heritage

Article

Geoheritage and Cultural Heritage Interface in a Place of Worship: The Historical Development of the Monumental Complex of San Francesco le Moniche in Aversa (Italy) and Its Underground Artificial Cavities

Daniela Ruberti [1,*], Maria Assunta Fabozzi [1], Paolo Maria Guarino [2], Ivana Guidone [3,4], Arcangelo Pellegrino [5] and Marco Vigliotti [1]

[1] Dipartimento di Ingegneria, Università degli Studi della Campania "Luigi Vanvitelli", 81031 Aversa, Italy; mariaassunta.fabozzi@unicampania.it (M.A.F.); marco.vigliotti@unicampania.it (M.V.)
[2] ISPRA—Istituto Superiore per la Protezione e la Ricerca Ambientale, 00155 Rome, Italy; paolomaria.guarino@isprambiente.it
[3] Dipartimento di Ricerca e Innovazione Umanistica, Università degli Studi di Bari, 70122 Bari, Italy; ivana.guidone@uniba.it
[4] CNR-ISPC—Consiglio Nazionale delle Ricerche-Istituto di Scienze del Patrimonio Culturale, Campus Universitario Ecotekne, 73100 Lecce, Italy
[5] Ministero della Pubblica Istruzione, 81031 Aversa, Italy; arcangelo.pellegrino@liceocirillo.edu.it
* Correspondence: daniela.ruberti@unicampania.it

check for updates

Citation: Ruberti, D.; Fabozzi, M.A.; Guarino, P.M.; Guidone, I.; Pellegrino, A.; Vigliotti, M. Geoheritage and Cultural Heritage Interface in a Place of Worship: The Historical Development of the Monumental Complex of San Francesco le Moniche in Aversa (Italy) and Its Underground Artificial Cavities. *Heritage* **2024**, *7*, 5839–5864. https://doi.org/10.3390/heritage7100275

Academic Editor: Dmitry A. Ruban

Received: 13 September 2024
Revised: 15 October 2024
Accepted: 17 October 2024
Published: 18 October 2024

Abstract: The case study of the monumental complex of San Francesco le Moniche, built in the ancient Norman county Aversa, in northern Campania (Italy), is analyzed here. The cultural heritage of the complex and the additional value associated with geoheritage (building stones and underground extraction cavities) have been highlighted. The building stratification of the complex was reconstructed based on documentary sources, including historical cartography and photographic documentation of postcards from the early 1900s. It began around 1200 and ended in the 20th century; part of the original citadel was dismantled and incorporated into the urban fabric in the Fascist era. The building stratification of the complex was also read from the distribution and architecture of the existing underground cavities from which the building stones were extracted. The subsoil, reconstructed on the basis of geological and geophysical data, is made up of a tuff substrate, starting from approximately 5–6 m from the ground level, which represents the main building stone as well as being an important testimony to the long volcanological history of northern Campania. Laser scanner surveys of the known and accessible cavities were carried out to obtain a three-dimensional view of the entire monumental complex and its underground spaces. The results provide a clear example of a geoheritage–cultural heritage interface which reminds us of the importance of an integrated approach in their valorization, specifically in urban areas. Additionally, the results of the study allowed us to improve the knowledge of the complex and the site, and provide useful tools for the planning of future targeted investigations.

Keywords: Campanian Plain; Italy; monumental complex of San Francesco le Moniche in Aversa; Campania Grey Tuff; underground cavities; building stone; architecture; cultural heritage; geoheritage; historical cartography; multidisciplinary characterization; laser scanner

1. Introduction

In recent years, multiple linkages between cultural heritage and geoheritage have been identified and highlighted [1,2], although the term "geoheritage" is more often related to rock, fossil and landform records [3]. The themes underlying geoconservation contribute to cultural heritage, especially in an architectural context, for example, where the preservation of buildings of cultural interest also involves the adequate consideration of building stone heritage. Indeed, attention has increasingly been paid to building and decorative stones as heritage features from a cultural, historical, archeological and architectural point of view [4]. They can be considered as evidence of local natural resources and offer insights into the evolution of the Earth, becoming significant also for research and teaching [1,5] Therefore, stone heritage represents a theme of growing interest with numerous examples from European cities, and the World Heritage Committee of UNESCO stated in 1972 that it is not possible to separate natural from built heritage [4–6].

The geological background of these cities can be read not only in famous historical buildings erected from characteristic stones and from the way in which these rocks were assembled and worked, but also from the sites of stone extraction, that is, ancient quarries, often located within the cities or in the subsoil [7].

The use of natural mineral resources is also considered a topic at the interface between geoheritage and cultural heritage, aspects that are readable in the various sites and methods of extraction, up to the use of rock blocks and their transport to destination sites. From this perspective, quarrying can be considered part of cultural heritage, including excavation techniques; the architecture of the underground cavities, up to their subsequent reuse, is sometimes also converted into burial areas (under places of worship) and is in turn included in "cemeterial geotourism" [8,9]. These artificial cavities are considered a witness of the historical relationship between man and territory and have become the object of study as "underground heritage", also emphasizing the use of stone resources for buildings, including conversion to other uses, sometimes as dwelling houses [10].

Therefore, the enhancement of the architectural, artistic and landscape heritage cannot be separated from a detailed knowledge of the underground environments of anthropic origin. The growth of cities has not only obliterated previous landforms, but has also eliminated traces/evidence of the sites of origin of building stones, to the point of representing a risk for city structures' susceptibility to sinkholes where these sites are in the subsoil [11–15]. This is even more dramatic when it happens underneath buildings of historical and cultural interest. From this perspective, the Italian Speleological Society recognized and provided a classification of artificial cavities, later adopted by the International Union of Speleology [16,17], thus attributing a cultural dimension to mining and quarrying that has increasingly received recognition from the World Heritage Committee of UNESCO [2].

Geological exploration thus becomes fundamental for the identification and characterization of the hypogea, in addition to the stability analysis that allows for the verification of the maintenance conditions and the possible reuse of the hypogea themselves [18,19]. The development of indirect, non-invasive analysis techniques, such as Electric Resistivity Tomography (ERT), Ground Penetrating Radar (GPR) and Seismic Tomography, helps to locate voids in the subsoil and to recognize their extent, which, currently, can then be accurately mapped at the mm scale through laser scanner surveys, which allow the exact distribution of voids in the subsoil to be visualized [20,21].

Geoheritage aspects also benefit from the support of artistic and literary documentation. Artistic presentations of sites that have been destroyed or altered can help to decipher the landform changes that occurred through time and to read any signs of past characteristics [22]. In this sense, the analysis of paintings, postcards and historical maps would help understand the above changes and valorize what remains as evidence of them. It is well known, in fact, that bibliographic and archival sources are essential for tracing and understanding the different socio-cultural contexts during various eras [23] which have determined important urban and landscape transformations [24–26]. Historical cartography offers a unique perspective on the geospatial development of an area [27]: historical maps not only represent territories, but also reflect the perception and knowledge of the world in different eras [28], and therefore allow urban expansion and landscape transformations to be traced, offering insights into urban planning and infrastructure development [29] and, with the support of historical sources, valuable information for the conservation and valorization of the historical-architectural heritage [30]. Historic illustrations (author's sketches, drawings and photographs) are also a window on the past, offering a visual confirmation of places and a detailed picture of their transformations over time, contributing to the understanding of their evolution [31–34].

Finally, it should be underlined that many sites which are recognized as having a high cultural value, also as UNESCO World Heritage sites, can contain interesting information both in terms of landforms and rock outcrops [35], which, in turn, significantly help in the interpretation of the history and evolution of these cultural heritage sites [36].

In northern Campania (Southern Italy), the historic center of many towns is characterized by the widespread presence of underground cavities excavated in the pyroclastic deposits widely distributed in the subsoil of the plain areas [37–47]. These deposits are mainly composed of thick tuff units characterized by good geomechanical behavior. The tuff rock was extracted from the subsoil as building stone; starting from vertical access points excavated from the ground level, the tuff was extracted by creating cavities with "bottle" or "bell" shapes [46,47]. The presence of these underground cavity networks testifies to the multi-centennial exploitation of local geo-resources through the extraction of the tuff rock, widely used in construction, from ancient structures through medieval convents and basilicas to seventeenth-century churches and palaces and up to modern-age buildings [48]. The resulting underground environments then responded to various social needs, such as the conservation of agricultural products, the burial of the dead, the cult of saints and the general hydraulic needs of inhabited areas such as the transport and storage of water, both rain and spring. Therefore, these underground environments, in addition to guarding any archeological finds, are themselves architectural assets of considerable cultural and scientific value.

On this basis and considering the importance of such elements as attractors for tourism, a multidisciplinary study was conducted on a worship in the Caserta area: the monumental complex of San Francesco le Moniche, in Aversa (13th century CE). The stratification of the complex can be read not only from documentary sources, old photos and postcards, but also from the distribution and architecture of the existing cavities. The recovery can certainly be included in a geotourism itinerary also based on its virtual presentation.

2. Study Area

2.1. Geological Context

The study area, in the north-western part of the Campania Region (Italy; Figure 1a) corresponds to the northern and north-eastern part of the Campanian Plain, a broad, complex graben closely controlled by NE-SW, NW-SE and E-W normal fault activity, established in the Late Pliocene or the Early Pleistocene along the Tyrrhenian side of the Apennine Mountains. The sedimentary evolution of this graben was conditioned by the fluvial and marine processes and the volcanic activity of the Campi Flegrei, Somma-Vesuvius and Roccamonfina volcanoes [49–54].

The considered sector of the plain is characterized by a flat morphology between 95 and 20 m a.s.l. In this area the subsoil is formed by the succession of different units composed of volcaniclastic deposits, in particular related to the Campania Grey Tuff (CGT; 39 ky B.P) [55] and Neapolitan Yellow Tuff (NYT; 15 ky B.P.) [56] pyroclastic eruptions from the Campi Flegrei volcanic district [57].

The CGT deposits, in particular, were settled on the whole Campanian Plain, giving rise to a thick (up to 40 m thick), laterally continuous volcaniclastic unit, characterized by different lithofacies mostly derived from the different mineralogic composition [58–60]. The good mechanical characteristics of the tuff lithofacies justify the presence of numerous quarries and/or cavities, according to the availability of adequate thicknesses of coherent lithofacies [46,47].

The city of Aversa is located in the Campanian Plain north of Naples and was built on a flat surface characterized by a predominantly volcaniclastic substrate originating from the eruptive activities of the Campi Flegrei volcanic complex. The CGT, in particular, present a few meters from the surface, is predominantly in its yellow and gray lithofacies, with good mechanical characteristics, and has therefore been the object, in the history of the city, of numerous underground mining activities.

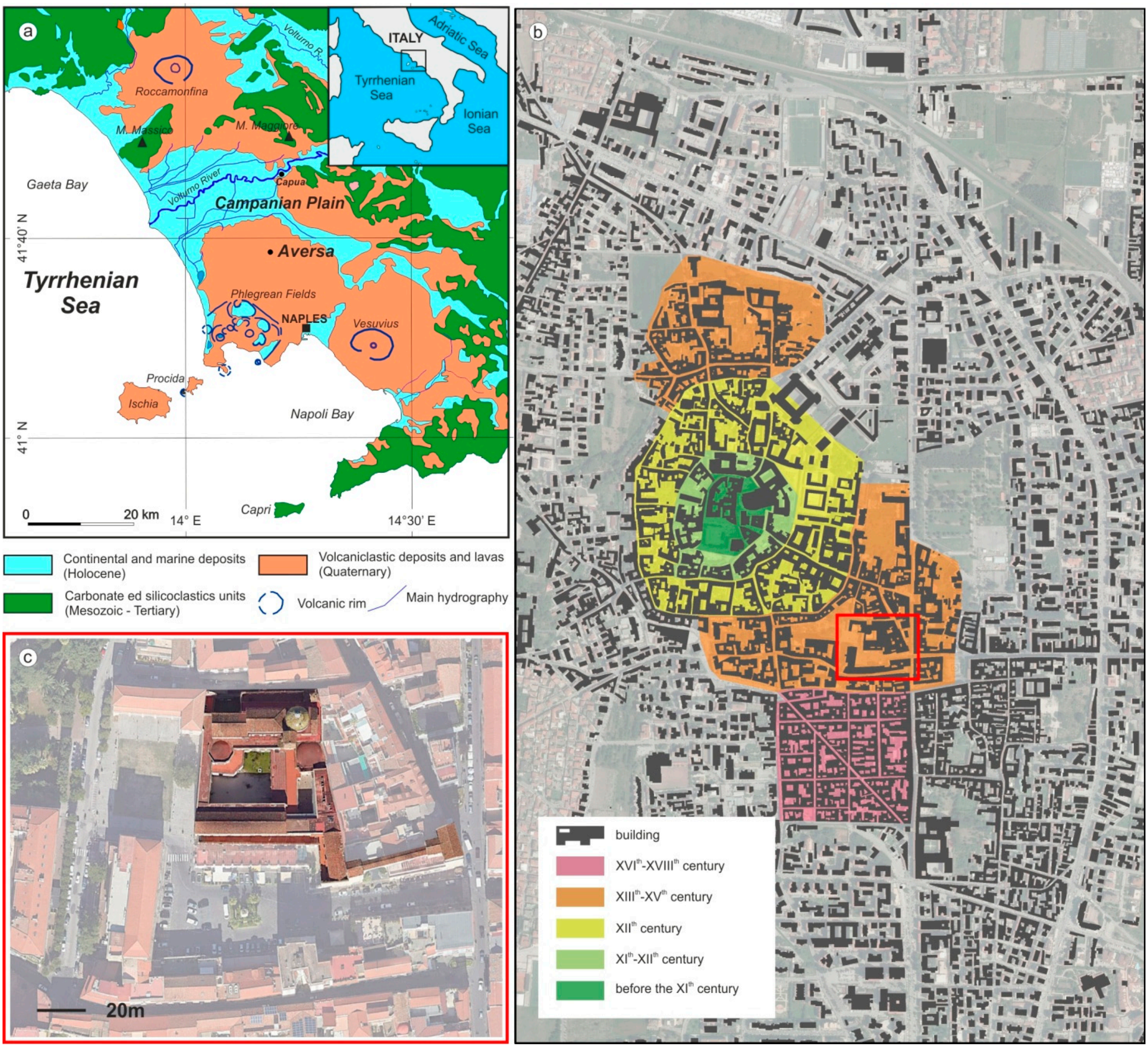

Figure 1. Location map of the study area and the monumental complex of San Francesco le Moniche. (**a**) Geographical and geological framework of the Campanian Plain and location of the city of Aversa (from [46], modified); (**b**) urban evolution of the city in various historical periods [61,62]; the study site is indicated by the red rectangle; (**c**) aerial view of the current San Francesco complex (Google Earth image; 14.206673° E, 40.973515° N) and surrounding areas.

