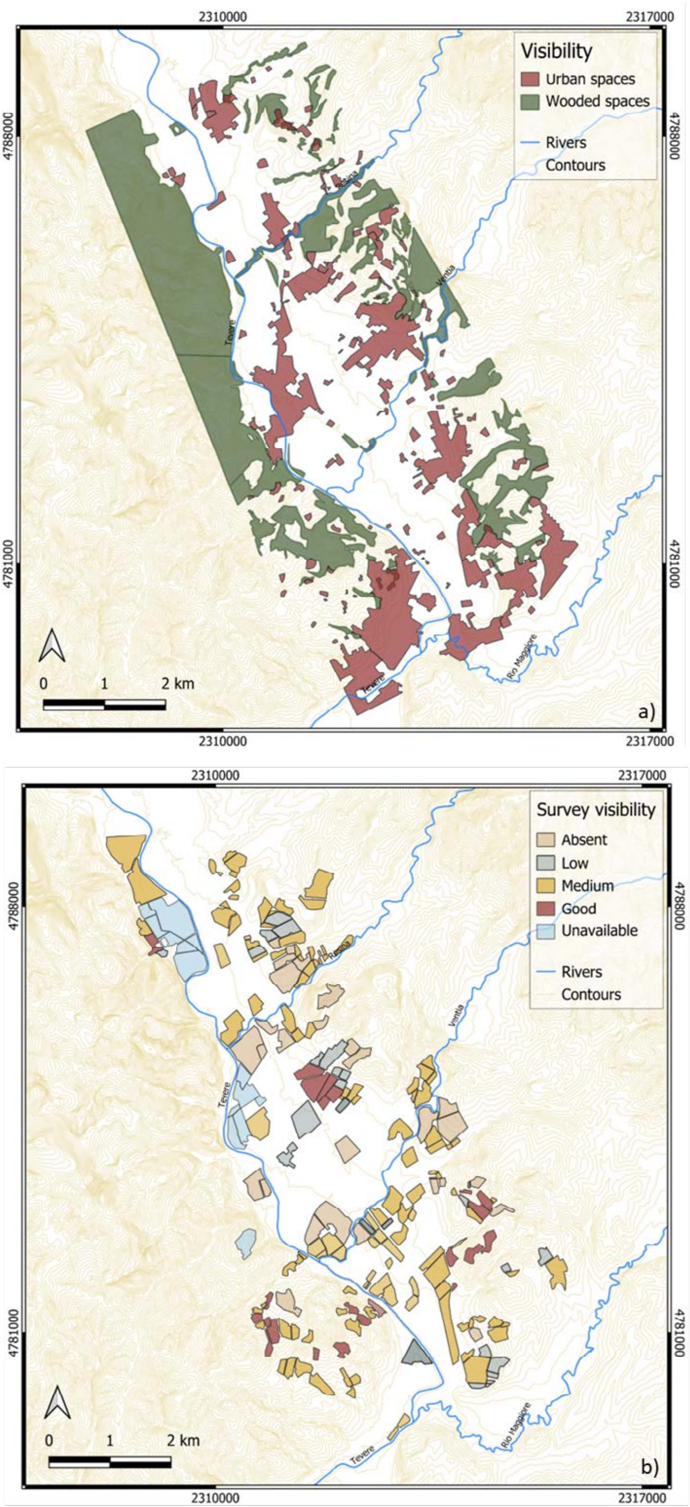

Figure 4 – Visibility maps of the examined territory: a) urban and wooded spaces are highlighted; b) survey visibility map in relation to the fields investigated between October 2020 and September/October 2021.

The third task included reorganisation of the collected data in a GIS database and the study of the material recovered during the survey activities. Each piece of information underwent critical elaboration, and QGIS facilitated the production of precise distribution maps of the evidence. Field activities allowed identification of a considerable amount of data relevant to periods ranging from Prehistory to the Middle Ages[2].

The approach adopted for the creation of the "Topographic Units" is based on the use of the main interpretative categories outlined during the *Carta Archeologica della Provincia di Siena* (*see* Valenti 1995, 35; Valenti 1999, 53; Campana 2001, 70), which are consistent with the guidelines provided by the ICCD (*Istituto Centrale del Catalogo e Documentazione*; *see* Mancinelli and Imperatori 2020), and also adopted by the *Soprintendenza Archeologia, Belle Arti e Paesaggio* for the production of the Archaeological Map of Umbria. In summary, the interpretative categories used in this research, which define the identified Topographic Units, are frequentation, sporadic, earth house with brick cover (as a building type), farm, and *villa*.

Population diachrony: settlement and socioeconomic models

4.1 Prehistory and Protohistory

Evidence provided by the survey data is scarce regarding the Prehistoric period, and evidence for the Protohistoric period is completely absent. In general, these data fit in with the broader regional framework, which provides some sporadic evidence for the territories bordering Perugia (Moroni *et al.* 2011, 173). The first documentary evidence of human presence in this territory - mainly attested by lithic artifacts collected by Giuseppe Bellucci between the late 19th and early 20th centuries - dates back to the Lower Palaeolithic (Bellucci 1915). Most of these contexts are distributed near Lake Trasimeno, at the confluence of the Tiber and Chiascio rivers, and in the southern suburb of Perugia (De Angelis *et al.* 2014). In the northern and northeastern areas of the studied territory, surveys and stratigraphic excavations revealed a complex pre-Protohistoric settlement network along the northern Tiber Valley at the Umbrian-Tuscan border between Città di Castello and Sansepolcro (Lanfredini and Benvenuti 2010, 1-8), and in the territory of Gubbio (Malone and Stoddart 1994).

Regarding the territory examined here, all the collected Prehistoric material consists of lithic artifacts, e.g. flint. These are concentrated in the central-northern area, mainly near Casa del Diavolo and Resina (Fig. 5), not far from the secondary watercourses and tributaries. They are completely absent in the southern area of the examined territory. The lithic industry artifacts found here document the frequentation of the area; in fact, there are no surface concentrations suggesting the presence of substantial underlying deposits related to stable settlements. A general analysis of the distribution of artifacts has shown a preference for valley contexts along the terraced alluvial deposits and eluvial colluvial cover. In this context, Prehistoric occupation seems to be linked to the exploitation of flint, which is abundant due to the presence of pebbles as a result of the Ventia and Resina Rivers' deposition. Moreover, the examined areas are in proximity to the outcrops of Red Scaglia (Cretaceous and Tertiary) in the Perugia Massifs, especially near Mounts Tezio and Acuto.

[2] Uncertain findings are not considered here.

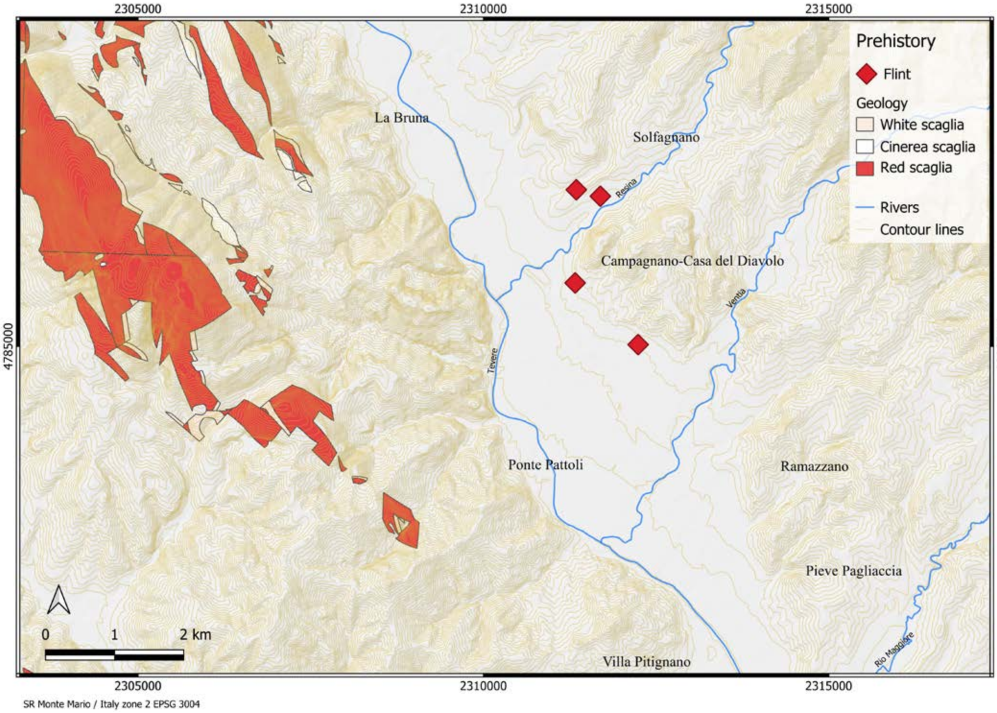

Figure 5 – Presence of Prehistoric materials due to the geological deposits of "scaglia".

Along the Tiber riverbank, in the area investigated in this study, there is a significant absence of documentary evidence for the Proto-villanovian and Villanovian periods and for the subsequent ones. The valley does not seem to have been populated at all, whereas high areas at approximately 930 and 960 m a.s.l. were preferred, as evidenced by the hillforts on Monte Tezio (Matteini Chiari and Mattacchioni 2008) and Monte Acuto (Cenciaioli 1992), as well as by the evidence from the southwestern suburb of Perugia (Cenciaioli 1991, 97-104). Similar to other major centres in the region, such as Orvieto (Colonna 1985; Stopponi 2014) and Gubbio (Malone and Stoddart 1994; Negro *et al.* 2024), Perugia developed during the Villanovian period from a series of small settlements between Colle Landone and the Monte del Sole hills, with a phase of occupation dating from the late 10th to the 8th centuries BC (Feruglio 1990; Bartoloni 2002).

Hellenistic - Late Republic (3rd/2nd century BC - first half of 1st century BC)

Compared to the situation previously described, starting from the Archaic period there was an increase in the population within the territory of Perugia. Here and in the immediate southern and southeastern suburb, there is a much greater concentration of archaeological evidence. This is closely related to the formation of the city-state (Cenciaioli 1991, 97-104): from the early 6th century BC, people were attracted by the increasing role of Etruscan Perugia. This phenomenon is evidenced by the appreciable increase in settlements as highlighted by the necropolises of the 6th and 5th centuries BC and then in those of the 4th and early 3rd centuries BC (Di Stefano *et al.* 2012, 10-11).

As for the area under investigation, it was only from the mid-3rd century BC that the development of rural settlements was observed. This occurred during the period of major urban renewal works of the main pre-Roman cities in the central area of the region, such as Perugia and Assisi (Di Stefano *et al.* 2012, 24-25). The published data regarding the studied territory are supported by two types of evidence: one epigraphic and two funerary pieces of evidence: the chamber tomb containing travertine cinerary urns of the "Assisian type" in the Ramazzano village (Dareggi 1972, 25), a cinerary urn found in the Solfagnano area (Cenciaioli 2004, 395)[3] and the Etruscan inscription found near the locality of Civitella Benazzone. This inscription dates back to the 3rd and 2nd centuries BC and could support Sisani's hypothesis about the presence of an Etruscan centre in this area (Sisani 2007, 53-54).

The data collected during the survey reveal only one context dating back to the 3rd century BC in the territory of Solfagnano (UT 13). The materials analysis showed that the site was abandoned around the early 1st century AD. The typology of materials found here, including a fragment of a bronze object (a ring?) and the handle of a large coarse pottery lid, suggests the presence of a funerary site. However, more data are still needed to confirm this hypothesis. This thesis could be supported by the discovery of a cinerary urn in the same area, now preserved at Villa Bennicelli in Solfagnano (Belardi *et al.* 2017). Also, in the area southwest of the studied territory, other funerary contexts are present (Cenciaioli 2004, 391): to the west of Villa Pitignano, the necropolises of Monte Giogo (Fig. 6, n 1) and Monte Bagnolo (Fig. 6, n 2); the necropolises in the Casamanza-Montelaguardia area (Fig. 6, n 3) San Marino (Fig. 6, n 4) and a tomb from the 3rd-2nd centuries BC in the Cordigliano area (Fig. 6, n 5).

The other contexts identified through surveys date back to the 2nd century BC. Such contexts provide confirmation of the 'Romanisation' phenomenon, as documented by Roman finds, especially *vernice nera* (Fig. 7). The data seem to indicate a limited number of scattered settlements, mostly characterised by a few, though significant, pottery fragments, as evidenced by sporadic findings in the La Bruna area (Fig. 6, UT 20). At the southeast boundary of the studied territory, in the Colombella area, a concentration of evidence that may have belonged to a dwelling made of a presumably perishable material with brick covering was identified ("Earth house," Fig. 6, UT 12). This is the only case in which *dolia* rims, morphologically similar to the Republican types have been found (similar in Braconi and Uroz Saez 1999, 168, fig. 13). In the central section of the studied territory, in the Campagnano-Casa del Diavolo area, a series of inhabited nuclei composed of structures made of perishable material and with brick covering ("Earth house" Fig. 6, UT 4) made of more durable materials such as rough and semi-worked stones, tiles, roof tiles, as well as paving blocks for *opus spicatum* flooring (Fig. 6, UTs 1, 6, 7) were found. The findings and materials were located within a radius of about 20 meters, thus indicating a close relationship between the described structures. UT 6 is quite interesting, as the analysis of the material distribution, especially *vernice nera*, coarse and fine potteries dating back to the 2nd and 1st centuries BC, suggests an "*L*" shaped concentration area of approximately 450 m². This context was interpreted as a farm.

Overall, the archaeological evidence identified for this period is scattered across an area of approximately 250 m², situated between 230 m (Tiber plain level) and 300 m a.s.l., generally favouring valley contexts corresponding to terraced alluvial deposits.

[3] Location and state of preservation unknown.

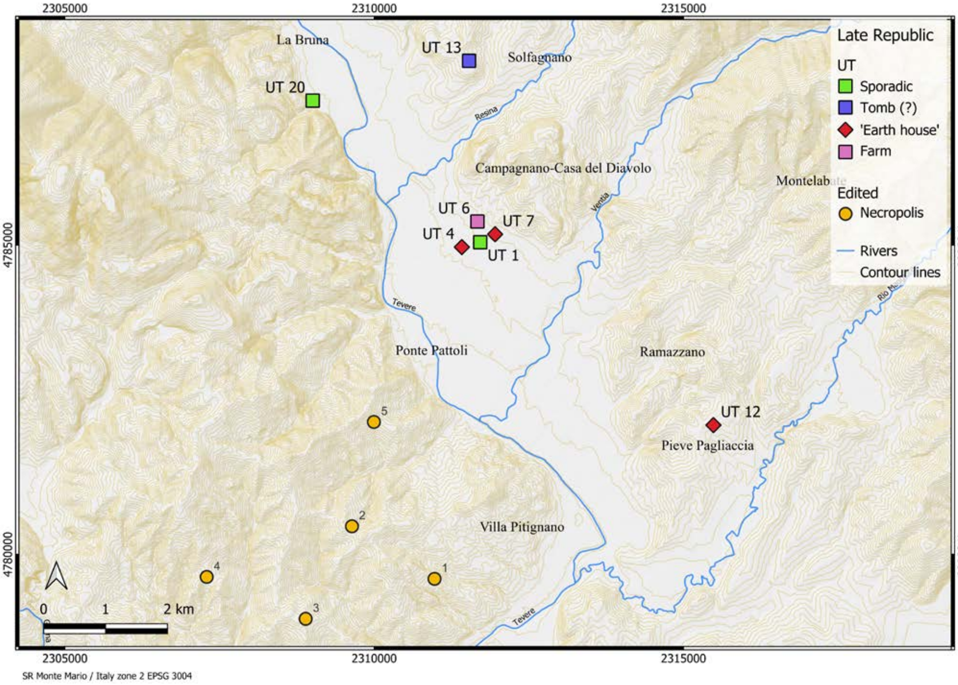

Figure 6 – Hellenistic-Late Republic evidence mentioned in the text and the survey data (the 3rd/2nd centuries BC - first half of the 1st century BC).

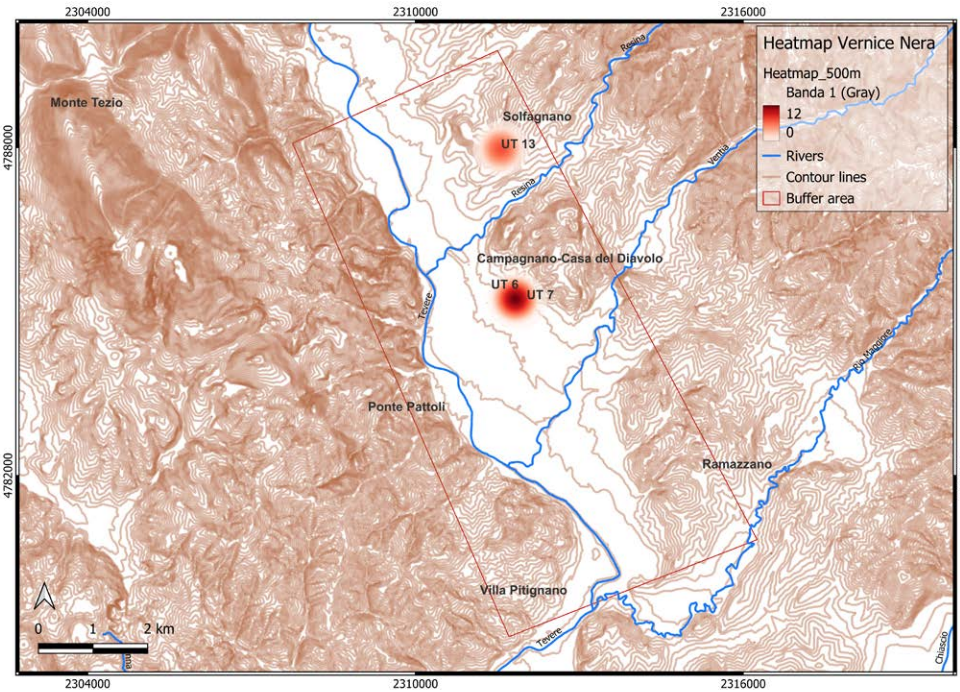

Figure 7 – Heatmap of Vernice Nera.

4.3 Early Mid Roman Empire (mid-1st century BC - early 3rd century AD)

The number of settlements increased consistently from the Augustan period, thus characterising in a widespread manner the entire territory examined in this study, as can be seen in the rest of the surrounding Perugia landscape (Bratti 2007, 35-36). This increase may be a consequence of one of the most significant ancient conflicts that has marked the history of the city of Perugia and its territory, the *Bellum Perusinum* (41-40 BC): Octavian's victory over Marcus Antonius's brother, Lucius Antonius. This war was a step forward toward the final victory of the future Augustus over his rival and led to the expropriation of numerous lands in the countryside of Perugia, previously owned by local aristocracies, and to the destruction of a large part of the urban sector (Sisani 2006, 17; Cenciaioli and Sisani 2009, 179). The reorganisation of the territorial structure promoted by Octavian ensured new land assignments to his veterans and, from an archaeological perspective, this seems to correspond to the increase in settlements within the studied territory. Survey activities identified a total of twenty-six contexts (Figs 8-9). Economic and commercial activities related to the exploitation of natural resources and raw materials are also fundamental to the development of the territory. Timber and wheat from Umbria were among the two most demanded products in Rome (Diosono 2008, 252 ff.): Livy (Liv. XXVIII 45, 14-18) wrote that Perugia, with Chiusi and Roselle, supplied fir trees for shipbuilding and large quantities of wheat during the Second Punic War; Vitruvius also recommended fir and oak as the best woods for constructions (Vitr. II 9,5 and 8-9). Within such an economic and sociocultural context, the villa system prospered in this territory: archaeological field surveys have identified two *rustic villae* dating from the mid-1st century BC onwards. These production and residential sites are located on ancient geological deposits, such as river terraces, on eluvial-colluvial soils, at approximately 235 m a.s.l. near the Tiber River. The site selection for this settlement seems to be unusual compared to the general landscape of the central Umbrian territory, where this typology is attested at higher altitudes compared to smaller inhabited buildings (Di Stefano *et al.* 2012, 27). The first *villa* is located at the foot of the Pieve San Quirico (Fig. 8, UT 19) and is related to UT 20, dated back to the previous period. The deposit is heavily damaged due to the construction of a farmhouse that was built on the concentration area between 1954 and 1977, as shown in the historical satellite image. The second villa is in the Ramazzano area (Fig. 7, UT 8). The distribution of the material combined with aerial photography and three-dimensional modelling using UAV highlighted a complex internal structure consisting of various rooms and a series of oblique anomalies perpendicular to each other, perhaps related to a division of the land belonging to the villa (Mandorlo 2024, 6, fig. 6). This is the only context where it is possible to hypothesise an internal division between *pars rustica* and *pars dominica*. Thanks to the finding of square *tubuli*, the distribution of artifacts allows for the identification of the residential part of the villa, likely composed of rooms with *opus spicatum* and mosaic flooring, frescoed walls, architectural and marble decorations, and thermal structures located at the southwest corner of the concentration. The northward and north-eastward distribution of storage and transport amphorae could indicate the *pars rustica* of the villa.

An interesting settlement evolution was observed in the late Republican context in the Campagnano Casa del Diavolo area (Fig. 6, UTs 1, 6, 7). In this phase, there was an intense reorganisation of inhabited spaces and a considerable expansion of their dimensions: it is no longer possible to separate the previously identified building units, as the material found is continuously distributed throughout the area (Fig. 8, n 3). There was a continuity of settlement

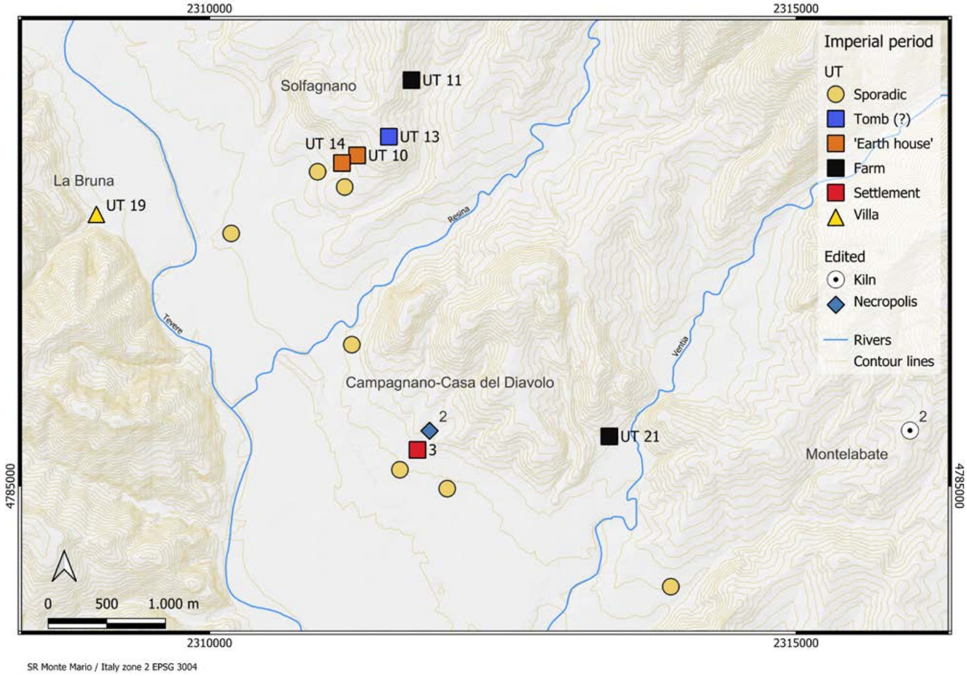

Figure 8 – Evidence in the north sector and the survey data mentioned in the text during Proto-Mid Imperial (mid-1st century BC - early 3rd century AD).

