

Article

Cultural Heritage and Geology: The Example of the Mascheroni Fountain and Its Qanat in the Rupestrian Town of Laterza (MurGEopark UGGp and “Terra delle Gravine” Regional Park, Puglia, Southern Italy)

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Abstract

Water resources allow us to trace the history of many of our towns. In settings with limited surface water, a very interesting case study is represented by the presence/preservation of water in the rupestrian towns located along the rocky walls of canyons (locally named “gravine”) southward, cutting the Murge karst area (Puglia, Southern Italy). In some sections of their valleys, soft rocks, easy to dig, are exposed, and, along the canyon flanks, favored the development of rupestrian towns (cities where dwellings are carved in these soft rocks). Here, before the construction of aqueducts that now bring water from the “distant” Apennines (at least 30 km away), the building of historical fountains, in addition to the collection of rainwater in cisterns, testifies to the presence of an aquifer now undervalued as a local water resource useful for human settlements in a predominantly karst territory. Our study regards an aquifer feeding the Mascheroni Fountain (Great Masks Fountain) through a short qanat that allowed for the development of the old town of Laterza, in Puglia (Southern Italy). Starting from the attractiveness of the ancient fountain, the connection between geological features of the area and the ancestral origin of the city could be proposed to a large audience, representing an intriguing opportunity to develop themes useful for geotouristic purposes and disseminating concepts about sustainability and the importance of preserving local renewable resources. This topic is of paramount importance since the town of Laterza is located at the boundary between the UNESCO MurGEopark and the “Terra delle Gravine” Regional Park, making it the ideal starting point for both parks.

Keywords: Murgia di Matera-Laterza; Gravina di Laterza; rupestrian towns; hydrostratigraphy; geoheritage; water; qanat



Academic Editor:
Abdelouahed Lagnaoui

Received: 8 July 2025

Revised: 20 August 2025

Accepted: 29 August 2025

Published: 2 September 2025

Citation: Bellini, F.; Bellini, D.; Clemente, F.; Sabato, L.; Tropeano, M. Cultural Heritage and Geology: The Example of the Mascheroni Fountain and Its Qanat in the Rupestrian Town of Laterza (MurGEopark UGGp and “Terra delle Gravine” Regional Park, Puglia, Southern Italy). *Geosciences* **2025**, *15*, 341. <https://doi.org/10.3390/geosciences15090341>

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1. Introduction

The urbanization of an area is closely linked to the availability of water, and this resource must be taken into account in order to trace the beginning of the history of many of our towns ([1,2], among many others). A water source, like a spring, was frequently considered a sacred gift [3,4], and a real asset that needed to be protected and defended; as a consequence, the control of water resources was, and still is, one of the main causes of conflict in ancient and present times [5,6]. The Goal 6 of the 2030 Agenda for Sustainable

Development of the United Nations [7] “Ensure access to water and sanitation for all” [8] must be framed in this scenario, is crucial to recognize the significance of this water issue in arid/semi-arid territories like the karst area of Murge in the Puglia region (Southern Italy) [9–13]. In this setting, with limited surface water [14], a particularly interesting case study is the historical presence of water resources [15,16] and its preservation in the fascinating rupestrian towns located along the rocky walls of canyons cutting the Murge karst area that faces the Taranto Gulf (Ionian Sea). These canyons and waterways that flow at their bottom are locally known as “gravine” (a plural term; singular “gravina”) [17,18], and, in some sections of their valleys, soft rocks, easily to be excavated, are exposed; this led to the development of rupestrian towns, i.e., peculiar cave settlements where dwellings were excavated directly into the rock (rather than occupying natural cavities). These settlements became underground (“unbuilt”) cities following a “negative building” (digging) housing culture [19–22] such as the rupestrian old town (“Sassi”) of Matera (see location in Figures 1 and 2), which, in the first half of the last century, housed up to 20,000 people [23–28]. In the following, the terms “rupestrian” and “gravina/e” will be used in accordance with the previous definitions.