2.2. Historical Context

The city of Aversa has had a rich and complex history that has determined various architectural and urban transformations over the centuries (Figure 1b) [61,62]. The historic center still preserves significant traces of the Norman, Angevin and Aragonese eras, with religious and civil buildings of great historical and artistic value. From an urban planning point of view, Aversa has a compact fabric in the historic center, with narrow and winding streets typical of medieval cities, while the more modern areas develop with a more regular and wide road system.

According to proven historical evidence, Aversa developed in the territory where in the 11th century the hamlet of Sancti Pauli at Averze existed, placed in a position of dominance on the main communication routes between the north and the south and between the inland countries and the sea [63]; however, it was the Normans who founded the city in 1030 [61–64]. During the Norman period, the city became an important political and military center, with the construction of the castle, which served as a residence and fortification. The territory was characterized by the presence of hedges and ditches. However, it was the increased military strength, the increase in population and the decision to close a section of the ancient road between Capua and Naples (today's Via Roma) that determined, from an urban planning point of view, the transformation of the Angevin city from a radiocentric system to a linear scheme, with a substantial expansion of the perimeter walls since the 13th century [62,64].

Aversa maintained its strategic importance with the arrival of the Swabians and then the Angevins, between the 13th and 14th centuries [61,64]; the latter marked a period of intense development for the city. The multiplication of religious foundations should also be considered in this sense, which, following alliances concluded with the ecclesiastical apparatus, gave the city a sacred character. Above all, following a weakened predominance of the communities inspired by the rule of Saint Benedict, the city recorded the spread of numerous male and female places of worship, including the complex of San Francesco le Moniche, which was incorporated into the walls after the Angevin expansion of 1382 (Figure 1c).

The Spanish domination of the Aragonese marks a further urban and architectural renewal of the city [64,65]. Starting from the end of the sixteenth century, numerous noble palaces and churches were built in the central nucleus of the urban layout, which had the effect of decentralizing the population towards the peripheral areas.

The creation of the "Lemitone" district can be dated back to the early 17th century. It arose on the extreme south-eastern edge of the city, with a plan that follows the pattern of the Spanish quarters of Naples [65]. The construction of the new district marked the definitive abandonment of the medieval radiocentric plan, giving rise to a quadrilateral-shaped plan, within which the area was divided by the orthogonal axes of the communication arteries and cut, in an oblique direction, by a main road [66].

In the Baroque era, the city was further enriched with elaborate decorations on pre-existing monumental structures [62,64]. In the 19th century, Aversa experienced further urban expansion with the construction of new streets and squares. The city was modernized while maintaining its historical heritage. In the 20th century, the historic center of Aversa was gradually abandoned, while new residential and commercial areas developed in the surrounding area, as evidenced by the neighborhoods, born in a wild manner, starting from the 1960s in the southern area, to the detriment of a failed recovery of the historic center which, with the exception of some interventions, is in a state of pitiful abandonment.

2.3. Architectural Context

The monumental complex of San Francesco le Moniche originated between 1219 and 1234 [61]. It was a true monastic citadel measuring approximately 1 hectare. It is the result of building stratifications that began from the date of its foundation until the 20th century. The entire citadel was dismembered, especially during the Fascist period. In particular, what was originally the garden of the ecclesial complex was transformed into a square and connected directly to the railway station, cutting through the Franciscan insula [67].

Currently, the monumental complex of San Francesco le Moniche consists of the following (Figure 2a,b):

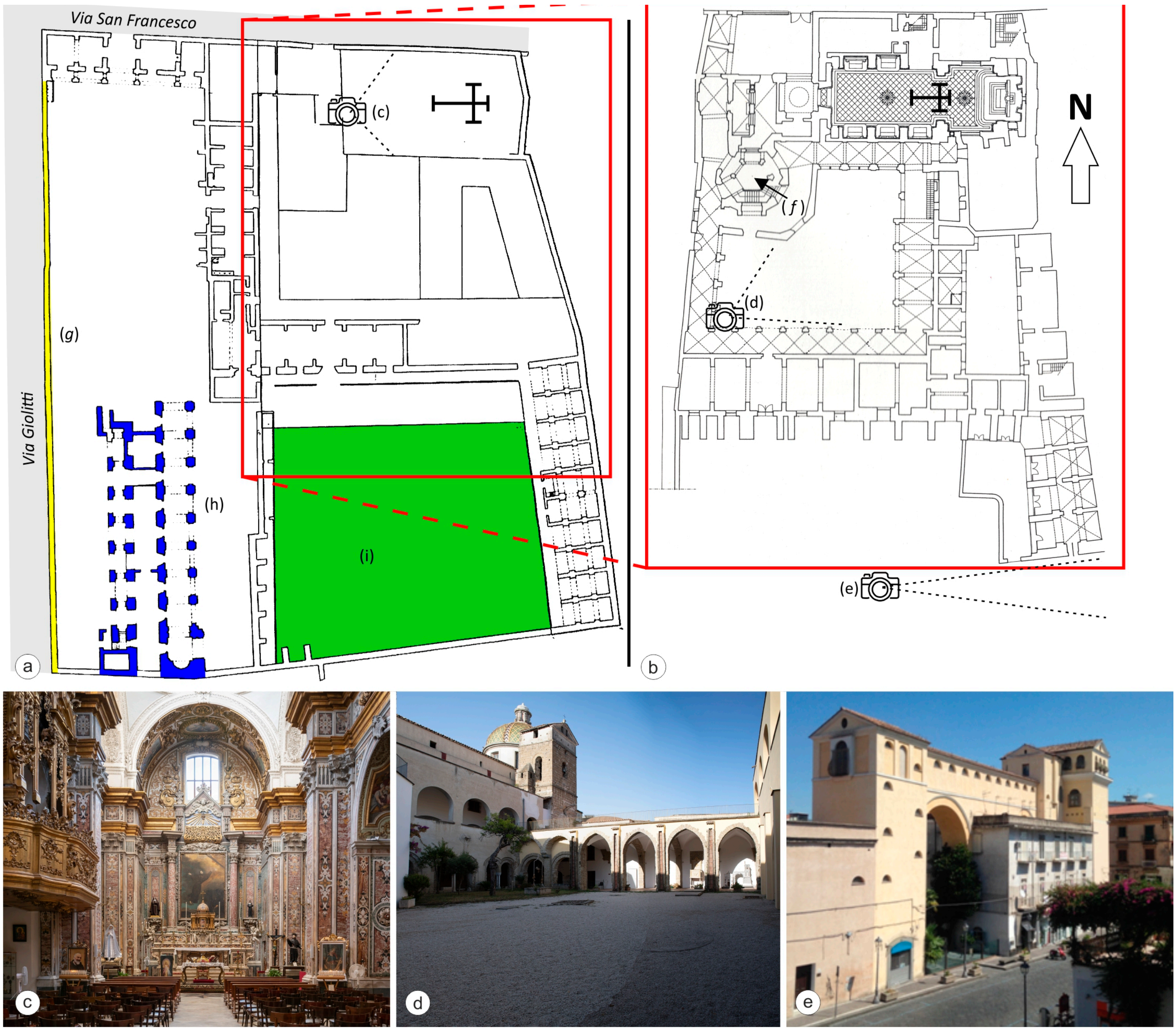

Figure 2. Plan of the monumental complex, both of the original insula (**a**) (from [68], modified) and of the current configuration (**b**) (from [65], modified). The labeling in the plans highlights some details described in the text (to which one should refer for further explanations): (**c**) church (also in photo (**c**); (**d**) cloister with view of the dome and bell tower and portico (also in photo (**d**); (**e**) belvedere (also in photo (**e**); (**f**) octagonal staircase; (**g**) western perimeter wall (in yellow); (**h**) Palazzo San Francesco (in blue); (**i**) garden (in green). Ph. M. Vigliotti.

(1) The church, in Baroque style, with a single nave covered by a barrel vault, on the sides of which there are chapels and the sacristy (Figure 2c); the presbytery is covered by a dome externally covered with colored tiles (Figure 2d) [67];

(2) The cloister, which lost its typical medieval rectangular shape (*d* in Figure 2b) with the construction of the octagonal staircase in the north-western corner in the 18th century;

(3) The belvedere (Figure 2e), a building with a complex structural articulation, composed of three climbing structures and a long corridor gallery. This path culminates in a suspended pathway that leads to the heart of the belvedere, an environment divided into two levels connected by a staircase. This architectural jewel of extraordinary interest, unique in its kind, allowed the nuns a privileged view and participation in the sacred processional rites that took place along the Reggia Strada (now Via Roma) [68];

(4) The octagonal staircase (*f* in Figure 2b), conceived as an open staircase with a single ramp with an independent static structure. In fact, each change in direction and each portion of the ramp, on a flying buttress, are supported by quadrangular pillars.

On the western side, a very high wall enclosed the complex on Via Giolitti (*g* in Figure 2a). The complex included Palazzo San Francesco, where the public schools were located (*h* in Figure 2a), the current seat of the City Hall; and a large garden, currently Piazza Municipio (*i* in Figure 2a).

Below the current complex, there are several voids in the ground: one is used as a burial area, one as a cellar and, finally, a water cistern. Other voids are known on the southern edge of the original garden, while there is no information on the subsoil of the current Piazza Municipio, characterized by frequent deformations of the road pavement.

3. Materials and Methods

3.1. Historical Documents

To describe the evolution of the San Francesco le Moniche complex, the use of bibliographic data, archival sources, historical cartography and old illustrations has proven to be a fundamental pillar for the historical, architectural and urban research of the site.

The Topographic Map of Italy, 184 I-NO (AVERSA), at a scale of 1:25,000, in the editions of 1906, 1936 and 1957, was used to highlight the urban transformations that occurred in the first half of the 20th century. The different maps were georeferenced, using the Ground Control Point (GCP) technique as a georeferencing method. This allowed the researchers to overlap the maps and therefore to highlight the urban changes.

The combination of bibliographic data with historical cartography was validated in some cases through the use of old illustrations, especially vintage postcards, from the first half of the 20th century.

3.2. Subsoil Geological Characterization

Available borehole data and geophysical investigations were used to reconstruct the stratigraphic framework of the subsoils. The data come from a database developed over the years by the authors at the Engineering Department and deriving from both specific investigations on the subsoil and from stratigraphies and penetrometer tests (Dynamic Penetrometer Super Heavy-DPSH-type) performed for administrative purposes by local municipal administrations [54,57]. In particular, the depth of the CGT formation and the thickness of the overlying loose pyroclastic soils were evaluated. This reconstruction constitutes a reference basis for the interpretation of the Electrical Resistivity Tomographic (ERT) survey.

The characterization of the subsoil in the study area was achieved by implementing Electrical Resistivity Tomography in the areas surrounding the complex. Given the complexity of the monumental complex, it was suspected that there were other voids in the area. For this reason, to understand the possible presence and the true extent of the cavities, electrical tomography investigations in the areas surrounding the complex were carried out. Geoelectric surveys represent a modern methodology of non-invasive geophysical investigation and are based on the detection of the electrical resistivity of the various types of land investigated. This type of prospecting is the most suitable to localize the presence of cavities.

The survey was conducted by placing on the ground a large number of electrodes connected to an instrument called a Georesistivimeter, a system where the soil is fed with a known amount of electrical current. The measurements acquired were processed by means of special processing software (Res2DINV), allowing a pseudo-section 2D, qualitative representation of the electrostratigraphy of the subsoil to be obtained. The measurement of changes in these geophysical parameters and their subsequent processing allowed the geometry and characteristics of geological bodies to be defined, as well as indications on the presence of voids in the subsoil.