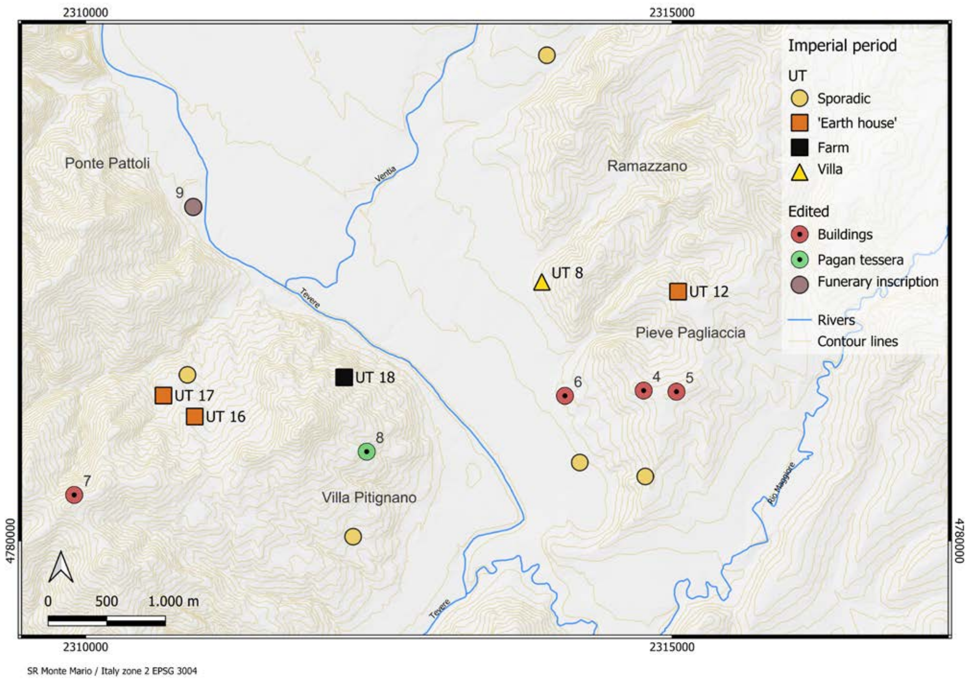

Figure 9 – Evidence in the south sector and the survey data mentioned in the text during Proto-Mid Imperial (mid-1st century BC - early 3rd century AD).

life until the Late Antique period. From the analysis of the material distribution, the central role of this settlement is quite straightforward: a quantity of iron slag suggests the productive vocation of the context, and mosaic tesserae of different lithotypes, the floor and fragments of square *tubuli*, coloured *intonaco* fragments (red, yellow, green, black, and white), and a fragment of architectural *terracotta* suggest the presence of a modestly wealthy residential nucleus. The certain economic vitality of the area and its relationship with Rome, including the neighbouring and western Mediterranean areas, is also confirmed by the presence of amphorae containers, some produced locally, such as "fondopiatto" amphorae, and likely attributable to the Montelabate production site (Fig. 8, n 1) (Ceccarelli 2017; Ceccarelli 2021a), and other items produced in Spain. In addition to this central nucleus, other residential units were found in the settlement area, such as the context associated with the interpretative category of "Earth House". The almost exclusive presence of large containers and amphorae, both locally produced and imported (Dressel 2/4 betica amphora), also suggest storage and warehouse spaces. Furthermore, the Imperial age necropolis, found at the end of the 20th century (Cenciaioli 2004, 395) and consisting of *cappuccina* tombs and a quadrangular funerary monument in *opus caementicium* covered with sandstone blocks (Fig. 8, n 2), suggests that this settlement played a key role in the territory, also considering its overall extension of ca. 7 ha.

Within this settlement area, other rural buildings dating between the 1st century BC and the late 2nd/early 3rd centuries AD were found during the surveying activities in the northern area of the territory of the Solfagnano village (Fig. 8, UTs 10, 14) and in the southernmost area of the Villa Pitignano village. Two "Earth Houses" (Fig. 9, UTs 16, 17) and concentrations of materials related to heavily depleted underground deposits were located throughout the territory. In the Solfagnano area (Fig. 8, UT 11), Casa del Diavolo (Fig. 8, UT 21) and Villa Pitignano (Fig. 9, UT 18) areas, three farms were identified. The importance that these rural settlements had in Roman times is also indicated by their pivotal position: the first two farms are located along a presumed secondary road, whose routes possibly connected the valley with the territory of ancient *Iguvium* (Gubbio).

The third farm is located in a significant area, in which it is possible to suppose that a secondary road connected it with the surrounding and inner territory of the Villa Pitignano village (*see below*). They are located at altitudes between 260 and 300 m a.s.l.

These settlements are also associated with the already documented buildings (*Ville e insediamenti* 1983, 84; Cenciaioli 2005, 217) located in the southeastern area of the territory: the Ramazzano-Colle delle Vigne (Fig. 9, n 4) and Colombella-Boschetto (Fig. 9, n 5) sites and a frequentation area at "La Volpe" (Fig. 9, n 6). Other documented findings, such as the sporadic site near Pieve San Sebastiano (Fig. 9, n 7) are not far from the settlement units identified in the Villa Pitignano area and located near the rich funerary contexts of Monte Giogo and Monte Bagnolo, as previously mentioned. Near the church in the historic village of Villa Pitignano (Fig. 9, n 8), a pagan bronze *tessera* which dates back to the 2nd century AD was found in 1872 and is now on exhibition at the National Archaeological Museum of Umbria (Rossi 1872, 16-17; Spadoni *et al.* 2018, 73 and 304-305). The small bronze object with dotted inscription has an eyelet for attachment (*CIL*, XI 1947): as the inscription states it is a public document that the *Magister pagi* gave to the *Pagus of Paetinianus* during the *lustratio* religious ceremony, which was held annually for the sacred recognition of the boundaries of the *pagus* (Zaccaria 1994, 320-323). This finding indicates the presence of an important administrative site that gave the name to the current Villa Pitignano village.

To complete this detailed picture of the territory, it is also important to mention a Latin funerary inscription found in the Ponte Pattoli area (*CIL*, XI 1936) and dating to the Traianic period. This inscription relates to the presence of a hypothetical settlement, located near the current Ponte Pattoli village (Fig. 9, n 9).

4.4 Late Antiquity (4th - early 6th century AD)

In the Late Antique period, starting from the early 4th century AD, the rural space seems to undergo a new economic change thanks to the interest of emperors Constantine, Valentinian, and Gratian, who promoted the restoration of main road axes and secondary roads (Di Miceli 2012).

In the studied territory, this situation is evidenced by the reoccupation (or possible continuity of life) of some sites already existing and having arisen between the early 4th and early 6th centuries AD. This is documented by ceramic finds and coins of Constantine II (324-326 AD) and Constans Gallus (351-355 AD) (*see above* Fig. 3c). The situation seemed to disappear during the Greco-Gothic war (535-553 AD).

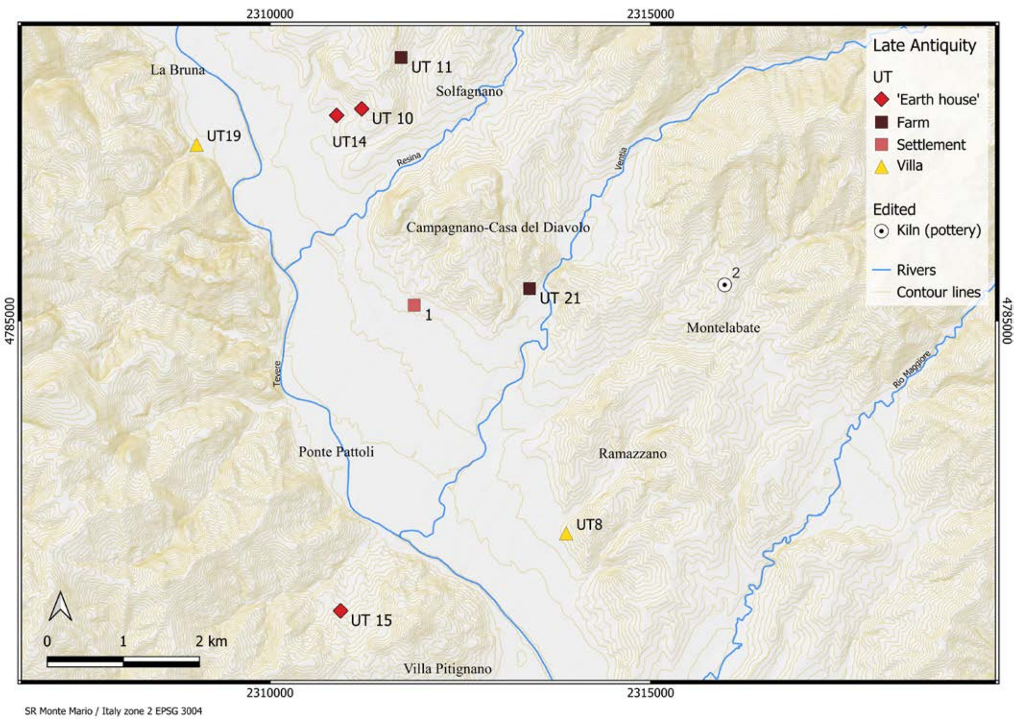

Figure 10 – Evidence and the survey data mentioned in the text during Late Antiquity (4th - early 6th century AD).

The settlement analysis shows that there is a reduction in the amount of evidence material compared to the Imperial period, from thirty sites to nine. This seems to have had little impact on the vitality of the social and economic structure of the territory. Some of the existing settlements have been reoccupied or simply continue to be inhabited, changing their size and shape. This phenomenon is documented in the Villa Pitignano area (Fig. 10, UT 15), which from the mid-4th century AD seems to undergo an expansion towards the east (Fig. 9, UT 16). This seems to have occurred also in the Solfagnano area (Fig. 9, UTs 10, 14). In the Campagnano settlement (Fig. 9, n 1), a decrease in the material found and a significant reduction in size are clearly attested in this phase. However, the settlement seems to maintain an important attractive role especially when compared to other sites of the territory. Towards the north and northeast, the presence of a fragment of Africana I and some other fragments of coarse ceramics found in the two Imperial farms (Fig. 9, UTs 11, 21) could suggest a form of seasonal reoccupation of the sites rather than continuous use from the Imperial period. The findings from the villa in the Ramazzano area (Fig. 9, UT 8) are different: these imported materials, such as a fragment of Tripolitana II amphora dating between the 2nd and 3rd centuries, a fragment of Africana I amphora and fragments of cooking pots showing morphological continuity from the 1st to the 5th century AD, and imitations of *sigillata Africana* could suggest a continuity of occupation of the site from the Imperial to Late Antique periods. In this period, the production of "*fondopiatto*" amphorae is well attested, as evidenced by findings and kilns from Montelabate (Fig. 9, n 2; Ceccarelli 2021b).

4.5 Middle Ages (8th – 14th century AD)[4]

Information about the management of the territory and the transformations of the agricultural landscape that occurred between Late Antiquity and the early medieval periods in Umbria is rare, too rare for Perugia (Augenti 2018, 367-378). During the late 6th century AD, as seen in other areas of Byzantine Italy, the local administration of Umbria was reorganized. This is marked by the appearance of the exarch office and the creation of small internal Duchies (Zanini 1998, 59). At this time, the territory of Perugia – as well as that of Gubbio – was incorporated into the Byzantine corridor, where the *Via Amerina* plays a key role in connecting Rome with Ravenna (Scortecci 1991, 61-73). However, the territory described in this paper does not show any material evidence related to the Byzantine presence, whereas evidence of the Lombard passage is visible in the mention of "vila Francorum Ramancani" (Moretti *et al.* 1992, 167-186). "Ramaççani" is a Lombard-origin anthroponym, and the toponym "Castrum Podij Gualdi" is mentioned as "Castle of Poggio Gualdo vestiges" in the map of the *Catasto Chiesa* (A.S.P., UTE, Catasto Chiesa, 1727, sheet 178). However, the survey activities near the lands associated with these toponyms has not yielded any evidence.

The first territorial attestations in documentation concern the monastery of S. Maria Valdiponte. A document signed by Pope Giovanni XIII in November 969 regarding extensive and consolidated territorial possessions testified the existence of the monastery long before the mid-10th century (Fig. 11, n 3) (Ceccarelli 2021b, 332). Based on the edited historical documentation, the territory seems to have been populated from the 10th century and more fully from the early 11th century, matching with the phenomenon of the "*primo incastellamento*" (Francovich and Ginatempo 2000; Bianchi 2015, 163), a phase between the late

[4] The analysis of archival documentation and relevant church records from the medieval period is currently incomplete; the information provided below refers to an initial archival survey.

9th and 11th centuries. In this period, nine instances of monumental evidence are attested in the territory, including three *castra*: these are located at altitudes between 340 and 410m a.s.l. and are identified in the localities of Pieve S. Quirico (Fig. 11, n 4), Civitella Benazzone (Fig. 11, n 5), and Ramazzano (Fig. 11, n 6). The management of the *castrum* of Civitella, an attractive centre and important conjunction in the valley. It is first mentioned at the donation of two small plots of land for the salvation of the soul, given to the monastery of S. Maria Valdiponte in the mid-11th century AD, through which the monastery gained control over the castle and its possessions (DeDonato 1988, 44-46). The castle of Ramazzano was founded built and continuously inhabited by the Ramazzani family ("*Ramancani*") until the mid-17th century. It is first mentioned in 1097, at the cessation of rights over some properties given to the monastery of S. Maria Valdiponte (De Donato 1988, 60-62). Originally, the complex structure of the castle was supposed to consist of four rectangular corner towers of which only the one located to the southwest remains intact. Although in a state of neglect, the Guelph-style battlements characterising the entire perimeter wall can still be seen.

Further south, in the territory of Villa Pitignano, archaeological data prior to the archival documentation are not available. The first mention of the castle with a polygonal tower (Fig. 11, n 7) appears in relation to the construction of the church of S. Maria Assunta in a document dating back to at least the early 11th century and refers to the church located within the walls (Fig. 11, n 8) (Ricci 1936, 593; Angelucci 2011). A second church situated in the territory between Villa Pitignano and Ramazzano, the Church of S. Clemente (Fig. 11, n 9) mentioned in the archival documentation as "*ecclesiam S. Clementis in ripafluminis*" was built on the alluvial plain near the Tiber River – now Villa Simonetti. This religious building, the only one in a flat context, must have been a point of great political relevance and control over the crossing of the Tiber River.

Many of the possessions in the territory and the mentioned churches were divided between the properties of the Benedictine abbeys of S. Maria di Valdiponte di Montelabate and S. Paolo di Valdiponte (Fig. 11, n 10). The latter was most likely founded by S. Maria Valdiponte's monastery and it "*always remained the mother abbey in relation to it*" (Ricci 1935, 38). Excavation surveys carried out between 1971-73 document the life of the abbey between the 10th and 17th centuries (Adams *et al*. 1972; Blagg 1975, 360).

Two parish churches are documented in the territory; their origin can be traced back to this period, even though, at the current state of research, they are not mentioned in documents prior to the early 11th century (Maiarelli, 2006, 44; Ricci 1936, 7-10). To the north is Pieve S. Quirico (Fig. 11, n 1), known as *Plebis Sancti Quirici*, and to the southeast, Pieve Pagliaccia (Fig. 11, n 2), known as *Plebem de Palacio* ("Pieve del Palazzo"). The current documentary incompleteness can be partially overcome by the materials found during survey activities. A few hundred meters from the first parish church, surveys permitted identification of the already mentioned *villa* in the Bagnara-La Bruna area, which shows human presence until the 5th century AD. Near the second parish church, surveys have revealed a context related to the Imperial period, and occupation of the area remained continuous until the central centuries of the Middle Ages (Fig. 11, UT 3). On the one hand, these elements can suggest the possibility that the parish church overlaps those of the Roman/Late Antique periods (Campana *et al*. 2008); on the other hand, it is possible that in the Late Antique period the territory could already have been divided into parish districts, as highlighted in another peninsula territory

(Fiocchi Nicolai and Gelichi 2001, 304-307) and organised in the *cura animarum* (Violante 1982, 972-992).

Between the late 11th and early 12th centuries, there was a new economic and demographic growth, which was motivated by the increasingly important role played by the *Comune* of Perugia (Grohmann 1981). The structuring of the territory is also characterised by the presence of small fortified inhabited centres, now lordly residences, and new religious buildings. All of them built in the summit areas, at altitudes between 300 and 480m a.s.l., strategically dominating the Tiber Valley. Some fortified sites identified in the territory are documented in textual sources from the mid-12th century: the castle of Solfagnano (Fig. 11, n 11) with the Church of S. Silvestro (Fig. 11, n 12), the castrum of S. Giuliano (Fig. 11, n 13) located at the foot of Monte Tezio at an altitude of 485m a.s.l., the present village of Ponte Pattoli (Fig. 11, n 14), the *castrum* Rustichelli in the Prozonchio-P. Pattoli area (Fig. 11, n 15) and the Carestello to the east (Fig. 11, n 16). From the second half of the 12th century, the existing fortified settlements are transformed into large settlements, and new villages are formed even in lowlands. The formation of new villages is documented in the Ponte Pattoli area starting with the foundation of La Fratticiola village (Fig. 11, n 17) located near the Tiber River.

In this period, in the area of the Villa Pitignano village, survey activities evidenced a human occupation as demonstrated by the sporadic nature of fragments of *maiolica* pottery (Fig. 11, blue point). In the same area, on the top of the hill and below the Santa Croce church,

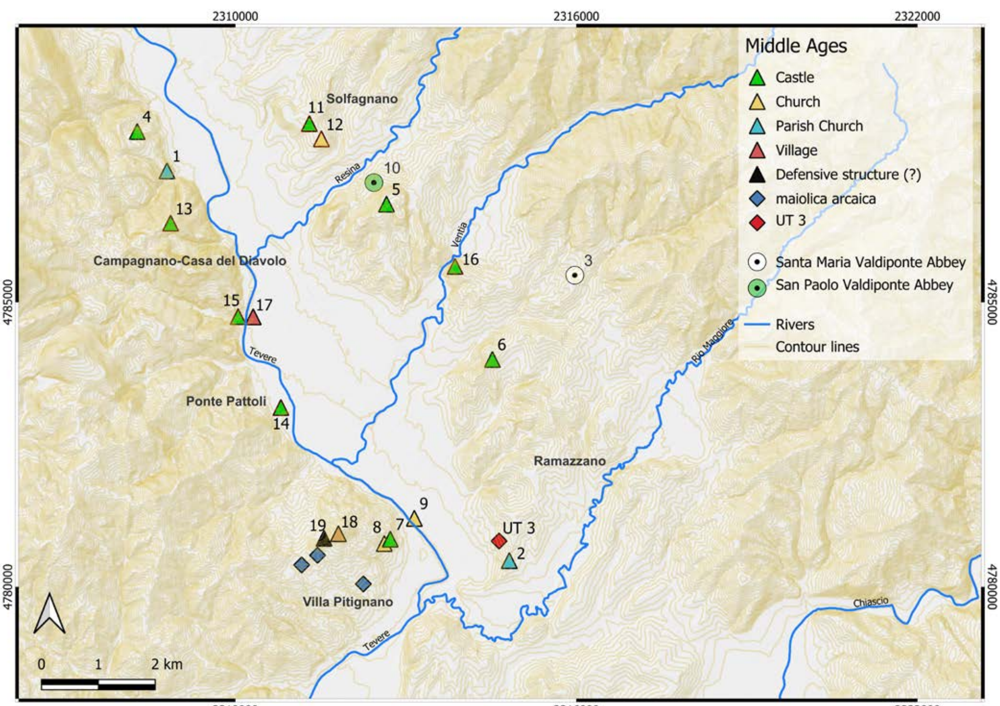

Figure 11 – Evidence and survey data mentioned in the text during the Middle Ages (8th – 14th century AD).

mentioned for the first time in the mid-13th century (Fig. 11, n 18; Ricci 1936, 593), survey and analysis of aerial and historical images from IGM of 1954-55 have allowed identification of the presence of a structure. During the field-walking survey a perimeter wall built in sandstone, which measures ca 7 x 20 m, was found. The presence of some slits, several postholes and a perimeter wall could suggest some sort of defensive structure (Fig. 11, n 19), even if this is not mentioned in archival documentary sources. However, in the late 19th century, the finding of a plaque may still suggest the possibility that the remaining structure could be attributed to the *castrum,* or *oppidum* already mentioned in the epigraphic evidence (Rossi 1872, 118). The identification of large accumulations of rubble stones and bricks to the north and northwest of the site could suggest the presence of an inhabited area in the medieval period. This site may be the second settlement mentioned in archival documentation around the mid-13th century in the historical documentation of "Villa Pitignani" (Ricci 1936, 593)[5].

Conclusion

The topographic survey described in this paper has highlighted the high archaeological value of the studied territory (a total of 32 Topographic Units). The data offer a significant contribution to the understanding of ancient settlement dynamics. Prior to this survey carried out on the portion of territory located northeast of the city of Perugia, most attestations were related to the medieval period, such as settlements, churches, and abbeys. However, few records referred to the Etruscan and Roman periods and those related to the Pre-Protohistoric period were completely absent. Thanks to the interpretation of the archaeological data collected, not least from the late Republican period, it is now possible to observe an articulated and densely populated area. The archaeological data concerning the phase prior to the Roman and medieval periods are still very scarce. This lack of data can be attributed to the different survey methods used for the identification of Prehistoric and/or early medieval contexts combined with the experience and attention permitting recognition of material from that period. This is the main cause of the general "non-visibility" (Pizziolo *et al.* 2009, 222; Campana 2009). Furthermore, the visibility factor decreases significantly in certain areas, such as alluvial plains, due to the continuous deposition of material and to landslides, post-depositional phenomena and the presence of dense vegetation leading to the obliteration of any underlying deposits (Belvedere 2010).