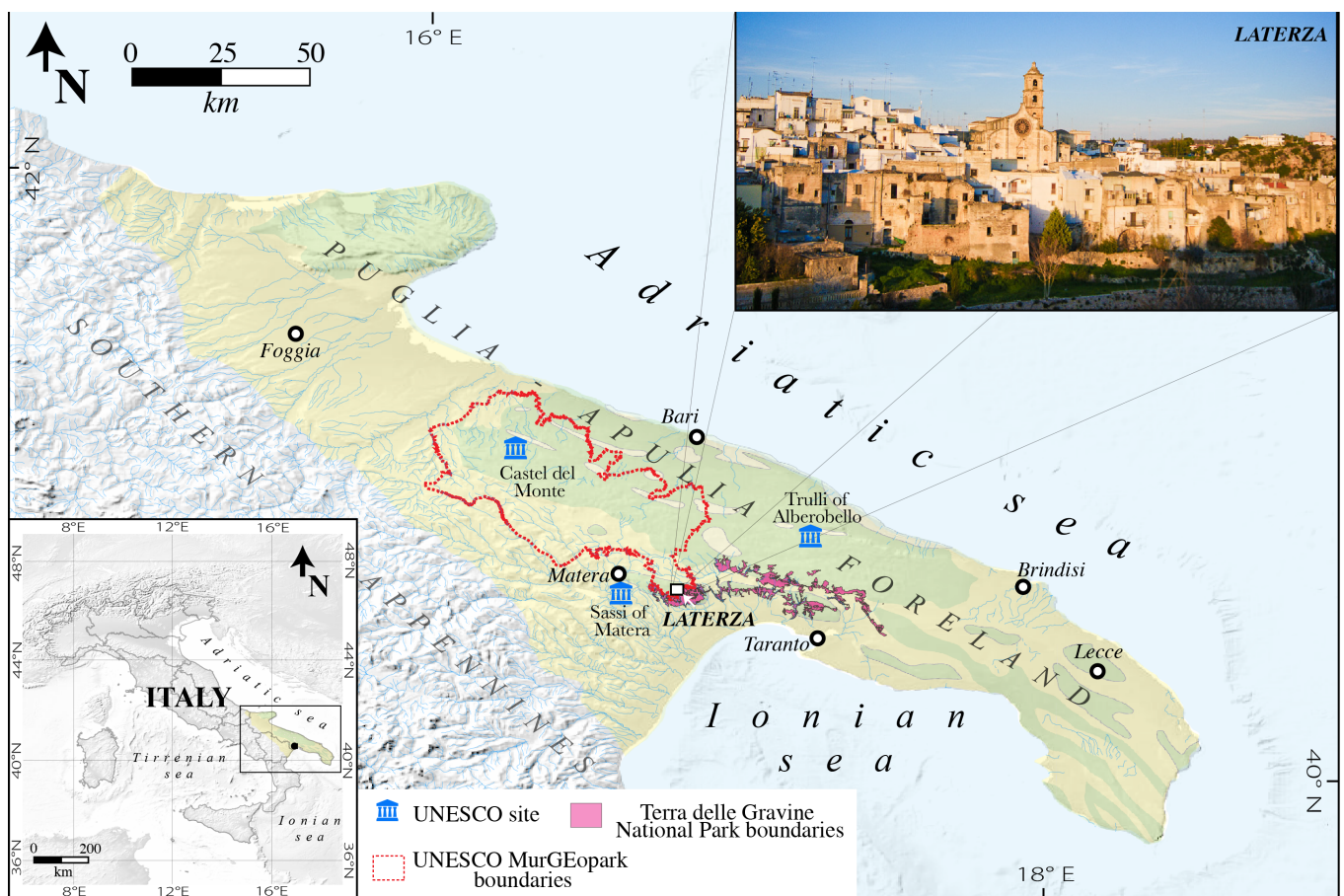


Figure 1. Geographic location of the city of Laterza ($40^{\circ}37'49''$ N, $16^{\circ}48'11''$ E) in Southern Italy. See also location of the nearby city of Matera, often quoted in the text. Note also the extension of the UNESCO MurGEopark and the “patchwork” of the Terra delle Gravine Regional Park. In the top right, panoramic view of the rupestrian town of Laterza, in Puglia (Southern Italy). The back of facades and below-constructed rooms were dug in the same soft rocks used as building blocks, and an underground (“unbuilt”) city developed.

In such rupestrian towns, the building of historical fountains provides evidence of the presence of shallow aquifer and/or spring undervalued as an important local

water resource and as an ancestral reason for human settlements of a predominantly karst territory [29].