3.3. Laser Scanning

The use of a laser scanner survey in the characterization of an underground cavity has numerous advantages. Laser scanners provide highly precise and accurate measurements of the size and shape of a cavity, allowing the output of three-dimensional models with high spatial resolution and precision in measurements, essential for the detailed characterization of complex underground structures, in a short time, reducing the margin of human error present in traditional topographic survey methods [69–71]. The digital models obtained can be used to perform structural analysis, stability of geological structures and risk assessment, improving the planning of interventions and safety measures [72]; but above all, when the laser scanner survey is georeferenced, it allows an integrated view of the hypogea in relation to the buildings above.

A laser scanner survey of the cavity networks extending beneath the Piazza Municipio on the opposite side of the monumental complex of San Francesco le Moniche in Aversa and below the cloister was performed, using a Leica BLK360 laser scanner (Leica Geosystems JSC. Cornegliano Laudense, 26854, Italy).

The Leica BLK 360 laser scanner is a particularly suitable instrument for scanning underground premises due to its small size and portability, high scanning speed, 360-degree data acquisition capability and the availability of software produced by the same parent company, capable of managing large amounts of data with great precision, even when the data come from different scanning campaigns.

In this work, in fact, the acquisition of point clouds was carried out in different phases, due to the different logistical conditions faced in the underground environments, one of which consists of a water collection cistern. In all acquisitions, it was possible to carry out the survey without target positioning, thanks to the redundant number of performed scans and the high precision of the used instrumentation (Figure 3).

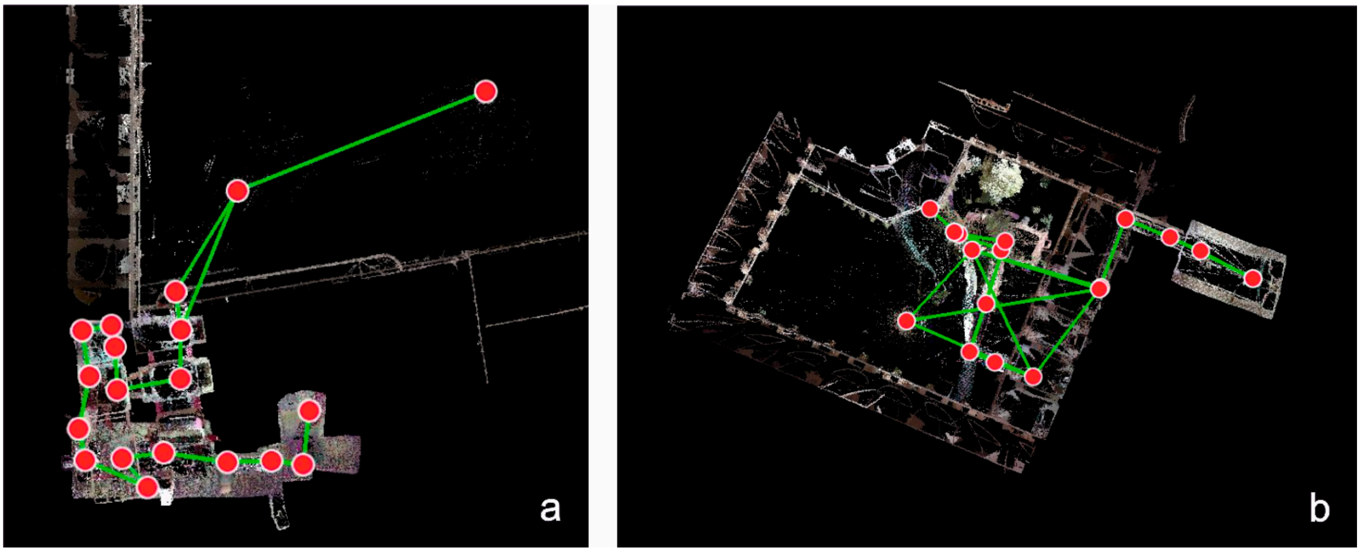

Figure 3. Location underground and on surface of laser scanner scans (red circles) and links between scans processed by Register 360 software (green lines) at (**a**) San Francesco le Moniche complex and (**b**) Piazza Municipio.

In the processing phase, 19 scans were assembled in the case of the cavities beneath the San Francesco le Moniche complex and 19 scans in the case of the cavity beneath Piazza Municipio; in both cases, some scans were performed up to the surface, to connect the structures present in the subsoil to the historical buildings on the surface, obtaining single three-dimensional models.

4. Results

4.1. Architecture of the Monumental Complex and Urban Transformation

The monastic complex and the surrounding area are the result of continuous transformations that occurred following numerous architectural, structural and urban interventions over the centuries, with modifications that continued until the first half of the twentieth century.

From an architectural point of view, the first significant alterations to the original Romanesque-Gothic structure occurred at the end of the 17th century. During this period, in response to the indications of the Counter-Reformation, the convent was adapted and expanded. One of the most important interventions was the construction of the large cloister, which represented not only a spatial expansion but also a functional transformation of the entire complex [67,68].

The construction of the cloister began in the Late Romanesque period and was completed in the 13th century (Figure 4).

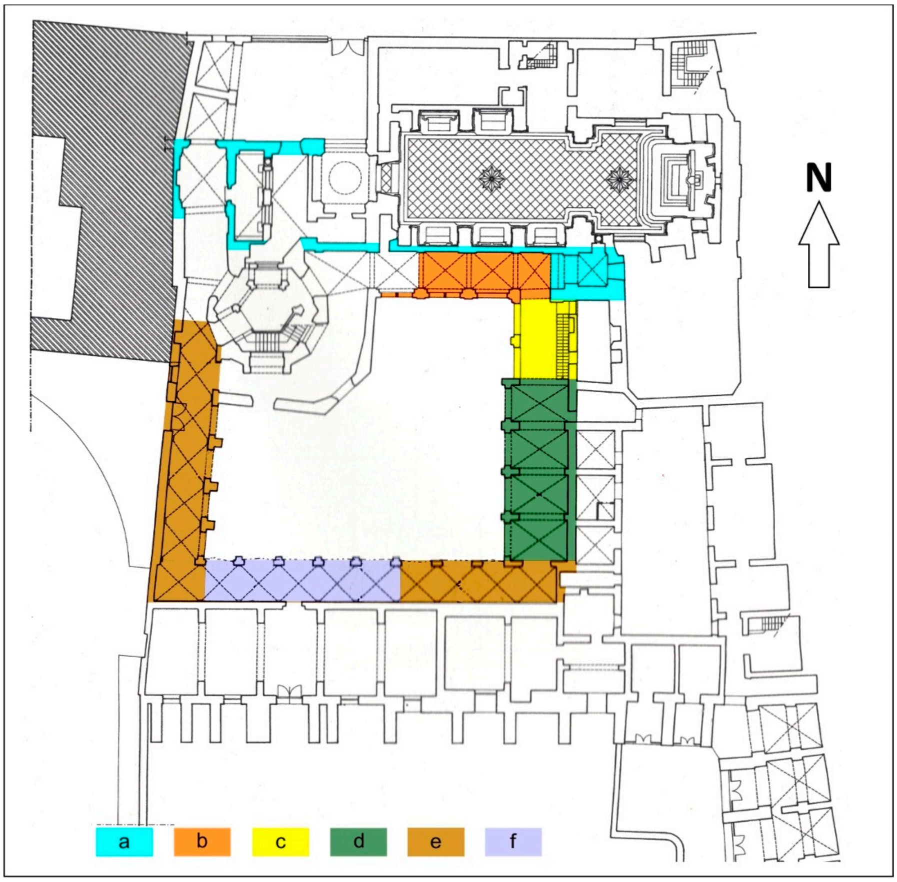

Figure 4. Chronological evolution of the construction of some parts of the San Francesco complex: (a) 13th century (construction of the church); (b) 13th century (construction of the northern ambulatory of the cloister); (c) late 13th century (completion of the church); (d) 14th century (construction of the eastern ambulatory); (e) 14th century (construction of the northern and western ambulatory of the cloister); (f) sector of the southern ambulatory which collapsed in 1997 and was rebuilt in the same year. Plan from [65], modified.

The northern ambulatory was initially composed of seven spans, of which the first three, to the west, were demolished to make way for the octagonal staircase (Figure 5). The four surviving spans are covered by round cross vaults, punctuated by transverse arches and pilasters leaning against the wall. On the external side, towards the old garden, there are three arched mullioned windows with double architraves, with twin columns.

Figure 5. Photographic evidence of the main urban transformations in the monumental complex: (**a**,**c**,**e**,**g**) 1920s–1940s shots (early 1990s postcards); (**b**,**d**,**f**,**h**) May 2024 shots (Ph. M. Vigliotti); shooting points in Figure 6. In (**a**), the red arrow indicates the building that will be demolished to open the passage to Piazza Municipio (see details on maps in Figure 6); in (**c**), the green arrow indicates the perimeter wall (g in Figure 2a) that will be demolished to allow the connection between Piazza Municipio and Via Giolitti; (**e**) monument to the fallen of the Great War: note the undergrowth and how the San Francesco building is reduced to ruins, signs of neglect in the area; it was restored to be used as a town hall; (**g**) Piazza Municipio now completed: note the large opening to create the connection with Via Roma.

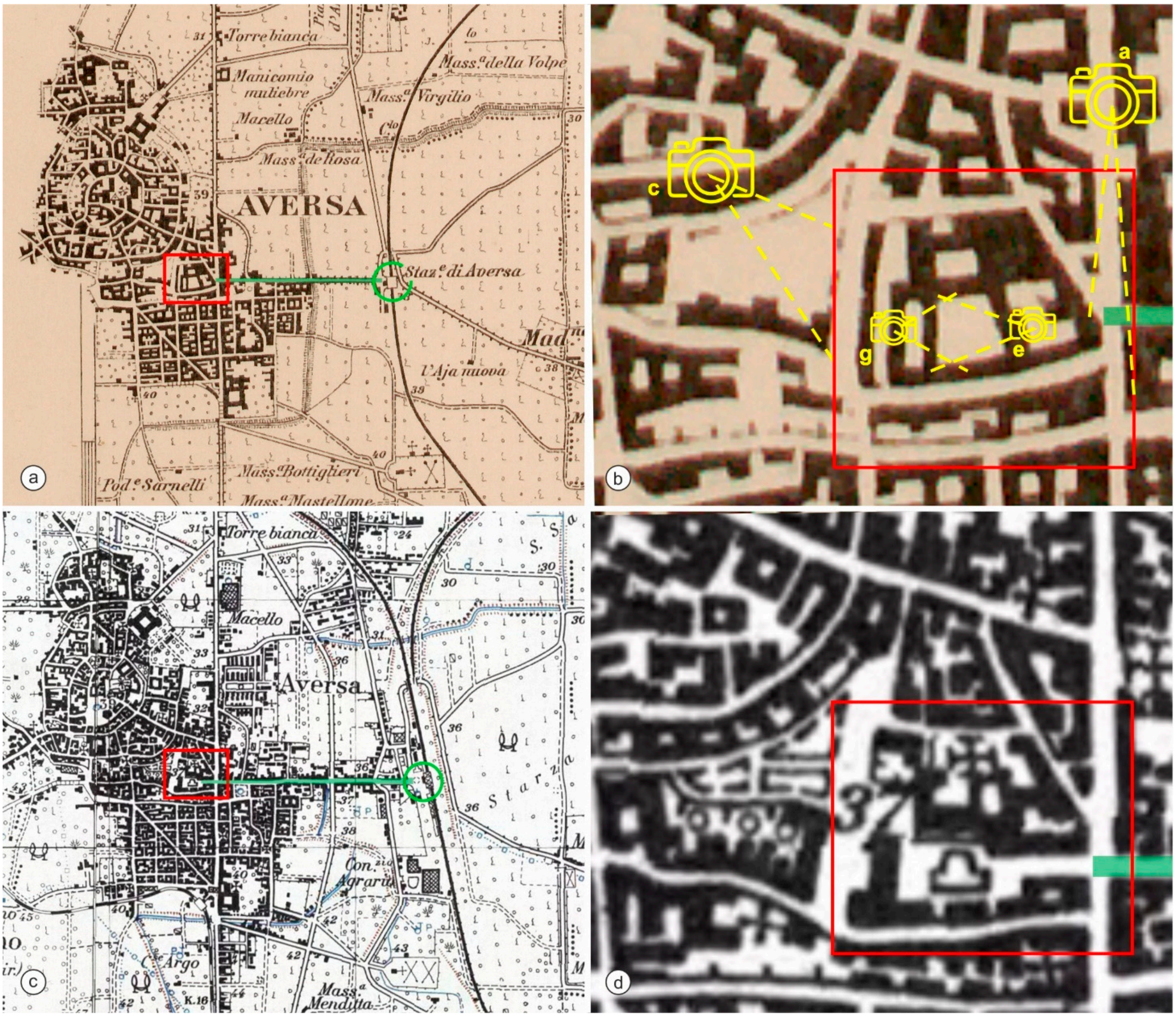

Figure 6. Historical cartography comparison, using topographical maps from the beginning of the XX century: it shows the urban evolution of the area (in red boxes) based on the Topographic Map of Italy at a scale of 1:25.000 published by the Military Geographical Institute of Italy: (**a**) Sheet 184 I-NO (Aversa), edited in 1906. (**b**) Close-up of the map, in which note the closure of the complex on Via Roma and where the shooting points of Figure 5 are indicated. (**c**) Sheet 184 IV-NE (Trentola-Ducenta) and Sheet 184 I-NO (Aversa) Series 25V, published in 1957. (**d**) Close-up of the map. The green lines show the connecting road between Via Roma and the railway station. The green circles show the railway station.

