DOI: 10.2436/15.1000.02.18

Peltuinum. City and landscape between tradition and new techniques

Dario Canino[1]
Sapienza Università di Roma

Alessandro Vecchione[2]
Sapienza Università di Roma

Received 26 February 2021· Accepted 11 May 2021

Abstract

Peltuinum was a Roman city located in central Italy, approximately in the middle of a wide valley defined by the highest mountains of the Apennines. The first investigations of Sapienza University took place in the years 1983-85, subsequently a new series of excavations started in 2000 and, since 2001, excavations have been carried out annually. The archaeological area is known above all for its monumental remains. In addition to public buildings, past archaeological investigations have revealed various residential structures. Within the broader archaeological project, a three-year research project (2016-2019) was carried out in order to collect aerial photogrammetric data regarding the walled city and the very first suburban area. The goal of this activity was to pinpoint new anomalies from aerial photography, exploiting the low-cost digital technologies available and creating a three-dimensional hub capable of collecting and linking traditional archaeological documentation to 3D geometry. Observing the landscape from a privileged point of view such as an aerial perspective, and virtually modelling the archaeological structures excavated during the different annual excavation campaigns, gave us the chance to more accurately identify potential buried buildings, necropolises and evidence relating to the city's road system.

Keywords: Landscape archaeology, aerial photo interpretation, digital archaeological data management, archival research, Roman urbanism, *Peltuinum.*

1. The Roman city of *Peltuinum*

The ancient city of *Peltuinum* is located in central Italy, in the Abruzzo region (in the province of L'Aquila) on a plateau surrounded by the highest mountains of the Apennines: the Gran Sasso, the Maiella and the Sirente (Fig. 1)[3]. The area of the ancient city is now included in two municipalities (Prata d'Ansidonia and San Pio delle Camere), divided between the two administrative areas by the "Tratturo". The plateau emerges within a valley once occupied by a lake, which then naturally dried up (Migliorati 2014, 249; Migliorati 2008, 341). It was located in the ancient territory of the Vestini[4] and, already in pre-Roman times, was a strategic stopping point during the herding of livestock from central Italy (*Sabina*) to northern Puglia (*Apulia*)[5]. In the middle of the 1st century BC, *Peltuinum* was planned and founded in this location in order to manage and control such transhumance and therefore also the resulting economic income.

1. E-mail: dario.canino@uniroma1.it
2. E-mail: alessandro.vecchione@gmail.com

3. Regarding the geomorphological context on which the Roman city was founded and the relationship between morphological system and architecture, see Migliorati, 2014; Migliorati-Canino, 2014.

4. An Italic people who occupied the area of the modern Abruzzo region, between the Gran Sasso and the northern bank of the Aterno River.

5. Occupation by the Vestini is attested by a large necropolis, located outside the north-west sector of the walls of the ancient centre, providing a chronological arc from the 7th century BC to the 1st century AD (D'Ercole-Martellone 2014; Acconcia *et al.* 2011). For an in-depth analysis on the pre-Roman phase of the area, see Migliorati, 2008.

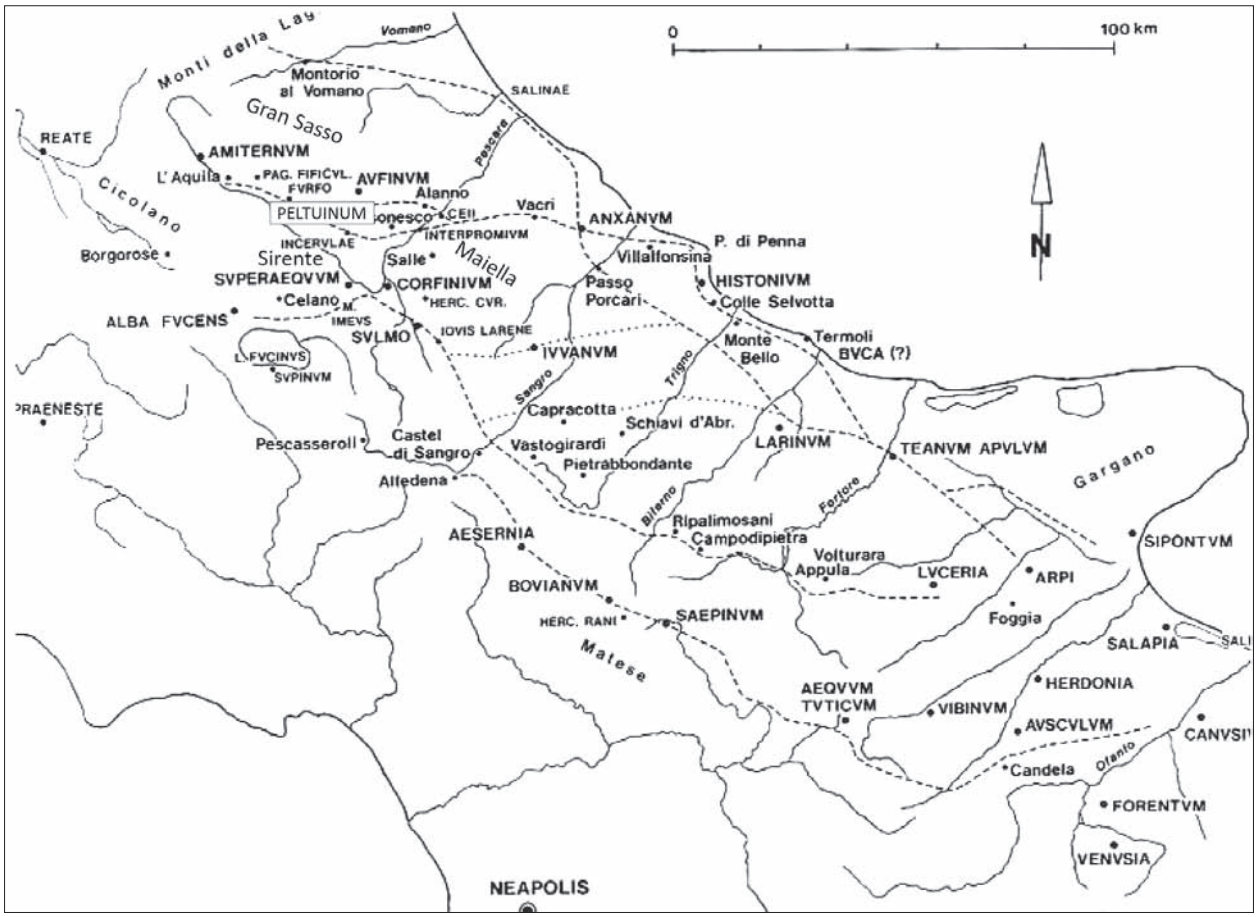

Figure 1. Location of the Roman city of *Peltuinum* in its regional context, with an indication of the main sheep tracks in Apennine Italy (image modified by author from original in van Wonterghem 1999).

In the age of Augustus, the city was an object of interest for the *Princeps* and was later involved in the works conducted by Claudius (41-54 AD) in the Fucino area (Migliorati, 2007). Stratigraphic excavations and structural analysis show that, despite various earthquakes affecting the area, *Peltuinum* survived until at least the 5th century AD, when it was finally destroyed and abandoned because of a more violent earthquake (Migliorati 2014, 256-257; Migliorati 2011-2012)[6]. Afterwards, the city system turned into small scattered settlements, although the west gate continued to be used as a checkpoint for the passage of livestock along the "Tratturo Magno".

6. A catastrophic event that was so violent it also had disastrous consequences in Rome.

Today, the archaeological area is mainly known for its monumental remains (Fig. 2): the city walls (Migliorati-Casazza-Sgrulloni, 2018; Migliorati 2014, 252), theatre and sacred complex, whose dedication is still uncertain (Migliorati, 2014, 2008; Bianchi, 2012; Sommella, 1995). The position of these structures is due both to the original morphological structure of the area and to the presence of pre-Roman cultic elements, which probably influenced the choice of the location to erect the main temple of the city (Migliorati, 2008).

Archaeological research in *Peltuinum* began in 1983, thanks to an agreement between Sapienza University and the Archaeological Superintendence of Abruzzo, with the collaboration of the "Comunità Montana Gran Sasso-Monti della Laga" and local authorities. During the excavations carried out in the 1980s,