Surveys have shown concentrations of lithic artifacts from the Prehistoric period exclusively in the central-northern area. Analysis of the distribution of these finds has highlighted a preference for the valley due to the presence of terraced alluvial and eluvial-colluvial deposits, near secondary watercourses. The studied territory presents a documentary void for this period which, seems to continue at least until the Archaic period. The first significant attestations in the examined territory can be identified between the second half of the 3rd and the beginning of the 2nd century BC. This is evident in the surrounding territory, e.g. Civitella d'Arna (Donnini and Rosi Bonci 2008), Montelabate (Stoddart *et al.* 2012), along the middle Tiber Valley (*Tiber Valley Project* in Di Giuseppe 2005) and more generally in central Etruria (Potter 1979; Patterson *et al.* 2020, *South Etruria Survey Project*), where small-sized residential units are found distributed sparsely throughout the territory. The spatial distribution of the survey evidence suggests a certain preference for flat areas, near terraced alluvial deposits

[5] This is only a hypothesis, considering that its location is still unknown and the materials not yet sufficient.

along secondary watercourses and not far from the Tiber River. Furthermore, a subsistence economy can be inferred from the analysis of the ceramic material. This is linked to agricultural exploitation and some limited contact with the external market evidenced by the faint presence of *vernice nera* pottery. The survey data do not permit an interpretation related to funerary contexts during this and the following periods, but only to buildings, sporadic and frequented contexts. The possible exception could be the context in the Solfagnano area. Between the mid-1st century BC and the 1st century AD, there was a great increase in settlements in the territory, which with few exceptions continued without interruption until the period between the end of the 2nd and the beginning of the 3rd century AD. In the territory of Perugia, this increase was linked to the completed 'Romanisation' of the city of Perugia from 130 BC with the election of the new consul Paperna and to the acquisition of Roman citizenship in 89 BC (Sisani 2007, 62-64). This outcome was further enhanced by the territorial reorganisation and the *viritane* allocations to which the territory was subjected during the Augustan and Tiberian periods (Sisani 2009, 54). It was precisely in this phase that there was a significant development of medium-sized rural settlements and villas, generally for self-consumption and possibly for short-range trade (Vaccaro *et al.* 2009, 289). A short-range trade is suggested involving several fragments of "*fondopiatto*" amphorae from Montelabate kilns (Ceccarelli 2021a). These fragments were identified on 2/3 UTs attributed to the Imperial period, and for this reason we can consider the "fondopiatto" amphorae as a guide fossil of the examined territory (Fig. 12). Moreover, this element suggests that the main product of the territory is wine.

At the same time, imported material found in many UTs could suggest interesting contacts between this central area and other parts of the Umbria region or other regions of the peninsula. Some fragments of *terra sigillata* most likely produced in the Tuscan region or in the southern territory of the Umbria region – several forms of *terra sigillata* are similar to those produced at the Scoppieto kilns, Terni (Bergamini 2008) – and a few fragments of *pareti sottili* – some of which are similar to the those of the kilns in the locality of Vittorina, Gubbio (Cipollone 1988) – suggest contacts as well as medium and log-range trade. In all these cases it is clear that the Tiber River as well as the roads played a key role in the commerce. Finally, the identification of imported amphorae from Baetic and North African contexts supports hypotheses about certain types of trade even on a Mediterranean scale. Based on the types of amphorae found, it can be inferred that oil and fish sauce were mainly imported, at least during the Imperial period.

Therefore, between the 1st century BC and the 3rd century AD, the territory appears to have been richly articulated with numerous settlements as evidenced in the Civitella d'Arna area (Donnini and Rosi Bonci 2008) and around Perugia (*Ville e insediamenti 1983*). This settlement network emphasizes the focal role of *villae* and the Campagnano settlement. The calculated distance in a GIS environment between the Ramazzano and Bagnara-La Bruna *villae* and the settlement is exactly 3.7 km (= 2.5 Roman miles). The distribution analysis of the rural settlements suggests the presence of a precise settlement model based on a system of perches of five centuries, the so-called *pertica quintaria* composed of an irregular square of 20x17 *actus* (Camerieri and Mattioli 2013; Camerieri and Mattioli 2014, 122). The settlement model became more complex when inserted into a specific administrative framework, where the territorial entity of the *pagus* was the smallest possible unit enjoying partial administrative freedom of the municipium of *Perusia*. The pagan *tessera* found near the Villa Pitignano castle

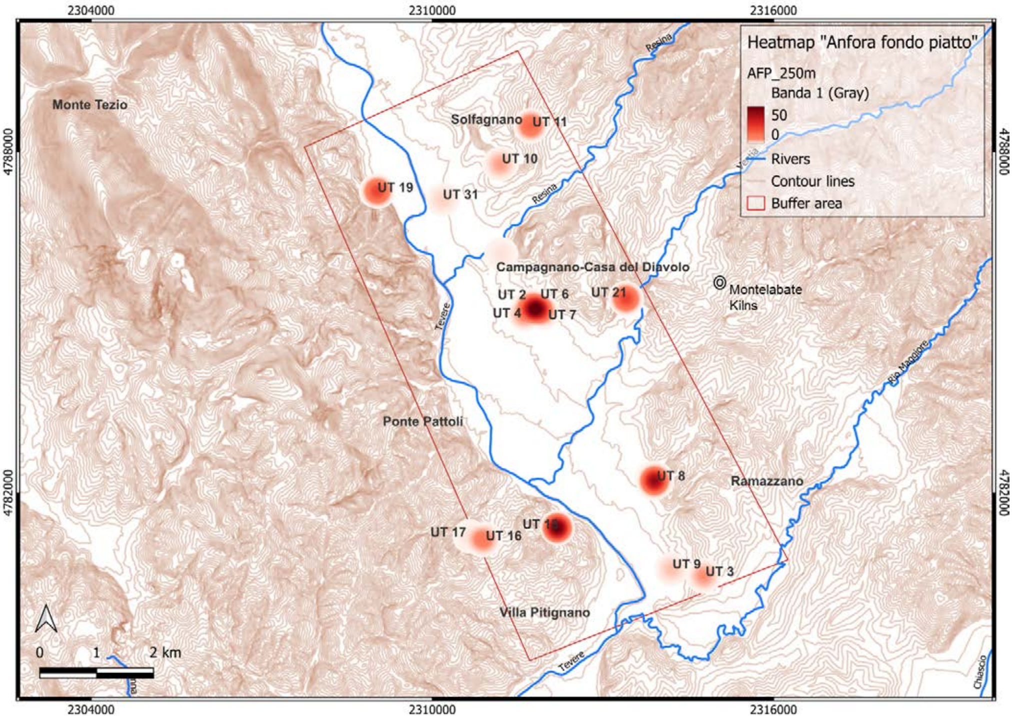

Figure 12 – Heatmap of "fondopiatto" amphorae from Imperial period.

and the set of contexts identified around this locality support the hypothesis of the presence of the administrative center. Between the *pagus* area and the *villa* of La Bruna area the distance calculated on the reclassify DEM in a GIS environment corresponds to ca 8.5 km (= 6 Roman miles) (Mandorlo – *in press*). This allows us to suppose that this portion of the territory was probably divided by two main roads on either side of the Tiber River. However, we do not know much about the roads that could have connected all these buildings. The main hypothesis is that one of the ancient routes corresponds to the Tiberina Nord road (Cenciaioli 2015). Even though the study is still in progress, the calculation in QGIS and photo interpretation of the satellite and historical orthophoto anomalies suggest an alternative orientation and development path.

Between the 3rd and 6th century AD, the analysed territory shows a decrease in settlement units compared to the Imperial period, and for some of them, it is only possible to hypothesize a certain life's continuity. The studied territory seems to develop a countertrend compared to regional dynamics, where a general break is already evident from the 5th century AD onwards (Di Stefano *et al*. 2012). The main contexts examined in the territory seem to survive until the beginning of the 6th century AD, as evidenced by the production of pottery and "fondopiatto" amphorae from the Montelabate kilns (Ceccarelli 2021b, 329-330), which met the territory's demands. Moreover, the fragments of "fondopiatto" amphorae represent again the guide fossil for the attestation the UTs at the Late Antique period (Fig. 13).

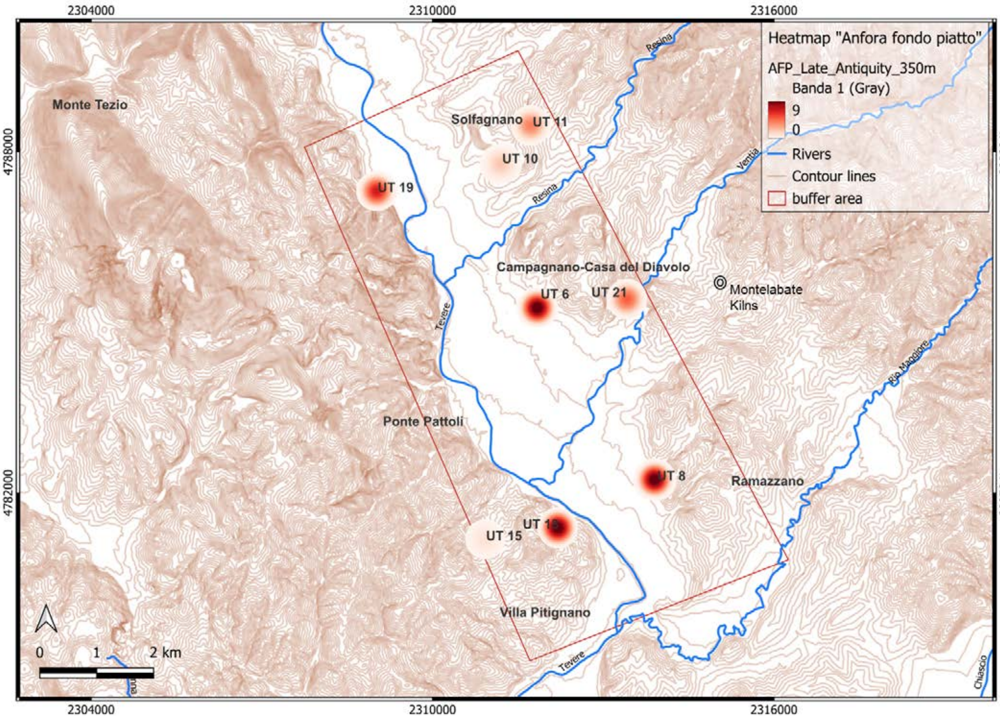

Figure 13 – Heatmap of "fondopiatto" amphorae from Late Antique period.

The socio-economic and political crisis generated by the Greco-Gothic war (535-553 AD) seems to be a significant moment of rupture contrary to many regional realities (Di Giuseppantonio *et al.* 2003, 1378).

By the end of the 6th century AD, Perugia and its territory along the Tiber Valley were part of the 'Byzantine corridor' (Menestò 1999, 117-127). The reorganisation of the agricultural landscape, between the 7th and 8th centuries AD, which was recorded in other areas of the peninsula, such as Tuscany (Farinelli 2007, 47-48), does not seem to find a counterpart in Umbria. The archaeological data for these centuries are significantly inconsistent probably due to the lack of targeted research to understand the early medieval agrarian landscape (Augenti 2018, 367-378) in addition to the archaeological invisibility of the surface. Although we currently do not have any material evidence that can help us understand the evolution of settlements during the early medieval period, it is difficult to hypothesize a total absence of human activity in the territory, as evidenced in other areas of central Italy (Campana *et al.* 2008). From a reading of the survey data and its comparison with the monumental emergences of the territory, an interesting fact emerges: the main fortified nuclei and the two parish churches were built near the *villae*, the settlement, and the *pagus*. Although it is not yet possible to establish a connection between Roman and Late Antique contexts with *castra* and parish churches, the data cannot be completely overlooked (Violante 1982). Only 250 m from the Roman-Late Antique villa in the La Bruna locality, the Church of S. Quirico was constructed; 1.5 km from the Campagnano-Casa del Diavolo settlement the castrum of Civitella Benazzone was established; 1.8 km from the Ramazzano *villa* the homonymous castrum was built; probably at the location of the *pagus Paetiniano*, the *castrum* with the church of S. Maria may have been built and in the Pieve Pagliaccia area with small residential units a parish church may have been built.

During the following centuries, the rural landscape was articulated in a complete manner with fortified villages and churches (*Catasto Giudiziario del Podestà,* A.S.P., 380r-415r, 1258). The archival documentation reveals that the "*primo incastellamento*" in Umbria was to begin from the 11th century. The absence of targeted excavation surveys leaves open the question of the origin of the first settlements (Augenti 2018, 371-372). Archival sources furthermore reveal, that certainly from before the 10th century, a territory was divided among the major ecclesiastical entities through land donations made to the Church of S. Pietro and the Cathedral of S. Lorenzo in Perugia and to the Benedictine abbeys of the territory (Grohmann 1981). From the last decades of the 11th and the beginning of the 12th century, there was a widespread distribution of fortified sites, which were equipped with walls or other defensive elements, such as ditches and embankments. The lordly residences were the most direct evidence of a new political and economic stability of the Municipality of Perugia, which was fully extended into the territory.

In conclusion, the study carried out on the territory northeast of the city of Perugia along the Tiber Valley has highlighted a richly articulated palimpsest, a result of transformations that have occurred over time. These transformations are still visible in the contemporary landscape and others are preserved in the memory of the people who have been part of it.

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ArcheoDB, a new geodatabase of archaeological findings for conservation and research in the Emilia-Romagna region (Italy): the case of the *Soprintendenza* of Parma and Piacenza

Mattia Francesco Antonio Cantatore

Mattiafrancescoantonio.cantatore@univr.it – Università di Verona

Ilaria Di Cocco

ilaria.dicocco@cultura.gov.it - MiC - Segretariato regionale per l'Emilia Romagna

Cecilia Moine

cecilia.moine@cultura.gov.it - Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Parma e Piacenza

Marco Podini

marco.podini@cultura.gov.it - Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Parma e Piacenza

Massimo Sericola

massimo.sericola@cultura.gov.it -Direzione regionale musei d'Abruzzo e musei archeologici nazionali di Chieti

Abstract:
The Emilia-Romagna regional branch of the Italian Ministry of Culture (MiC) developed the ArcheoDB geodatabase to facilitate comprehensive and real-time mapping of archaeological sites and activities. The project, initiated in 2019 as part of a PhD research, is based exclusively on open-source technology; it has become the primary research tool for field archaeologists and Ministry officers. The regional Soprintendenze of the MiC actively participates in the retrieval of historical data stored in archives, which are progressively digitized. As of 2023, the cataloging process was mandatory for submitting new excavation documentation. This system is fully compatible with the Geoportale Nazionale per l'Archeologia (GNA - National Archaeological Geoportal) and collects regional data. It offers real-time updates and allows citizens, government entities, professional archaeologists, and researchers to access the open data collected through a web-based platform.

Keywords
Archaeological geodatabase, Cultural heritage management, WebGIS, Emilia-Romagna (Italy), Piacenza

Introduction

The 2018 proposal to create a simple and reliable mapping system of all archaeological sites and excavation activities in Emilia-Romagna coincided with the realisation of a PhD project dedicated to the evolution of the city of Piacenza from the Late Antique period to the early

Middle Ages (Cantatore 2023). The research, conducted by Dr. M.F.A. Cantatore, necessitated the creation of a GIS encompassing all findings within the Farnese walls of the city. Its realisation required immediate collaboration with the Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Parma e Piacenza (Parma and Piacenza Superintendence, hereafter SABAP-PR) to access the archives. This collaboration evolved into a formal agreement among SABAP-PR, the Municipality of Piacenza, the Diocese of Piacenza and Bobbio, the University of Bologna, and the University of Verona.

The potential of the mapping system as a research tool and a means of documenting ongoing conservation activities became even more evident when connected to a broader GIS platform on Cultural Heritage currently available in the region. In fact, new archaeological data were made accessible via the interactive maps created in 2014 by the Segretariato regionale del Ministero della Cultura per l'Emilia-Romagna (Regional Secretariat of the Ministry of Culture Emilia-Romagna), which already provided a comprehensive mapping of the region's protected heritage[1]. This WebGIS platform has become an indispensable tool for professionals working in the fields of conservation and planning, enabling immediate identification of protected assets.

The ambitious goal of locating all archaeological data, including negative outcomes, on a single platform would have increased environmental and administrative control through, for example, quicker response times to urgent requests, higher quality, and a larger amount of available information.

It was possible to achieve this purpose via two fundamental conditions. First, the data acquisition strategy builds on the reliability and precision of cartographic information: precise georeferencing minimises duplications, overlaps, and data ambiguities. Since the information was now spatially linked, it was easier to identify different type of sites of interest.

Secondly, cataloguing had to be succinct: extremely detailed descriptions would only slow down and potentially impede the completion of territorial mapping. The record thus had to be based on both concise and essential descriptions.

The work of Cantatore (2023) provided a basic template in which fields and terms — derived from the authority files of the Istituto Centrale per il Catalogo e la Documentazione (ICCD) (http://www.iccd.beniculturali.it/) — were refined.

Close cooperation between the regional and state local authorities was crucial. Full sharing of requirements and all other aspects of database construction, ranging from the basic structure to the definition of fields and vocabularies, enabled the rapid accomplishment of the project. Strict collaboration between the regional Soprintendenze enabled functional improvement

[1] The development of the geodatabase of the cultural heritage of Emilia-Romagna (https://www.patrimonioculturale-er.it) was led by some of the authors of this paper (Ilaria Di Cocco and Massimo Sericola), who completed the integration of the new database into a consolidated system (cfr. Paragraph 3). With the essential collaboration of Cooperativa Alveo-Progetti per l'ambiente e il territorio, the two databases concerning the structural framework and visualization were successfully integrated within the WebGIS portal. Special thanks are extended to Francesco Marucci for his constructive dialogue and adaptability in meeting the various technical requirements during the implementation phase.

of the ArcheoDB during the initial experimental period when the archival digitisation was initiated (see below, section 2)[2].

From the initial stage of the work, a precious collaboration with the GNA (Geoportale Nazionale per l'Archeologia: http://www.ic_archeo.beniculturali.it/it/336/il-geoportale), was set up[3]. This cooperation laid the foundation for the future interoperability of the two systems, allowing ArcheoDB to be officially adopted by the Emilia-Romagna Soprintendenze as the standard tool for the collection of all data of archaeological inteterest.

(M.F.A.C., I.D.C., C.M., M.P., M.S.)

1. Designing a geodatabase: the case of Piacenza

In the context of a study on the urban evolution of Piacenza, it was evident from the outset that it was necessary to design a geodatabase capable of accommodating data derived from excavations and findings. After a survey of the excavation documentation, I determined that including all archaeological investigations would be detrimental to a study focusing on a narrower timeframe (3rd century BCE – 9th century CE). I therefore considered only archaeological investigations concerning phases predating the Renaissance era, in order to optimise time and avoid processing data that would unnecessarily multiply the workload[4].

After setting these limits, it became essential to integrate the information with geographic data. Consequently, in collaboration with SABAP-PR and the *Segretariato*, I created an initial template to catalogue excavations, with fields primarily designed to serve specific research goals. The aforementioned formal agreement, together with the encouragement of SABAP-PR, paved the way for a data digitisation model that could serve not only academic research but also the acquisition of accurate information on the archaeology of the regional territory more generally. The work carried out led to the development of a shared model. Simultaneously, the design of a geodatabase to link collected information to the geographic positioning of individual elements within the current urban framework of Piacenza began[5].

The working group decided to utilise SpatiaLite[6], a software that extends the SQLite database engine, to create a complete spatial database, as the former implements an SQL92 engine and

[2] Special thanks go to the *Soprintendenze* of Bologna and Ravenna, who joined the project at its onset: to Monica Miari, Annalisa Pozzi, Valentina Manzelli, Vanessa Poli, Rossana Gabusi and Kevin Ferrari, who worked on this project together with the authors.

[3] The project benefited from an innovative idea proposed by Dr. Cristina Ambrosini, who was the *Superintendent* in Bologna at the time.

[4] A broader chronological range beyond the 9th century was considered, acknowledging the relevance of gaining at least a preliminary understanding of early medieval urban evolution in relation to archaeological discoveries.

[5] For the construction of the geodatabase and the selection of its fields, the team reviewed a substantial portion of archaeological projects related to both broader national and regional contexts involving the cataloguing of excavations and discoveries. Among the national projects, notable examples include: *Mappa* developed for Pisa (http://www.mappaproject.org/, with bibliography indicated therein); the *Sistema Informativo Territoriale Archeologico di Roma* (SITAR, https://www.archeositarproject.it/); and *Ricerca Archivi e Pratiche per la Tutela Operativa Regionale* (RAPTOR, https://www.raptor.beniculturali.it/, with bibliography indicated therein). Regional research efforts considered include work conducted in Cesena (Gelichi *et al.* 1999; Gelichi 2001, 7–9; Gelichi and Negrelli 2008; Gelichi and Negrelli 2011; Negrelli 2021), Faenza (Guarnieri 2000), Modena (Cardarelli *et al.* 2001, 200–210), Forlì (Prati 2001, 211–214), and Ravenna (Cirelli 2008, 10–17; 2016, 209–226).

[6] Francesco Marucci, a specialist in geographic database development collaborating with the Segretariato per l'Emilia-Romagna and one of the creators and managers of the WebGIS, recommended using this software and

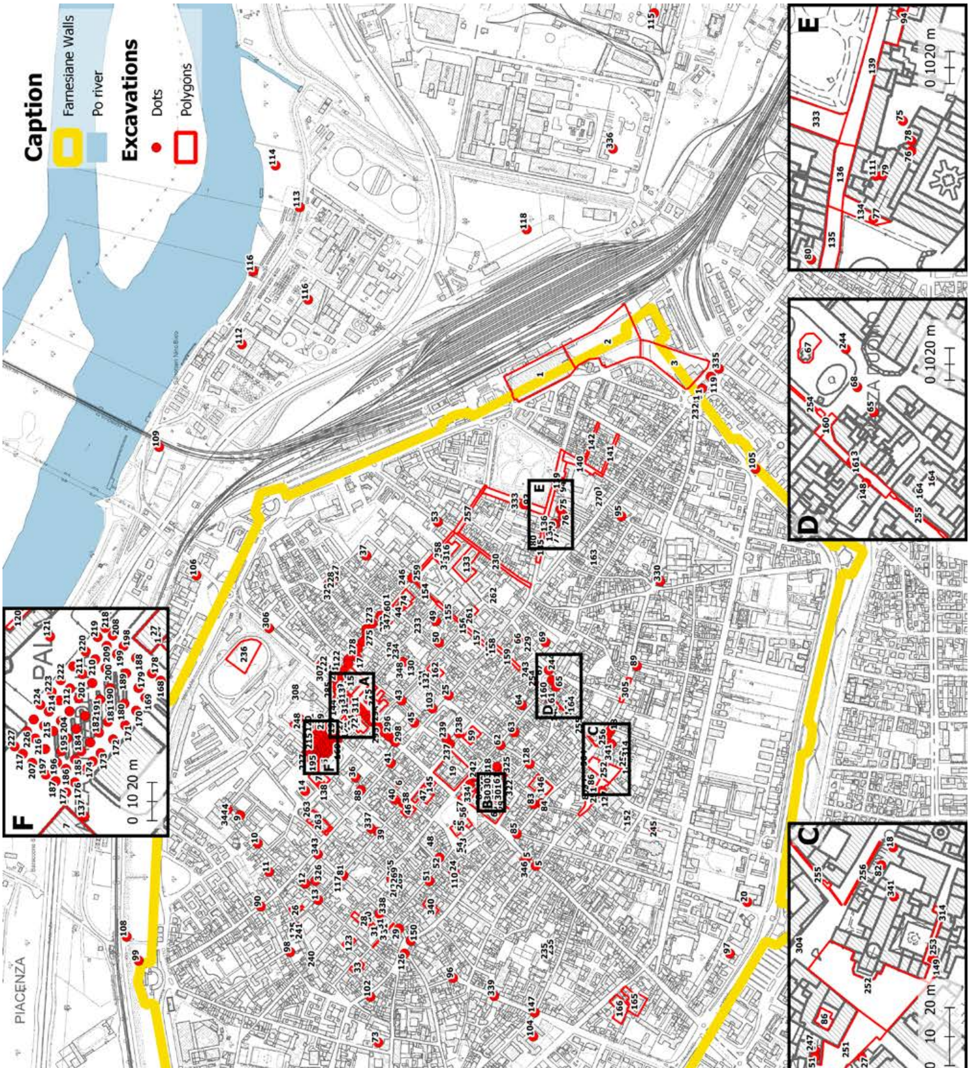

Figure 1 – Map of PIACENZA on CTR 1:5000: numbers refer to the Database for excavations and findings.

the latter enhances the core of the OGC-SFS standard[7]. The advantage of this software lies in its essential architecture, resulting in simpler database management. This database consists of a single file that can be read by any computer without specific adjustments. Moreover, it is easy to transfer the entered data into a WebGIS, which represents the final goal of the original pilot project. Though these are positive aspects, a limitation is that this type of database functions as a personal database, restricting concurrent access (Furieri 2011).