The eastern arm of the cloister was built in two phases. The first two modules to the north date back to the late thirteenth century, covered by cross vaults without separating arches. These spans open onto the cloister via round arches with double architraves. The remaining part of the eastern arm is composed of four fourteenth-century spans, covered by pointed cross vaults, interspersed with eighteenth-century tuff reinforcement arches [65,67].

The two arms to the south and west have different modules and rhythms, connecting "badly" to each other and to the northern ambulatory. The external arches and the cross vaults are pointed, with "T"-shaped pillars and contrasting pilasters. In 1997, the five western bays collapsed due to abandonment and neglect, causing the loss of frescoes and Romanesque decorations, and were rebuilt according to the principle of stylistic restoration [68].

The 18th century saw the beginning of the construction of the octagonal staircase which served as access to the summer choir (an area where the Poor Clares, during the summer months, attended religious services without a view). However, this construction remained incomplete. In the 19th century, further modifications were made with the creation of the belvedere. These interventions further modified the original configuration, which culminated with the promulgation of the laws on the suppression of monasteries, which led to significant transformations in the architecture and use of the spaces of the complex. These changes culminated in the twentieth century with interventions that profoundly altered the original layout of the monastic citadel [68].

Since 1914, the area of the complex and its surroundings have been the subject of study for an urban planning intervention that included a large program of road development. In particular, one intervention contemplated the connection between Strada Garibaldi with Viale Giolitti by means of the demolition of the Franciscan insula, consisting in the demolition of convent structures and private buildings, and the crossing of the monastery (Figures 5a,b and 6). In this way, the railway station, located to the east of the municipal territory, was connected to the city center where the new municipal headquarters was planned and an area suitable for hosting the monument to the fallen of the Great War (Figure 5e–h), financed with a public subscription [73], in one of the cloisters of the ancient convent that was once attached to the monastery. During the same period, the perimeter wall on the western side was demolished (g in Figures 2a and 5c,d). All this represented the first major urban planning intervention since the post-unification era that was completed only in 1940 [68].

4.2. Subsoil and Cavities

The stratigraphic framework of the subsoil has been reconstructed using data from the literature and the interpretation of borehole stratigraphies and penetrometer tests (DPSH-type) performed for administrative purposes in an area of about 1 km^2 around the study area (Figure 7). The first 4–5 m from the ground level are characterized by loose pyroclastic deposits, deriving from eruptions subsequent to the emplacement of the CGT, which instead characterizes the underlying levels with the zeolitized yellow facies. The contact between the two units is marked by a thin layer of "cappellaccio", representing the upper portion of the lithoid tuff formation (CGT) altered in subaerial environment (Figure 7a). This stratigraphic sequence is also confirmed by the analysis of the DPSH tests: the low numbers of boulders measured during the penetrometer tests reveal the presence of very loose layers of granular soils, identified as Post-CGT and "cappellaccio", in the first 6 m; at the base of this unit, a sudden increase in measurement parameters occurs, indicating a transition to the CGT formation (Figure 7c). On the basis of such results, the geotechnical model was derived and the subsoil was schematized as two layers of cohesionless pyroclastic soil 6.2 m thick directly lying on the CGT formation. The parameters used for the rock and soil are shown in Table 1 in terms of unit volume weight (γ), Poisson coefficient (ν), effective cohesion (c'), friction angle (φ') and the uniaxial compression (σ_c) strength of the lithoid tuff [45,74,75]. It has to be noted that the indicated value of cohesion for the "cappellaccio" (15 kPa) is not a true cohesion but it takes into account the beneficial effect of the unsaturated state on the shear strength of the soil [74].

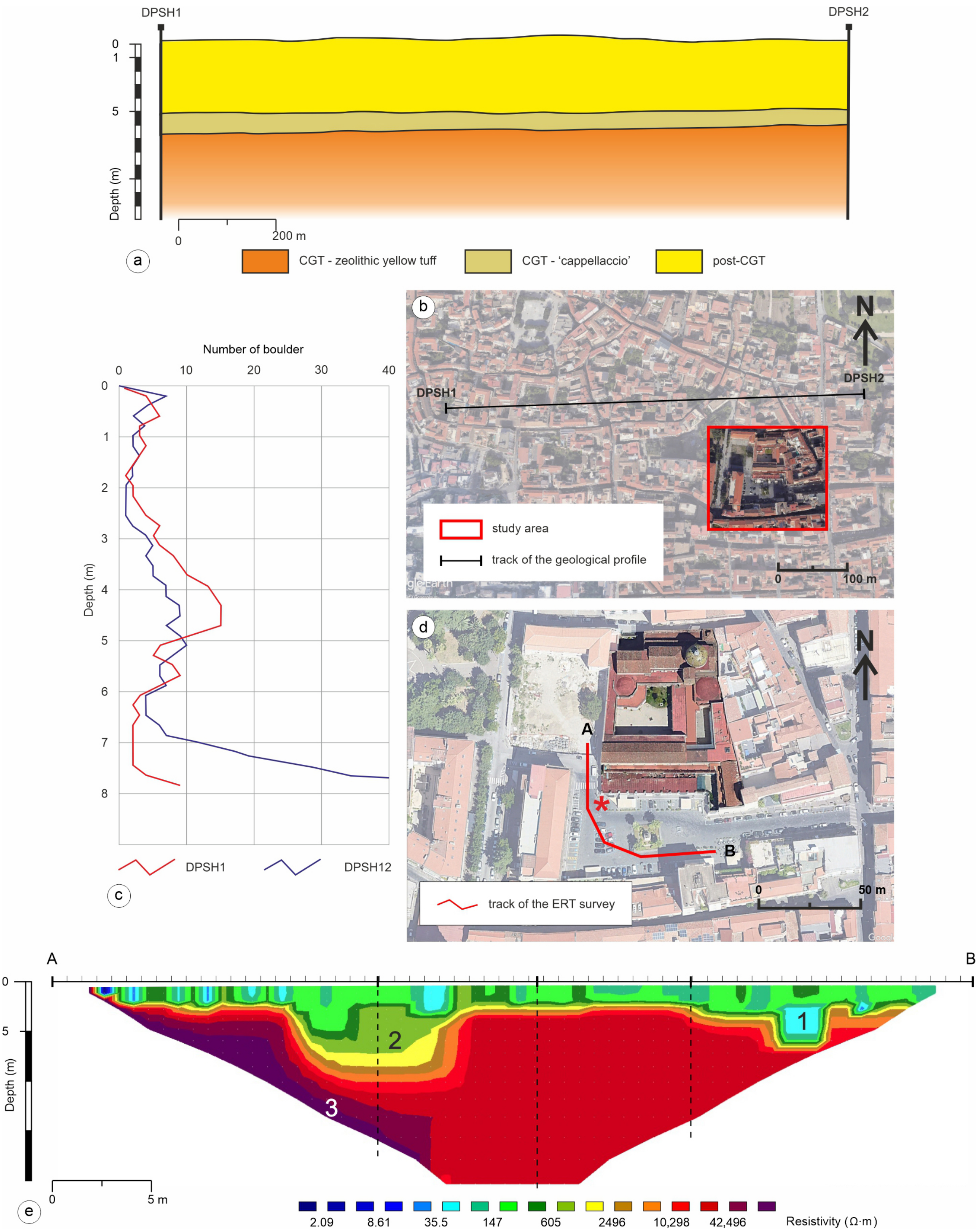

Figure 7. (**a**) Geological cross-section showing the general stratigraphy of the area (**b**); (**c**) results of penetrometer test used for soil characterization; (**d**) aerial view of the monumental complex of San Francesco le Moniche and Piazza Municipio and the location of ERT profile trace (in red); (**e**) ERT resistivity profile; the dotted lines indicate the beginning of each segment: (1) sewer duct; (2) excavated area; (3) possible underground void, whose possible position is indicated by the red asterisk in (**d**).

Table 1. Mechanical properties of the soils.

Depth (m)	Soil	γ (kN/m^3)	ν	c′ (kPa)	φ′ (°)	σ_c (kPa)	E (MPa)
0–4.6	Post-GCT	15	0.3	0	35°	-	170
4.6–6.2	CGT *Capp*	14.5	0.3	15	37°	-	420
>6.2	CGT	14	0.3	300	37°	1100	800

This marked distinction in lithologies allows for the easy reading of the indirect geophysical investigations (ERT) carried out to identify other possible voids in the subsoil of the monumental complex. The data acquired during the ERT survey were processed and the result obtained is a section (Figure 7e) that shows the 2D distribution of the electrical resistivity of the soil investigated. By associating the lithology with the resistivity values obtained, it was possible to obtain the following general data:

- Dark blue to light blue electrical resistivity between 2.05 and 35.5 Ω·m, associated with humidified pyroclastics, often humified (pedogenized), with slightly compacted silty grain size distribution;
- Electrical resistivity between 147 and 605 Ω·m of light green and dark green colors, associated with dry, medium-compacted reworked sandy pyroclastics;
- Electrical resistivity around 2496 Ω·m of yellow, brown and orange color, associated with dense sandy pyroclastics;
- Red to dark bordeaux electrical resistivities between 10,298 and 42,496 Ω·m, which could be associated with very compact gray tuff or voids due to cavities.

From the analysis and interpretation of the geological data, it was possible to detect the presence of two main electrostrates:

- A more conductive surface layer, varying in thickness between 3.00 m and about 4.50 m, associated with sandy and sandy loamy soils, humidified, very aerated and little thickened.
- A more resistive underlying layer, associated with sandy and sandy loamy soils in the upper part of the section, while in the lower part it is associated with the tuffaceous formation.

This interpretation fits well with the stratigraphic data presented above. In the right portion of the section, in particular, there is an area colored in blue at about 3 m of depth characterized by an anomaly of electrical resistivity, with low values of resistivity, presumably attributable to a ductwork used as a sewer duct, judging by the size and shape (Figure 7(e1)). On the other hand, in the section overlooking the town hall, there is a large area likely excavated and filled with material clearly reworked, as derived from the values of resistivity obtained (Figure 7(e2)). Moreover, what has aroused the greatest perplexity is the considerable increase in the electrical resistivity of the values in the lower left portion of the section (adjacent to the perimeter wall of the cloister), attributable to the presence of an underground void (Figure 7(e3)).

4.3. The Cavities Below the Monumental Complex

Given the extension and complexity of the entire monumental complex, the search for hypogea is very complicated. From information handed down for generations, their presence under the buildings surrounding Piazza Municipio is known, even if, in recent times, many have been covered over and their extent and position are no longer identifiable. Only one cavity located under a building adjacent to the town hall is accessible. The results of the ERT investigations suggest the presence of a void under the rooms outside the cloister. Finally, inside the latter, three different cavities are known, accessible and explorable (Figure 8).

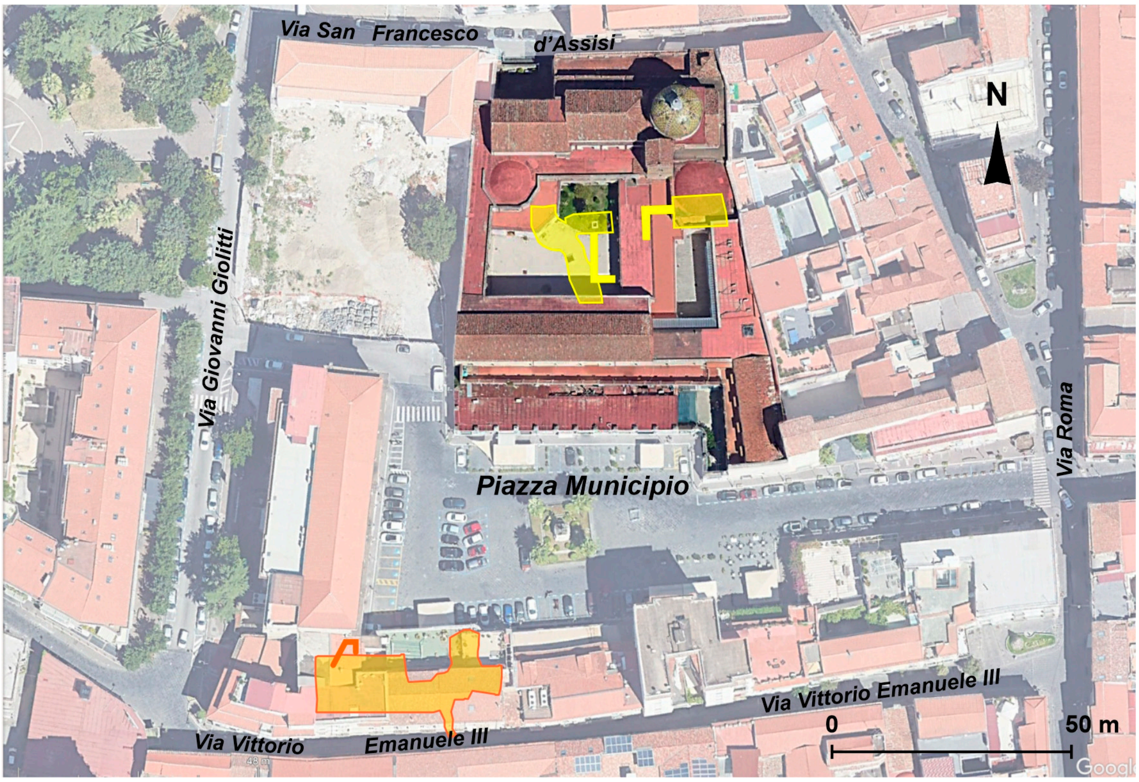

Figure 8. Aerial view of the monumental complex of San Francesco le Moniche and Piazza Municipio and the location of the studied cavities.