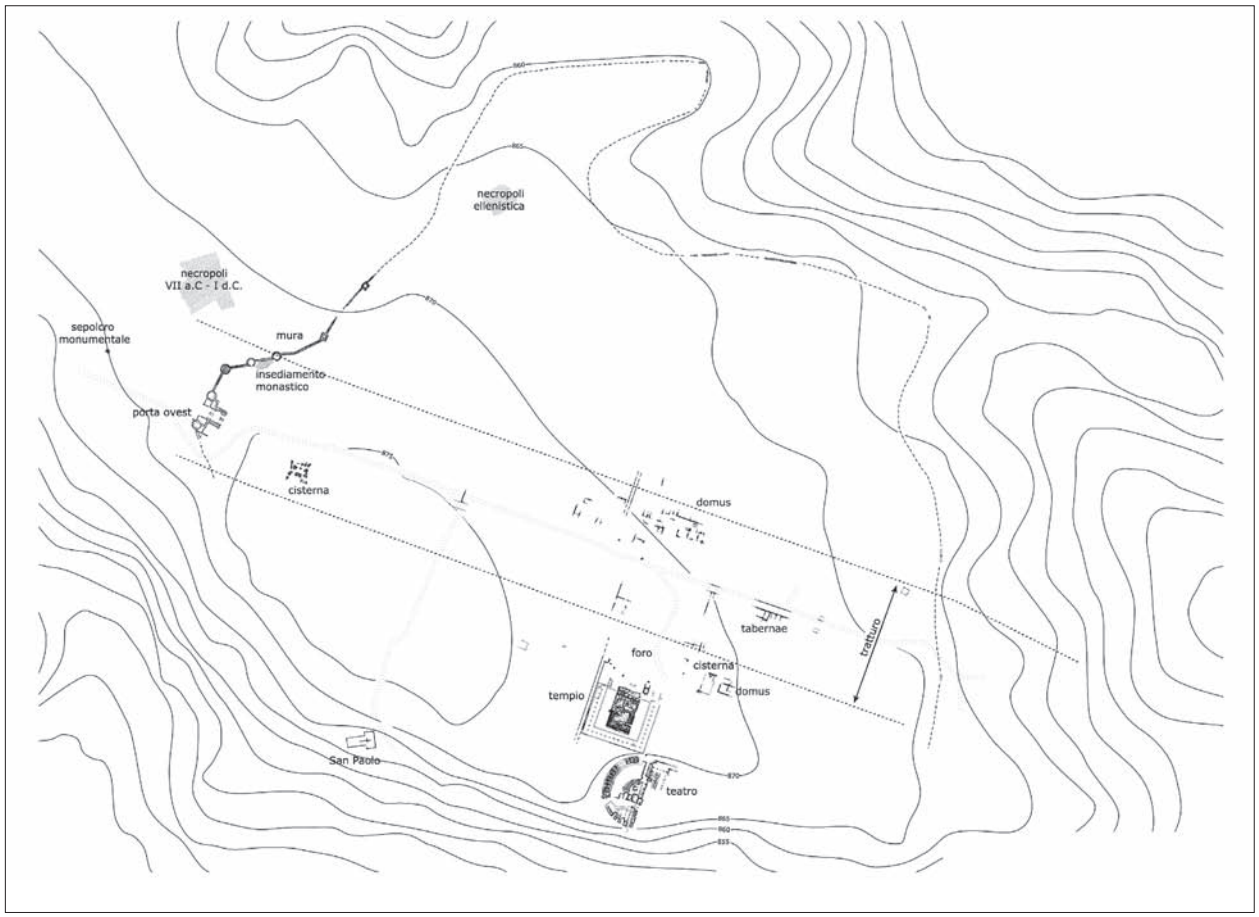

FIGURE 2. *Peltuinum*: Location of archaeological presences on an orographic basis (Sapienza - Department of Ancient World Studies - *Peltuinum* research area).

important remains were brought to light, such as a section of the western walls with one of the urban gates, the temple of the forum, a part of the theatre and some remains of houses. Between 1986 and 1996, the Archaeological Superintendence expanded the excavation areas and carried out consolidation work. In 2000, research resumed by Sapienza (the URBANITAS project of the EU) and, since 2001, excavation has continued annually under the direction of Luisa Migliorati.

Since the 2000s, investigations have concentrated mainly on the public area of the city and its buildings, the theatre and sacred complex, built around the second half of the 1st century BC in the central-southern area of the plateau. However, surveys have also been conducted in many other different areas of the plateau in order to answer specific questions regarding the urban planning of the ancient city and its different phases.

In particular, the theatre has been completely uncovered and all the phases of use have been defined: from the 1st century BC to the 5th century AD (Migliorati *et al.*, 2017; Nepi, 2014; Nepi, 2012). After a disastrous earthquake that caused the buildings to collapse in the 5th century, a long period began in which buildings materials were recovered from the area. Between the 9th and 11th centuries, when the buildings had already been abandoned and largely destroyed, a fortified watchtower was built on the southern half of the theatre, with the function of controlling the valley south of the plateau. This fortification was part of a system that included several other similar structures, placed on the various hills overlooking the valley (Migliorati 2014, 260). This system of

fortifications guaranteed control of the valley floor and the possibility of communication between the various structures, even over long distances.

In later times, a small settlement developed in front of the fortress, separated from it by a road. This was related to the work being carried out to recover and rework the construction materials taken from the ruins of the theatre and the nearby temple. A series of monocellular buildings were used as a place for processing the recovered materials and at the same time also as a shelter for the workers themselves. This small nucleus of buildings consisted of different rooms overlooking a road that led directly to the church of San Paolo[7]. In fact, the building materials were recovered and adapted to be reused as new building material, not only for the construction of the church of San Paolo but also for other buildings of Christian worship and for the numerous villages built near the destroyed Roman city (Migliorati, 2014, 257-260)[8]. On the plateau itself, a monastic complex was was built by using the north-west walls as a support, taking building materials from the urban area, already largely abandoned at that time. The complex has been recognised as a convent dedicated to Santa Maria Sidonia and dates back to the 7th century.

The terrace of the forum was in close connection with the theatre. The orographic terrace, at the end of which was set the sacred complex made up of the temple and the porticus, did not have suitable geological stability due to the alternation of inhomogeneous layers[9]. The conscious choice to use a non-homogeneous construction surface involved preventive ground levelling works for the forum terrace. Moreover, it also determined the decision to position the lower part of the theatre in such a way that it could function as a buttress to counter the thrust of the upper terrace, already occupied by the imposing architecture of the temple-porticus complex.

7. Some architectural and epigraphic elements present in the church of San Paolo testify to a foundation phase prior to the year 1000. The construction, therefore, may have exploited the further ruin of the Roman public structures following the earthquake of 29 April 801 (Migliorati 2014, 258-259).

8. An analysis of the materials found to date leads to a chronology of use ranging from the 12th/13th century to the 17th. For a detailed analysis and chronological classification of the materials found in one of the rooms completely brought to light (room ε), see Sgrulloni, 2015.

9. The plateau is characterised by a structure made up of different geological layers of variable thickness. Layers of silt alternate with layers of more or less cemented gravel, with rare thin layers of sandstone and the presence of limestone in the northern sector of the plateau.

1.1. *Peltuinum*: between archive research and new archaeological discoveries

Since 2015, research has also been carried out every year in the forum area. Compared to the theatre area, the terrace of the forum had already been more thoroughly investigated in previous excavation campaigns carried out in the 1980s and 1990s. For example, the sacred temple-*porticus* complex had already been completely excavated and musealised. Nevertheless, the scientific documentation relating to these past investigations is somewhat superficial and incomplete. There is a large number of photographs (mainly black and white) from the excavations in the 1980s. However, the written and graphic documentation is not as extensive, this being rather heterogeneous and not-standardised.

For the excavations of the 1990s the situation is worse. The scientific documentation is not kept in the archive (except for some sporadic and brief reports) and the main reference for the data relating to the excavations carried out during those years is merely a monograph published in 1996 (Campanelli, 1996).

In recent years, archive documentation has been the subject of study and revision, with the aim of acquiring new data from the limited documents available. For example, among the documentation relating to the first series of excavation campaigns in the 1980s, there is only a single archaeological map defining the positioning of the excavation trenches (Fig. 3). In this document, the trenches have all been indicated on the map but not in a specific, measured way. However, it is possible to compensate for this deficiency thanks to the contribution of the new data collected annually in each excavation campaign, through the surveys that take place in the various areas of the ancient city. Furthermore, new surveys are always complemented by new

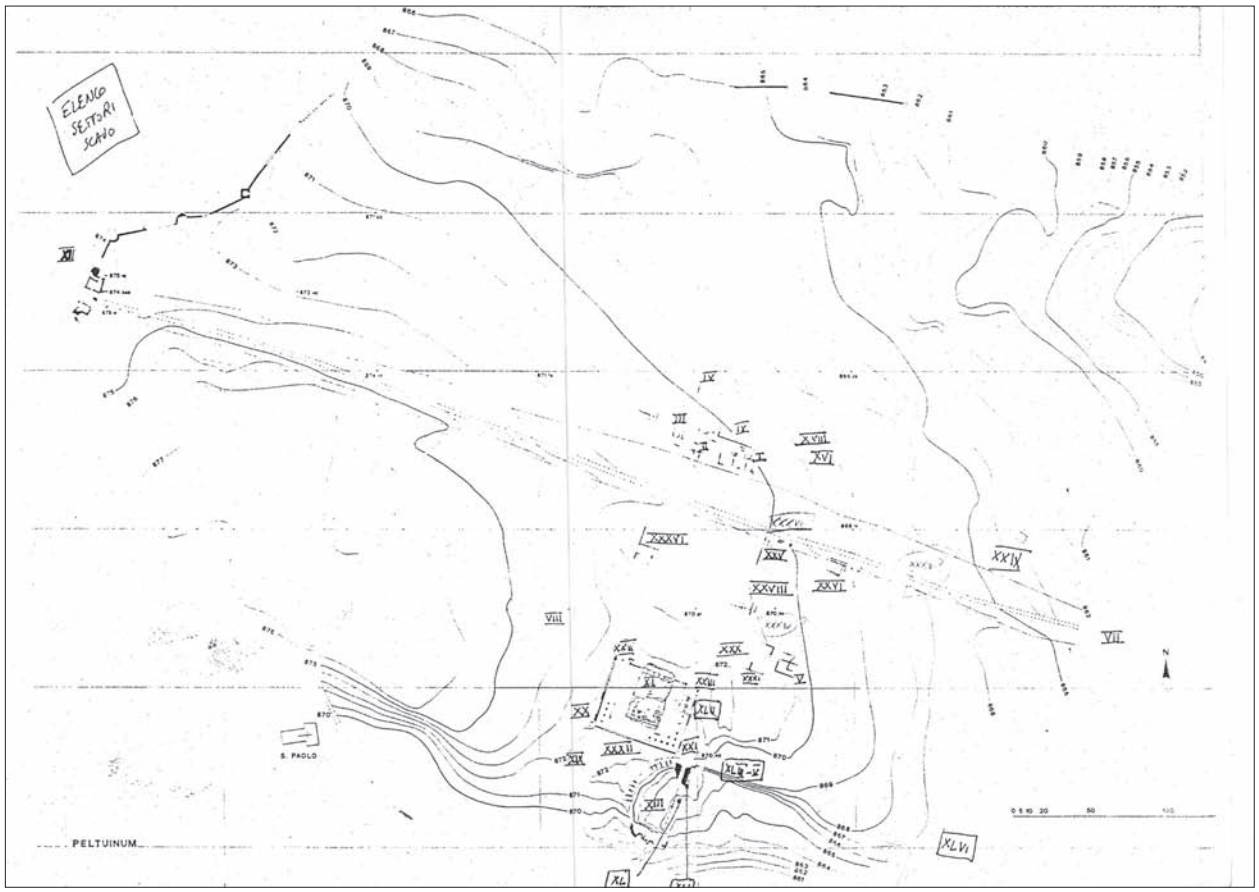

FIGURE 3. Archaeological map of *Peltuinum* that defines the positioning of the trenches made during the excavations of the 1980s, with subsequent additions in pencil (Sapienza - Department of Ancient World Studies - *Peltuinum* research area).

survey techniques (such as the use of aerial photography). In this way, by integrating the various types of data, it is possible to recover old information and plan future investigations.