As for the database structure and data entry, the working group decided that the main focus would be the archaeological excavation. This decision had several consequences. First, users had to evaluate the quality of the available geographic data to determine the most appropriate means of representation on the map. We chose a symbolic representation (point) for historical excavations whose exact location and extent were unknown, and a realistic representation (polygon) for those with an accurately documented spatial extent. Given the volume of available data, we decided not to store all layers and structures uncovered in individual excavations. Instead, only the general extent was indicated. Each of these geometries was associated with a hierarchy of tables, with the main tables dedicated to excavations and their chronology. This structure made it possible to connect occupation phases with each excavation and to categorise them by period or century. In its complete version, the archaeological database for Piacenza contained 348 records, including excavations and core samples[8], and a total of 996 phases (Fig. 1).

Without delving into the specific details of each field or form created to structure the database (developed in collaboration with SABAP-PR and the *Segretariato* and subsequently incorporated into ArcheoDB), it is sufficient to highlight the elements that differentiate this type of cataloguing from those proposed in other projects.

The guiding principles behind the database structure included simplicity, intuitiveness, and the capacity to reconcile research objectives with conservation requirements. Thus, the working team created several fields with controlled vocabulary, a simplified structure, and a data entry form. Most importantly, efforts were made to associate multiple phases with each excavation. This feature significantly enhanced the geodatabase's usability for research purposes, enabling straightforward queries to generate advanced thematic maps. In the case of Piacenza, this structure facilitated the exploration of the city's urban evolution. The reconstruction of the Roman city layout could be visualised on different cartographic bases, displaying findings such as sections of city walls or paved streets (Fig. 2).

Furthermore, by creating a specifically structured data entry form, I was able to incorporate information from written sources. Piacenza is the city in northern Italy that preserves the highest number of medieval parchments dating from the 8th to the 11th century, with the possibility of examining approximately 400 documents from the 8th and 9th centuries alone. The merging of data from written and material sources fostered a better understanding of urban evolution between Late Antiquity and the early Middle Ages (Fig. 3).

provided me with technical training.

[7] Spatial DBMS (Database Management System) supports international standards such as SQL92 (Structured Query Language) and OGC-SFS (Open Geospatial Consortium – Simple Feature Specification).

[8] 240 excavations and 108 core samples.

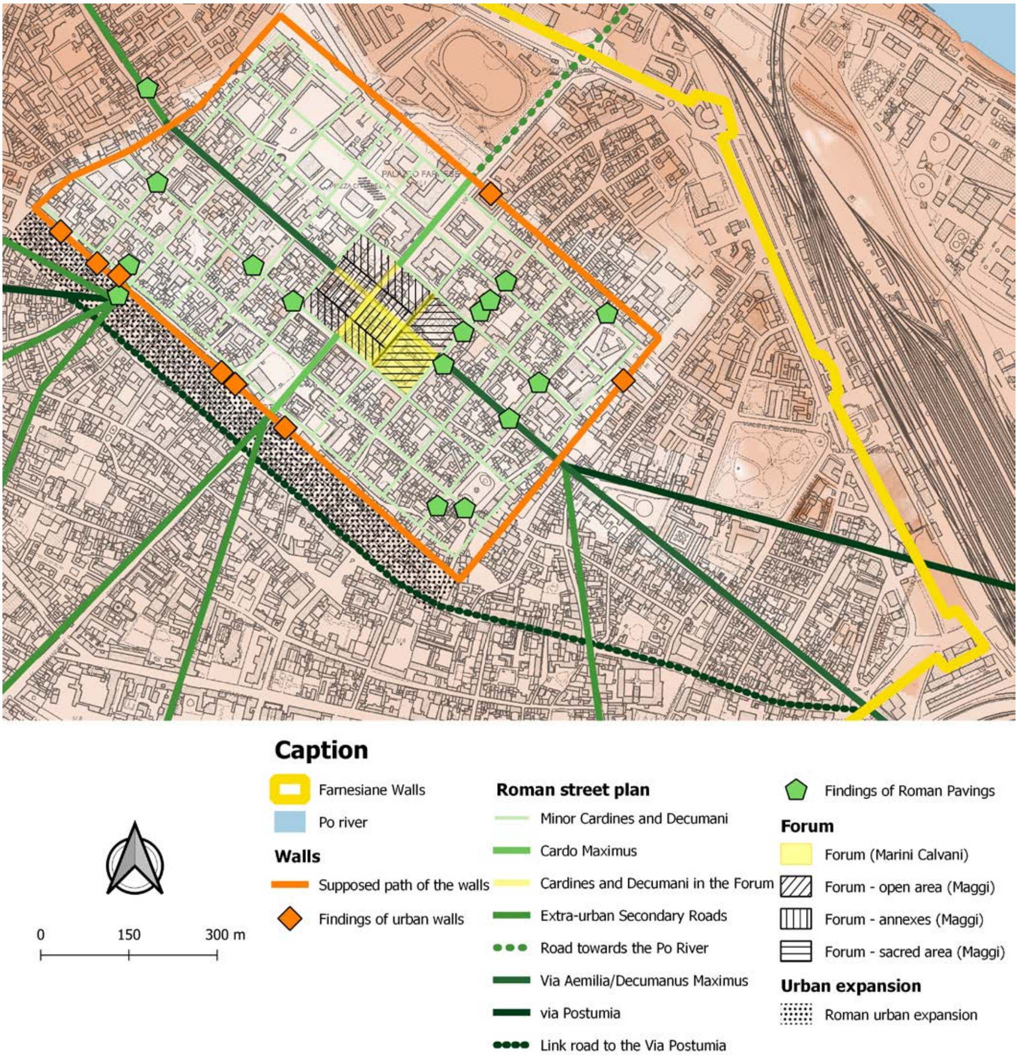

Figure 2 – Example of thematic map based on queried Geodatabase data. Urban plan of Roman Piacenza on CTR 1:5000 and DTM.

In those periods, Piacenza was characterised by city walls and churches. The former, preserving the layout established in the 5th and 6th centuries, included walls, outer defensive structures, towers, gates, and posterns; they were primarily owned by the publicum, with only the king or emperor authorised to alienate them. Both churches and monasteries experienced exponential growth. Written sources document the existence of at least 28 religious buildings within the city walls and the suburban area. These structures did not significantly alter the urban layout, with the exception of the San Sisto monastery and the episcopal area, which included the cathedral (Santa Giustina), San Giovanni Evangelista, the baptistery, the episcopal residence, and the residences of clergy and servants, as well as the canonical residence still

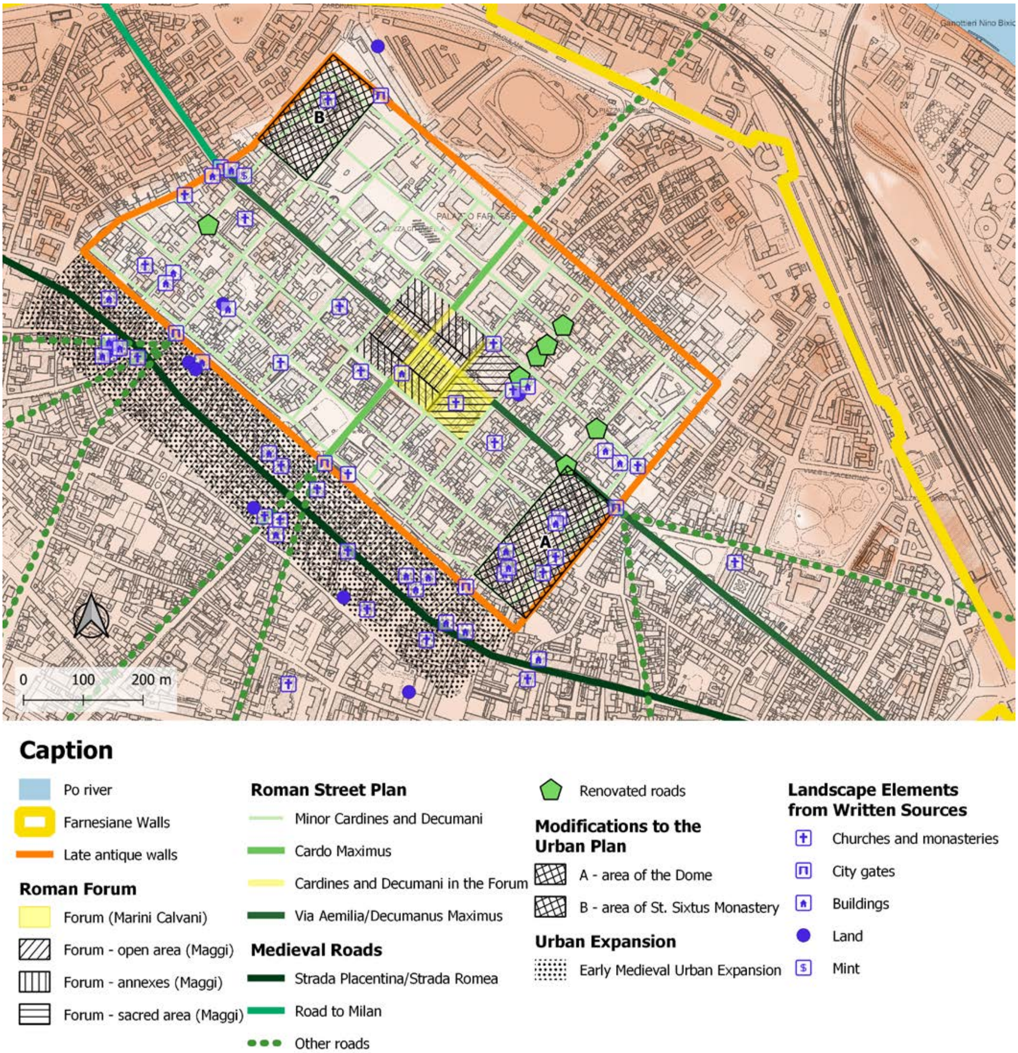

Figure 3 – Example of a thematic map based on queried data coming from written sources and findings in the Geodatabase. Urban plan of medieval Piacenza on CTR 1:5000 and DTM.

under construction at the end of the 9th century. All these elements disrupted the urban sectors in which they were erected (northwestern and southeastern corners).

Even so, they were not liturgically oriented, being influenced instead by the Roman orthogonal grid: the urban layout remained largely intact. Piacenza’s inhabitants continued to walk along the paths of ancient Roman roads, which were no longer paved but consisted of beaten earth and scattered bricks. Even the Roman Forum, likely no longer surrounded by the buildings that once bordered it, remained recognisable, as indicated by 9th-century documents (Cantatore 2023).

(M.F.A.C.)

2. The development of ArcheoDB on a regional scale

In recent years, two collaborative opportunities arose simultaneously, leading to the refinement of the system's initial template and the successful completion of the geodatabase, rendering it compatible with the GNA.

In 2019, collaboration with the 'Area Geologia, Suoli e Sismica' office of the Emilia-Romagna Region was re-established within the framework of the 'Archaeological Database Project' initiated in the 1990s (Di Cocco and Martini 2006). Its primary goal was to obtain accurate archaeological dating on a regional scale, in order to document the superficial stratigraphic units targeted by the National Geological Cartography Project (CARG). The Geological Service's essential requirements included a concise and flexible data structure, with a focus on chronological data and the depths at which findings were recorded. The database needed to allow for the entry of multiple chronological phases and their respective depths from the current ground level within the same site.

Particular interest was placed on access to continuously updated information from new excavations (https://ambiente.regione.emilia-romagna.it/it/geologia/geologia/carg/i-dati/la-banca-dati-archeologica).

At the same time, the new CARG sheets also covered territories within the Lombardy and Veneto regions, necessitating interregional collaboration based on national standards still in the process of being developed[9].

The collaboration between these regions enabled the involvement of the necessary expertise for the comprehensive IT development of the relational geodatabase, with the support of regional authorities. This support facilitated the design and implementation of the data structure within the existing geodatabase, the development of the required graphical interfaces for data input and modification, the creation of procedures for automatic uploads and exports, and the implementation of analysis tools and reporting mechanisms. These aspects were essential to ensure the consistent population and updating of the digital archive in a simplified manner by professionals conducting archaeological investigations. They also guaranteed the utmost reliability and completeness of the data, along with systems for monitoring the accuracy and consistency of the information entered.

The second crucial collaboration was with the GNA developers, whose data structure is still being finalised. This collaboration involved meticulous mapping of the fields in both systems to ensure the seamless transfer of data collected through ArcheoDB[10]. The working team maintained a simple approach to data entry and streamlined the vocabularies. This approach excluded terms expected by national documentation standards but not applicable to the archaeology of Emilia-Romagna.

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[9] We take this opportunity to express our sincere gratitude, especially to Simone Sestito, archaeological officer at the Soprintendenza Archeologia, Belle Arti e Paesaggio for the provinces of Cremona, Mantova, and Lodi, and to Giovanna Falezza, who in 2021 served as Responsible for Archaeological Preservation in the western sector of the province of Verona and the lower Polesine area for the Soprintendenza Archeologia, Belle Arti e Paesaggio for the provinces of Verona, Rovigo, and Vicenza.

[10] Thanks especially to the efforts of Dr. Ada Gabucci, the team successfully achieved this important goal by establishing complete mandatory data fields and consistent vocabularies.

ArcheoDB retained its specific focus on multi-stratified sites. The team organised the documentation process using a one-to-many relationship between the primary record—containing comprehensive information about archaeological interventions and random findings—and the individual records dedicated to specific chronological macro-phases when archaeological excavations yielded positive results (Figs 4–6).

The first challenge, primarily conceptual, was to clearly define the subject to be catalogued. In the archaeological context of Emilia-Romagna—as in many other Italian regions—information, interventions, and sites tend to overlap. The choice to record each archaeological intervention separately would undoubtedly have simplified the compilation of individual records, but it would also have resulted in multiple overlapping areas. Moreover, it would have contradicted the underlying logic of the entire geodatabase, which catalogues every architectural, archaeological and landscape asset with particular attention to avoiding data overlap. For example, when an architectural asset has been subject to multiple conservation measures over time, these are recorded as progressive updates to the existing record, with adjustments to its delimitation when necessary.

More generally, the same topographical logic guided the decision to dedicate a single record to each site, offering a concise overview of all findings or negative outcomes from investigations conducted at that location. Contributors were therefore required to verify the existence of

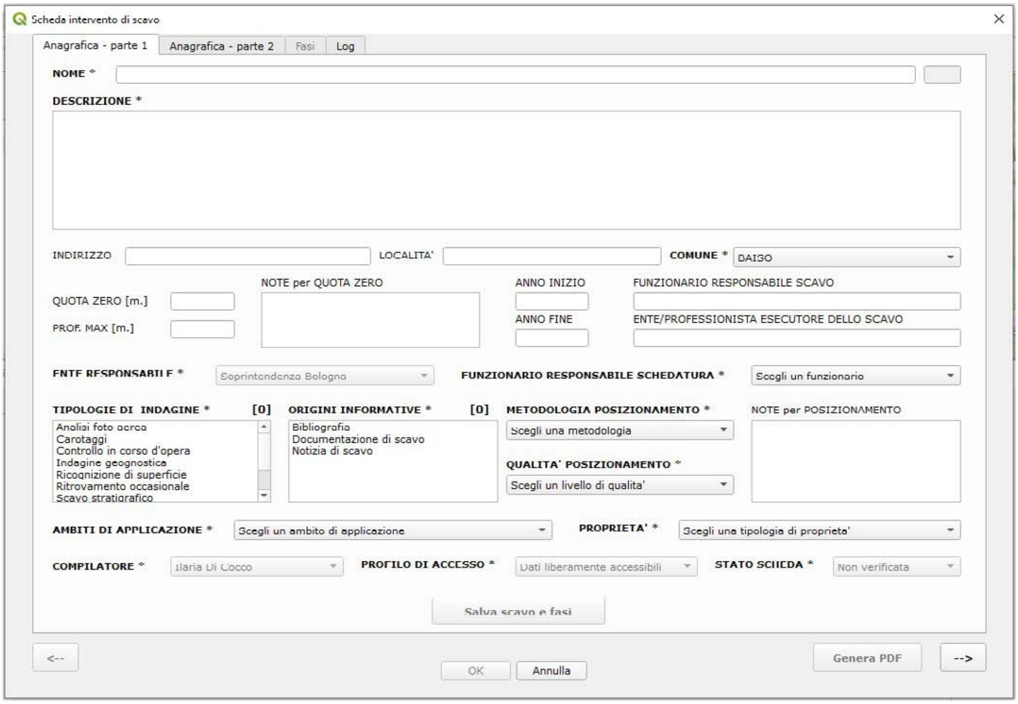

Figure 4 – First part of the template model. It includes fields with closed vocabularies, many of which are mandatory (in bold). The number of mandatory fields increases if data refers to interventions carried out from 2023 onwards. Some of the fields (municipality, territorial Soprintendenza office etc.) are automatically filled-in by the georeferencial system.

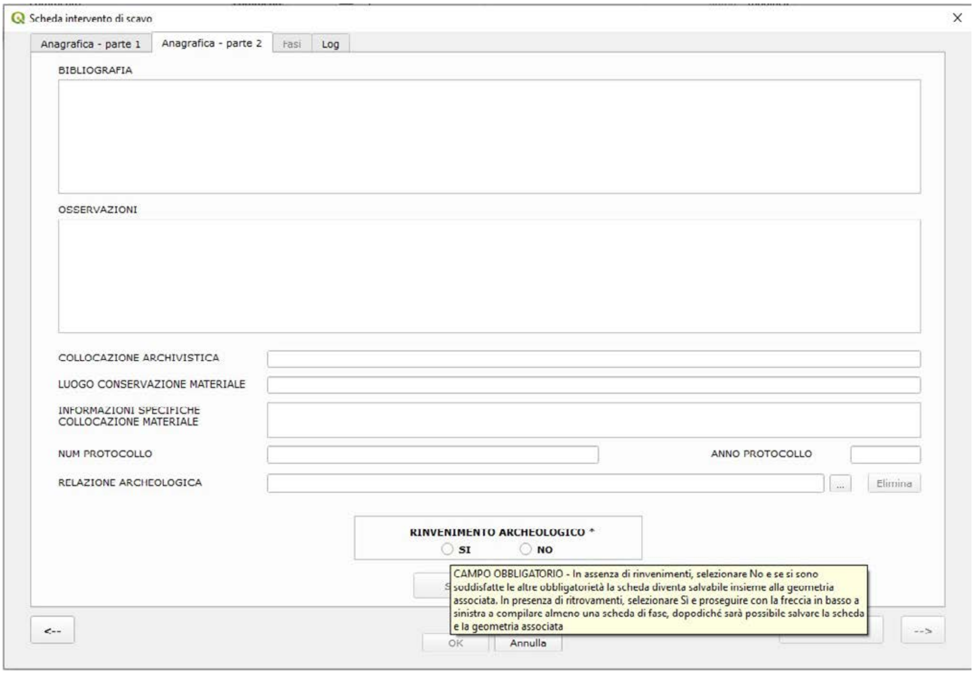

Figure 5 – Second part of the form template. Compilation instructions appear when the mouse is placed over each field. Data cannot be saved until all mandatory fields are filled in.

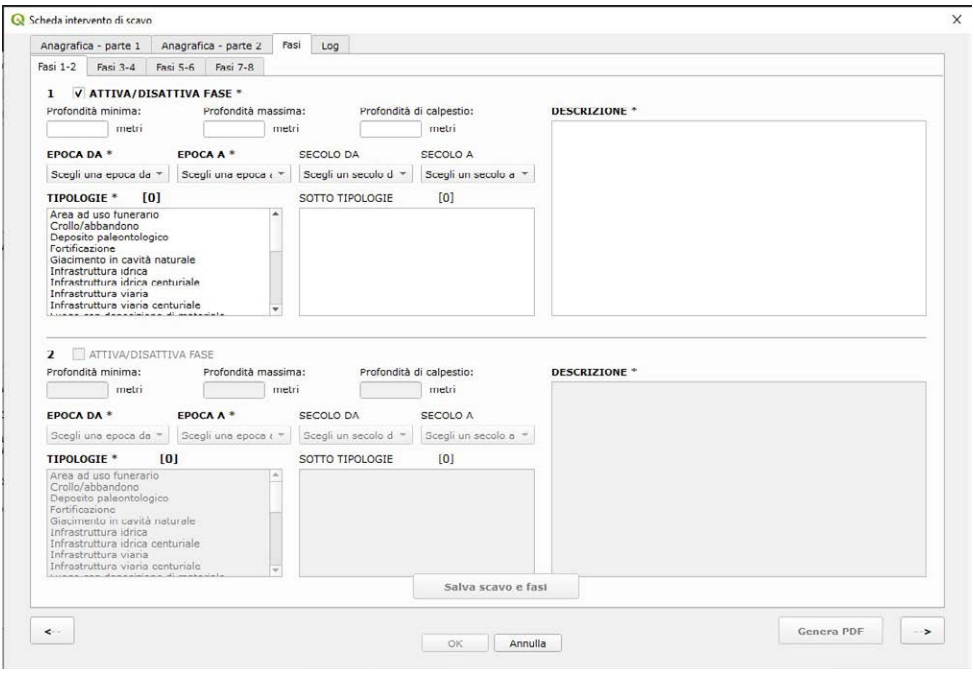

Figure 6 – Template for one or more chronological macro phases linked to archaeological findings. Coherency (e.g., chronological relationships) of the inserted data is verified.

any previous records in the area before entering new data. They also had to update existing records through a specific template re-attribution process managed by the cataloguing supervisor. This process preserves the memory of the previous compiler and records the dates of updates. This choice also facilitates the accessibility of integrated mapping in the WebGIS, ensuring that all available information can be accessed with a single click on the map.