The survey carried out in the few accessible cavities, however, has provided interesting hints for the reading of all the elements exposed so far. The following paragraphs will provide details of the surveys carried out.

4.3.1. Piazza Municipio

The cavity beneath Piazza Municipio is illustrated in Figure 9. It is accessed via a long staircase dug into the tuff, from inside a bar located along the southern side of the square (Figure 9a), and extends below the building that represented the edge of the original garden. In the past two centuries, the cavity has been used for the production and conservation of wine and was probably connected to a more complex underground system which extended towards the historic center of the city of Aversa.

The staircase initially proceeds towards the west and then bends at approximately 90° towards the south to enter the cavity at its short western side. The cavity is polygonal-shaped, roughly rectilinear in plan in the E-W direction (Figure 9b). The overall length is 21.9 m, and the average width is 6.6 m. It can be divided into two sectors (Figure 9c,d): the first, 12.7 m long, is separated by a more restricted space (about 6 m long) from another, smaller room, more irregular in shape. The height of the cavity is approximately 6 m, with the exception of the sector opposite the access staircase, where it reaches 9.4 m. The vault has a low arch profile; two square section wells (l = 1 m) start from the vault, are closed by an iron grate and overlook the external wall of the building on via V. Emanuele III; another two wells, one of which is approximately 2 m large, are closed at the top end by a grate and masonry works.

Figure 9. Representation of the cavity at the south-west edge of Piazza Municipio (**a**), through processing of the laser scanner survey. Note the position of the cavity with respect to the above buildings; (**b**) longitudinal section of the cavity; details of sector 1 (**c**) and sector 2 (**d**) described in the text (Ph. M. Vigliotti).

4.3.2. Cloister

On the eastern side of the courtyard, from the cloister floor level, a rectangular door oriented east–west opens (Figure 10(R)); from this, a tuff staircase extends for approximately 11 m until it reaches a hypogeal room (Figure 11).

Figure 10. View of the cloister courtyard with the location of the accesses to the underlying hypogea. R: ramp; A–E: wells (Ph. M. Vigliotti).

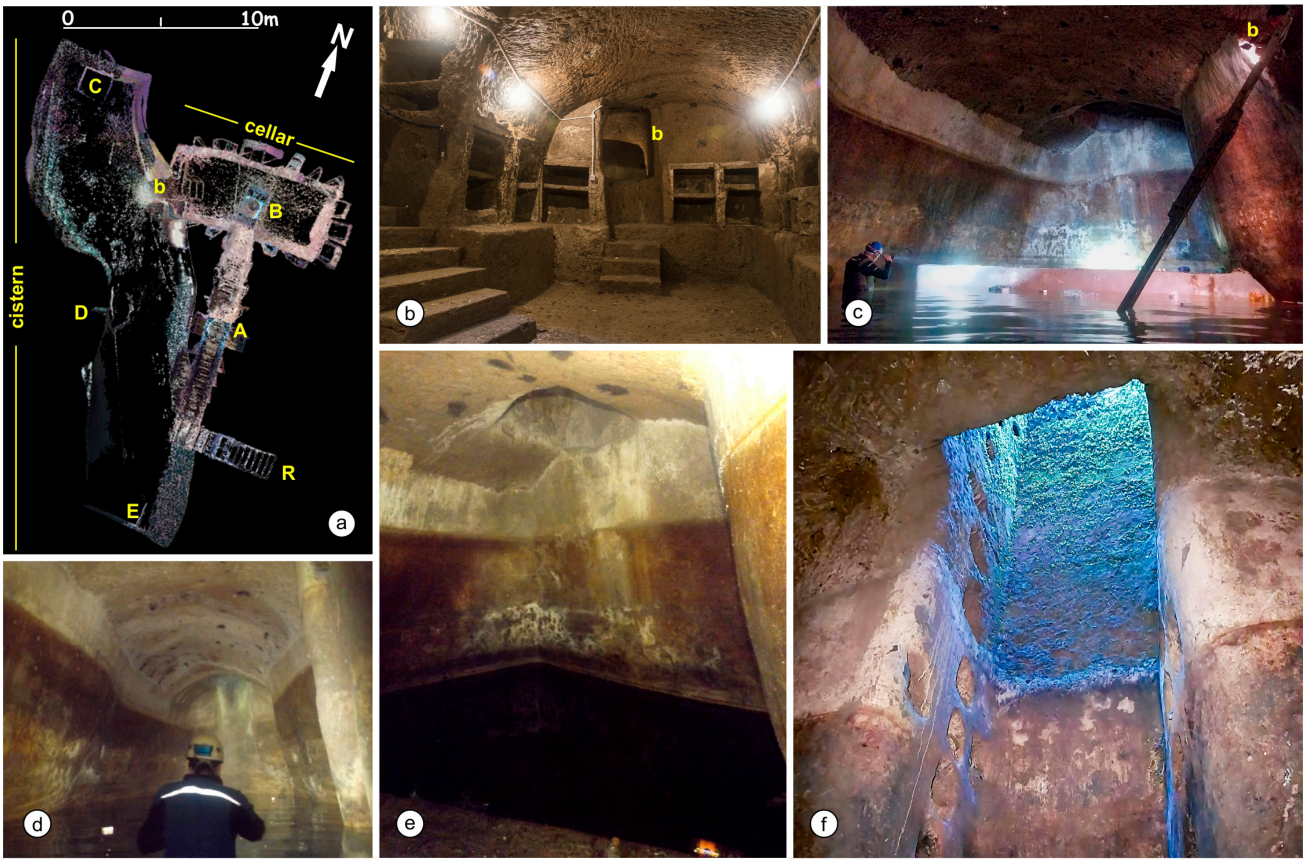

Figure 11. The hypogea beneath the courtyard of the cloister. (**a**) Plan obtained from laser scanner survey. R: ramp, A–E: wells of Figure 10. (**b**) (in yellow) shows the break through the wall that interrupts the continuity of the hydraulic plaster. (**b**) View of the cellar and the shelves dug into the tuff, as well as the opening towards the cistern. (**c**) Northern portion of the cistern. (**d**–**f**) View of the three wells visible from inside the cistern. The "grappiate" are visible in picture (**f**) (Ph. I. Guidone, M. Vigliotti).

This has a rectangular plan, 7.5 m × 3 m, 2.7 m high, with a vault at −5.9 m from ground level (Figure 11a). Both the ramp and the underground room, dug into the tuff rock, are characterized by the presence of brick shelves which are hypothetically functional for the conservation of food supplies. This room has been recognized as a cellar serving the convent structure (Figure 11b). The presence of traces of modern cement, poorly preserved and used to reinforce old shelves, would testify to the use of the room at least until the first half of the 20th century, but the chronological identification of its original layout remains controversial.

The second section of the access ramp to the cellar, oriented north–south, intercepts a circular well recognizable from the floor of the internal courtyard (Figure 10, well A); finally, another well is clearly identifiable in the center of the vault of the cellar and is evidenced, on the surface, by the presence of a "decorative" well in the northern part of the courtyard (Figure 10, well B).

An important structural element, which could help highlight the temporal and functional relationships between the underground rooms and the surface system, is the presence of a break through the western wall of the cellar which is marked as "b" on Figure 11b,c, made at a later time, which leads directly into a large underground room whose floor is located at a level approximately 3–4 m lower than that of the cellar (Figure 11b,c). This large room has approximately 1.5 m of rainwater at the bottom which, together with the hydraulic plaster recognizable on all walls, allows the hypogeum to be identified as a large cistern; the hydraulic plaster, in fact, is well preserved for approximately 4 m of the vertical development of the walls, i.e., almost up to the impost abutment of the ceiling which, on the contrary, is left as rough rock without any wall facing.

The cistern is approximately 20 m long and 5.5 m wide, and has a very low arched ceiling, approximately 5.5 m high from the bottom (Figure 11d). Of particular interest is the sigmoid-shaped plan of the cistern, which extends in the center of the cloister courtyard with a NW-SE orientation (Figure 11a). The northern side of the cistern is characterized by the presence of a large rectangular basin (Figure 11e), delimited by a wall partition approximately 1.5 m high, presumably used for the sedimentation of silt suspended in the water. The cistern, like the cellar and the access ramp, is equipped with three rectangular light wells, closed on the surface by an iron grate. The northernmost of these, located right on the aforementioned internal basin, connects to the octagonal staircase pertaining to the eighteenth-century phase of the quadriportico (Figure 10, well C), and is characterized here by the presence of a low parapet. The other two emerge into the internal courtyard right along the development line of the cistern; in the central well (Figure 10, well D), the grappiate can be recognized along the entire vertical development of two walls: they are holes dug into the tuff, which allowed people to go up and down into these underground environments, evidence of an original service access to the cistern (Figure 11f). Finally, there is the last well (Figure 10, well E), positioned to the south-east at the edge of the perimeter of the cistern; this does not have grappiate and seems to have the sole function of a light well.

Inside wells C and E, at a depth of about 50 cm, some columns can be seen protruding perpendicularly to the well (Figure 12), one of which is twisted (helical columns; well E, Figure 12b): they are not only a decorative element but, perforated along their entire length, they were used as water pipes, in order to channel rainwater towards the underground cistern, thus ensuring a constant water supply for the religious community. The age of the columns, probably from the Roman era, is certainly much older than the convent itself: starting with the Normans in the 11th century, but also during the Middle Ages and the Renaissance, many materials and structures from the Roman era were reused for new buildings. In Aversa, numerous examples of spoliation can be found: columns, capitals and other architectural elements of Roman origin are integrated into later buildings, both religious and civil.

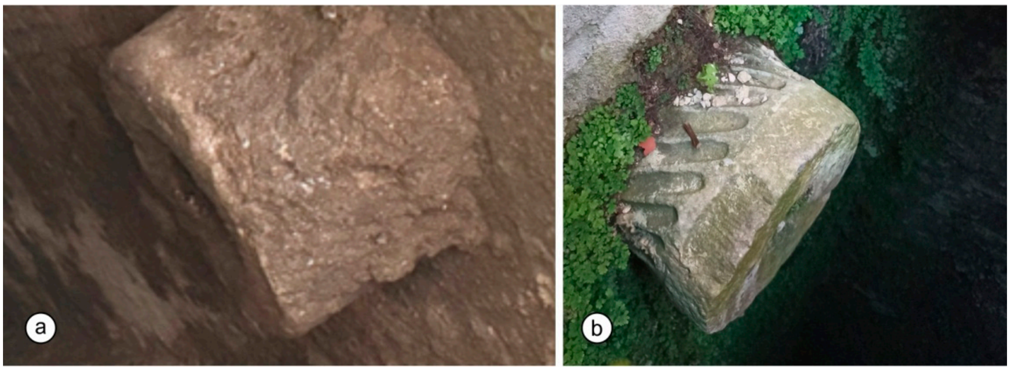

Figure 12. (**a**) From the wellhead of well C, it is possible to observe the end of a column reused as a water pipe; (**b**) in well E, the shaft of the column appears helicoidal (Ph. M. Vigliotti).

The convent also has a third hypogeum (Figure 13): a burial place, *putridarium* (also known as the draining room—"*scolatoio*"—of the dead). From the floor of the eastern cloister, a ramp with low steps leads to a large underground room with a rectangular plan. This room, covered by a barrel vault, is characterized by the presence of ten mortuary seats on both long sides, has dimensions of 10 m × 6 m and is approximately between 3.8 and 4.3 m high. All walls and the ceiling of the burial place are smoothed by the presence of a layer of light plaster; on the back wall, in front of the entrance, a faint frescoed crucifix survives.