An interesting example of fruitful integration between old and new data took place following the 2015 excavation campaign, when a fragment of a particular artifact (Fig. 4) was found in the forum area, in trench 79 (Fig. 5, C) (Migliorati-Canino, 2016). Thanks to the examination of the photographic archive documentation, it is known that a similar artifact had already been found in 1983 and the place of its discovery was indicated on the map as trench VIII (Fig. 5, A). In the excavation journal there is only a brief description accompanying two photographs, which show an artifact preserved in its entirety (Fig. 6).

FIGURE 4. *Peltuinum*: Fragment of an architectural artifact, found during the 2015 excavation campaign in Trench 79, within the *forum* area (photo by D. Canino).

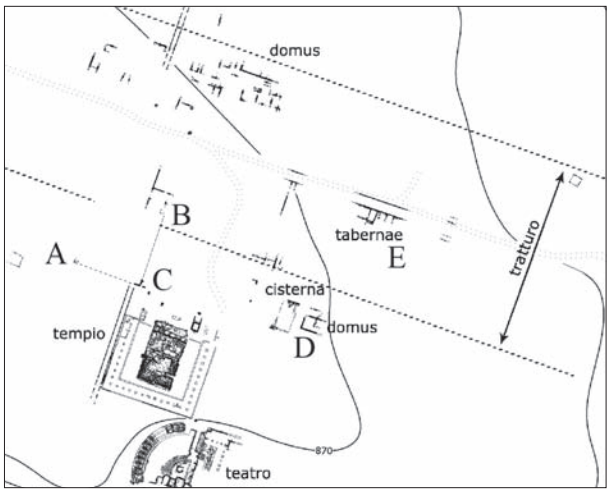

FIGURE 5. *Peltuinum*: Location of the trenches carried out during the excavation campaigns of the 1980s on an orographic basis. A: Trench VIII; B: Trench XXXVI; C: area of the Trench 79, opened in the 2015 excavation campaign; D: Trench V; E: Trench XXVI (Sapienza - Department of Ancient World Studies - *Peltuinum* research area).

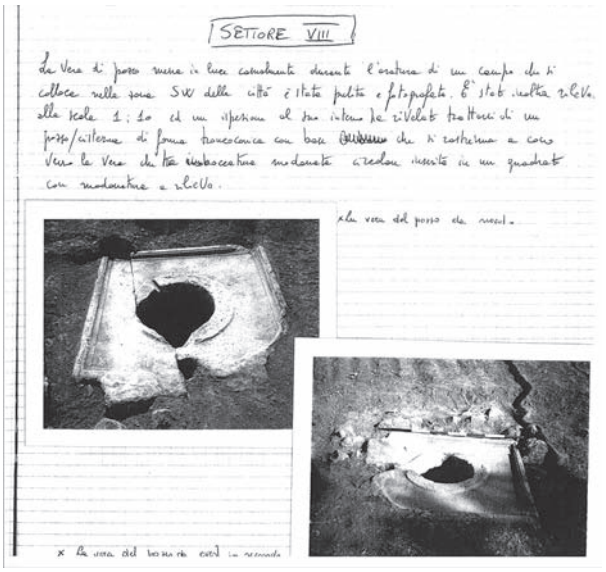

FIGURE 6. Excavation journal on 23 September 1983, Trench VIII, page 48 (Sapienza - Department of Ancient World Studies - *Peltuinum* research area).

Unfortunately, no clear indications are provided to identify the exact positioning of trench VIII and the artifact. However, it was possible to observe that the places where the two artifacts were found seem to be aligned with each other and are located close to the same road[10]. Furthermore, the distance between the artifact found in trench VIII (Fig. 5, A) and that in trench 79 (Fig. 5, C) is equal to the distance between the latter and another quadrangular structure, found further north in the 1980s. This last small quadrangular structure is depicted on the map and the area is identified as trench XXXVI (Fig. 5, B). Looking at the map, these three points define two segments in relation to each other at an angle that appears to correspond to a right angle. Also in this case, the structure is close to a road but, unfortunately, there is no description in the documentation of the 1980s so, at the moment, the real identity of this structure is not known, nor is it possible to clarify whether this may have been in connection with the other two artifacts.

10. This road is visible from the aerial photographs and has been partially documented archaeologically in the past excavation campaigns.

The artifact found in 2015 has clear processing marks with a point chisel both inside the central cavity and on the lower face, while laterally the processing is with a tooth chisel, used to remove the protuberances left by the point chisel in order to achieve a finer finish. This suggests that the block was embedded within a floor and may have acted as a closure of a well (Migliorati-Canino, 2016, 61-62)[11]. Regardless of the real nature of the structures found in trench XXXVI, the two artifacts found in trench VIII in 1983 and trench 79 in 2015 are certainly connected with water, either its disposal or its supply (as the consistent traces of limestone deposits on the lower face of the block found in 2015 seem to imply). Given our present state of knowledge, it is not

11. The two artifacts found in *Peltuinum* are very similar to another one from a production settlement located outside the walls of the Roman *Mutina*. The artifact is defined as well-equipped with a pourer, which connected it to a small rectangular basin. It came to light a few years ago, during excavations for an underground car park, and is now visible inside the Novi Sad Archaeological Park. It was placed on an alluvial deposit of modest thickness, dated between the 2nd and 3rd centuries AD, and it seems to have been used until Late Antiquity as it was sealed by a second alluvial layer dated to the 5th-6th century AD (Labate *et al.*, 2009, 435-436).

possible to determine whether such hydraulic structures were related to a private or public use or even less if their position is due to a cadenced distribution at fixed distances. In any case, these observations, which are the result of the integration between new excavation data, analysis of the old archive documentation and aerial photography, constitute an interesting starting point for planning future investigations, in particular with regard to the city's urban supply and disposal systems.

1.2. Reconstructing the characteristics of the ancient city with the contribution of old archive data

As regards the methods of water supply, the investigations carried out at *Peltuinum* during past excavation campaigns have already provided a range of other data. First of all, we should note that the availability of water has certainly influenced the dynamics of the plateau's population since the 8th century BC. In fact, the outcrop of an aquifer probably already attracted people to the site in pre-Roman times, even though the valley floor contains numerous springs which could also have been useful for reasons related to agricultural exploitation, as well as for the herds of livestock passing through.

At a lower scale factor, the presence of water has also influenced some important architectural decisions, such as the choice of the site to construct the most important building for urban worship: the temple of the forum. In fact, this choice seems to have been conditioned by the desire to confirm the sacredness of the area, linked to an outcrop point of the aquifer. This hypothesis seems to be confirmed by the exact correspondence between the outcrop point of the aquifer and the median point of the rear of the temple, the one corresponding to the position of its religious statue.

Today it is an unequivocal fact that the Roman city was certainly served, at least in part, by a water distribution system. This arrangement has been attested, for example, in trench XXVI (Fig. 5, E), which was investigated in the 1985 excavation campaign. The trench was opened south of the *Via Claudia Nova*, near the southern limit of the sheep track. Here were found the remains of some structures interpreted as *tabernae* (Fig. 7). In particular, a section of a wall was uncovered that had been made partly with blocks and partly in *opus reticulatum*. Between the two sections of the wall was a threshold of white limestone, with sliding grooves for a double closing door. To the north of the threshold (and aligned with it), a walkway was unearthed, forming the southern limit of the *Via Claudia Nova*. At this point, above the surface of the road, a section of lead *fistula aquaria* was found. Other traces of water pipes, both lead *fistulae* and fictile tubules, have been found at various points of the urban system, for example, near the cisterns[12].

The water supply of the Roman city was also guaranteed by cisterns. Small cisterns were already in use in pre-Roman times but in Roman times two larger cisterns were also built, one near the west gate and one in the forum area. Near the west gate there is a first cistern (approx. 16 × 14 m), positioned in a small depression in the highest part of the plateau. Given this structure's location near the west gate, we can also assume it was connected to a trough, used to refresh transhumant herds. Similarly, the cistern near the forum has been excavated entirely; it is larger than the previous one (approx. 20 × 16 m) and the filling system seems to be more varied, including the preservation of snow melt (Migliorati-Canino, 2014, 132).

However, there are also data regarding the existence of an aqueduct, the *Aqua Augusta*, that might have reached *Peltuinum*, going from the hill to the north of the city and crossing the intermediate valley over arches, the memory of which still remains in the toponym Vodarce[13]. From two inscriptions, we know that the aqueduct was built in the age of Tiberius and was

12. For example, a small cistern that was connected to the aforementioned point of the aquifer's outcrop dates from a period before the forum temple was built. The excavation of this cistern, carried out in the 2005 campaign, also identified a part of the adductor *fistula*, which was made with terracotta tubules inserted into each other (Migliorati 2008, 344-345).