It bears repeating that the team conceived the project to ensure the easy identification of areas where archaeological data are available, not to replace more in-depth consultation of archival or bibliographic resources. It is this essential logic that ensures rapid territorial coverage. This approach allowed for the retrieval of past data for entire municipal, and in some cases provincial, territories within a short timeframe—from 2020 to November 2023. As of now, more than 12,000 sites have been catalogued by compilers. The initial data recovery campaigns were launched by the regional *Soprintendenze* in 2020, involving interns from the *Scuola di Specializzazione in Beni Archeologici* of the Universities of Bologna, Trieste, Udine, and Venice Ca' Foscari. This combination of expertise led to the development of clear instructions for data entry and a *vademecum* to clarify the purpose of each field and the interpretation of vocabulary. Most importantly, these early campaigns contributed to improving the structure of the system by eliminating redundancies and resolving ambiguities. At the same time, the working team made the fundamental—albeit complex—decision to design an interface allowing concurrent data entry by multiple accredited users. Each user was assigned specific credentials, with varying territorial scope and the ability (or restriction) to modify previously entered data. Each compiler operated through a downloadable plugin within the open-source QGIS system, enabling direct and streamlined interaction with the geodatabase. Any record, along with its associated geometry, became immediately available to other users upon saving, thus minimising the risk of duplicate entries.

The recovery of archival data was made possible, as will be further detailed, through the involvement of expert archaeologists working in collaboration with the *Soprintendenze* and the allocation of funds specifically dedicated to the implementation of data for the GNA. These funds were made available by the *Direzione Generale Archeologia, Belle Arti e Paesaggio* (DG ABAP – Directorate General for Archaeology, Fine Arts, and Landscape[11]). Full interoperability between ArcheoDB and the GNA standards was implemented and formally recognised. In this context, ArcheoDB functions as a regional *hub* and data collection centre, ensuring consistency and the avoidance of duplicate records subject to cataloguing obligations under various legal frameworks. It enables all authorised personnel to enter data directly into the central server: as each record is added, it becomes immediately accessible to all users. Consequently, once a site is catalogued, it is instantly visualised in real time on the maps available to all users through the plugin, thereby preventing erroneous duplication.

As a result, the regional *Soprintendenze* assumed a leading role in the retrieval of archival data and in providing more efficient consultation tools to support the timely initiation and development of protection procedures. Another significant advancement resulted from the implementation of the Preventive Archaeology Guidelines and the subsequent requirement for professionals to use the standardised data entry template, as specified in the DPCM of 14 February 2022[12]. Faced with this new requirement, and in order to strengthen ArcheoDB's

[11] Circulars 32/2020, 32/2021, 37/2022, 22/2023.

[12] Article 25 of Legislative Decree 50/2016, as clarified by the Decree of the President of the Council of Ministers

role as the regional hub, it became necessary to ensure that all preventive archaeological measures were implemented at the MOSI level (MOdulo di area/SIto archeologico = Area Form/ Archaeological Site) through the use of the regional geodatabase. This enabled professionals both to access and reuse all available information and to enter new data. Consequently, starting in June 2022, training courses and user support initiatives were organised to assist the growing number of data entry personnel. The increasing availability of a standardised and comprehensive dataset, combined with a user-friendly data entry interface, contributed significantly to the project's success.

Between 2022 and 2023, the working team achieved two important goals: the completion of the ArcheoDB template upon submission of new excavation documentation, and the real-time publication of updated data.

The completion of the form upon submission began experimentally and on a voluntary basis in 2022, providing professionals with an opportunity to familiarise themselves with the data entry process while simultaneously managing archaeological documentation. The underlying aim of this trial phase was to ensure that completing the form did not represent an excessive burden for professionals, but rather served as a verification tool. The template supports the completeness of essential information and simplifies data retrieval through mandatory fields and internal consistency checks. This feature proved particularly useful in cases involving extensive documentation, where retrieving specific details could be complex. During data entry, compilers attach the excavation report, which becomes immediately available in digital format to the *Soprintendenze*. Furthermore, once completed, the form can be exported as a printable PDF including a cartographic extract and a timestamp.

As of 1 January 2023, the completion of the ArcheoDB template became mandatory for all submissions of excavation documentation to the *Soprintendenze* of Emilia-Romagna.

This decision brought two major benefits to the project: (1) it ensures the continuous and timely updating of the geodatabase with all archaeological data at the point of submission; (2) the new records are entered directly by the professionals responsible for the excavations. This guarantees both the quality of the data and the precision of the georeferencing, as it derives directly from fieldwork, without requiring reinterpretation or synthesis by a third party. Entrusting professionals with the responsibility of producing high-quality public data also recognises their expertise and attributes intellectual authorship appropriately.

At the same time, a validation phase was introduced and assigned to archaeologists from the *Soprintendenze*, allowing for improvements to the data when necessary. A dedicated desktop application—equipped with search and correction functions—was developed to streamline this review process.

As of November 2023, 230 professionals had been authorised to enter data into ArcheoDB. Approximately 100 sites are added each week, with an increasing proportion of the data originating from new excavation projects.

(DPCM) dated 14 February 2022 (published in Official Gazette No. 88 on 14 April 2022), applies to professionals and entities defined in Article 25, paragraph 1 of Legislative Decree 50/2016, which has since been replaced by Legislative Decree 36/2023.

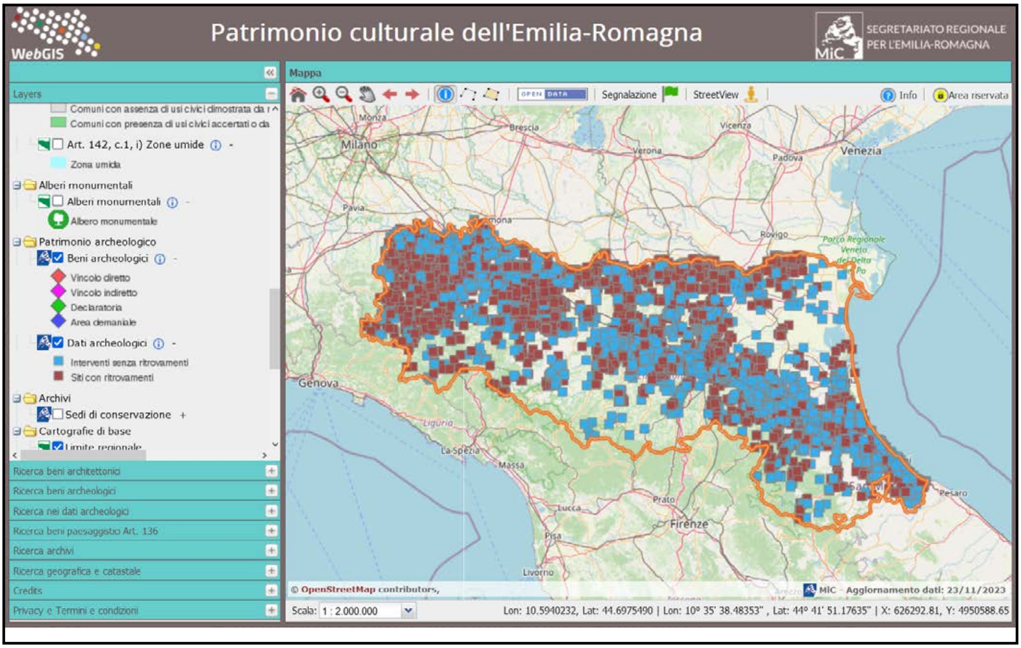

Figure 7 – ArcheoDB data are integrated through the WebGIS www.patrimonioculturale-er.it to include all pertinent information essential for identifying the protected immovable heritage (architectural, landscape, archaeological, and archival assets). This facilitates the implementation of proper measures for the protection, administration, and enhancement of such heritage.

During the first eleven months of 2023, over 800 records concerning interventions conducted in the same year were entered into the system, underscoring the validity of the decision to integrate data entry into ArcheoDB with the submission of documentation to the *Soprintendenze*. These figures reflect the substantial workload consistently managed by the *Soprintendenze* and the efficiency of the new workflow.

The decision to make all available data accessible in real time marked a radical yet necessary shift (Fig. 7). To balance transparency and data reliability, the working group added a disclaimer clarifying the non-validation status of some records. This was the only viable approach to ensure full and timely data sharing with the broader community, including researchers, field professionals, and stakeholders involved in land management and planning.

Experience with the WebGIS has demonstrated that, although heritage data is always susceptible to improvement and necessarily partial, its public availability fosters correction and enrichment. It promotes the engagement of various stakeholders in the protection, management, planning, and enhancement of the territory. In many cases, new data have emerged from sources such as local authority archives or from individuals possessing in-depth and site-specific knowledge.

At the same time, some critical issues have emerged. Those planning interventions on the territory have shown an increasing reliance on the WebGIS platform, at times to the detriment of consulting complementary sources, especially traditional and printed ones. Although this

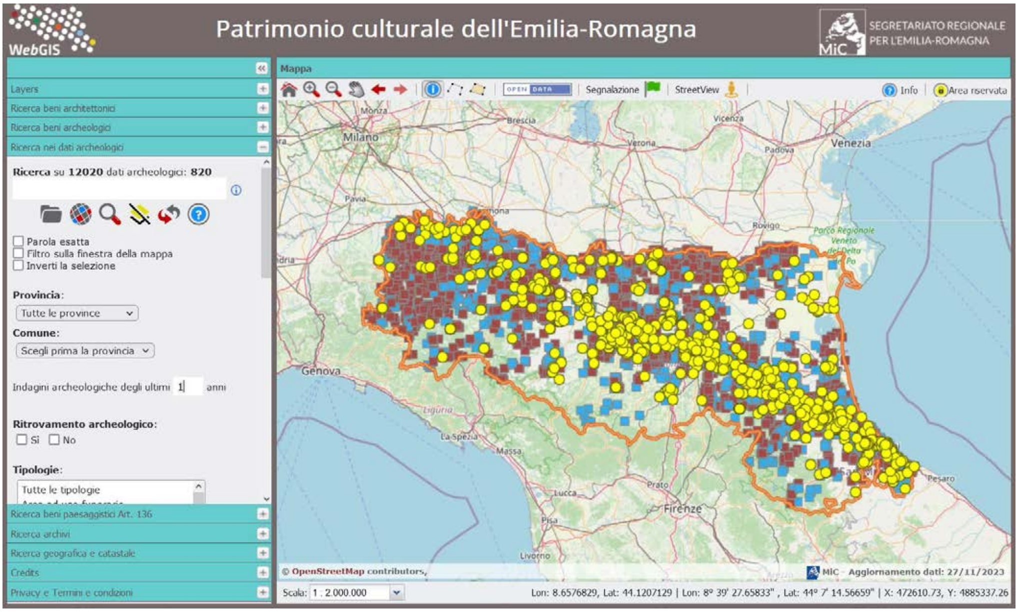

Figure 8 – The search criteria applied to sites containing archaeological data enable the identification of information resulting from recent investigations, thereby accounting for the intensive efforts in conservation and documentation currently underway. In the given example, by filtering data pertaining to interventions conducted in the past year, more than 800 results become apparent.

shift entails some risk, the simplification it offers is, in many respects, appropriate: it provides the most comprehensive and up-to-date synthesis of available archaeological information.

One year after its launch (15 September 2022), the database has been positively received. It has effectively supported decision-making processes in the protection of archaeological heritage and has become an immediate and reliable source of archaeological information for the scientific community.

For planners and researchers alike, the constantly updated WebGIS interface facilitates the extraction of data based on criteria such as geographic location, chronology, type of evidence, or depth of findings. It is also possible to filter for recently investigated sites, providing essential and timely "excavation news" (Fig. 8).

Furthermore, the provision of open data through web services—particularly WMS (Web Map Service) and WFS (Web Feature Service)—has significantly expanded the system's potential. These services allow users to reuse and integrate datasets within custom cartographic projects, maintaining an active link to the continuously updated source. This ensures that the most recent information is always available, even when visualised in external platforms or systems.

(I.D.C., M.S.)

3. The experience of the Parma *Soprintendenza* office (SABAP-PR)

The necessity to catalogue excavation data compelled SABAP-PR officials to reorganise their archaeological archives[13], dividing documents into four main territorial groups and and creating an Excel-based inventory[14]. A similar approach was adopted for other specific archival collections, such as documentation centres located in different offices (including Bologna's Soprintendenza office and the civic museums of Travo and Pianello Val Tidone) or archives organised thematically (for example, the archive of prehistoric excavations)[15].

Additionally, the team labelled all excavation documentation folders with their respective inventory codes. A similar reorganisation is currently underway for the extensive archive of archaeological drawings, which, until about 1995, were separated from the written documentation and stored independently.

The creation of ArcheoDB records involved multiple approaches:

- Internal *Soprintendenza* staff directly catalogued excavation interventions;
- Initial contracts with external companies and professionals were funded through annual allocations provided by the General Directorate of the Ministry (DG ABAP) for cataloguing activities[16];
- Archaeologists appointed by DG ABAP have provided crucial support, beginning the organisation of archives and cataloguing work in July 2021[17];
- Public project funds have supported the reorganisation, digitisation, and cataloguing of external archives[18].

In addition to the minimum standards of ArcheoDB, the completion of the following three template fields became mandatory:

1. 'Archival Location' which uses abbreviations (e.g., 'SABAP PR, PRP 546') to indicate respectively physical location, archival collection, and inventory number[19], thereby facilitating further investigations or verifications;
2. 'Notes' associated with the Datum Point field ('Quota zero') to indicate 'where' and 'how' the information was detected (via GPS, Google Earth, CTR, etc.);

[13] The archival organisation framework was initially established in 2020 by Dr. Alberto Stignani, archaeologist and archival official, to address accessibility challenges arising from the pandemic.

[14] These include: *Comune di Parma* (abbreviated as "PR"), *Territorio provinciale di Parma* ("PRP"), *Comune di Piacenza*("PC"), and *Territorio provinciale di Piacenza* ("PCP"). Each registry assigns a sequential number to every excavation intervention, restarting from "1" for each category (e.g., PR 1, PR 2...; PRP 1, PRP 2...).

[15] The dispersion of the archives was a consequence of the re-organisation of the Ministry carried out in 2016.

[16] This was made possible thanks to early agreements between the Soprintendenze, Segretariato Regionale, ICA, and DG ABAP. From the outset, data quality was identified as a priority, leading to an agreement to entrust cataloguing exclusively to experienced professionals and to suspend the use of trainees for experimental purposes.

[17] Special thanks go to Dr. Gianluca Bottazzi and Dr. Maria Maffi for their extraordinary dedication, expertise, and precision. Their deep knowledge of the territory has enabled the creation of highly reliable records, culminating in the comprehensive mapping of interventions in the provinces of Piacenza and Parma.

[18] Notably, the acquisition and integration project at the Bologna Soprintendenza headquarters—home to the historical archive—has been especially significant.

[19] Over time, thanks to the archival reorganisation, information regarding the location of drawings has also been added.

3. 'Notes' linked with the positioning methods field ('Metodologia posizionamento'), describing the means used to determine the location of the excavation area (e.g., by using GPS, cadastral data, IGM, etc.)[20].

Following the introduction of the mandatory ArcheoDB template (effective from 1 January 2023), professional archaeologists implemented operational changes in the submission of excavation reports. As a result, SABAP PR resolved to accept documentation exclusively in digital format (Fig. 9).[21]. The documentation is transmitted via PEC (Certified Electronic Mail) and assigned a protocol number within the G.I.A.D.A. system (the ministerial digital archive). The ArcheoDB form now refers to the original documentation by recording the protocol number and year, which has replaced the previous reference to archival location.

These developments required the Superintendence officers to adopt a shared strategy for managing data flow: once the report is received via PEC, it is saved in the management system along with the exported PDF of the ArcheoDB record (Fig. 10). After verifying the completeness and accuracy of the documentation, the officer accesses the "ArcheoDB Desktop" application, searches for the corresponding record ID, integrates the protocol number, and validates the record. The final documentation is then stored in a digital archive folder using a codified naming convention.

This workflow has had significant practical implications. From a conservation standpoint—which lies at the core of the Soprintendenze's mission—the secure preservation of excavation documentation is ensured, safeguarding a digital copy in case the physical records are lost or deteriorate. Additionally, the complete retrieval and georeferencing of the documentation enable more effective territorial monitoring. For instance, in the municipalities of the province of Piacenza, all interventions have been mapped: the WebGIS for that area now contains the main contents of the local archival records, effectively replacing the need to consult paper documents (Fig. 11). A similar process is currently being undertaken for the substantial documentation of the province of Parma.

From the user's perspective, the ability to retrieve excavation documentation remotely has significantly improved. This is particularly relevant considering that consultation of such documentation is mandatory for the execution of public works in Italy[22]. The full availability of georeferenced excavation data also plays a strategic role in territorial planning. Numerous municipalities in Emilia-Romagna are currently engaged in the drafting or revision of urban planning tools, actively integrating the archaeological information provided by ArcheoDB into their analyses.

Moreover, the platform serves as a scientifically robust and comprehensive reference point for a wide range of research and outreach initiatives. These include undergraduate and doctoral

[20] When new information about old excavations emerges, the compilation of these fields increases the reliability of the record.

[21] However, we still require the submission of printed copies for particularly significant, complex, and extensive excavations.

[22] In particular, reference is made to the procedure known as *Verifica preventiva dell'interesse archeologico* (preliminary verification of archaeological interest), as specified in Annex I.8 of Legislative Decree 36/2023, Article 41, paragraph 4. Online forms are available for archaeological interventions and for the archival location of the complete documentation. When necessary, this documentation can be promptly requested and retrieved.

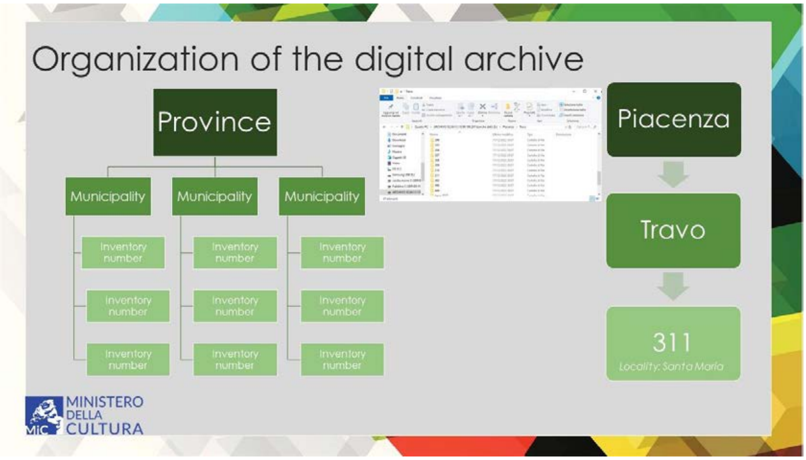

Figure 9 – Organization of the digital archive of the Parma and Piacenza Soprintendenza.

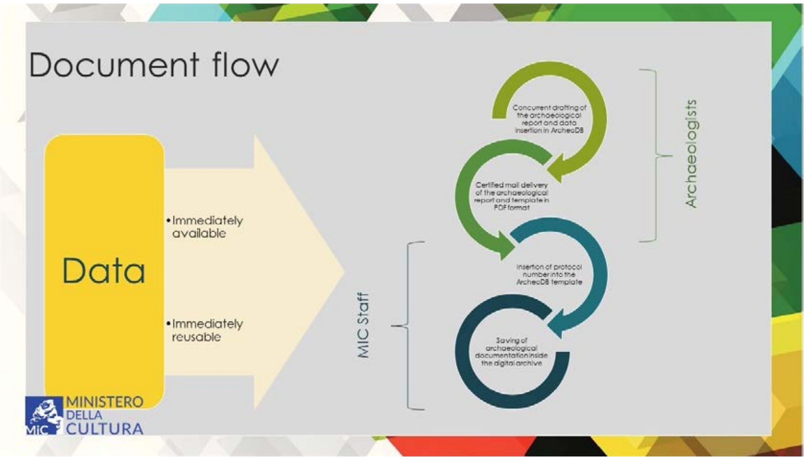

Figure 10 – Archaeological documentation workflow.

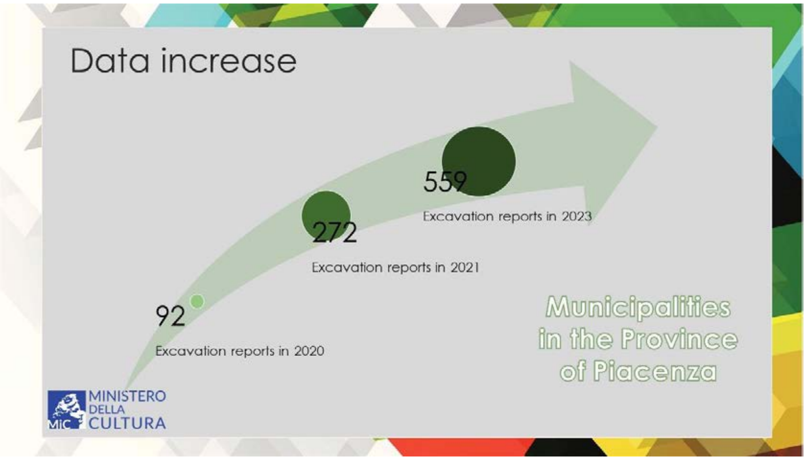

Figure 11 - Data increase after project completion.

theses, institutional and independent research projects, as well as preliminary studies supporting the development of new museum exhibits, archaeological parks, and tourist guides. In this way, ArcheoDB contributes to ensuring that all such activities are grounded in accurate, verified, and up-to-date archaeological data.

(C.M., M.P.)

4. Conclusion: Current status and future perspectives

The development of ArcheoDB remains aligned with its original objectives. The digital template and the core functionalities of the cartographic plugin have reached a reliable level of stability. Nonetheless, regular maintenance and continuous data enhancement remain indispensable. Ongoing updates are essential not only to ensure compliance with evolving GNA standards and GIS platform developments but also to strengthen the protection of archaeological heritage.

The principal aim of ArcheoDB is to ensure complete and consistent data entry throughout the regional territory. This goal will be progressively achieved through systematic archival review and the structured input of new excavation documentation. A significant opportunity is currently offered by the drafting of the General Urban Plans (PUG) underway in several municipalities. In many cases, the adoption of the ArcheoDB model has increased local awareness of archaeological assets and fostered greater engagement with cultural heritage data.

While historical data recovery is time- and resource-intensive, ArcheoDB provides a continuously updated and accessible reference framework without requiring additional long-term investments.

Furthermore, the integration of ArcheoDB into the Regional Crisis Unit—an inter-institutional body responsible for emergency response involving cultural heritage—represents a crucial advancement. Composed of representatives from the Regional Secretariat, the Soprintendenze, and other Ministry of Culture (MiC) entities, this Unit benefits from real-time access to reliable archaeological information. Such access is critical for identifying and prioritising areas requiring immediate intervention during emergencies such as earthquakes or floods.

(M.F.A.C., I.D.C., C.M., M.P., M.S.)

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Notes

The Archaeological Map of Ancona: new IT tools

Eleonora Iacopini

eleonora.iacopini@uniroma1.it - Sapienza Università di Roma

Abstract

This paper presents the technological innovations introduced to the Archaeological Map of Ancona (Italy) in 2024, when the platform was first published online. The new IT structure is based on the use of two open-source software: Directus for database management and Geonode for the open access distribution of archaeological datasets supported by relevant metadata.