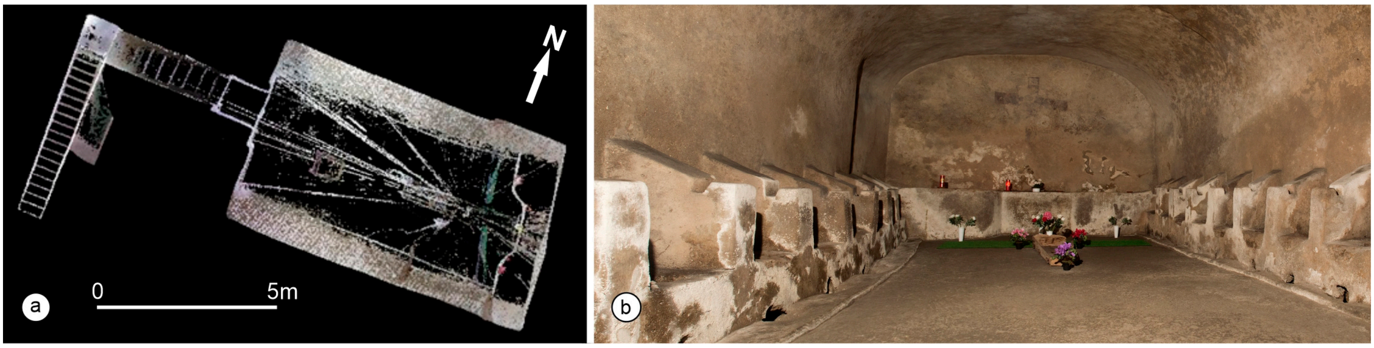

Figure 13. (**a**) Plain view obtained from the laser scanner survey; (**b**) *putridarium*: the seats on the sides and the altar in the background (Ph. M. Vigliotti).

5. Discussion

The monumental complex of San Francesco represents a well-preserved monument of fundamental importance in the evolutionary history of the ancient Norman county of Aversa. The complex has been affected by successive phases of construction and destruction, starting from around 1200. It was configured as a true citadel, with a large garden annexed to the cloister and enclosed in buildings [61,68]. Starting from the beginning of the 20th century and up to the Fascist era of the Second World War, the citadel was dismantled and the garden was converted into a square hosting the monument to the fallen, while the main building (San Francesco building) was used as a town hall; the entire area originally occupied by the garden was opened to the growing city by eliminating part of the building that closed the connection to Via Roma and to the railway station.

The documentary bibliographic sources offer elements to reconstruct this history, but, in this study, a valid support to the validation and a better definition of the more recent succession of events came from historical cartography and the photographic documentation of postcards from the early 1900s.

Nevertheless, the multi-centennial history of the complex can be read not only from the documentary sources, but also from the characteristics of the building materials and the related extraction areas.

The cultural relevance of geological heritage has increasingly been recognized in studies concerning cultural heritage. From this perspective, within the broad range of themes and specific topics that have been explored to highlight the strong interface between these two notions [1,2,4], a particularly focused theme in the urban context is that of heritage stones and their use in the construction and decoration of buildings.

In the Campania Region, already in Greek and Roman times, many rocks, volcanic and sedimentary, present in that area, were used for the construction of both valuable architectural works and buildings for common homes. Campania therefore boasts an ancient tradition in the stone sector [75]. Furthermore, it can be said that a building constructed with rocks coming from a quarry created nearby and used in various ways is almost a "museum" of that type of rock. In fact, it will show various geological attributes that we could easily see on an outcrop or in extraction sites. With respect to the latter, the underground cavities are of particular interest: they have been developing for many centuries in the subsoil of the Neapolitan area and northern Campania, represent above all original sites of extraction of tuff and loose pyroclastic materials, and were subsequently used for other purposes after excavation.

The most common building stones extracted from the subsoil were the NYT and the CGT. The latter, being present in the subsoil of the whole of northern Campania, north of Naples [57], has been extensively extracted and used. This material presents different lithological features deriving from post-depositional processes. It is the product of a fixural eruption that occurred about 39 ka ago in the Phlegraean Fields [55,57]. The explosive character of the eruption can be recognized, among others, in the numerous cavities quarried in the subsurface: there, starting from an area close to the vent site, the tuff contains very large black scoria that gradually disappear towards the north and east across the area under consideration [47,57,76]. These elements, together with other lithological aspects, have helped to understand the aspects related to the explosiveness of eruptive events and the characteristics of the deposition and subsequent transformation of the tuffaceous material [57,76]. In this sense, the underground cavities become a volcanological "laboratory" and tell us an interesting story, embedded in the tuff blocks extracted from them and fixed in the buildings.

Also, the methods of extraction and use of the extracted materials can provide important information on the history of a building or a residential settlement. The qualification of the building heritage, over time, has in fact been directed towards the recognition of the building stratifications [77]. For each building, the complexities of the construction phases can be recognized, with analytical methods specific to the natural sciences. A particular research [77], for instance, has deepened the study of the construction techniques of the masonry works made in tuff from the post-Middle Ages onwards in the territory of Naples and northern Campania. The possibility of dating the building stratifications contributes to the qualification of a particular building civilization, otherwise historically indistinct, thus giving it a specific historical individuality and, consequently, a cultural qualification.

In the specific case of tuff walls, of particular interest is the observation of the techniques used to create the internal blocks [77–79], extracted from the subsoil through underground excavations carried out in correspondence with the courtyards or gardens. The aggregates used for making the mortars were found in the most superficial incoherent layers (sands, pumice, lapilli and "pozzolane"—pulvis puteolanus) [80,81].

In the absence of certain historical evidence, we can propose a chronological reading of some structures based merely on the masonry works and of construction techniques of the San Francesco complex. This allows the stratification to be recognized through the shape and arrangement of the tuff blocks.

Initially, the walls were built using the "a cantieri" technique, that is, with extracted, split material of heterogeneous size, stacked without paying excessive attention to the horizontal position and bound with mortar. The masonry in the "a cantieri" technique (Figure 14a), in which the resources and techniques were less sophisticated than in subsequent periods, dates back to the first phase of the construction of the church (13th century). It is recognizable in the use of irregularly shaped tuff stones, arranged randomly and bound with mortar, creating an irregular but resistant structure. Since the 18th century, instead, recourse was made to rows of "bozzette", that is, rough-hewn stones with differentiated size and arranged in horizontal rows. Inside the complex, masonry of the "bozzette" type is also recognizable (Figure 14b), which shows the use of squared and regular blocks, arranged in horizontal courses, which gave solidity and durability to the structure; one can notice the use of stones of different sizes for the construction of the church and the ambulatory adjacent to it, and this indicates a different periodization of the construction phases. From the first decades of the 19th century, the masonry work with rows of "blocchetti", squared and flattened blocks, with dry masonry mass, became popular and was adopted until about the middle of the 20th century [78,82–84].

The material constituting the masonry works observable in the complex largely comes from the cavities present in the subsoil of the entire structure, even in those portions now inserted into the urban fabric with the modifications of the early 1900s. Looking in detail at the shape and size of the cavities and their spatial distribution, it is also possible to hypothesize a temporal interpretation.

The architecture of the cavity detected under Piazza Municipio is very similar to those present in a large part of the city's subsoil [46], and suggests an original quarry for extracting material to be used for construction; subsequently, the cavity, developed beneath structures that surrounded the original garden of the complex, was reused as a cellar for storing foodstuffs and wine at least in the past two centuries [46]. The latter use is still very common as the physical characteristics of the tuff favor the fermentation of the musts, ensuring constant temperature values and humidity in underground environments. Of particular interest is the production of a wine typical only of this area, the "*asprinio*", of millenary origins, whose production has become so important in the past decade as to request recognition as a UNESCO heritage [46,85]. This wine is also praised in musical works, and, in particular, in "La finta parigina", a musical comedy in three acts by the composer of Aversan origins Domenico Cimarosa. [86]

Figure 14. Examples of walls built with (**a**) technique "a cantieri" and (**b**) with technique "a bozzette" (Ph. M. Vigliotti).

The three hypogea developed below the cloister, on the other hand, document different chronological interventions pertaining to at least two different architectural phases. The cistern, located at a greater height/depth (Figure 15), could correspond to the first settlement phase and be functional for collecting water for the convent community. The cellar, on the other hand, would appear to be later than the cistern; the discriminating element for this relative chronology is the opening of a passage from the west wall of the cellar on the northern side of the cistern; this passage clearly destroys part of the waterproofing plaster of the cistern (Figure 11c). The *putridarium*, or draining room, has no architectural relation with the two cavities described above; although it is difficult to date, the chronological context could be identified between the 13th and 15th centuries, that is, between the oldest phase of the convent structure, to which the cloister and bell tower are dated [67], and the first Renaissance phase.

Finally, the ERT analysis highlighted the possible existence of other voids beneath the area originally occupied by the entire citadel. However, the outcomes of the survey also need further investigation through more specific GPR surveys, which, however, require entry into private homes and are, therefore, difficult to implement.

The study of the complex, therefore, requires further investigations to accurately document all the changes that have occurred in its history. However, the results obtained already highlight the connection between architectural elements and geological context, offering an integrated reading of a monumental complex that represents one of the cornerstones of the history of an old Norman county (i.e., Aversa) and narrates a thousand-year-old history that is also based on the geomorphological and geological context from which it arose.

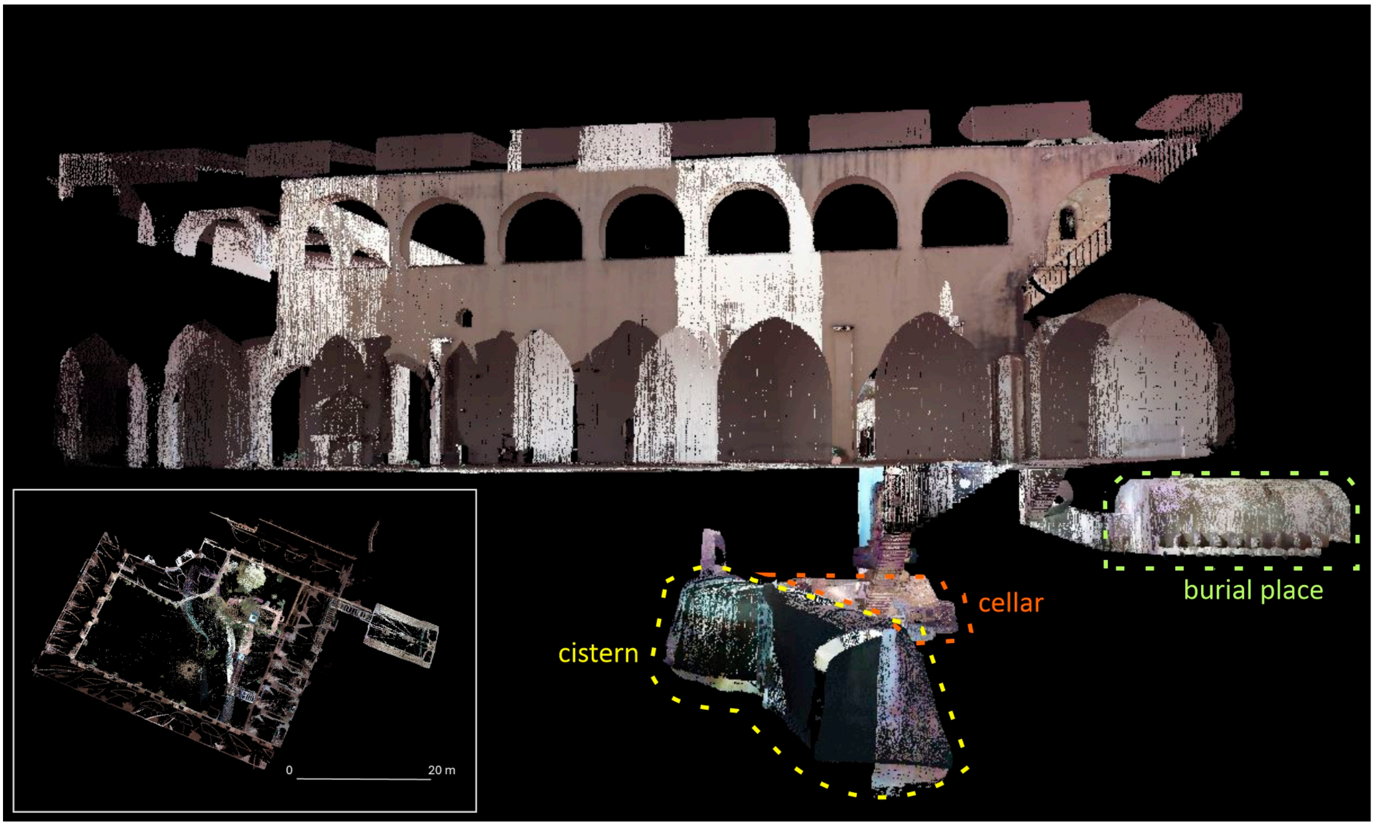

Figure 15. Perspective view from south: location of cistern, cellar and burial place with respect to the above S. Francesco le Moniche cloister. Plan view of the cloister and the cavities in the box on bottom left.

The valorization of the geoheritage aspects of a site, therefore, offers a different reading of the cultural value of a monument and is becoming the mainstream within these studies. It has, in fact, been highlighted that many sites in the world, included in the UNESCO list, are known above all for their cultural value, although they contain interesting landforms and rock outcrops [35], whose consideration could significantly improve the knowledge of the history of these sites.

The example reported herein, far from being exhaustive, offers evidence of a geoheritage–cultural heritage interface whose reading provides a rich resource of geological material and adds value for educational and urban geotourism purposes [4,8,87], with the latter being an emerging sector of sustainable tourism in many parts of the world, including Italy [88–93].