13. This toponym is present on the IGM maps but is also still found on the current cadastral map of Prata d'Ansidonia in the variant Valle Vadarcia (Migliorati-Canino 2014, 131).

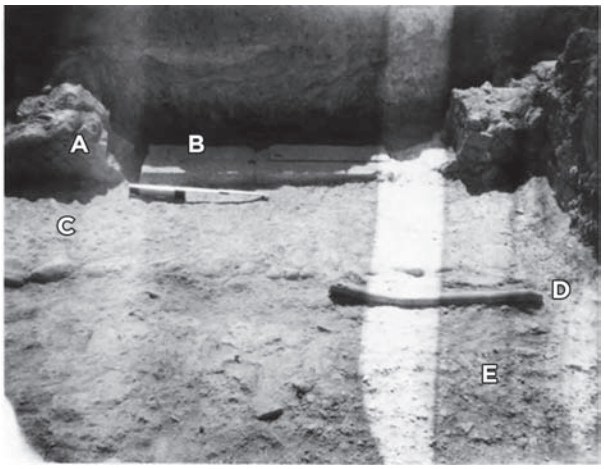

Figure 7. *Peltuinum*: Trench XXVI opened in 1985 south of the *Via Claudia Nova*, near the southern limit of the sheep track. A: section of the wall in *opus reticulatum*; B: threshold of white limestone; C: pavement; D: section of lead *fistula aquaria*; E: *Via Claudia Nova* (Sapienza - Department of Ancient World Studies - *Peltuinum* research area).

Figure 8. *Peltuinum*: Trench V (1983). Image of the *domus* south of *Via Claudia Nova* being excavated (Sapienza - Department of Ancient World Studies - *Peltuinum* research area).

renovated in 78 AD. The first inscription (*CIL*, IX 4209 = D 163) reveals that, between 23 and 37 AD, two *ediles quinquennalis*, Paolo and Floro, members of the Salvieni family, brought the *Aqua Augusta* to *Peltuinum* (Migliorati-Canino, 2014, 130-131)[14]. The second one reveals that Sesto Vitulasio, *consul suffectus* in 78 AD, carried out *sua pecunia* an extension of the aqueduct[15].

The Roman city was also served by a sewer system, although its real extent is not known. This certainly served the central urban area, as evidenced by the sewer found under the floor of a rich *domus* from the Augustan age, located near the forum area (Fig. 8). Furthermore, the excavation of the theatre unearthed evidence of its water collection system, channelled south from the orchestra through a canal that ran below the southern *aditus*.

Perhaps following one of the earthquakes that hit the city, probably the one in the 5th century AD, the aqueduct was no longer functioning. However, the area was never totally abandoned and the people who remained living on the plateau, exploited for purely pre-agricultural purposes, were forced to use wells again, both for water supply and for disposal. Today, excavations indicate that this was the case. For example, in the excavation campaign of 2020, two adjacent wells were found (Fig. 9), one of which was certainly used, since the wall of the well was marked, for its entire height (up to the point where it was investigated), by two mirror rows of footholds, while the second one was perhaps never completed. Initial observations suggest a difference in the chronology of the materials that were used to fill in the two wells. However, only a study of the materials, currently underway, will confirm or reject this hypothesis.

The analysis of the old archive documentation was also of fundamental importance with regard to another research topic, that of residential buildings, whose investigation has been resumed in the course of the latest excavation campaigns. In the 1980s, in fact, several *domus* were excavated along the *Via Claudia Nova*. Following the

14. *Aquam Augus[tam / in honorem [Ti. Cae]/saris Augusti n[epo]/tumq(ue) eius Pelt[uin(ates)] /adduxer(unt) pr(o) ae[tern(itate)] / Caesarum; /Salvieni Paul[us et] / Florus / aed(iles) q(uin)[q(uennales) ded(erunt)]* (Buonocore, 2011, 326-327; Buonocore, 2007, 147-149; Buonocore-Firpo, 1998, 882).

15. *Sex. Vitulasius L. f. / Q[u]i. Nepos cos. / aq[u]am Aug(ustam) adiect(am) / f[on]ti(bus) novis sua pec(unia) / pe[r]duxit et arcus / [n]ovos f[ec]it*. (Buonocore, 2011, 326-327; Buonocore, 2007, 149-150; Buonocore-Firpo, 1998, 885).

FIGURE 9. *Peltuinum*: Trench 90, sector B. The two adjacent wells found during the 2020 excavation campaign: the well on the left seems never to have been used or completed, while the one on the right retained two mirror rows of footholds, to allow descent/ascent inside (orthophoto by A. Vecchione).

analysis of the archival documentation, it was possible to place each structure already found in the past in its exact position, thanks also to a comparison with the anomalies visible on the ground, through the observation of aerial photos and satellite images.

On this basis, it was possible to direct the new investigations that led to the discovery of new housing structures. As well as the houses identified during the 1980s, the new buildings discovered along the *Via Claudia Nova* also retained traces of the walls. The construction techniques used for the walls are various. In fact, walls have been found with curtains curtains in *opus reticulatum* or *opus incertum* and even walls made of beaten clay covered with plaster and built upon a stone foundation.

The floors consisted of beaten surfaces or mosaics, neither type being associated with a specific type of walling (Migliorati-Canino, 2016, 53-55). The residential buildings with preserved mosaic flooring have revealed motifs widely used during the 1st century BC and the 1st century AD, both in the region and in the rest of Italy (Canino-Migliorati-Trivelloni, 2021). Instead, the lower-ranking structures presented simpler clay floors, which were certainly more functional, for uses other than residential ones.

Of particular interest is the above-mentioned *domus* from the Augustan age, located south from *Via Claudia Nova*, near the *forum* area (trench V, Fig. 5, D; Fig. 8). During the excavations of the 1980s, three rooms with mosaic floors were brought to light. The discovery of a silver *denarius* from 29-27 BC (Campanelli, 1996, 66, no. 7) in the preparation of the mosaic of one of the rooms made it possible to establish the exact date of the first phase of the flooring[16]. Later, a repaving took place in the middle of the 1st century AD, as evidenced by a bronze *quadrans* from the Caligula era (Campanelli, 1996, 66, no. 6), found inside the screed[17].

Although the owners of this house are not known, they must certainly have been wealthy members of the local community. In addition to the mosaic decorations, excavation diaries from the 1980s show that numerous fragments of coloured plaster and moulded white stucco have been found, revealing a certain richness of this residence. Moreover, the same position of the *domus*, which gravitates in the immediate

16. The obverse of the coin represents the head of Octavian, devoid of ornaments, looking to the left; on the back there is a military trophy placed on the bow of a ship and in the field the words IMP CAESAR.

17. The bronze *quadrans* dates backto the years 40-41 AD. On the obverse of the coin there is a *pileus* between the letters S and C and the words (C CAESAR DI) VI AUG PRON (AUG); on the back appears the inscription RCC - PON M TR IIII (PP COST T)ERT (*Pontifex Maximus, Tribunicia Potestate Quarta, Pater Patriae, Consul Tertius*). The acronym RCC means "*Remissa ducentesima*" and recalls the abolition of a tax.

vicinity of the *forum* area, together with the size of its rooms, helps to qualify it as a residence of undoubted prestige.

D.C.

2. Digital survey techniques applied to *Peltuinum* archaeological project

The use of digital technologies in archaeology usually consists of an extensive phase of data collection in the field, which generates an enormous amount of digital data. The production of digital models is often followed by a demanding data management phase, including activities related to conservation, indexing and sharing data with institutions and colleagues. Over a five-year period (2015-2020) on *Peltuinum* archaeological site it was possible to collect a heterogeneous set of data, quantifiable in about half a terabyte; the dataset is composed of RGB images, multispectral aerial images, orthophoto maps, DSM, DTM, and CAD elaborations. The data collected represent a great resource both for the analyses strictly related to the archaeological campaign documentation, the aerial photo-interpretation study of the images and for reuse in landscape monitoring contexts; however, the limited manageability of these data has led to the designing of a digital archive that exploits 3D data as a digital access point.

The tools used to produce the graphic documentation included a Canon Eos M3 camera, equipped with a 15-45mm lens, a Canon Eos 500D with a 18-55mm lens and a telescopic pole of 3-10 metres; through this last support it was possible to integrate the images collected from the ground and extend the coverage of the photogrammetric models, with the aim of obtaining complete orthophoto planes of the areas excavated and those in progress. The topographic instrumentation used to scale, orient and geo-reference the three-dimensional models included a Leica TS06 total station and an Emlid multi-frequency RTK GNSS receiver; the images were captured at an altitude between 20 and 70 metres above ground level with a DJI Drone Phantom 3 Adv equipped with a Sony EXMOR 1 / 2.3 " 12 MP / 2.7K CMOS camera.

2.1. Remote sensing campaigns 2015-18: the in-wall city and the *plateau* area

Between 2015 and 2018 a research project based on archaeological aerial and remote sensing survey campaigns was carried out. The main purpose of this project was to map the entire *plateau* of the ancient Roman city and identify cropmarks and possible archaeological features connected to ancient structures or buildings. This research was meant to confirm and update the aerial photo-interpretation studies conducted during the second half of the 20th century regarding the Roman city area (Adamesteanu 1963; La Regina 1964; Tartara 2008). These studies gathered information through the analysis of aerial photos taken by the surveyors of the Allied forces during WW2, currently preserved in the photographic archive of the Aerofoteca Nazionale – ICCD in Rome.