Keywords

Geonode, archaeological map, Directus, archaeology, Ancona

Introduction

The project of the Archaeological Map of Ancona was first set up in 2019 through an agreement between the Superintendence of Archaeology, Fine Arts, and Landscape (SABAP) of the Marche region, in central Italy, and the University of Bologna. The project aims at using the Archaeological Map for three different goals: protection and urban planning by public authorities, research purposes, and tourist targets. Each of these aspects is reflected in various design choices, from a structural point of view, up to the database and available tools setup, as well as in the content and levels of data access and usability. From the conservation of cultural heritage perspective, this tool aspires to be employed as a platform for managing archival resources, which can be consulted and searched for in a more organized manner and made directly accessible thanks to their digitization, thus allowing easier and faster data access. It is not merely a matter of scanning documents, but rather the setup of a complex organization of existing resources. Therefore, this tool aims at complementing and interacting with the Italian National Geoportal for Archaeology, which currently represents the model used by the Italian Ministry of Culture for academic field research and for rescue archaeology practices as well (Circular no. 9 of March 28, 2024, [http://www.ic_archeo.beniculturali.it/getFile.php?id=2128]).

Over the past six years, the IT infrastructure has undergone adaptations and updates in line with the development of new open-source data management applications. Initially, a web app called PuntoZero (Iacopini 2023) was developed specifically in PHP, HTML, and JavaScript for the management of archive data and the visualization of the archaeological map, while using Leaflet JS Library for the cartographic version. In 2024, the IT infrastructure was completely modified, favoring fully open-source solutions developed and maintained by a broad international community: Directus (https://directus.io) was used for database management, and Geonode (https://geonode.org/) for the cartography. Compared to the first version used at the beginning of the project, the update offered by the new version 4.1 positively affected the outcome. The migration to this system was primarily guided by the experience and tests conducted during the implementation of various research projects led by the Digital Archaeology Laboratory at Sapienza University of Rome (LAD, https://lad.saras.uniroma1.it).

Geonode was tested in the Op.e.r.a. project (Portal for the knowledge of Cultural and Historical-Archaeological Heritage), while Directus was tried out for the database management of the archaeological mission in Çuka e Ajtoit, Kestría (Albania) (https://lad.saras.uniroma1.it/ricerca/missione-archeologica-sapienza-a-cuka-e-ajtoit-albania), as well as in the IN-Rome project led by the Scuola Normale di Pisa (http://inrome.sns.it). The creation of the Archaeological Map of Ancona takes place during a period rich in initiatives and innovations in the field of cultural heritage digitization. Among these, we can mention the National Geoportal for Archaeology (GNA, Calandra 2022, Calandra 2021, [https://gna.cultura.gov.it/]) promoted by the Central Archaeology Institute, MAGOH by the University of Pisa (Gattiglia 2021, [https://magoh.cfs.unipi.it/]), and, of course, the pioneering Territorial Information System of Rome (SITAR, [https://www.archeositarproject.it/]), which is undergoing further developments.

The completion of data digitization and the analysis of all documents related to the archaeology of Ancona have led to a new understanding of the city's urban planning compared to previous studies and to the reconstruction of paleosols from a diachronic perspective, going from prehistoric times up to the Roman era[1].

Digitization and data archiving

The archive documents related to archaeological findings in the city of Ancona were digitized in 2019. This involved cataloguing various archival units located at the headquarters of the SABAP in Ancona. Archaeological data is divided into six archive collections: historical, administrative, dossier, excavation diaries, drawings, and photographs.

Each one preserves a specific part of the archaeological data, from the history of its discovery (historical or administrative archive) to the development and results of the excavations (dossier, excavation diaries, drawings, and photos). The scattering of information stimulated one of the project's initial aims to make all available data accessible on a single screen. Approximately 12.000 files related to 212 items were scanned at a resolution of 300 dpi. Data entries cover a wide chronological range from the Eneolithic age to the Renaissance period and they comprise both the most significant archaeological evidence and individual accounts of sporadic findings. They also include details of stratigraphic sections exposed during archaeological surveys that did not yield structural evidence, core samples and other interventions that did not bear any results at all. At the same time, available archive plans were georeferenced to precisely locate archaeological evidence.

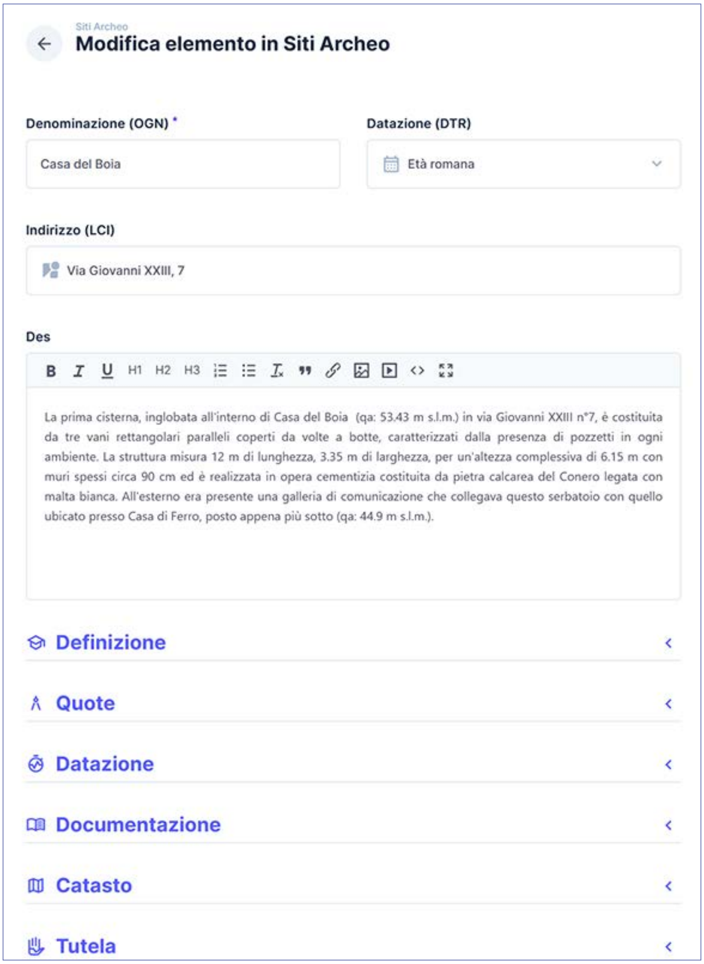
After the initial phase, the next step was to build a PostgreSQL database with the PostGIS extension to store all the information derived from individual folders. The database mainly consists of an "Archaeological Sites" table connected in a one-to-many relationship with six others: "Document Archive", "Drawing Archive", "Elevations", "Dating", "OGTT (object type)", and "Structures". At the project's outset, the "Archaeological Sites" table included all the fields of the ICCD's "Scheda Sito" 3.0 model. At present, they have been reduced to those required by the MOSI card to facilitate interchange with the GNA by the Central Archaeology Institute. Directus, an open-source software, was chosen for administrative

[1] The research is forthcoming.

area management and database handling. In addition to a user-friendly interface for data entry and modification, it offers numerous features, including Access Controls/Permissions, Configurable Workflow, Content Management, Customizable Forms, Data Import/Export, Document & File Management, Filtering, Full Text Search, and Visual Modeling. The software also allows API access both in REST and GraphQL to manage data within the database. The API has predictable resource-oriented URLs, relies on standard HTTP status codes, and uses JSON for input and output. The choice to use this software stems from its excellent performance demonstrated during tests on some projects of the Digital Archaeology Laboratory directed by Julian Bogdani, who has been involved in finding possible alternatives or replacements for the Bradypus (Bogdani 2022) software he developed himself (https://lad.saras.uniroma1.it/ricerca/bradypus-cloud-databases/). The test bench was the Archaeological Mission in Çuka e Ajtoit, Kestría (Albania) in 2022, when Directus was used as software for managing archaeological data from both excavation contexts and field research. The software proved extensively versatile in handling the complexity of archaeological data, leading to the migration of the Archaeological Map of Ancona to this system. The transition was relatively swift since Directus, like the original project, employs PostgreSQL as reference database. Therefore, it was possible to quickly transfer data from one database to another.

Moving to the sections that compose the descriptive tab for each archaeological record in the administration area, these are divided into two. The first is more general, including code, name, whereabouts, generic dating, and description, while the latter is divided into six specific groups: definition, elevations, specific dating, documentation, cadastre, and conservation acts (Figure 1). In "Definition", archaeological data is described according to the ICCD's OGD and OGT fields specifying the definition and type, e.g., Burial Area (OGD) and Tombs (OGD). In addition, discovery modality (OGM), year of detection and conservation status (OGB) are also reported. "Elevations" includes general data for both relative and absolute site elevations. There is an additional linked table reporting all elevations of the archaeological site, specifying the absolute reference elevation, the absolute deposit elevation, the relative deposit elevation, and what that specific data refers to—whether it is a calculated elevation point from the crest of a wall or a floor plane and the chronology to which it could be associated. Clarifying this information for each archaeological record allowed the reconstruction of planimetric trends for the living levels in those area of the city where data were numerous enough and the stratification of different chronological phases was more evident. In the "Dating" section, the initial and final dates are entered in numeric format (e.g., -700 for 8th century BCE), along with their reliability assessment. A table is associated with these basic elements, listing the general dating (e.g., Roman period), the specific one (e.g., Republican period), definition, and type, highlighting the different phases of the site, the typological change over time, and the different ways areas were used. Two tables are associated with the "Documentation" section as well, one listing all archive documents related to that specific site, and the other for all drawing codes available in the archive. From here, archive folders are directly accessible and downloadable in .zip format, or it is possible to view drawings with additional information about individual files. In addition to the Cadastre section (which includes some fields for storing historical cartographic information) and the one related to Conservation acts, the last part of the site card consists of a table detailing vectorized elements related to the digitization of drawings.

Figure 1 - Site card management in the Directus administration area. It allows administrators to view, edit, and manage detailed information about archaeological sites.



The digitization of drawings involved vectorizing each element of the floor plan, specifying a few well-defined attributes such as the site ID, the chronological phase ID of the site, the description of the element, the typology (M: wall; S: threshold; C: channel; P: floor, Pm: mosaic, T: tomb), and the consistency (0: non-existent/hypothesized; 1: existing). With these elements, it is possible to automatically build a map with different chronological phases, labeled with different colours. For each floor plan, users can get an idea of which records actually exist and which have been hypothesized while wall structures and floor plans are distinguished by different graphic textures. A similar schema was used in the PAThs project, which proposes a Simple Vectorization Protocol (https://docs.paths-erc.eu/data/svp; Bogdani 2020).

From the administration area, both documents and drawings can be consulted directly using the search tool to identify elements of interest, which can then be exported in various formats (CSV, JSON, XML). The platform already provides the ability to manage access permissions to different data in both read and write mode, and user groups with specific permissions can be created: for example, a freelance professional can be allowed to access a specific card to add excavation data or floor plans (Figs 2–3).

Figure 2 - Section for the management and visualization of geospatial data through an interactive planimetric map interface in the Directus administration area.

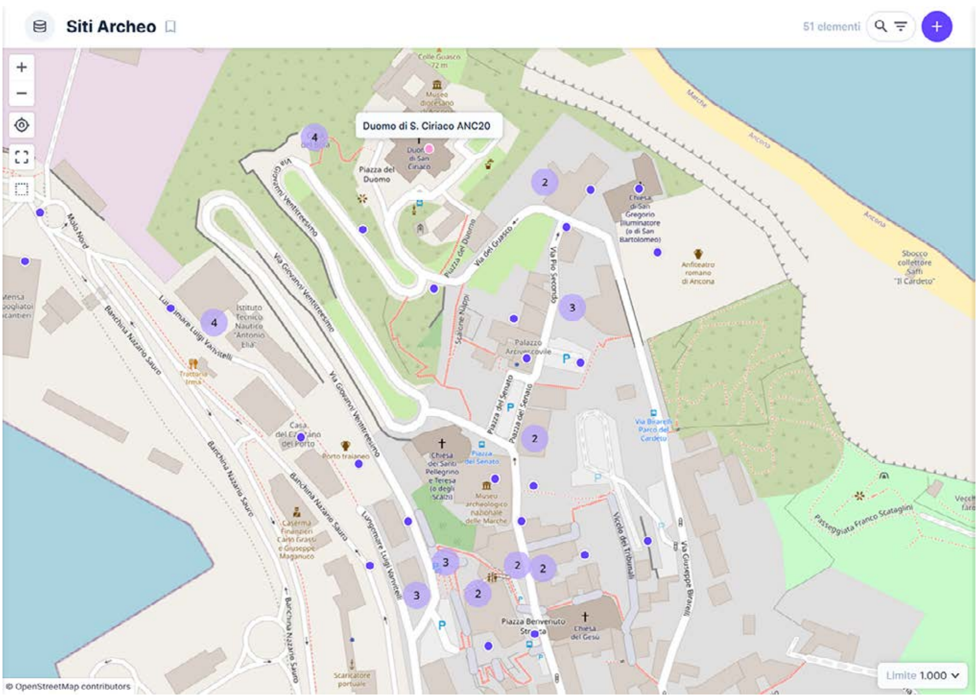


Figure 3 - Management and visualization of geospatial data through an interactive point map interface in the Directus administration area.

Website and online cartography

In order to provide open access to all the archaeological sites cards for the general public, a website (http://archeoancona.cultura.gov.it) has already been developed. Each card contains various information about the site with a list of relevant documents and drawings downloadable in different formats (CSV, JSON, XLS, and PDF).

The “Document Archive” and “Drawing Archive” sections list the individual elements corresponding to archive folders or drawings in tabular format. For each document, the archive (administrative, historical, dossier), protocol number, description, and date are specified. Regarding the drawings, the site’s chronology, inventory number, description, and year of creation are reported. Data downloading is not possible from the public area.

From the Web-GIS section, users can access two cartographic versions, one tourist-oriented, developed with the Leaflet JS JavaScript library (https://leafletjs.com), allowing precise and planimetric visualization of archaeological sites. In the pinpoint version, the sites are divided into different layers based on general chronology; clicking on the point leads to the site card that can be printed. In the planimetric version, data are distinguished by chronological phases using different colour schemes (e.g., red for the Roman era), and each element is characterised by a specific texture based on what is indicated in the attribute table (M: wall, P: floor, C: channel, etc.). Existing elements are marked with a solid colour, while destroyed/hypothesised ones share the same colour gradient although with a higher degree of transparency. Clicking on each individual element allows users to view its description, such as “polychrome mosaic floor” or “*opus testaceum* wall.” In the tourist map, the informational pop-ups only provide a description of the context and do not include all technical information described in the previous section, including excavation details, plans, and administrative files (Figure 4).

Figure 4 - Map texture – Leaflet JS Tourist map.

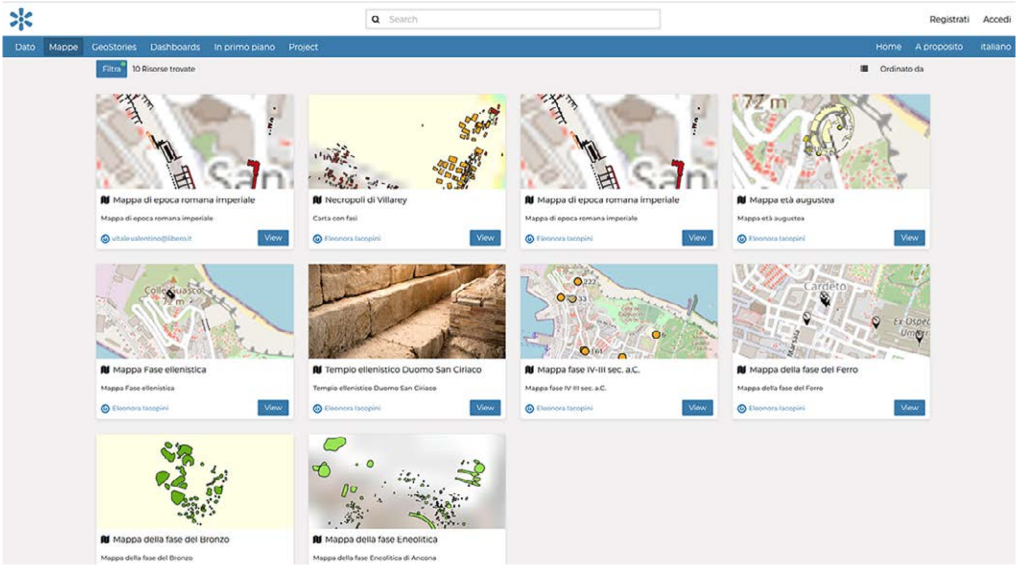


Figure 5 - Interface of the archaeological map of Ancona in the Geonode platform.

This tourist distribution of cartography was already present in the first PuntoZero software and has been preserved in the latest system release. Whereas the use of Geonode v. 4.1 as a geographic platform is an innovation. Compared to the previous version, the most recent one has notable elements of interest for the open access distribution of archaeological data and associated metadata, particularly the ability to upload not only shapefiles but also geopackages to the system. Within Geonode (https://cartaarcheologica.it), all shapefiles related to point data and multi-phase floor plans of archaeological sites in Ancona have been uploaded, totaling 105 datasets and 10 maps. Geonode allows the creation of customized maps from datasets uploaded to the system or by adding WMS layers to view data from various sources (Figure 5).

After registering, users can create their maps and add their datasets, a useful feature for technicians as well, who can simply add their work area if they need to check if a public work interferes with archaeological remains. This shared use could benefit both public administrations for urban planning and supervisory bodies, which will gradually build a map of sub-services. Users cannot modify or delete data they do not own, whether maps or datasets; however, they can download and use them. Public visibility of data uploaded by individual users on the portal must be validated by the system administrator; otherwise, data remains for private use.

Maps currently in the system relate to the chronological phase visualization of the city of Ancona, from the Eneolithic age to the Imperial Roman era, with a more specific focus on the Villarey necropolis and the Hellenistic temple beneath the Cathedral of San Ciriaco, presenting not only the floor plan but also the entire distribution of elevations relative to the church's entrance step. The distribution of elevations throughout the city's territory, distinguished by chronological phases and characteristic elements (threshold, wall crest, floor, etc.), has allowed for the development of soil maps for some areas and the evaluation of archaeological deposit thickness relative to the current surface.

Conclusions

The organic and integrated reorganization of archive data and their complete digitization has made it possible to formulate new hypotheses about the urban development of Ancona compared to previous works (Sebastiani 1996) and to assess how the landscape has consequently changed, undergoing significant adaptations both in antiquity and more recently due to the devastating effects of World War II and the 1972 earthquake (X degree on the Mercalli scale).

The exclusive use of open-source software for the complex and heterogeneous management of archive data aims to be an example of entirely free data management, without the need to develop complex home-made or proprietary solutions.

Through the GitHub space of the Digital Archaeology Laboratory of Sapienza (LAD, https://github.com/lab-archeologia-digitale), the database structure in SQL format will be shared so that the system can be easily replicated on another Directus installation. At the same time, an explanatory guide to Geonode installation and use is already available on the LAD website (https://lad.saras.uniroma1.it/blog/installazione-geonode-su-linux).

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FortNet Project: a *longue durée* approach to the study of settlement, economic and defensive systems in coastal Chaonia (Albania)

Enrico Giorgi

enrico.giorgi@unibo.it – University of Bologna

Julian Bogdani

julian.bogdani@uniroma1.it – Sapienza University of Rome

Federica Carbotti

federica.carbotti2@unibo.it – University of Bologna, University of Salento

Giacomo Sigismondo

giacomo.sigismondo2@unibo.it – University of Bologna, University of Salento

Nadia Aleotti

Sapienza University of Rome

Abstract

This short paper presents an overview of the methodology, fieldwork and activities of the FortNet Project, a joint collaborative effort of the University of Bologna and Sapienza University of Rome. Aiming to fill gaps in the research of hillfort settlements in southern Albania, the project utilizes cutting-edge methodologies to investigate settlement patterns, construction techniques, and material culture from the Bronze Age to the medieval period. Through non-invasive techniques and the development of a shared geodatabase, FortNet contributes to the preservation and sustainable development of the region's cultural heritage while fostering public engagement and academic exchange.

Keywords

Chaonia, Albania, ancient topography, remote sensing, hillforts, field survey, digital archaeology

Introduction

The broader territory of the historical region of Chaonia (southern Albania) remains largely understudied compared to the major urban centres that developed within it. The region's topography has played a pivotal role in shaping settlement patterns over time. Its natural barriers, including the steep Ionian coastline and the imposing Ceraunian mountain range, have influenced both connectivity and defensive strategies. In the contemporary era, as has been the case in antiquity, communication routes follow these ridges and exploit the narrow valleys carved by the streams flowing into the Ionian Sea. The region's relationship with the sea is characterised by a high degree of complexity. While the coastline facilitated

Figure 1 – Heading of the FortNet Project (https://site.unibo.it/fortnetproject/en).

connections with inland trade routes, the number of available docking points was limited to a small number of seaports. Consequently, a substantial network of hillforts was established on the hills overlooking the Ionian Sea. These hillforts served both defensive and economic functions by controlling strategic access routes and the landing points along the Ionian coast (Bogdani 2024a).

Despite their strategic importance and long diachronic occupation from the Late Bronze Age to the Middle Ages, these sites often lack systematic archaeological documentation, as research in the area has mostly focused on better-known locations, namely Phoinike, Butrint, and Antigonea. Preliminary documentation of the Albanian archaeological landscape was provided by early studies, beginning with Luigi Maria Ugolini's Italian Archaeological Mission in the 1920s and 1930s (Ugolini 1927). Subsequent contributions, including Dhimosten Budina's (1971) research in the mid-20th century and Ilir Gjipali's (2007, 2009) studies on prehistoric and protohistoric settlements, offered valuable insights but lacked systematic survey methodologies (Jones 2017). The SITARC Project (Giorgi, Bogdani 2012), field research by the University of Macerata (Perna, Çondi 2012), and Kriledjan Çipa's (2016) surveys marked a significant step forward by cataloguing sites in the districts of Gjirokastra, Delvina, and Saranda. Nonetheless, the primary focus of the research was a reassessment of existing documentation, with the generation of new topographic and archaeological data being a secondary consideration.

FortNet[1] is a joint project undertaken by the University of Bologna and Sapienza University of Rome that seeks to bridge this significant research gap (Fig. 1). By applying cutting-edge methodologies in landscape and upland archaeology, the project aims to provide scholars, local authorities, and stakeholders with essential tools for advancing scientific research, heritage preservation, and sustainable territorial development in the region.

[1] PRIN 2022 FortNet Project (Unione Europea – Next Generation EU, Missione 4 Componente 1, CUP J53D23000100006).

Research aims and methodology

The objective of the project is to investigate the diachronic role of hillforts, with the aim of tracing their development from the Bronze Age to the medieval period. By examining settlement patterns, construction techniques, and material culture, FortNet seeks to address fundamental questions regarding the function and evolution of these sites within broader historical dynamics. The research is particularly focused on the chronology and motivations behind the emergence of hillforts. The factors influencing their development and significance, their relationship with major urban centers such as Phoinike and Butrint, and the role of intermediary sites like Borsh and Çuka e Ajtoit are also examined.