6. Conclusions

In this study, the cultural heritage of the monumental complex of San Francesco le Moniche and the additional value associated with geoheritage (building stones and underground extraction cavities) was highlighted. The history of the complex, represented by a temporal stratification of interventions, was investigated based on documentary sources and with the help of historical cartography and old images and postcards. This history is intertwined with the materials used for the construction and the techniques of both extraction and working and use of the same.

The geological context of the subsoil was highlighted through the processing of geological data and with geophysical surveys (ERT). The latter were conducted on an area previously affected by the development of the entire citadel, hypothesizing the presence of other cavities, some already known at the edges of the study area. Laser scanner surveys of the known and accessible cavities were carried out to obtain a three-dimensional view of the entire monumental complex and its underground spaces. Furthermore, the volcanic material extracted from the cavities and used for the construction of a large part of the buildings in question offers extensive volcanological evidence of one of the most impressive eruptions of the Phlegraean Fields.

The results of the above multidisciplinary study allowed us to improve the knowledge of the study site and provide a clear example of a geoheritage–cultural heritage interface, which reminds us of the importance of an integrated approach in their valorization, specifically in urban areas.

Author Contributions: Conceptualization, D.R. and M.V.; methodology, D.R., M.V., P.M.G., I.G. and M.A.F.; software, M.V. and P.M.G.; validation, D.R. and M.V.; formal analysis, P.M.G., I.G. and M.A.F.; investigation, M.V., M.A.F., P.M.G., I.G. and A.P.; resources, D.R.; data curation, M.V.; writing—original draft preparation, D.R., M.V., A.P., I.G., P.M.G. and M.A.F.; writing—review and editing, D.R. and M.V.; supervision, D.R. and M.V. All authors have read and agreed to the published version of the manuscript.

Funding: D.R. received funding for the research activities from the Collaboration Research Program on "Census, analysis and evaluation of the Cavity System" present in the territory of the Hydrographic District of the Southern Apennines (Italy). Funder: Autorità di Bacino Distrettuale dell'Appennino Meridionale; INAM.RubertiD22ContrRicSistemaCavità.

Data Availability Statement: The data used in this research work are available upon request from the corresponding author.

Acknowledgments: The authors thank the association Amici di San Francesco for their collaboration in the surveys in the cavities and the inspections in the monumental complex. Special thanks goes to Mons. Pasquale De Cristofaro (Rector of the monumental complex of San Francesco).

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Brocx, M.; Semeniuk, V. Geoheritage and geoconservation—History, definition, scope and scale. *J. R. Soc. West. Aust.* **2007**, *90*, 53–87.
2. Pijet-Migoń, E.; Migoń, P. Geoheritage and Cultural Heritage—A Review of Recurrent and Interlinked Themes. *Geosciences* **2022**, *12*, 98. [CrossRef]
3. Bollati, I.M.; Caironi, V.; Gallo, A.; Muccignato, E.; Pelfini, M.; Bagnati, T. How to integrate cultural and geological heritage? The case of the Comuniterrae project (Sesia Val Grande UNESCO Global Geopark, northern Italy). *AUC Geogr.* **2023**, *58*, 129–145. [CrossRef]
4. Brocx, M.; Semeniuk, V. Building Stones Can Be of Geoheritage Significance. *Geoheritage* **2019**, *11*, 133–149. [CrossRef]
5. Pereira, D.; Marker, B. The value of original natural stone in the context of architectural heritage. *Geosciences* **2016**, *6*, 13. [CrossRef]
6. De Wever, P.; Baudin, F.; Pereira, D.; Cornée, A.; Egoroff, G.; Page, K. The importance of geosites and heritage stones in cities—A review. *Geoheritage* **2017**, *9*, 561–575. [CrossRef]
7. López-García, J.A.; Oyarzun, R.; López Andrés, S.; Manteca Martínez, J.I. Scientific, educational, and environmental considerations regarding mine sites and geoheritage: A perspective from SE Spain. *Geoheritage* **2011**, *3*, 267–275. [CrossRef]
8. Del Lama, E.A. Potential for urban geotourism: Churches and cemeteries. *Geoheritage* **2019**, *11*, 717–728. [CrossRef]
9. Pereira, L.S.; do Nascimento, M.A.L.; Mantesso-Neto, V. Geotouristic trail in the Senhor da Boa Sentenca Cemetery, Jo.o Pessoa, State of Paraíba (PB), Northeastern Brazil. *Geoheritage* **2019**, *11*, 1133–1149. [CrossRef]
10. Prosser, C.D. Geoconservation, quarrying and mining: Opportunities and challenges illustrated through working in partnership with the mineral extraction industry in England. *Geoheritage* **2018**, *10*, 259–270. [CrossRef]
11. Del Prete, S.; Galeazzi, C.; Germani, C.; Martimucci, V.; Parise, M. Geohydrological Problems Related to Underground Artificial Cavities. In Proceedings of the Convegni Lincei "Frane e Dissesto Idrogeologico: Consuntivo", Accademia dei Lincei, Rome, Italy, 22 March 2010.
12. Parise, M.; Lollino, P. A Preliminary Analysis of Failure Mechanisms in Karst and Man-Made Underground Caves in Southern Italy. *Geomorphology* **2011**, *134*, 132–143. [CrossRef]
13. Parise, M. A present risk from past activities: Sinkhole occurrence above underground quarries. *Carbonates Evaporites* **2012**, *27*, 109–118. [CrossRef]
14. Parise, M. A procedure for evaluating the susceptibility to natural and anthropogenic sinkholes. *Georisk* **2015**, *9*, 272–285. [CrossRef]

15. Vennari, C.; Parise, M. A Chronological Database about Natural and Anthropogenic Sinkholes in Italy. *Geosciences* **2022**, *12*, 200. [CrossRef]
16. Galeazzi, C. The Typological Tree of Artificial Cavities: A Contribution by the Commission of the Italian Speleological Society. *Opera Ipogea-J. Speleol. Artif. Cavities* **2013**, *1*, 9–18.
17. Parise, M.; Galeazzi, C.; Bixio, R.; Dixon, M. Classification of Artificial Cavities: A First Contribution by the UIS Commission. In Proceedings of the 16th International Congress of Speleology, Brno, Czech Republic, 21–28 July 2013; Filippi, M., Lollino, P., Eds.; The Czech Speleological Society: Praha, Czech Republic, 2013; pp. 230–235.
18. Parise, M. Engineering-geological studies in artificial cavities, aimed at evaluating the possibility of failures in underground settings. In Proceedings of the Congress in Artificial Cavities "Hypogea 2017", Cappadocia, Turkey, 6–8 March 2017.
19. Castellanza, R.; Lollino, P.; Ciantia, M. A methodological approach to assess the hazard of underground cavities subjected to environmental weathering. *Tunn. Undergr. Space Technol.* **2018**, *82*, 278–292. [CrossRef]
20. Singh, S.K.; Banerjee, B.P.; Raval, S. A review of laser scanning for geological and geotechnical applications in underground mining. *Int. J. Min. Sci. Technol.* **2022**, *33*, 133–154. [CrossRef]
21. Ducut, J.D.; Alipio, M.; Go, P.J.; Concepcion, R., II; Vicerra, R.R.; Bandala, A.; Dadios, E. A Review of Electrical Resistivity Tomography Applications in Underground Imaging and Object Detection. *Displays* **2022**, *73*, 102208. [CrossRef]
22. Gordon, J.E. Geotourism and cultural heritage. In *Handbook of Geotourism*; Dowling, R., Newsome, D., Eds.; Edward Elgar: Cheltenham, UK, 2018; pp. 61–75.
23. Crisman, P. Documenting Historical Architecture: The Importance of Bibliography and Archival Research. *Arch. Res. Q.* **2013**, *17*, 253–267.
24. Fairclough, G. New Heritage, An Introductory Essay–People, Landscape and Change. *Landsc. Res.* **2009**, *34*, 7–26.
25. Mingione, E.; Ruberti, D.; Strumia, S.; Vigliotti, M. Cartografia storica e sistemi GIS per lo studio dell'evoluzione dei caratteri fisici ed antropici del territorio. *Il caso di Capua (CE). Il Quat. Ital. J. Quat. Sci.* **2004**, *17*, 629–642.
26. Ruberti, D.; Vigliotti, M.; Di Mauro, A.; Chieffi, R.; Di Natale, M. Human influence over 150 years of coastal evolution in the Volturno delta system (southern Italy). *J. Coast. Conserv.* **2018**, *22*, 897–917. [CrossRef]
27. Edney, M.H. Theory and the History of Cartography. *Imago Mundi* **1996**, *48*, 185–191. Available online: http://www.jstor.org/stable/1151272 (accessed on 15 June 2024). [CrossRef]
28. The History of Cartography. *Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean*; Harley, J.B., Woodward, D., Eds.; University of Chicago Press: Chicago, IL, USA, 1987; Volume 1, p. 622.
29. Gislason, G. The Use of Historical Maps in the Study of Long-Term Landscape Change: A Case Study of the Oulu Region, Northern Finland. *Fenn. Int. J. Geogr.* **2011**, *189*, 32–47.
30. Lane, B.M. Architectural Restoration: Criteria and Guidelines for Historic Building Preservation. *J. Arch. Conserv.* **1996**, *2*, 7–26.
31. Kostof, S. *The City Shaped: Urban Patterns and Meanings Through History*; Thames and Hudson: London, UK, 1992; p. 320.
32. Green, D. From Sketch to Structure: The Role of Architectural Drawings in the Preservation of Historical Buildings. *J. Soc. Arch. Hist.* **1996**, *55*, 414–439.
33. Hill, J.; Kohane, P. The Use of Historical Imagery in Understanding the Transformation of Urban Spaces. *Plan. Perspect.* **2001**, *16*, 247–267.
34. Gruber, A. Depicting Change: The Use of Historical Photographs in Architectural Heritage Research. *Arch. Herit.* **2008**, *19*, 65–80.
35. Migoń, P. Geoheritage and World Heritage sites. In *Geoheritage: Assessment, Protection, and Management*; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands, 2018; pp. 237–249. [CrossRef]
36. Gray, M. Geodiversity, geoheritage and geoconservation for society. *Int. J. Geoheritage Parks* **2019**, *7*, 226–236. [CrossRef]
37. Ebanista, C. L'utilizzo Cultuale Delle Grotte Campane nel Medioevo. In Proceedings of the Campania Speleologica, I Convegno Regionale di Speleologia, Oliveto Citra, Italy, 1–3 June 2007.
38. Ebanista, C. Abitati e luoghi di culto rupestri in Campania e Molise. In *Le Aree Rupestri Dell'italia Centro Meridionale, Nell'ambito Delle Civiltà italiche: Conoscenza, Salvaguardia, Tutela, Proceedings of the IV Convegno Internazionale Sulla Civiltà Rupestre, Savelletri di Fasano, Italy, 17 November 2011*; Menesto, E., Ed.; Cisam: Spoleto, Italy, 2011.
39. Palmer, A. *Cave Geology*; Cave Books: Dayton, OH, USA, 2007; pp. 1–456.
40. Parise, M. Il Progetto "La Carta degli Antichi Acquedotti Italiani". *Opera Ipogea* **2007**, *1*, 3–16.
41. Parise, M. Distribution and characteristics of ancient underground aqueducts in Italy. In Proceedings of the IWA Specialty Conference, 2nd International Symposium "Water and Wastewater Technologies in Ancient Civilizations", Bari, Italy, 28 May 2009.
42. Parise, M. Lo sviluppo degli insediamenti rupestri in funzione delle caratteristiche fisiografiche del territorio. In Proceedings of the Seminario Internazionale CRHIMA "Rupestrian Settlements in the Mediterranean Region", Massafra, Italy, 28 April 2011.
43. Varriale, R.; Parise, M.; Genovese, L.; Leo, M.; Valese, S. Underground Built Heritage in Naples: From Knowledge to Monitoring and Enhancement. In *Handbook of Cultural Heritage Analysis*; D'Amico, S., Venuti, V., Eds.; Springer: Cham, Switzerland, 2022. [CrossRef]
44. Del Prete, S.; Parise, M. An overview of the geological and morphological constraints in the excavation of artificial cavities. In Proceedings of the 16th International Congress of Speleology, Brno, Czech Republic, 21–28 July 2013.
45. Damiano, E.; Fabozzi, M.A.; Guarino, P.M.; Molitierno, E.; Olivares, L.; Pratelli, R.; Vigliotti, M.; Ruberti, D. A Multidisciplinary Approach for the Characterization of Artificial Cavities of Historical and Cultural Interest: The Case Study of the Cloister of Sant'Agostino—Caserta, Italy. *Geosciences* **2024**, *14*, 42. [CrossRef]