The new data were collected using a drone equipped with RGB and hyperspectral cameras, therefore without the use of active sensors such as Lidar. The raw data were processed in a standard photogrammetric workflow: data recording campaign, pictures alignment, point cloud to mesh producing, 3D models and orthomosaic output. Starting from 2015 a series of scheduled drone flights was carried out, covering the entire area of the ancient city. The approximately 30 missions were carried out over years between the months of April and November only, due to the climate conditions of this area; the missions were repeated over different seasons in order to obtain the best visibility of the cropmarks based on the crop cycle. The flights were carried out at three different altitudes between 20 and 80 metres above ground level; this decision was taken in order to have a wider perspective of the site and higher resolution orthophotos of the single sectors of the *plateau*. In areas not covered by woods or intensive cultivation, micro-relief analysis could be carried out using processed data such as DEM and DSM. The processed data and the cropmarks map were overlapped on the most recent archaeological map available and allowed the research team to reflect on some aspects of the urban layout of the ancient city (Fig. 10).

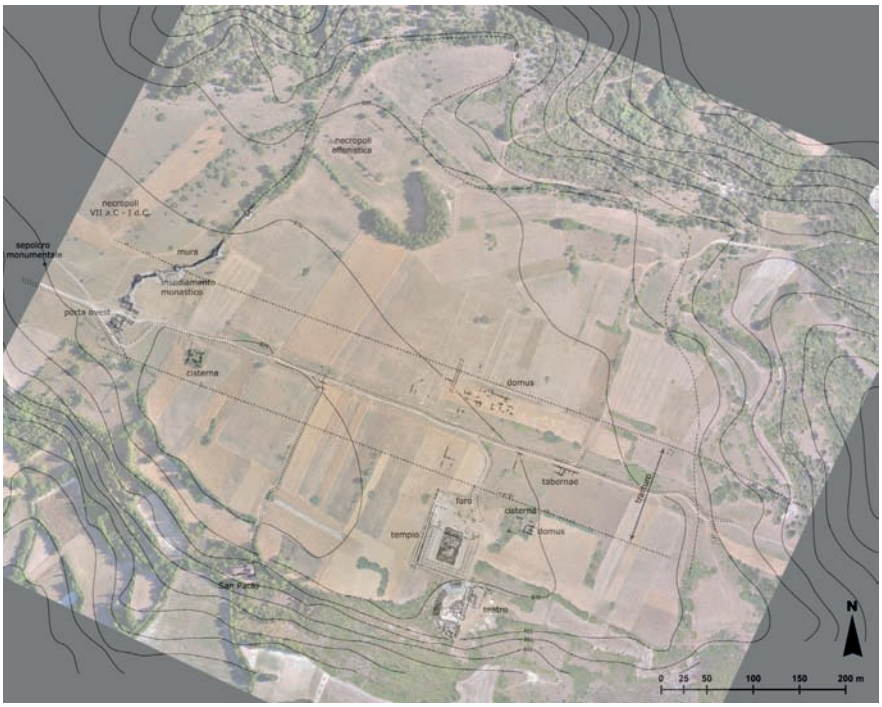

FIGURE 10. *Peltuinum*: orthophoto map of the plateau (2018) and the archaeological map (2019) (produced by A. Vecchione).

Two main necropolises were already known: a Hellenistic one within the Roman city walls, in the northern part of the *plateau*, excavated in 2013 by the University of Chieti; from the aerial photos at least three large groups of tombs are clearly visible. A second extra-urban necropolis dating back to the 7th century BC was also found. This was excavated by the local Superintendency (Acconcia *et al.* 2009; D'Ercole, Martellone 2011) and, after the aerial survey, a comparison between the archaeological maps drawn up during these two archaeological excavations and the aerial orthophotos was possible.

Inside the west gate there was a cistern, well documented during several archaeological campaigns. An elongated feature, clearly visible from RGB, NIR and NDVI images and which is divided into two segments, is connected to a cropmark and these traces are located close to the cistern. An archaeological investigation is needed in order to identify a possible connection between the cropmarks (Fig. 11). Another type of anomaly clearly visible both on historical aerial photography and on recent photos are the signs related to the urban road network of the ancient city (Fig. 12): from the altered colour in the images it is possible to see features located north and south of the *Via Claudia Nova.* The orientation of these anomalies seems to be consistent with the already identified road network and with the orientation of the buildings located in the main public area. Furthermore, the post-ancient road system, or at least the one used to reach the church of San Paolo, is clearly visible from the DEM analysis (Fig. 13). Modern agricultural activity, natural reforestation and even archaeological excavation have partially erased the profile of the road, which was perfectly visible until 1944. The aerial survey campaign also confirmed the features identified during the 1980s that led to the 1983-86 archaeological campaigns being planned: among these, along the main road, are several cropmarks related to minor buildings and secondary roads (Fig. 14).

2.2. Digital data recording applied to the archaeological campaigns 2019-20

During the 2019 and 2020 archaeological excavation campaigns the research team focused on studying the area of the forum of the ancient city and on the post-ancient structures located

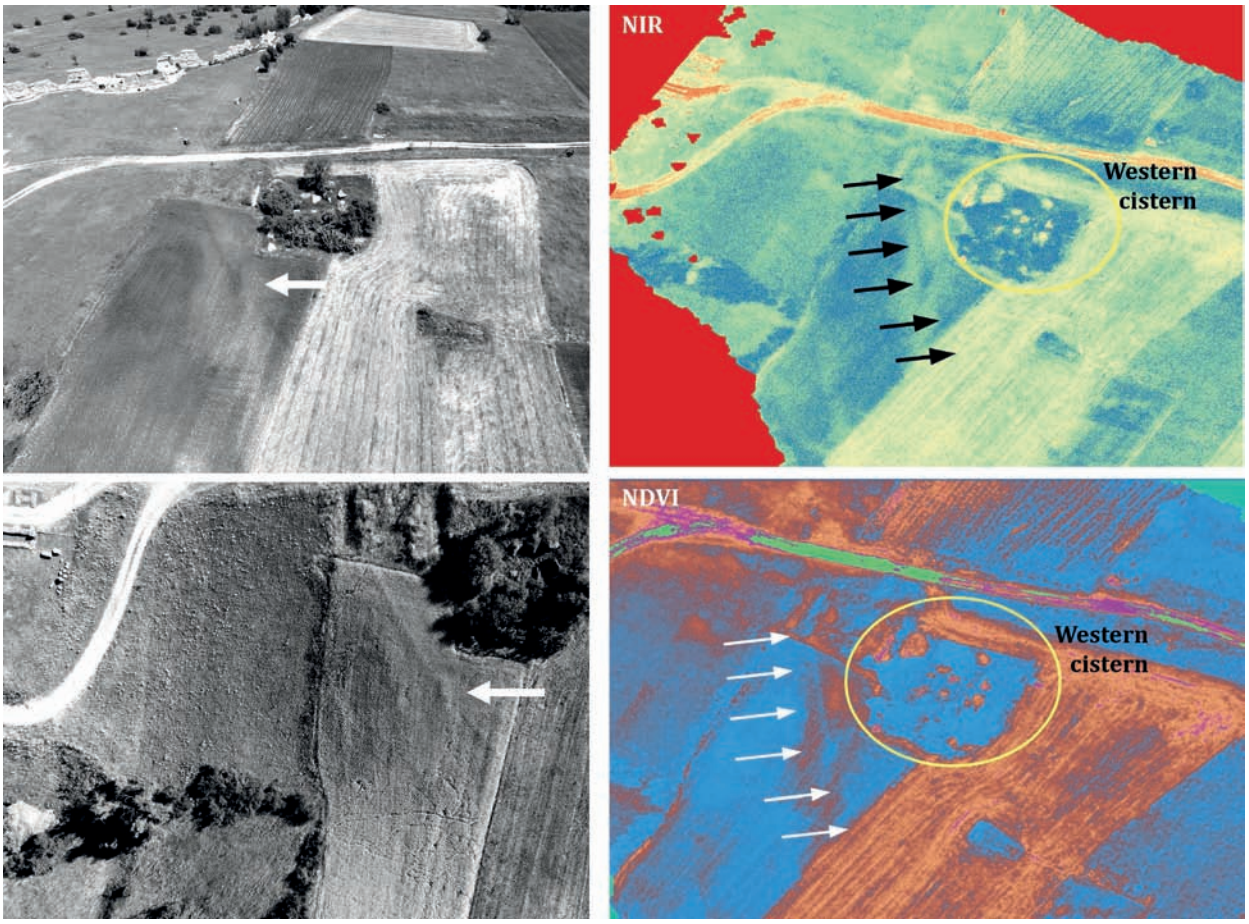

FIGURE 11. *Peltuinum*: possible archaeological feature close to the western cistern, RGB, NDVI, NIR cameras (2019) (produced by A. Vecchione).

close to the Roman theatre. From a methodological point of view it was decided to create several 3D models using a photogrammetric technique: this choice not only allowed the research team to obtain metric and colorimetric documentation but also led to the creation of a multiscale digital access point that would act as a virtual archive for recent and older documentation. A dense network of control points was distributed along the trenches. In order to obtain scaled and oriented graphic drawings on absolute geographic reference systems, the coordinates of the topographic points and part of the targets located on horizontal surfaces were acquired via the GNSS receiver. The great potential of photogrammetry methodology has been confirmed by room ε (Fig. 15). In this case, the survey campaign conducted in 2019 did not allow a complete data set to be collected relating to the northern wall; in fact, the western portion is covered by a wooden support structure. Thanks to the use of images taken during the 2010 and 2011 campaigns, it was possible to develop a photogrammetric model of the portion of the masonry no longer visible. This model was later combined with the one produced in 2019 and a complete orthophoto of the entire sequence of the room was obtained.