The research methodology employed non-invasive techniques, supplemented by surface find analysis (Fig. 2). The fieldwork encompasses the systematic documentation of sites through remote sensing and ground surveys. This process integrates historical cartography, archival aerial photography, and high-precision topographical mapping. The advent of unmanned aerial vehicles (UAVs) has ushered in a new era of precision in the realm of remote sensing, particularly through the methodologies of photogrammetry and laser scanning. These technologies have facilitated the generation of intricate digital models, thereby enhancing our comprehension of settlement structures. The project's adoption of a diachronic approach is predicated on the objective of generating a comprehensive and reliable dataset, with the overarching goal of contextualizing settlement dynamics over time. This endeavour is expected to make significant contributions to the reconstruction of ancient landscapes and their evolution. Furthermore, the integration of advanced technologies, such as the Laser Aided Profile (LAP) method, has led to substantial improvements in the documentation of ceramic analysis. A fundamental aspect of the project is the development of a shared, web-based geodatabase for the storage, analysis, and dissemination of data. This tool ensures efficient, high-performance cloud-based data management and accessibility for researchers, while also serving as a collaborative space for integrating multidisciplinary research findings and fostering data-driven interpretations. Furthermore, the geodatabase assists heritage professionals in formulating conservation strategies, a necessity that has become increasingly imperative in the face of mounting threats posed by tourism and urban development.

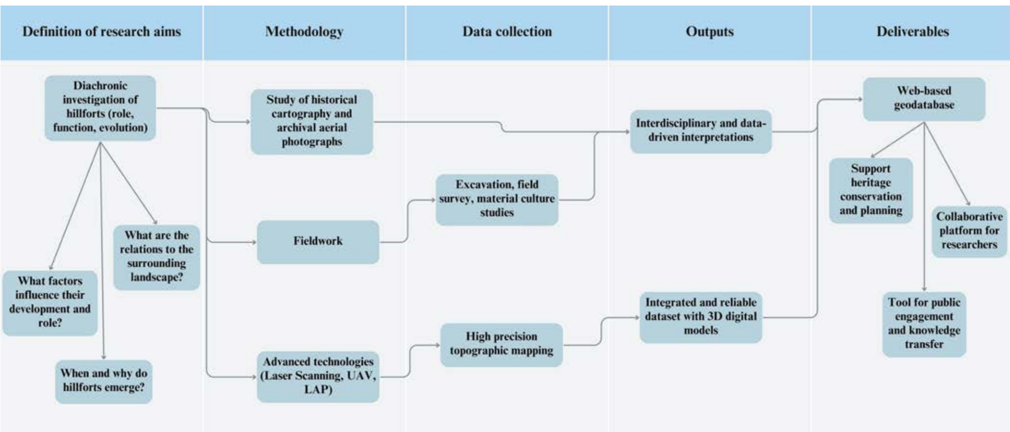

Figure 2 – Project workflow.

Figure 3 – Sites involved in FortNet's fieldwork activities through excavations and surveys.

Fieldwork

The execution of fieldwork was facilitated by the ongoing archaeological initiatives of the University of Bologna at Butrint and the Sapienza University of Rome at Çuka e Ajtoit. The FortNet Project has engaged in collaborative research with the Archaeological Institute of Tirana, leading to the identification of three areas of particular interest (Fig. 3).

The first zone is the coastal region between the bay of Porto Palermo and the Borsh river mouth, where the Ceraunian mountain range extends in a series of hilly ridges that directly overlook the coast. These ridges delineate a limited number of access points to the hinterland, primarily river valleys (Budina 1971; Çipa 2016; Çipa and Meshini 2016; Carbotti *et al.* 2024, 27–34). The natural communication routes through these valleys are controlled by numerous hillforts, as investigated by FortNet's surveys. Their prolonged occupation renders them an exemplary case study for the analysis of settlement patterns. A comprehensive investigation encompassing fieldwalking and topographic surveys in the sites of Kukum, Karos, Badhra, Ngura, Muzga, Borsh, and Lukova has been undertaken. The findings of this investigation have revealed a continuous occupation of the area from the Early Bronze Age up to the Ottoman period. This discovery provides significant insight into the communication networks and exchange within the region and across the Mediterranean (Fig. 4).

The second area of interest encompasses Çuka e Ajtoit and the Konispol surroundings (the ancient region of Kestrine), situated along the southern border that divides Albania and

Figure 4 – Drone image of Kukum highlighting the direct visual connection with the Ionian Sea.

Greece. Recent research has emphasized Çuka e Ajtoit's role within the Hellenistic settlement system of Chaonia and its prolonged occupation into the medieval period, contributing to the understanding of fortifications, urban layout, and settlement chronology (Bogdani 2024b; Bogdani, D'Erasmo 2024; Bogdani 2023). Excavations have revealed the initial indications of Late Bronze Age activity at the site, along with materials dating back to the 4th–3rd centuries BCE in the area of the so-called "Palace", indicating an earlier sacred function. Furthermore, the investigations have centered on the Venetian-Ottoman settlement, the Basilica of Çiflik, and Kisha e Psarit, which have yielded evidence of Roman and medieval structures (Fig. 5).

The third area involves fortifications at the UNESCO World Heritage Site of Butrint and its surroundings. Excavations, surveys, and advanced digital documentation have yielded significant insights (Muka, Giorgi 2022; Giorgi *et al.* 2024; Rivoli *et al.* 2022; Aleotti *et al.* 2022). Research at Butrint has clarified the construction techniques, phases, and strategic role of its defensive system, particularly the Archaic wall circuit on the Acropolis and the Hellenistic city walls enclosing the lower city (Giorgi, Muka 2023; Castignani 2022). Meanwhile, ongoing underwater surveys have given some hints about the location of the ancient Pelodes harbour and identified the submerged remains of the Roman bridge piers, further highlighting Butrint's role within the regional context (Giorgi *et al.* 2024a, 2024b). High-resolution photogrammetry and laser scanning have produced accurate models for structural analysis, while surveys in the Pavlla river valley and Vrina Plain have allowed to revise previously explored areas with new methodologies to enhance the understanding of the archaeological landscape (Carbotti *et al.* 2025) (Fig. 6).

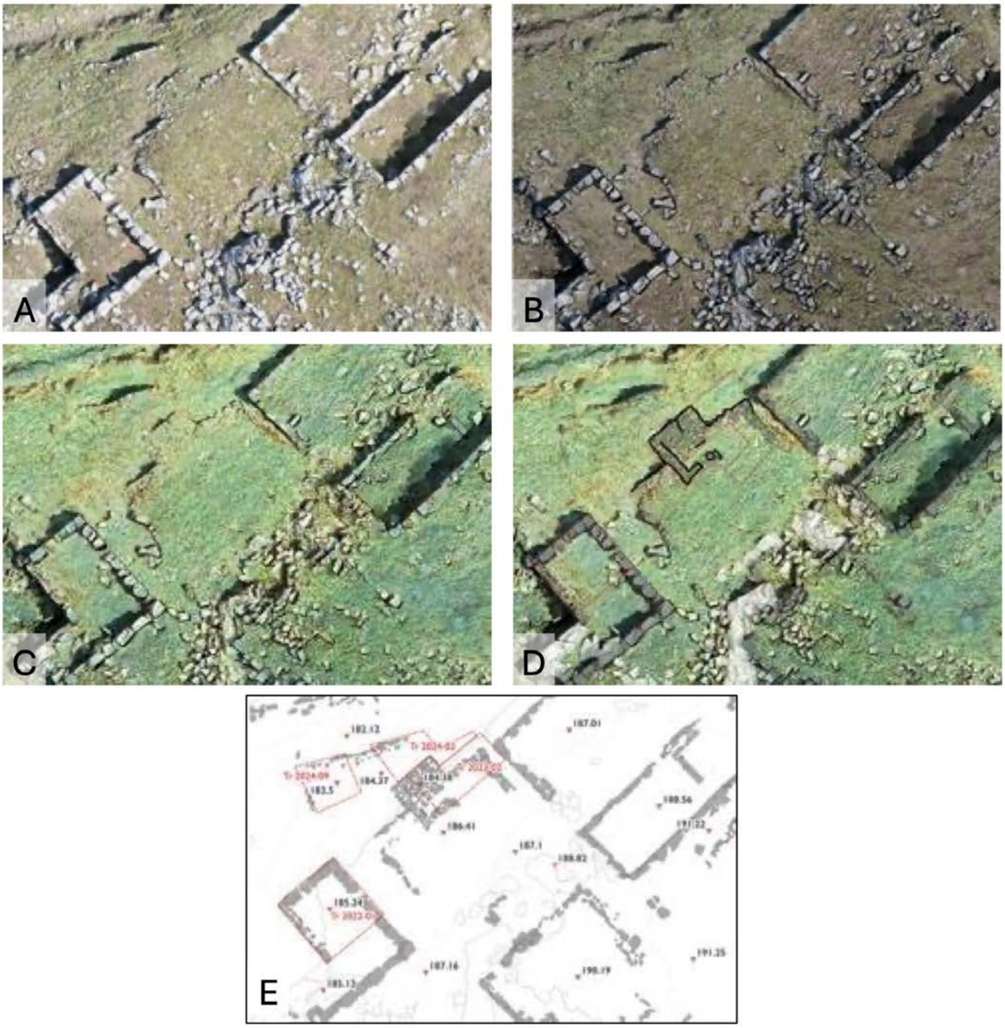

Figure 5 – Results from surveys in Çuka e Ajtoit. A. Orthophotomosaic; B. Hillshade model; C. Slope analysis; D. Detailed field survey; E. Location of excavation trenches.

The study of material culture: methodological approaches and research perspectives

The project provides a unique opportunity to investigate different aspects of the material culture of this region of ancient Epirus at a broad regional scale, rather than being limited to single contexts/sites. The research has thus far concentrated predominantly on ceramic material from the ongoing excavations in Butrint and Çuka e Ajtoit. However, the significant data set from the stratigraphic investigations at these sites has led to the identification of several research issues on a regional scale. These issues have been implemented in conjunction with the findings from the surveys at the other sites included in the project. From a methodological perspective, two aspects of our approach to the study of material culture are of particular significance. The employment of LAP (Laser Aided Profile) for the

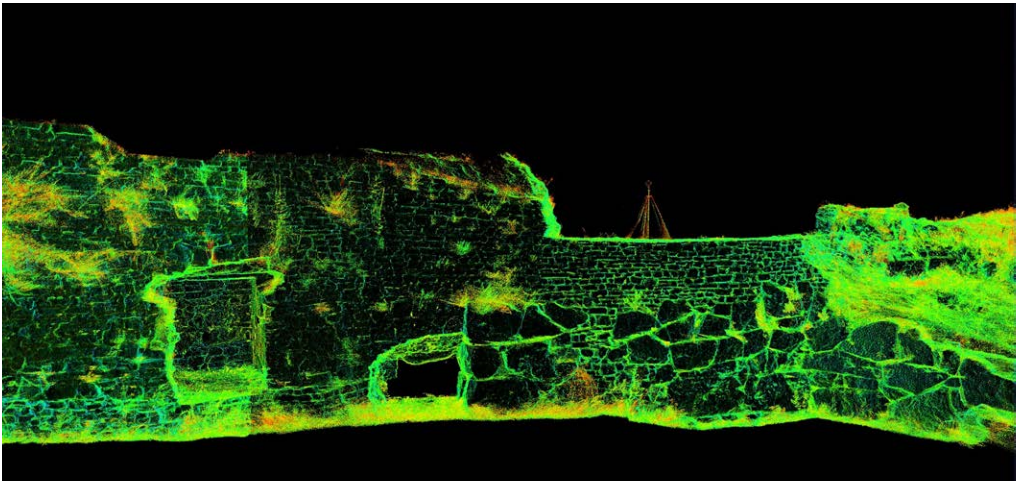

Figure 6 – Laser scanning point cloud of the Archaic and medieval wall circuit on the Acropolis of Butrint (post-processing by Veronica Castignani).

graphic documentation of the pottery has resulted in a substantial augmentation of the digital drawings produced in the field, thereby establishing a considerable database on which to base traditional typological studies. Consequently, this substantial assistance has enabled a more comprehensive examination of classes that were previously deemed less diagnostic due to their paucity of research, including coarse and common wares. Furthermore, sampling of the ceramic material has been undertaken since 2023, facilitated by the financial support of two specific research grants from Sapienza University of Rome. The analyses were conducted at the GeoMLab Laboratory for the archaeometric characterisation of geomaterials of the Sapienza Department of Earth Sciences, through the following techniques: optical microscopy (OM), Fourier transform infrared (FTIR-ATR) spectroscopy and X-ray diffraction (XRPD). The initial findings of this comprehensive approach to the study of material culture have resulted in the emergence of novel research perspectives, particularly with regard to the pre-Hellenistic phases, which remain archaeologically elusive within the regional context. In particular, a number of sherds of handmade pottery of local/regional production from Çuka and Ajtoit have been referred to the Late Bronze – Iron Age, on the basis of their technical and formal features. This constitutes strong evidence that the site was inhabited even during this ancient phase. It is evident that a notable body of evidence pertaining to the pre-Hellenistic phases pertains to the probable local and regional production of Corinthian types A1 and B amphorae from at least the latter half of the 4th century BCE. This hypothesis provides a foundation for new research directions, particularly concerning the economic and territorial organisation necessary for managing the production of the amphorae, their contents, and the surplus intended for export. This period, specifically the Late Classical age, still remains archaeologically opaque in Northern Epirus.

Dissemination and community engagement

FortNet employs a multifaceted dissemination strategy targeting various audiences. A dedicated website functions as a centralized platform for the dissemination of real-time updates on the project's mission, methodology, and progress. This platform serves to foster engagement with both the scientific community and the general public.[2] To promote academic exchange, FortNet has organized workshops and conferences, such as the "Butrinto Cento (1924-2024). Bilanci e Prospettive" (Bologna, November 13th-15th, 2024), and the workshop "Living in the Town, Living in the Countryside. Typologies, Models and Transformations of Residential Architecture in Hellenistic and Roman Epirus" (Rome, January 15th, 2024). Additionally, team members actively participate in international conferences and seminars, presenting research findings to peers worldwide, and in activity of capacity building in digital archaeology and heritage management for both Italian and Albanian students of Archaeology. Public engagement initiatives are integral to the project's dissemination efforts as well. Activities like the exhibitions in Bertinoro (Forlì-Cesena), Bologna, and Rome to remember the one hundredth anniversary from the beginning of Italian archaeological research in Albania aim to make archaeological knowledge accessible to local communities and stakeholders, fostering collaboration in heritage preservation[3]. These comprehensive dissemination activities ensure that FortNet's research contributes meaningfully to both academic discourse and public understanding of Cultural Heritage.

Conclusion

By shifting the archaeological focus from major ancient urban centres to smaller fortified settlements, FortNet introduces a significant research paradigm shift. Through extensive documentation and analysis, it explores human-environment interactions that extend beyond specific historical periods, thereby offering a more comprehensive perspective on settlement dynamics. The project's integration of digital documentation, geospatial analysis, and archaeological research establishes an innovative framework for the study and safeguarding of Albanian cultural heritage. The project's objective is to establish a new standard for the study and protection of Albanian fortified landscapes through the synergy of archaeological investigation, technological advancements, and public engagement.

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2 https://site.unibo.it/fortnetproject/en

3 https://site.unibo.it/butrint/en/butrinto-100/programma; https://lad.saras.uniroma1.it/notizie/2024-12-13-presentazione-mostra-sapienza-in-albania/

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MAPS Project: Ravenna as a case study for urban long-lasting settlement

Enrico Giorgi
enrico.giorgi@unibo.it – University of Bologna

Federica Boschi
federica.boschi5@unibo.it – University of Bologna

Sara Morsiani
sara.morsiani@cultura.gov.it – SABAP RA-FC-RN

Giacomo Sigismondo
giacomo.sigismondo2@unibo.it – University of Bologna, University of Salento

Abstract
Ravenna is one of the two case study of the MAPS Project (Sapienza University of Rome-University of Bologna), focusing on long-lasting ancient urban settlements. This contribution presents the aims of the project and the preliminary results regarding activities carried out in collaboration with the local Superintendence for archaeology. These have consisted in collection of legacy data, analysis of core samples from the area of Santa Croce, and studying of unpublished excavation context in the southern sector of the city. All data collected will be managed and shared through a digital infrastructure with a GIS interface.

Keywords
Ravenna, urban archaeology, archaeological map, GIS, paleo-environmental analysis, legacy data

Introduction

The MAPS Project (Methods and processes for the Analysis of Pluristratified Sites) aims to test the study of long-lasting urban centres with a holistic approach, providing in-depth knowledge of urban landscapes and their development over the centuries[1].

Pompeii and Ravenna were chosen as two case-studies, since they offer quintessential examples of ancient cities with two apparently substantial different evolutions: in the first case, a pre-Roman and Roman centre suffered a strong break in ancient time, corresponding to the volcanic eruption of 79 BC when it was buried, and its life has restarted from the 18th century but in a considerably distinct manner, as an extensive archaeological site; in the second case, the ancient settlement, whose establishment dates back to pre-Roman era, has

[1] NRP NRRP 2022 MAPS Project (European Union – Next Generation EU, Mission 4 Component 1, CUP J53D23017840001). PI of the project: prof. Maria Teresa D'Alessio (Sapienza University of Rome); substitute PI: Prof. Enrico Giorgi (University of Bologna).

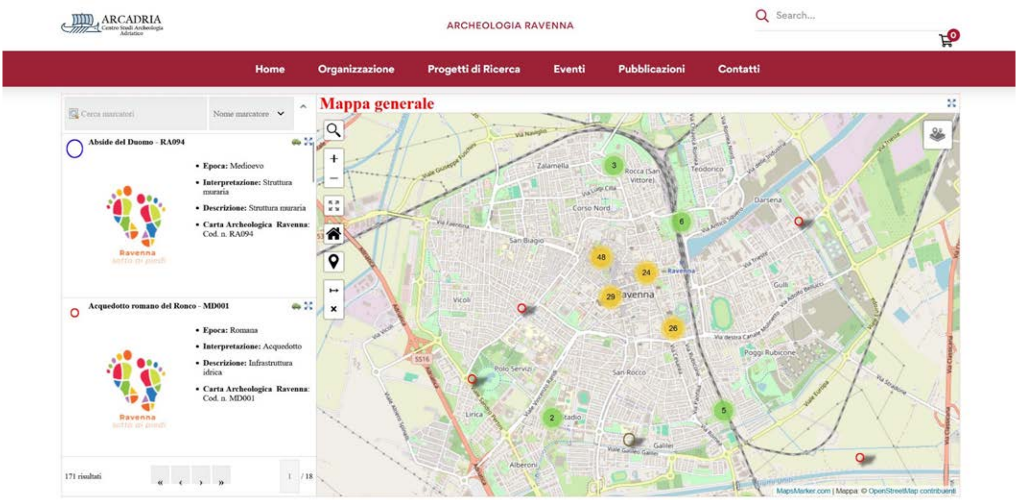

Figure 1. The online webGIS "Ravenna sotto i piedi" (https://www.arcadria.eu/carta-archeologica-ravenna/)

developed through over twenty-two centuries and has maintained itself in the present-day city of Ravenna. However, although a huge amount of data is available for the sites under examination, research has focused on best documented phases.-

The case of Ravenna is emblematic: on the one hand, from the wider public perspective the city is popular mainly for its Late Antique and medieval monuments; on the other hand, in the last decades relevant studies have dealt with the extremely complex urban history of Ravenna starting from archaeological findings in a diachronic perspective and considering the relationship with geomorphology of the area (Susini 1990, Manzelli 2000, Cirelli 2010; Boschi 2013, David 2013a).

In this framework, the widespread use of GIS has enhanced the knowledge and enabled data to be brought together within databases that can be constantly updated and easily accessible. A first step in this direction was taken by the Tolomeo LAB of the University of Bologna together with the Centro Studi per l'Archeologia dell'Adriatico, with the project named *Ravenna sotto i piedi* ("Ravenna under your feet")[2]. Through a webGIS interface, a database gathering bibliographical data regarding archaeology in the inner city was made available online, allowing scholars but also citizens and tourists to learn about the remains of Ravenna that cannot be seen but exist right below where they walk (Fig. 1).

In order to bring together the forces of those organisations involved in research and management of archaeological heritage, an agreement was signed between the University of Bologna (Department of History and Cultures, Department of Cultural Heritage), the Superintendence of Ravenna (SABAP RA-FC-RN), and the Municipality of Ravenna. This allowed the project to start data collection and to put them in a Territorial Data Infrastructure (TDI) platform, shared with the other partner of the project, which combines data managing and data sharing technologies with advanced flows of data integration, ensuring that every

[2] https://www.arcadria.eu/carta-archeologica-ravenna/.

information is coherent and blended, to support in-depth spatial analysis; the architecture of the TDI was designed according to the specific needs of the project and the type of data-entry, and considering previous positive experience of urban archaeological maps (Carandini, Carafa 2017; Iacopini 2025).

Thanks to the agreement, the fieldwork has begun on three side: the collection of legacy data, the study of two core-samples, and the study of unpublished archaeological material of a selected area.

Fieldwork and methods

After thorough bibliographic research, the acquisition of legacy data mainly involved documents owned by public institutions. A first step was to obtain the archaeological map of the Municipality of Ravenna (CPA), part of the Urban Planning Regulation (RUE). Then, an important part of data collection involved archival data of the local Superintendence for archaeology. Whereas currently all documents recording archaeological works are stored in the archive of the Superintendence of Ravenna (SABAP RA-FC-RN), those prior to the reforms concerning the organisation of the public departments can be found in the historical archives at the offices of the SABAP BO in Bologna. Therefore, targeted archival research was needed. All the data collected, mainly consisting of old unpublished archaeological reports and plans, were digitised, and flowed into the TDI, making them available through the custom-made GIS interface.

Simultaneously, the other main issue about Ravenna, on which the project is focused, is paleoenvironmental research. Bearing in mind that in long-term urban settlements extensive excavation are out of the ordinary, also when they occurred in the framework of rescue archaeology, it is difficult to obtain samples for this type of analysis. Nevertheless, other activities often carried out for non-archaeological purpose can be helpful. Among these, coring is the most common, also due to its relatively low-cost, the short time needed for fieldwork, and because it does not require large open areas.

Thanks to the cooperation with the Superintendence of Ravenna, two core samples were recovered in its storehouse. They were realised in 2022, when some geotechnical investigations were conducted (Fig. 2) in the archaeological area of Santa Croce by the University of Bologna in the framework of the SHELTER Project (Bitelli, *et al.* 2021). Those activities aimed at studying and monitoring the existing drainage system and identifying the local hydrogeological and geotechnical characteristic (Marchi, Bertolini, and Gottardi 2023; Marchi, Bertolini, and Gottardi 2024). Since the archaeological remains are exposed but lie several meters below ground level, they are threatened by flooding related to subsidence; a phenomenon that affects the entire area around Ravenna (Ugolini, *et al.* 2020; Bertolini, *et al.* 2023)[3].