46. Vigliotti, M.; Fabozzi, M.A.; Buffardi, C.; Ruberti, D. Artificial Cavities in the Northern Campania Plain: Architectural Variability and Cataloging Challenge. *Heritage* **2023**, *6*, 5500–5515. [CrossRef]
47. Vigliotti, M.; Ruberti, D. Campania Grey Tuff and Anthropogenic Tuff Cavites in the Southern Metropolitan Area of Caserta (Southern Italy). *Alp. Mediterr. Quat.* **2018**, *31*, 247–251.
48. Varriale, R. Underground Built Heritage: A Theoretical Approach for the Definition of an International Class. *Heritage* **2021**, *4*, 1092–1118. [CrossRef]
49. Milia, A.; Torrente, M.M.; Russo, M.; Zuppetta, A. Tectonics and Crustal Structure of the Campania Continental Margin: Relationships with Volcanism. *Mineral. Petrol.* **2003**, *79*, 33–47. [CrossRef]
50. Turco, E.; Schettino, A.; Pierantoni, P.P.; Santarelli, G. The Pleistocene Extension of the Campania Plain in the Framework of the Southern Tyrrhenian Tectonic Evolution: Morphotectonic Analysis, Kinematic Model and Implications for Volcanism. In *Developments in Volcanology 9*; Elsevier: Amsterdam, The Netherlands, 2006; pp. 27–51.
51. Amorosi, A.; Pacifico, A.; Rossi, V.; Ruberti, D. Late Quaternary Incision and Deposition in an Active Volcanic Setting: The Volturno Valley Fill, Southern Italy. *Sediment. Geol.* **2012**, *282*, 307–320. [CrossRef]
52. Ruberti, D.; Sacchi, M.; Pepe, F.; Vigliotti, M. LGM Incised Valley in a volcanic setting. The Northern Campania Plain (Southern Italy). *Alp. Mediterr. Quat.* **2018**, *31*, 35–38.
53. Vitale, S.; Ciarcia, S. Tectono-stratigraphic setting of the Campania region (southern Italy). *J. Maps* **2018**, *14*, 9–21. [CrossRef]
54. Ruberti, D.; Buffardi, C.; Sacchi, M.; Vigliotti, M. The late Pleistocene-Holocene changing morphology of the Volturno delta and coast (northern Campania, Italy): Geological architecture and human influence. *Quat. Int.* **2022**, *625*, 14–28. [CrossRef]
55. De Vivo, B.; Rolandi, G.; Gans, P.B.; Calvert, A.; Bohrson, W.A.; Spera, F.J.; Belkin, H.E. New constraints on the pyroclastic eruptive history of the Campanian volcanic Plain (Italy). *Mineral. Petrol.* **2001**, *73*, 47–65. [CrossRef]
56. Deino, A.L.; Orsi, G.; de Vita, S.; Piochi, M. The age of the Neapolitan Yellow Tuff caldera-forming eruption (Campi Flegrei caldera-Italy) assessed by 40Ar/39Ar dating method. *J. Volcanol. Geotherm. Res.* **2004**, *133*, 157–170. [CrossRef]
57. Ruberti, D.; Vigliotti, M.; Rolandi, R.; Di Lascio, M. Effect of paleomorphology on facies distribution of the campania ignimbrite in the northern campania plain, southern Italy. In *Vesuvius, Campi Flegrei, and Campanian Volcanism*; De Vivo, B., Belkin, H.E., Rolandi, G., Eds.; Elsevier: Amsterdam, The Netherlands, 2020; pp. 207–229. [CrossRef]
58. Di Girolamo, P. Petrografia Dei Tufi Campani: Il Processo Di pipernizzazione (Tufo-Tufo Pipernoide-Piperno). *Rend. Acad. Sci. Fis. Mat.* **1968**, *35*, 329–394.
59. Cappelletti, P.; Cerri, G.; Colella, A.; De'Gennaro, M.; Langella, A.; Perrotta, A.; Scarpati, C. Post-Eruptive Processes in the Campanian Ignimbrite. *Mineral. Petrol.* **2003**, *79*, 79–97. [CrossRef]
60. Morra, V.; Calcaterra, D.; Cappelletti, P.; Colella, A.; Fedele, L.; de Gennaro, R.; Langella, A.; Mercurio, M.; de Gennaro, M. Urban Geology: Relationships between Geological Setting and Architectural Heritage of the Neapolitan Area. *J. Virtual Explor.* **2010**, *36*, 261. [CrossRef]
61. Parente, G. *Origini e Vicende Ecclesiastiche Della Città di Aversa*; Cardamone Editor: Naples, Italy, 1857.
62. Jacazzi, D. *Aversa Dieci Secoli di Storia*; Tipolitografica: South Pozzuoli-Naples, Italy, 1995.
63. Amirante, G. *Aversa ritratto della città, in Terra di Lavoro, In I Luoghi Della Storia*; Migliorini, L.M., Ed.; Elio Sellino Editore: Avellino, Italy, 2009; p. 191.
64. Santagata, L. *Storia di Aversa*; Eve Editrice: Aversa, Italy, 1991.
65. Amirante, G. *Aversa Dalle Origini al Settecento*; Edizioni Scientifiche Italiane: Naples, Italy, 1998; pp. 1–296.
66. Cricco, G.; Di Teodoro, F.P. *Itinerario Nell'arte Versione Maior*; Zanichelli: Milan, Italy, 2010.
67. Pellegrino, A. *San Francesco le Moniche nel Medioevo*; Quorum Edizioni: Bari, Italy, 2020.
68. Cecere, T. Il Rettifilo e lo squarcio di San Francesco delle Monache. In *Aversa. La Città Consolidata*; Edizioni Scientifiche Italiane: Naples, Italy, 1998; pp. 261–282. ISBN 88-8114-686-X.
69. Yastikli, N. Documentation of cultural heritage using digital photogrammetry and laser scanning. *J. Cult. Herit.* **2007**, *8*, 423–427. [CrossRef]
70. Armesto-González, J.; Riveiro-Rodríguez, B.; González-Aguilera, D.; Rivas-Brea, M.T. Terrestrial laser scanning intensity data applied to damage detection for historical buildings. *J. Archaeol. Sci.* **2010**, *37*, 3037–3047. [CrossRef]
71. Tang, P.; Huber, D.; Akinci, B.; Lipman, R.; Lytle, A. Automatic reconstruction of as-built building information models from laser-scanned point clouds: A review of related techniques. *Autom. Constr.* **2010**, *19*, 829–843. [CrossRef]
72. Buckley, S.J.; Howell, J.A.; Enge, H.D.; Kurz, T.H. Terrestrial laser scanning in geology: Data acquisition, processing and accuracy considerations. *J. Geol. Soc.* **2008**, *165*, 625–638. [CrossRef]
73. De Chiara, S. Mobilitazione Civile e Propaganda Durante la Grande Guerra Nell'agro Aversano. Rivista di Terra di Lavoro-Bollettino On-Line Dell'archivio di Stato di Caserta–Anno XIII, n°2–Ottobre. 2018. Available online: https://ascaserta.cultura.gov.it/fileadmin/risorse/Rivista/20-05.pdf (accessed on 15 June 2024).
74. Damiano, E.; Olivares, L. The role of infiltration processes in steep slope stability of pyroclastic granular soils: Laboratory and numerical investigation. *Nat. Hazards* **2010**, *52*, 329–350. [CrossRef]
75. de Gennaro, M.; Calcaterra, M.; Langella, A. (Eds.) *Le Pietre Storiche Della Campania Dall'oblio Alla Riscoperta*; Luciano Editore: Naples, Italy, 2013; p. 380, ISBN 88-6026-1832-3.

76. Rolandi, G.; De Natale, G.; Kilburn, C.; Troise, C.; Somma, R.; Di Lascio, M.; Fedele, A.; Rolandi, R. The 39 ka Campanian Ignimbrite eruption: New data on source area in the Campanian Plain. In *Vesuvius, Campi Flegrei, and Campanian Volcanism*; De Vivo, B., Belkin, H.E., Rolandi, G., Eds.; Elsevier: Amsterdam, The Netherlands, 2020; pp. 175–205. [CrossRef]
77. Guerriero, L. Di tutta bontà, perfettione et laudabil magistero. In *Murature in Tufo Giallo e in Tufo Grigio a Napoli e in Terra di Lavoro (XVI–XIX)*; Fabrica: Naples, Italy, 2016; pp. 1–204, ISBN 978-88-94829-11-2.
78. Fiengo, G.; Guerriero, L. Atlante regionale delle tecniche costruttive tradizionali. In *Lo Stato Dell'arte, i Protocolli Della Ricerca. L'indagine Documentaria (Atti del I e del II Seminario Nazionale)*; Arte Tipografica: Naples, Italy, 2003; pp. 1–416, ISBN 88-87375-40-2.
79. Fiengo, G.; Guerriero, L. Atlante delle tecniche costruttive tradizionali. In *Napoli, Terra di Lavoro (XVI–XIX)*; Arte Tipografica: Naples, Italy, 2008; pp. 1–840. ISBN 978-88-6419-007-5.
80. De Cesare, F. *Trattato Elementare Di Architettura Civile*; Stamperia Della Vedova di Reale e Figli: Napoli, Italy, 1827; Volume 1, p. 287. Available online: https://books.google.it/books/about/Trattato_elementare_di_architettura_civi.html?id=nseo8OHrlUAC&redir_esc=y (accessed on 18 July 2024).
81. De Cesare, F. *La Scienza Dell'Architettura Applicata Alla Costruzione Alla Distribuzione Alla Decorazione Degli Edifici Civili*; Stamperia Della Vedova Di Reale e Figli: Napoli, Italy, 1855; p. 279. Available online: https://archive.org/details/bub_gb_xs0S5NJkWcYC/page/n3/mode/2up (accessed on 18 July 2024).
82. Coppola, G. *L'edilizia nel Medioevo*; Carocci Editore: Rome, Italy, 2015; pp. 1–344.
83. Parenti, R. Una proposta di classificazione tipologica delle murature post-classiche. In Proceedings of the Conoscenze e Sviluppi Teorici per la Conservazione dei Sistemi Tradizionali in Muratura, Atti del Convegno di Studi di Bressanone, Padova, Italy, 23–26 June 1987; Biscontin, G., Angeletti, R., Eds.; Libreria Progetto: Padova, Italy, 1987; pp. 280–302.
84. Parenti, R. *Sulla Possibilità di Datazione e di Classificazione Delle Murature*; Francovich, R., Parenti, R., Eds.; Archeologia e Restauro dei Monumenti: Florence, Italy, 1988; pp. 280–304.
85. Buondonno, A.; Colella, A..; Coppola, E.; de' Gennaro, B.; de' Gennaro, M.; Langella, A.; Leone, A.P.; Odierna, P.; Ricciardi, V.; Colella, C. A proposal for an eno-geopedological map of Campania region (Italy) based on vineyard/tuff formation links, a study case on "asprinio" terroir. In *Paesaggi, Terroirs e i Paesaggi del Vino, Proceedings of the Convegno Internazionale "Paesaggi, Terroirs e i Paesaggi del Vino"*; Gregori, L., Ed.; Nuova Phromos Ed: Citta di Castello, Italy, 2008; pp. 59–70, ISBN 978-88-902648-3-2.
86. Tibaldi Chiesa, M. *Cimarosa e il Suo Tempo*; Garzanti: Milan, Italy, 1939; p. 329.
87. Dowling, R.K. Global Geotourism—An emerging Form of sustainable tourism. *Czech J. Tour.* **2013**, *2*, 59–79. [CrossRef]
88. Rodolico, F. *Le Pietre Delle Città d'Italia*; Le Monnier: Firenze, Italy, 1965; p. 502.
89. Calcaterra, D.; Cappelletti, P.; Langella, A.; Morra, V.; Colella, A.; de Gennaro, R. The building stones of the ancient centre of Naples (Italy): Piperno from Campi Flegrei. A contribution to the knowledge of a long-time-used stone. *J. Cult. Herit.* **2000**, *1*, 415–427. [CrossRef]
90. Fratini, F.; Rescic, S. The stone materials of the historical architecture of Tuscany, Italy. In *Stone in Historic Buildings: Characterization and Performance Geological Society Special Publications*; Cassar, J., Winter, M.G., Marker, B.R., Walton, N.R.G., Entwisle, D.C., Bromhead, E.N., Smith, J.W.N., Eds.; Geological Society of London: London, UK, 2013; p. 391. [CrossRef]
91. Tropeano, M.; Sabato, L.; Festa, V.; Capolongo, D.; Casciano, C.I.; Chiarella, D.; Gallicchio, S.; Longhitano, S.G.; Moretti, M.; Petruzzelli, M.; et al. "Sassi", the old town of Matera (southern Italy): First aid for geotourists in the 'European Capital of Culture 2019'. *Alp. Mediterr. Quat.* **2018**, *31*, 133–145. [CrossRef]
92. Gambino, F.; Borghi, A.; d'Atri, A.; Gallo, L.M.; Ghiraldi, L.; Giardino, M.; Martire, L.; Palomba, M.; Perotti, L.; Macadam, J. TOURinSTONES: A Free Mobile Application for Promoting Geological Heritage in the City of Torino (NW Italy). *Geoheritage* **2019**, *11*, 3–17. [CrossRef]
93. Santi, P.; Tramontana, M.; Tonelli, G.; Renzulli, A.; Veneri, F. The Historic Centre of Urbino, UNESCO World Heritage (Marche Region, Italy): An Urban-Geological Itinerary Across the Building and Ornamental Stones. *Geoheritage* **2021**, *13*, 86. [CrossRef]