In 2020 the archaeological excavation carried out inside room δ (Fig. 15) required a new recording campaign. Inside the post-ancient room, mainly investigated during the 2013-2014 campaigns, part of a Roman sewer was revealed, related to the theatre. In this case too, the updating of the traditional graphic documentation and integration with the

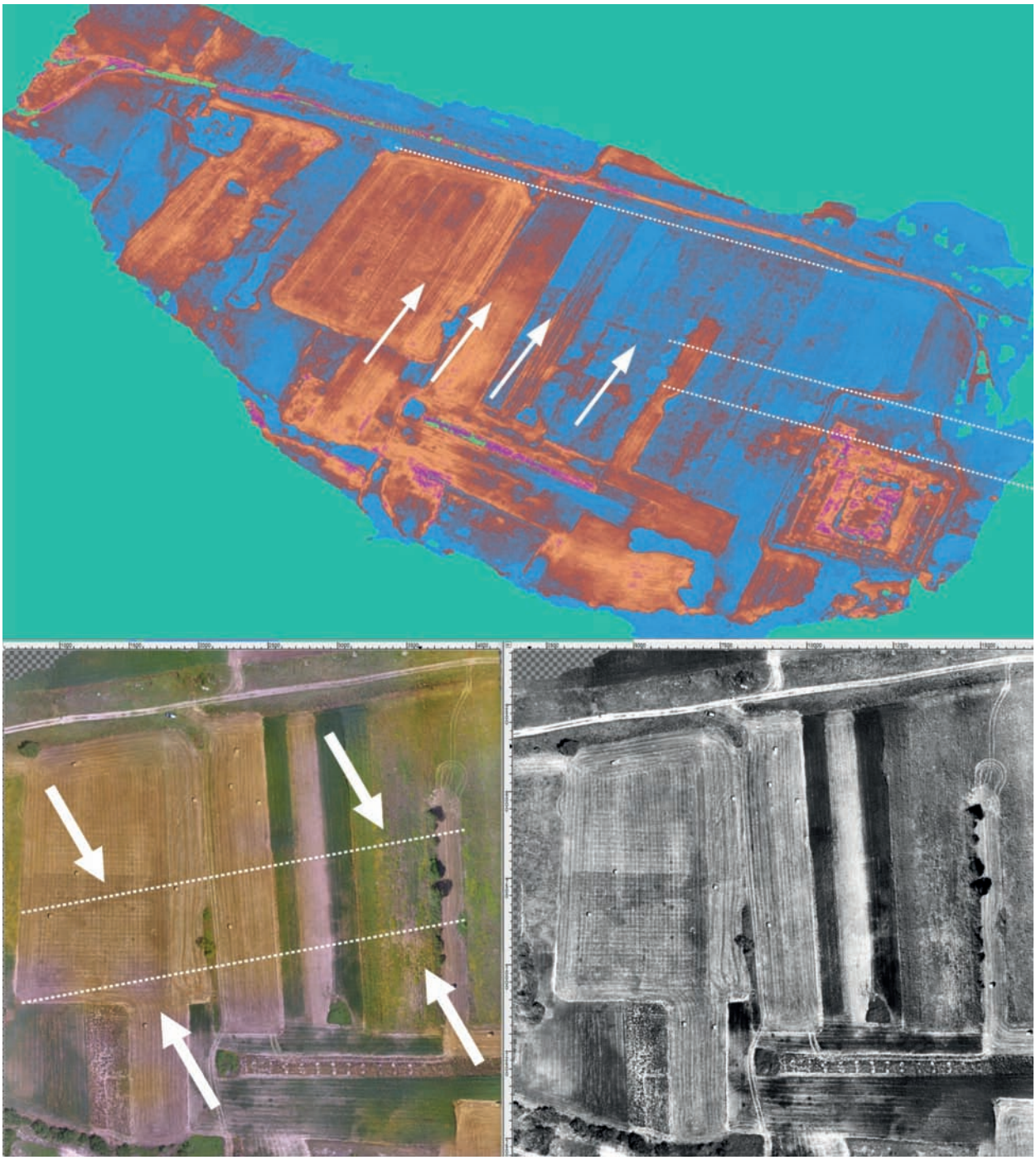

FIGURE 12. *Peltuinum*: anomalies related to the in-wall road network (2017) (produced by A. Vecchione).

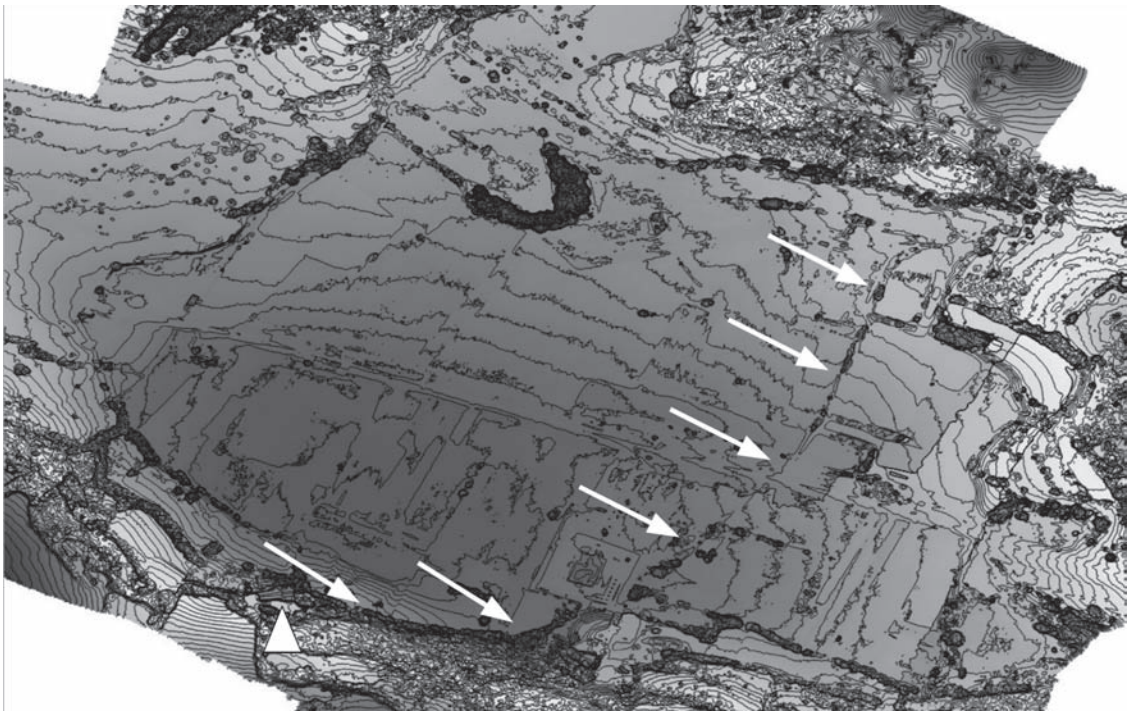

FIGURE 13. *Peltuinum*: anomalies related to the post-ancient road to San Paolo's church (2019) (produced by A. Vecchione).

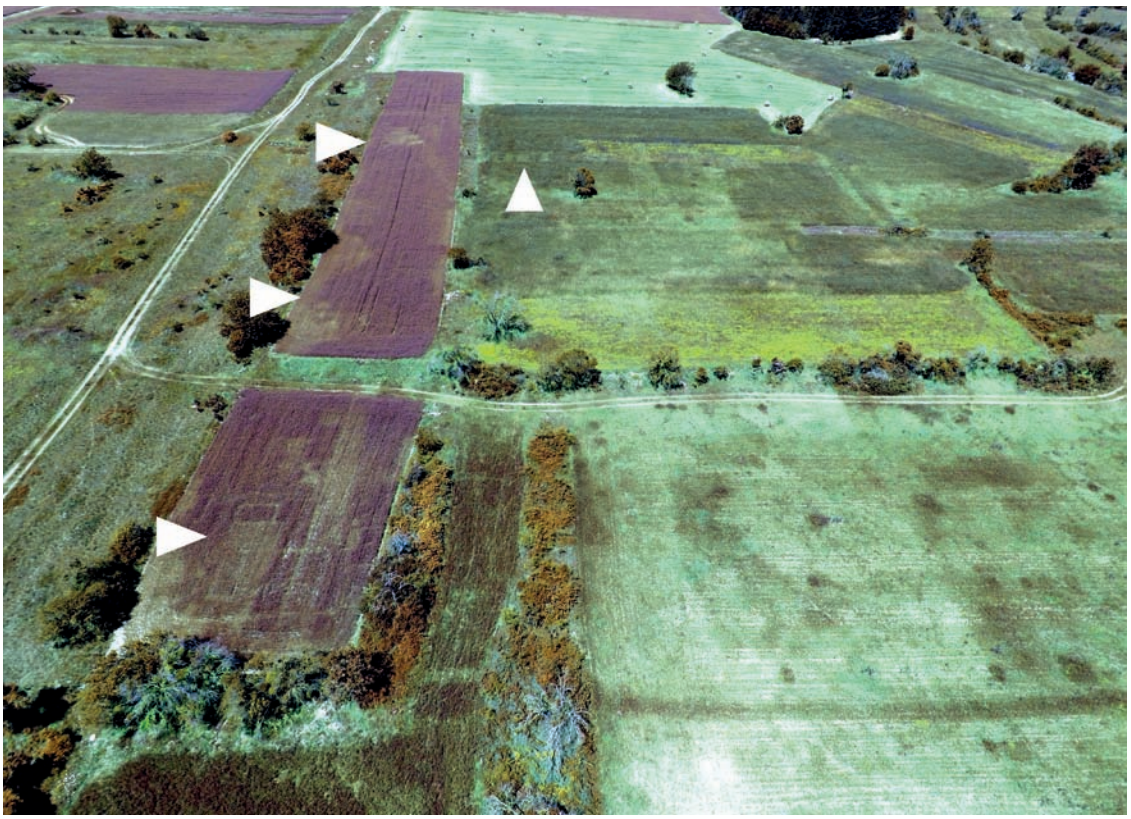

FIGURE 14. *Peltuinum*: cropmarks of minor structures and secondary roads (2017) (produced by A. Vecchione).