The archaeological area of Santa Croce is located in a crucial sector of the ancient settlement. In the Roman period it overlooked the northern bank of the *Flumisellum*, an ancient small watercourse flowing east-west, which likely marked the border of the city to the northern

[3] The area was considered as a case study in the framework of the SIRIUS Project (SIRIUS - Management strategies for cultural heritage at risk) of the University of Bologna, funded by NRPP EP05 CHANGES, Spoke 6, coordinated by Prof. Mariangela Vandini (European Union – Next Generation EU, Mission 4 Component 2, CUP J33C22002850006).

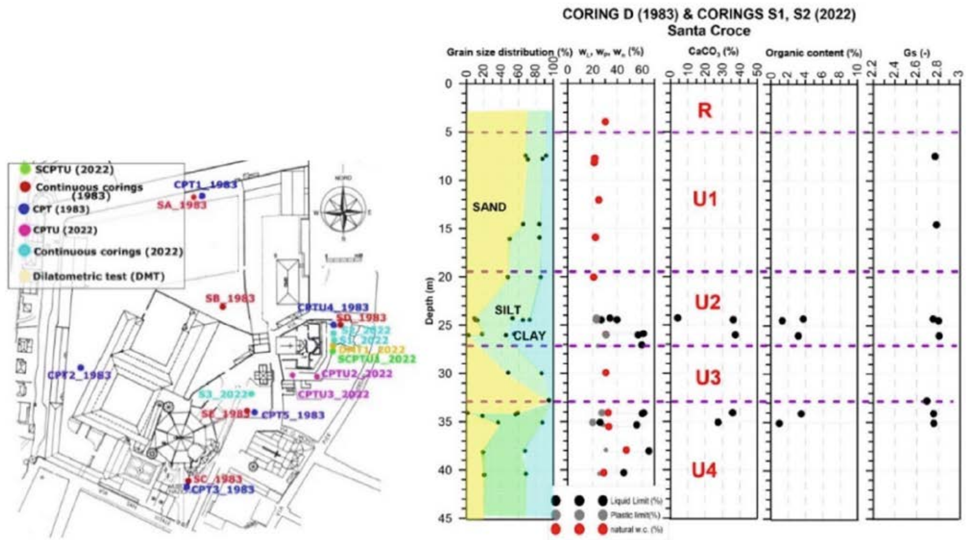

Figure 2. Left: plan of the field investigations in the area, with 2022 core drillings in light blue. Right: Soil profile after core samples geognostic analysis (Marchi, Bertolini, and Gottardi 2023).

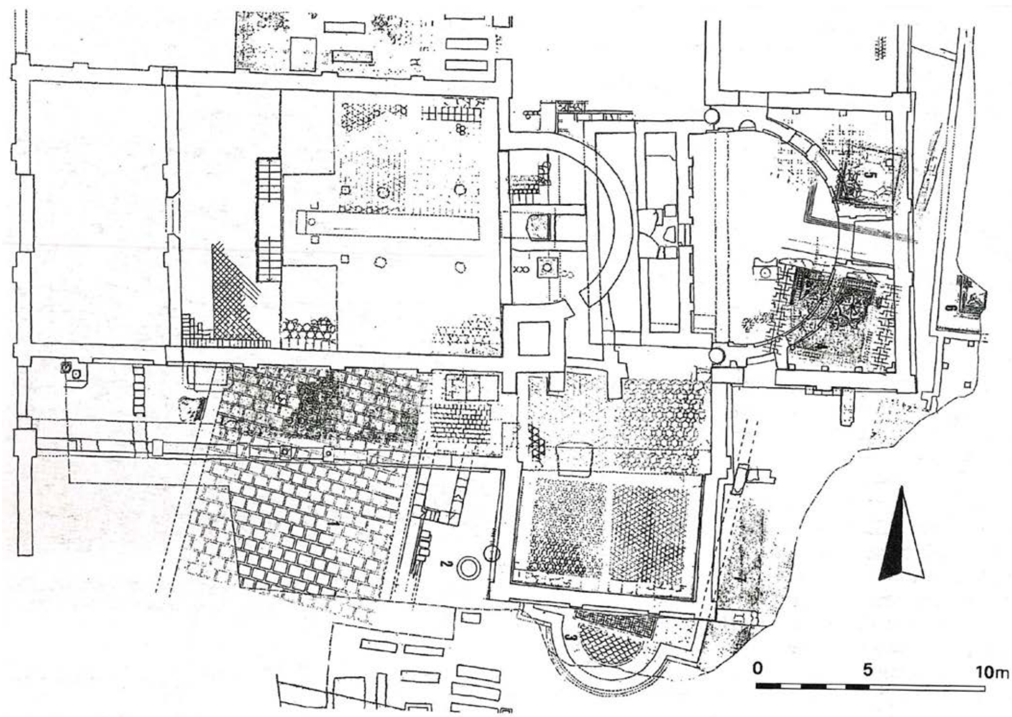

Figure 3. Plan of the domus under the basilica of Santa Croce (Manzelli 2000).

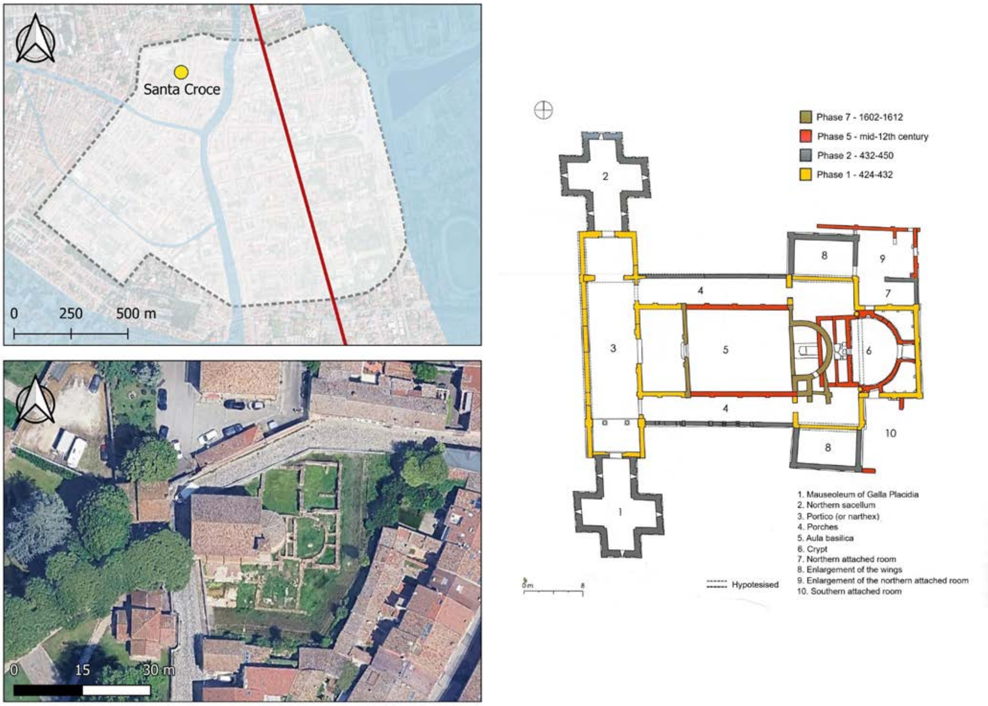

Figure 4. Right: phase plan of the church of Santa Croce (after David 2013b, with modifications). Above left: location of the archaeological area in the late-antique Ravenna (elaboration by G. Sigismondo). Bottom left: satellite image of the site (GoogleSatellite Imagery).

side and corresponds to the path of present-day Corso Cavour (Morsiani, Montevecchi 2025). Further north, beyond the *Flumisellum*, a suburban area expanded, at least from the Augustan period, when a stone bridge – the *pons Augusti*, under the modern via Salara – and some residential facilities were built (Fig. 3). These include a large *domus* with black and white and polychrome mosaic floors, whose remains were excavated during the 1970s and 1980s, and can still been seen today from via Galla Placidia, despite their poor state of preservation (Sericola, Agostinelli, and Ugolini 2020). After some restoration during the Imperial age, the complex was abandoned in the 3rd century AD, probably following a fire. The area was re-settled in the 5th century: at this time, the area north to the *Flumisellum* was probably comprised in new Late Antique city enceinte, much larger than the Republican one, built after the capital of the western part of the Empire was moved from Milan to Ravenna. Between 424 and 432 a new magnificent church, dedicated to the Holy Cross, arose by the will of Galla Placidia right over the collapsed and levelled Roman *domus* and it was soon enlarged between 432 and 450 (David 2013b, 13). In this period, the church had cruciform plan with three naves and a porch on the front side, with two small buildings – chapels or *sacella* for funerary purposes – at its opposite extremities (Fig. 4). Originally, the southern building was likely dedicated to Saint Laurence, while from the 9th century it was entitled to Saints Nazarius and Celsus; the northern one was hypothetically attributed to the *monasterium* of Saint Zacharia known by the sources (Cirelli 2008, 235; David 2013b, 15–18). At the present, only the southern one survives: the so-called Mausoleum of Galla Placidia (Cirelli 2008, 254). In the following centuries, the church was

Figure 5. Description of core samples' stratigraphy (photo by the authors).

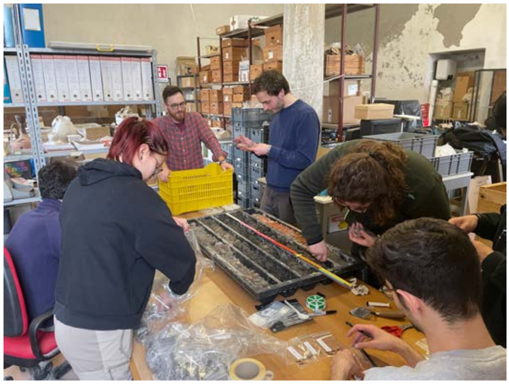

Figure 6. Activity of sampling for geoarchaeological analysis (photo by the authors).

part of the north-western quarter of the city, where several sacred buildings were erected. The church underwent some other modifications in the 14th century, but at the beginning of the 17th century the earliest structure was almost completely dismantled: the remains of the narthex were demolished, separating the so-called mausoleum from the main fabric, and the church was reconstructed in smaller dimensions, shortening the length of the church nave towards the façade, which was moved back. Probably in the same period, a bell tower was added (Novara 2022, 15–18).

The first core sample (S2) was carried out a few metres east of the apse of the Placidian church, on the slope of the depression created after the archaeological excavation, and provided a continuous sequence 35 m deep; the second core sample (S3) was taken some metres south-west of the so-called mausoleum, in the garden of the basilica of San Vitale, providing a sequence 13 m deep. For each of the two core samples, systematic sampling was conducted at the laboratory of the Superintendence in Ravenna, in the framework of a workshop on urban archaeology and geoarchaeology for the students of the First and Second Cycle Degree in History and Archaeology[4] (Figs 5-6). The activities resulted in a large number of samples for geoarchaeological, geochemical, paleo-environmental, and targeted archaeological analysis, including carbon-14 dating, which will be carried out by specialised laboratories in the next months.

In conjunction with the work on core samples from the area of Santa Croce, the re-analysis of the excavation of viale Galilei has been undertaken. In the spring and summer of 1995, a rescue archaeological activity was carried out during the construction of a private building on the southern edge of the modern city, between the channels Scolo Lama and Fiumi Uniti. This part of the periphery of Ravenna is little-known and the hypothesis locating the Augustan port in this area has never been clearly confirmed by archaeological evidence, despite it is very likely that the Roman harbour was located south of the ancient settlement (Cirelli 2008, 27). During the mid-1990s excavation in viale Galilei, archaeologist found a section of an ancient road, which was rebuilt several times until the Late Antique period, the remains of at least two

[4] The activities were carried out under the supervision of Dr. Sara Morsiani, Prof. Marco Cavalazzi, Dr. Michele Abballe, Dr. Giacomo Sigismondo, and Dr. Carlo Bicchierai, together with students of various degrees, we would like to thank for their valuable work.

imposing brick structures, and a single infant burial covered with tiles (Unpublished report in the SABAP BO archive). The preliminary survey of the material evidence showed that the area was settled from the Republican period to Late Antiquity (5th-6th century AD). However, a specific study of the archaeological findings is needed, together with the re-examination of the unpublished documentation[5]. This will provide new data about the development of the ancient city of Ravenna and possible relationship with the road network as well as the Augustan harbour.

Conclusion

The study of cities characterised by the persistence of settlement to the present day is challenging for urban archaeology, especially for the earlies phases. In the case of Ravenna, in addition to the difficulties connected to the presence of the modern urban fabric, other issues have emerged. First, the ancient settlement was deeply remodelled in Late Antiquity, when it became capital of the Western Empire, and in Middle Ages. Furthermore, radical environmental changes have transformed the landscape of Ravenna over time. Therefore, the MAPS Project offers an integrated approach to face challenges related to pluristratified urban landscape. A digital sharing platform with a GIS interface was created to manage different types of data; among them, a substantial part was made of legacy data collected from bibliography and archives. At the same time, analysis on core-samples from the area of the church of Santa Croce has given the opportunity to examine in depth the development of the urban landscape over a long-time span, comprehending earlier phases of settlement, and to focus on paleo-environment – it is worth noting that samples came from coring for non-archaeological purposes. On the other hand, a more traditional approach will provide information about an unpublished excavation in the southern sector of the city, through the study of archaeological materials from the site of viale Galilei.

All these activities have been possible thanks to the willingness and the collaboration between the University, the public authorities for the protection of cultural heritage, and the local agencies. In this way, data sharing not only provides an updated picture of the wide archaeological context of Ravenna but also gives the possibility, thanks to the TDI platform, to make it known to a wider audience at different levels.

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Reviews

Alessandra Caravale, *Le banche dati archeologiche. Articolazione e formalizzazione delle conoscenze*. Firenze: All'Insegna del Giglio, 2022 | Book Review

Erasmo di Fonso

erasmo.difonso@uniroma1.it – Sapienza University of Rome

Caravale, A. *Le banche dati archeologiche. Articolazione e formalizzazione delle conoscenze*. Firenze: All'Insegna del Giglio, 2022. ISBN: 9788892852266

Over the course of three chapters, the volume analyzes a rich corpus of archaeological and museological projects, exploring the potential of digital databases for data analysis, dissemination, and preservation. Its rigorous and meticulous approach succeeds in avoiding excessive use of technical terms, making it accessible even to non-specialist audiences. Overall, the text is clear and fluid, serving as a valuable resource to a wide range of readers.

The first chapter provides an overview on a selection of projects discussing one of the most representative material categories in archaeology: pottery. The author uses these case studies to emphasize pioneering projects in the field, highlighting the challenges encountered in the design, formalization, and standardization of datasets. These efforts laid the groundwork for critical discussions on the foundational principles of digital humanities, showcasing how the process not only redefined classification methods but also fostered the development of new interpretative approaches to archaeological data. In closure of the chapter recent applications are explored: digital corpora, which go beyond simple consultations to facilitate classification, identification, and analysis of new material.

The second chapter delves into the role of databases in the historical evolution of archaeological computer science, examining their impact and development through the lens of projects and research published in the journal *Archeologia e Calcolatori*. This chapter is structured around three main themes: contributions from French scholarship, the challenges and opportunities brought by the advent of the web, and projects developed by the Institute of Heritage Science (ISPC) of the Italian National Research Council (CNR).

Building on the concepts introduced in the first chapter, a more detailed analysis of critical contemporary issues is provided here, such as the need for interoperable digital infrastructures and the establishment of standards that would ensure fruitful communication between databases. These aspects are presented as pivotal for the advancement of Open Science, enabling new forms of collaboration and data access. Of particular interest is the third section, which explores challenges and opportunities posed by the proliferation of web technologies, introducing more recent concepts such as spatial databases and semantic web. These tools have significantly enhanced data dissemination and sharing within archaeological databases over the past decades. In closure of the chapter, an appendix by S. Fiorino adopts a practical perspective by providing a concrete example of using an open-source CMS like DRUPAL. This system is presented as an effective tool for managing and disseminating data from museum and bibliographic databases.

The third chapter addresses the theme of cataloging archaeological heritage, examining its historical evolution through a comparative analysis of the experiences of three different national administrations. The author emphasizes the importance of databases for the management, protection, and valorization of cultural heritage by state entities. The chapter begins with the pioneering studies conducted in the United States during the 1970s, with particular attention to the work of Robert G. Chenhall, before moving to the early adoption of these systems in Europe. Of particular value is the discussion on past attempts—some more successful than others—to standardize and catalog Italian cultural and archaeological heritage. This section offers a clear perspective on how institutions have approached these challenges and continue to do so, making it particularly useful for those unfamiliar with these initiatives, whether they aim to engage with them or merely consult their outputs. In this regard, the contribution of the Central Institute for Cataloguing and Documentation (ICCD) and the figure of Oreste Ferrari are highlighted. Once again, the case-study allows the author to highlight the need the necessity for standardization to overcome fragmentation in data management and integrate various types of information (textual, graphic, and geographic) into a single interoperable platform. Similarly relevant is the discussion about the benefits of open-source technologies and the creation of online systems that enable broader and more immediate access to data, facilitating information sharing among experts and institutions.

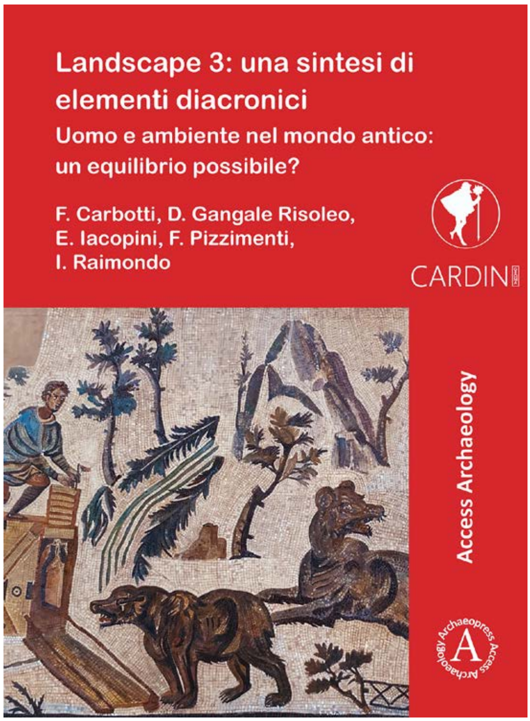
Concluding the chapter (and the book), the author reflects on future perspectives while underscoring how computerized cataloging, supported by advancements in digital technologies and the development of Open Science, constitutes a fundamental tool for the integrated and sustainable management of archaeological heritage.

Carbotti, F., D. Gangale Risoleo, E. Iacopini, F. Pizzimenti and I. Raimondo (eds) *Landscape 3: una sintesi di elementi diacronici. Uomo e ambiente nel mondo antico un equilibrio possibile?* Archaeopress, Oxford 2023 | Book Review

Stefano De Nisi

stefano.denisi@unisalento.it - Università del Salento

Carbotti, F., D. Gangale Risoleo, E. Iacopini, F. Pizzimenti and I. Raimondo (eds) *Landscape 3: una sintesi di elementi diacronici. Uomo e ambiente nel mondo antico un equilibrio possibile?* Archaeopress, Oxford 2023. DOI 10.32028/9781803277004



The volume *Landscape 3: una sintesi di elementi diacronici. Uomo e ambiente nel mondo antico un equilibrio possibile?*, edited by F. Carbotti, D. Gangale Risoleo, E. Iacopini, F. Pizzimenti, and I. Raimondo, published in 2023 by Archaeopress as part of the *Cardini di Groma* monograph series, represents the third contribution collecting the proceedings of the conference *Landscape 3: una sintesi di elementi diacronici*, hosted by the University of Bologna on May 5–6, 2022.

The volume presents papers addressing the future of eco-sustainable archaeological research, offering significant research insights proposed by young scholars. Some of these contributions introduce innovative approaches in the fields of ancient topography and urban analysis related to archaeology.

This proceedings also explore various aspects and themes concerning the challenges, solutions, and discoveries related to ancient landscapes, their evolution, and the interactions between humans and their environment. The conference proceedings were structured into four sections (*Urbanism*, *Communication routes*, *Methodological comparison and "contamination"*, and *Resource management and territorial* *exploitation*), which have been maintained in the volume. Each section is introduced by a keynote paper that provides a framework for the subsequent essays.

The first section presents a wide range of original studies covering geographically diverse areas between Central and Southern Italy and spanning different historical periods. These studies contribute to the understanding of urban and territorial contexts that are often underexplored or poorly documented.

The second section, despite containing only three contributions, offers clear and insightful studies on communication routes—both terrestrial and otherwise—along with reflections on their usage and the economic dynamics they generated.

The third section features a diverse array of studies focusing on research methodologies, particularly the use of *crossing methods* and their application in territorial archaeological investigations. This section presents various non-invasive survey methods employed in archaeological research.

The fourth and final section includes thought-provoking contributions, similar to those in the first section, that address different historical, cultural, and geographical contexts concerning resource management and territorial exploitation.

Additionally, the volume includes the presentation of several posters, categorized according to the same thematic sections. These posters offer space to showcase recent studies and newly launched projects.

This volume provides an opportunity to engage with high-level scientific contributions, including the posters, which introduce both new and well-established research methodologies in different topographical and archaeological domains.

The papers included in this edition represent the preliminary outcomes of young scholars' research, addressing a specialized audience with a sophisticated yet accessible scientific language, even when dealing with technical subjects such as geophysics.

The volume offers in-depth analyses of each topic examined, carefully assessing both the strengths and weaknesses of the research methodologies employed. As a result, it contributes to advancing the state of the art in various fields covered by the contributions.

The availability of the proceedings in *Open Access*, following the *Access Archaeology* policy of the publisher, is a highly significant factor, allowing unrestricted access to the publication. Nevertheless, Archaeopress also offers the option to purchase a print edition of the volume (352 pages, color illustrations, published in 2023) for £55.00.

In conclusion, this third volume of the *Landscape* conference proceedings provides a broad and coherent perspective on the evolution of landscapes over time and their interactions with the communities that inhabited them. The sequence of sections appears homogeneous, transitioning from a predominantly topographical focus in Sections I and II to a broader perspective that includes non-invasive investigation technologies. Perhaps shifting Section III to the end and bringing Section IV forward would have created a more effective sequence.

Despite this minor observation, the volume holds significant scientific value and contributes to the advancement of studies in various disciplines related to ancient topography.

Overall, all authors have presented contributions consistent with their respective paper titles. Regarding the visual materials, the high resolution of images—particularly maps and plans—is commendable, as is the inclusion of color images. Additionally, the careful selection of illustrations ensures that they do not overburden the text but instead enhance readability.

Finally, it is worth noting that the individual papers serve as starting points for further research, offering not only comprehensive overviews but also specific and valuable avenues for discussion and deeper analysis.

This volume provides an opportunity to appreciate the study of ancient topography "with the aim of addressing the subject through the comparison of different approaches and proposing reflections of a methodological nature" (Gangale Risoleo and Raimondo 2023, 10).

Reference

Gangale Risoleo Davide and Raimondo Ippolita. 2023. "Introduzione". In *Landscape 3: una sintesi di elementi diacronici. Uomo e ambiente nel mondo antico un equilibrio possibile?*, edited by F. Carbotti, D. Gangale Risoleo, E. Iacopini, F. Pizzimenti and Ippolita Raimondo. Archaeopress

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