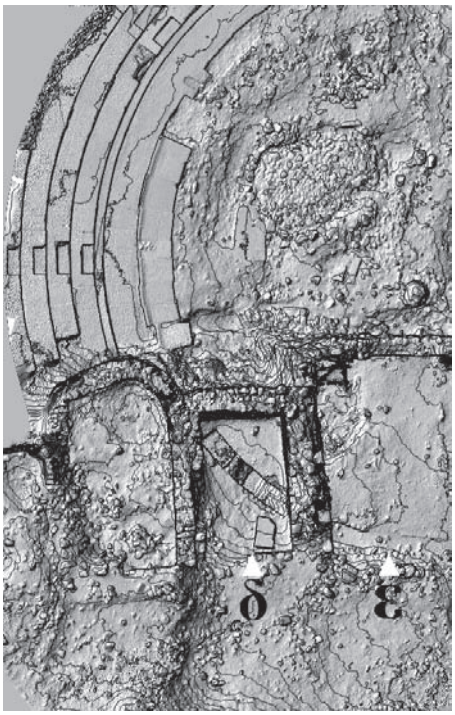

FIGURE 15: *Peltuinum*: post-ancient structures and the Roman theatre *cavea* (2020) (produced by A. Vecchione).

photogrammetric data acquired in the years 2019 and 2020 made it possible to place the new data in correlation with the Roman structures and contextualise them within the ancient orography on which the southern portion of the *cavea* of the theatre was built.

These two examples underline the importance of integrating photographic shots of different excavation campaigns. They also confirm the importance of reusing correctly acquired and complete archival documentation, even in those cases when data collected years later need to be combined. In fact, the heterogeneity of data collected in different years does not normally permit a complete merger of the final documents produced during the different survey campaigns. Given this situation, there is a need to draw up guidelines in order to achieve greater homogeneity with the aim of facilitating future merging operations between documents collected using different tools and methodologies.

2.3. Raw and processed data management

This large amount of digital data posed a serious problem in terms of conservation and accessibility, two of the major pillars of the FAIR manifesto for the management of scientific data which states that, according to the 2016 principles, research data should be Findable, Accessible, Interoperable and Reusable. Taking into consideration the guidelines of this international document, the data collected during the excavation campaigns were entered into a digital archive and these conditions forced the research team to think about a system to manage this large amount of data in order to improve its accessibility, sharing and updating (Vecchione *et al.* 2019). The data were uploaded to a server and managed using a simple Google Chrome browser via the 3DHop tools. 3DHop is an open-source framework for the creation of interactive Web presentations of high-resolution 3D models of up to one hundred million faces, aimed at the Cultural Heritage field. It was developed by the Visual Computing Lab of the Italian National Research Council (Potenziani *et al.* 2014; Scopigno *et al.* 2017; Apollonio *et al.* 2018).

The production of digital 3D documentation forms part of a broader digitisation process conducted through photogrammetric surveys. The digital models produced to document the trenches opened annually during the archaeological campaigns and the structures found were gradually transferred to the digital platform, assuming the function of a 3D archive and container for both new graphic and traditional documentation. The complexity of the data and their heterogeneity suggested a scheme common to both geographic information systems and CAD software should be used; i.e. with virtual containers of information overlapping at different scales. In turn, each of these virtual contents has different information layers within it. In a phase preliminary to data collection, a schedule was designed for the hierarchical organisation of the files: the first level of information is represented by a global 3D model obtained from high-altitude flights (60-70 metres above the ground) and data obtained from aerial photointerpretation (Fig. 16); the second level houses the 3D models of the individual monuments (20-30 metres above the ground) and

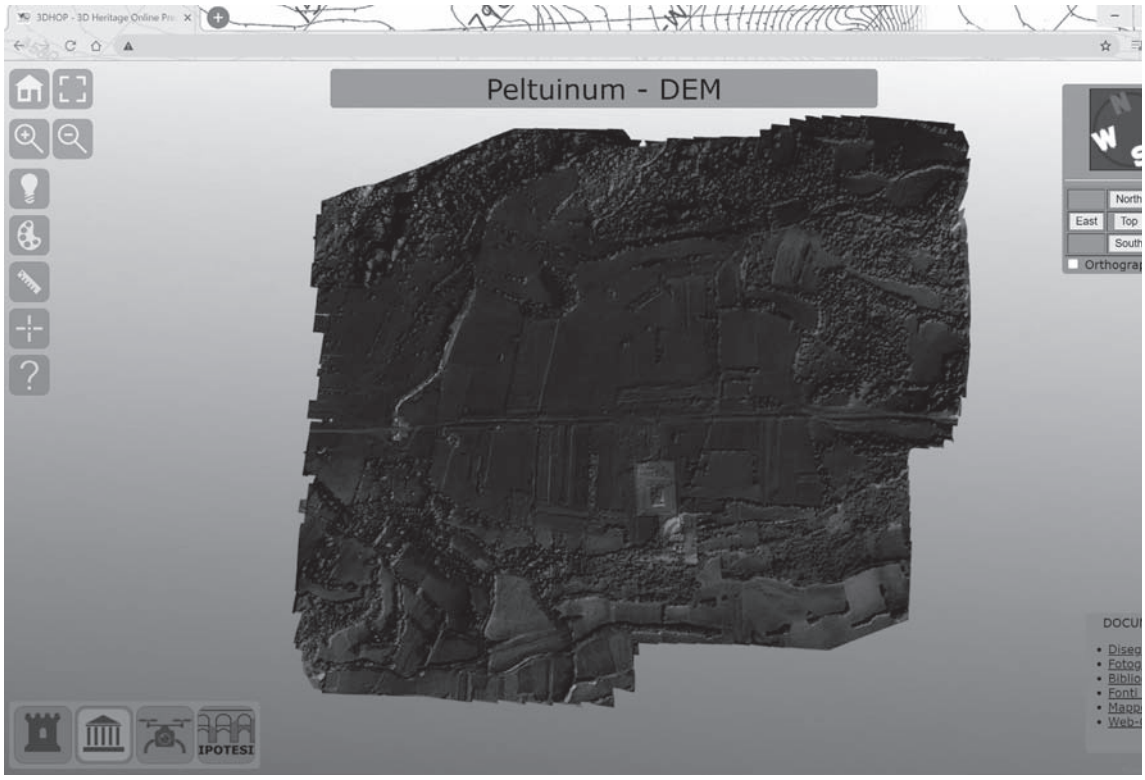

FIGURE 16: *Peltuinum* 3D access point page on 3Dhop tool, main information layer (2019) (produced by A. Vecchione and M. Callieri).

the data obtained from the analysis of the DSM and DTM; the third level presents the detailed 3D models (10-20 metres from the ground and terrestrial photogrammetry) (Fig. 17).

The 3D models were therefore used as both a volumetric hub of information and as navigable access points. The 3D model of the first level is geo-referenced on the WGS85 system while the second and third levels are oriented on the local coordinate system via the support polygon. The models have been corrected and saved in Ply format with attached texture (JPG or PNG formats). Later on, the single models were converted into multi-resolution meshes using the open-source Nexus tool and uploaded to the server for publication. They can be reached via the website URL .

Data accessibility and reuse, two of the four pillars of the FAIR Principles manifesto, are therefore adequately represented in this research context. The ability to access, update and reuse digital data resulting from photogrammetric campaigns through open-source tools means that the digital 3D model contains geographic, volumetric and colorimetric data; it can also act as a virtual access point to the traditional archaeological documentation. Data have to be indexed and divided by area, trench and stratigraphic unit.

In structuring an information system, 3DHOP has been adapted to the needs of the various case studies and has enabled the 2D and 3D archaeological documentation to be integrated. Interaction with the website pages was intuitive, even for less experienced users, and among the most significant advantages of this program is also its adaptability to different contexts and scales, an increasingly necessary feature in the field of cultural heritage. In conclusion, 3DHOP is not only a 3D viewer but can also be used as a crucial research tool that enables bespoke interactive systems to be designed for digital archaeology datasets, which can be shared remotely within multidisciplinary research teams.

A.V.

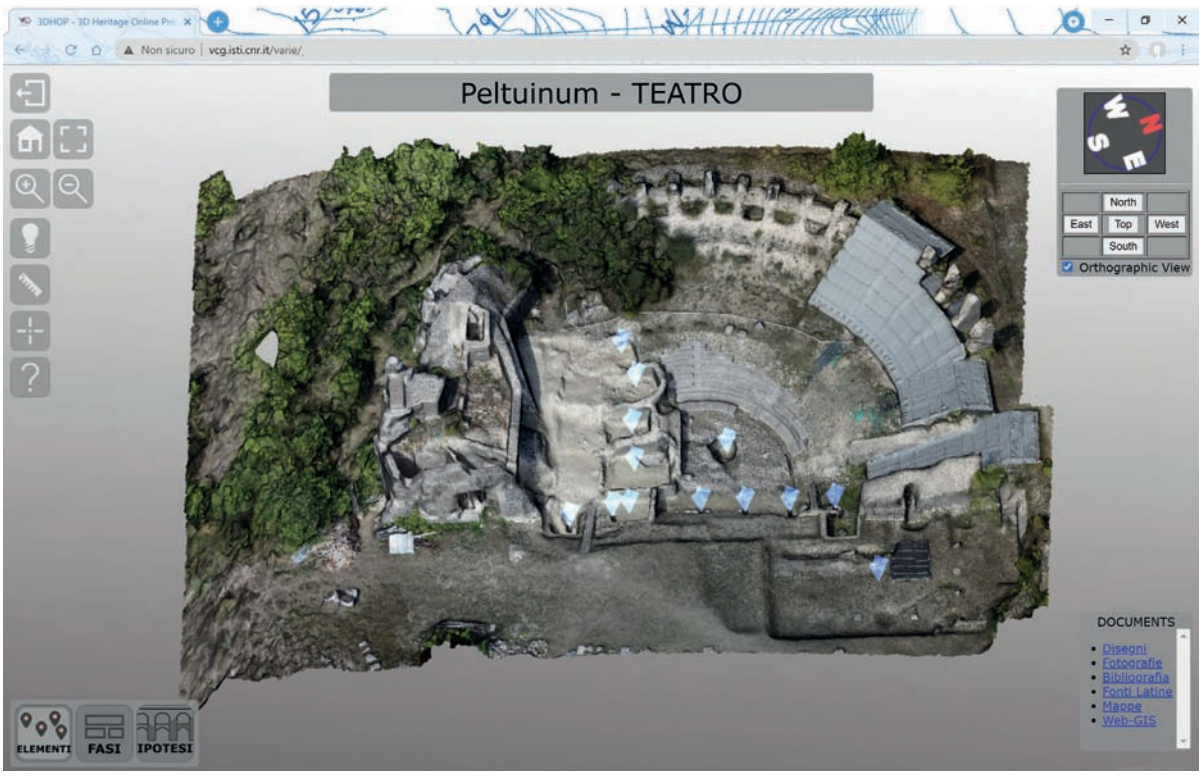

FIGURE 17: *Peltuinum* 3D access point page on 3Dhop tool, secondary information layer (2019) (produced by A. Vecchione and M. Callieri).

2.4. Conclusion

To sum up, the research activity carried out at *Peltuinum* for some years now has focused substantially on the re-evaluation and interpretation of data coming from old archive documentation as well as the contextual application of new investigative methodologies.

The possibility of documenting landscape morphology from an enhanced point of view such as the aerial perspective, and virtually modelling the archaeological structures, led to the creation of a local information system containing 3D data with several layers. This activity enabled 2D and 3D graphic support to be integrated and the results displayed. Given the consistency of the data collected, the team is now thinking of broadening the scope of the project to the surrounding area. The Navelli plain has always been characterised by a low population density and is primarily agricultural; moreover, the possibility of merging photogrammetric workflow with Lidar data would enable us to further our knowledge of those sectors that have slowly been recovered from wooded areas. A combination of these methods would facilitate the collection of very interesting data, helping to understand the settlement dynamics of the area and with a particular focus on the Roman and post-ancient eras.

These activities (which take place in addition to the annual archaeological excavation campaigns) are providing an increasingly complete and detailed reconstruction of the ancient city and the surrounding territorial context.

D.C. & A.V.

BIBLIOGRAPHY

ACCONCIA, Valeria; D'ERCOLE, Vincenzo; LERZA, Francesca (2011). "*Peltuinum* (Prata D'Ansidonia, AQ): le indagini del 2009 nella necropoli preromana". *Quaderni di Archeologia d'Abruzzo*, 1/2009, 182-185.

ADAMESTEANU, Dino (1963). "L'Aerofototeca". *Archeologia: Rassegna di studi e ricerche*, no.1 vol. 5, 1-3.

APOLLONIO, Fabrizio Ivan *et alii* (2018). "A 3D-centered information system for the documentation of a complex restoration intervention". *Journal of Cultural Heritage*, 29, 89–99.

BIANCHI, Fulvia (2012). "Il tempio del foro". *RendPontAcc,* LXXXIV, 287-330.

BUONOCORE, Marco (1998). "Peltuinum. Fonti epigrafiche". In: BUONOCORE, Marco; FIRPO, Giulio. *Fonti latine e Greche per la storia dell'Abruzzo antico II, 2*. L'Aquila: Edizioni libreria Colacchi, 864-891.

BUONOCORE, Marco (2007). "La tradizione letteraria ed epigrafica di Peltuinum in età romana". In: CLEMENTI, Alessandro (ed.). *I campi aperti di Peltuinum dove tramonta il sole... Saggi sulla terra di Prata d'Ansidonia dalla protostoria all'età moderna*. L'Aquila: Edizioni libreria Colacchi, 135-178.

BUONOCORE, Marco (2011). "Ancora nuovi documenti da Peltuinum". *Epigraphica*, LXXIII, 324-332.

CAMPANELLI, Adele (1996). *Peltuinum. Antica città sul tratturo*. Comunità montana di Campo Imperatore – Navelli: Carsa Edizioni.

CANINO, Dario; MIGLIORATI, Luisa; TRIVELLONI, Ilaria (2021). "Documentazioni di pavimentazioni dall'area archeologica di Peltuinum (AQ)". In: *Atti del XXVI colloquio AISCOM (2020)*. Rome: Edizioni Quasar, 293-303.

D'ERCOLE, Vincenzo; MARTELLONE, Alberta (2014). "*Peltuinum* (Prata D'Ansidonia, AQ). Seconda campagna di scavo nella necropoli". *Quaderni di Archeologia d'Abruzzo*, 3/2011, 345-350.

LA REGINA, Adriano (1964). "Peltuinum". *Quaderni dell'Istituto di topografia antica della Universita di Roma*. Rome, vol. I, 69-72.

LABATE, Donato *et alii* (2009). "Modena, Parco Novi Sad. Deposito archeologico pluristratificato con strutture databili dall'età del ferro all'età moderna". In: *Atti e memorie. Deputazione di storia patria per le antiche provincie modenesi, s. XI*, vol. XXXIII. Modena: Aedes Muratoriana, 434437.

MIGLIORATI, Luisa (2007). "Peltuinum: un aggiornamento". *Rivista di Topografia Antica*, 17, 107-126.

MIGLIORATI, Luisa (2008). "Peltuinum. Un caso di "pietrificazione" di un'area di culto". In: *Saturnia Tellus. Definizioni dello spazio consacrato in ambiente etrusco, italico, fenicio-punico, iberico e celtico. Atti del convegno internazionale Svoltosi a Roma dal 10 al 12 novembre 2004.* Rome: Consiglio Nazionale delle Ricerche, 341-356.

MIGLIORATI, Luisa (2011-2012). "La città e il territorio". *RendPontAcc,* LXXXIV, 351-386.

MIGLIORATI, Luisa (2014). "Gli scavi di Peltuinum". In: BOURDIN, Stéphane, D'ERCOLE, Vincenzo (eds.). *I Vestini e il loro territorio dalla preistoria al medioevo*. Rome: Collection de l'Ecole Francaise de Rome, 494, 249-260.

MIGLIORATI, Luisa *et alii* (2017). "Sepolti nel teatro: il valore simbolico dei cani in sepolture comuni infantili". *Scienze dell'antichità. Storia, archeologia, antropologia,* 23, Fasc. 3, 593-611.

MIGLIORATI, Luisa; CANINO, Dario (2014). "Note di Topografia Vestina". *Scienze dell'antichità. Storia, archeologia, antropologia*, 20, Fasc.1, 127-139.

MIGLIORATI, Luisa; CANINO, Dario (2016). "Peltuinum: nuove ricerche". *Scienze dell'antichità. Storia, archeologia, antropologia*, 22, Fasc.1, 53-64.

MIGLIORATI, Luisa; CASAZZA Giulio; SGRULLONI Tiziana (2018). "Nuove indagini sulle fortificazioni di Peltuinum". *Scienze dell'antichità. Storia, archeologia, antropologia*, 24, 295-308.

NEPI, Daniele (2012). "Il teatro. Aspetti architettonici". *RendPontAcc,* LXXXIV, 333-350.

NEPI, Daniele (2014). "Il teatro di Peltuinum. Studio tecnico strutturale". In: BOURDIN, Stéphane; D'ERCOLE, Vincenzo (eds.). *I Vestini e il loro territorio dalla preistoria al medioevo*. Rome: Collection de l'Ecole Francaise de Rome, 494, 261-264.

SCOPIGNO, Roberto *et alii* (2017). "Delivering and using 3d models on the web: are we ready? distribución y uso de modelos 3d en la web: ¿estamos listos?". *Virtual Archaeology Review*, 8, 1-9.

SGRULLONI, Tiziana (2015). "Peltuinum (Prata d'Ansidonia AQ). Stratigrafia e materiali dell'ambiente ε". *Quaderni di archeologia d'Abruzzo. Notiziario della Soprintendenza per i beni archeologici dell'Abruzzo*, 3/2011, 356-359.

SOMMELLA, Paolo (1995). "Il culto di Apollo a Peltuinum città dei Vestini". *Caesarodunum. Melanges Raymond Chevallier*, Tome XXIX, Vol. 2, 279-291.

POTENZIANI, Marco *et alii* (2015). "3DHOP: 3D Heritage Online Presenter". *Computers & Graphics*, vol. 52, 129-141.

TARTARA, Patrizia (2008). "Apporti della fotografia aerea all'identificazione delle necropoli e degli insediamenti vestini". In: TAGLIAMONTE, G. (ed.). *Ricerche di archeologia medio-adriatica I. Le necropoli: contesti e materiali.* Atti dell'Incontro di Studio (Cavallino-Lecce 2005), Galatina (LE), Congedo Editore, 163-194.

VECCHIONE, Alessandro *et alii* (2019). A. Vecchione, A. Lureau, M. Callieri, "Gestione del dato archeologico tridimensionale via web: l'esperienza con il software 3DHop del CNR-Isti". *Archeologia e Calcolatori*, XXX, 335-339.

WONTERGHEM, Frank van (1999). "Il culto di Ercole e la pastorizia nell'Italia centrale". In: Petrocelli, E. (ed.). *La civiltà della Transumanza*. Isernia: Cosmo Iannone Editore, 414-428.