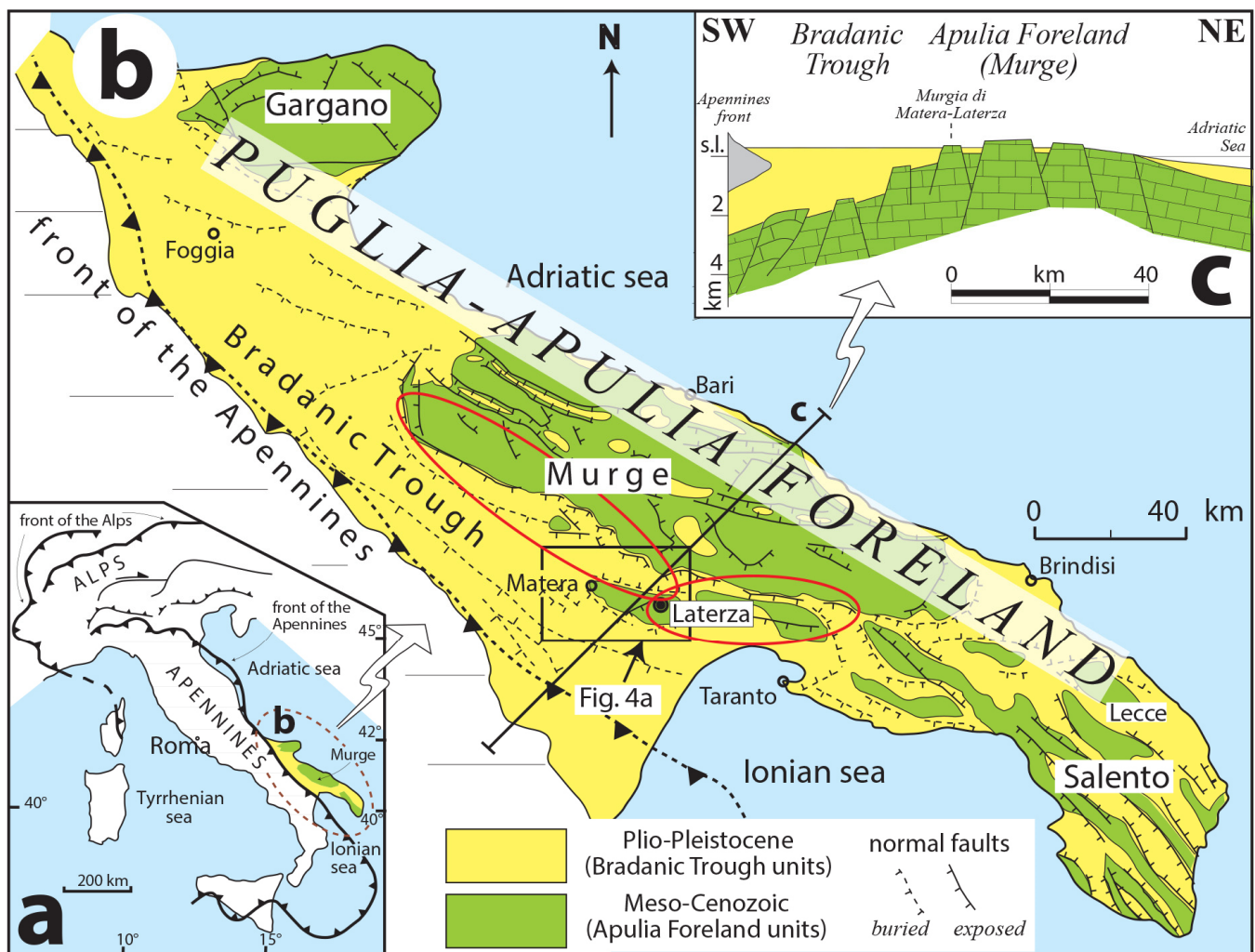


Figure 2. (a) Schematic structural map of Italy. Green and yellow areas correspond to the Apulia Foreland (Puglia) and its foredeep (Bradanic Trough). The Murge area is the central region of the foreland after [30]. (b) Schematic geological map of the Puglia region showing the position of the Gargano, Murge and Salento structural highs of the Apulia Foreland. The inset shows the location of the “Murgia di Matera-Laterza” area (Matera Horst). After [31]. The two red ellipses roughly indicate the UNESCO MurGEopark area to the North and the Terra delle Gravine Regional Park area to the South. The city of Laterza lies directly on the border between the two park areas. (c) Geological section crossing the Murge area and the Bradanic Trough [32] (modified). Note the position of the Murgia di Matera-Laterza, corresponding to an exposed horst of the horst and graben system flexing toward the Apennines (see later in text).

As a matter of fact, the topic never enjoyed attention in regional hydrogeological studies, mainly devoted, since the 1960s, both to risks of pollution of the deep karst aquifer of Murge and to the salinization of the same aquifer along coastal settings [33–40]. Before the advent of modern aqueducts, which facilitated the conveyance of water from the distant Apennine mountains to this region [41,42], the historical fountains represented the only source of water for drinking and for developing artisanal and agro-pastoral activities in the area, in addition to the rainwater collection system. Unfortunately, the presence of these resources is reported only in local studies, scattered in non-academic articles that are difficult to find and (if published on indexed journals) almost exclusively dealing

with history and architecture of fountains and cisterns (e.g., [22,43,44]) rather than with hydrogeology (i.e., why does the water spring in that place?).

The focus of the present study regards an aquifer/fountain allowing for the development of the old town of Laterza, in Puglia (Southern Italy) (Figures 1 and 2), dealing with the geological reasons to have that resource in that locality. Starting from the historical attractiveness of the ancient “Fontana dei Mascheroni” (Great Masks Fountain) of Laterza, hereinafter called Mascheroni Fountain (Figure 3), but also known as “Fontana Cinquecentesca” or “Fontana Medievale” (Sixteenth Century- or Medieval-Fountain, respectively), the connection between the geological features of the area and the ancestral origin of the city could be proposed to a large audience. This topic is of paramount importance since the town of Laterza is located at the boundary between the MurGEopark, the most recent UGCp (UNESCO Global Geopark) of Italy [45], and the geo-fascinating Terra delle Gravine Regional Park [46] (as evident in Figures 1 and 2), making it the ideal starting point for both parks. In addition, highlighting the presence of this geoheritage (the Mascheroni Fountain) could represent an intriguing opportunity to develop themes useful for geotouristic purposes [47,48], as already proposed in the nearby city of Matera [49–52].

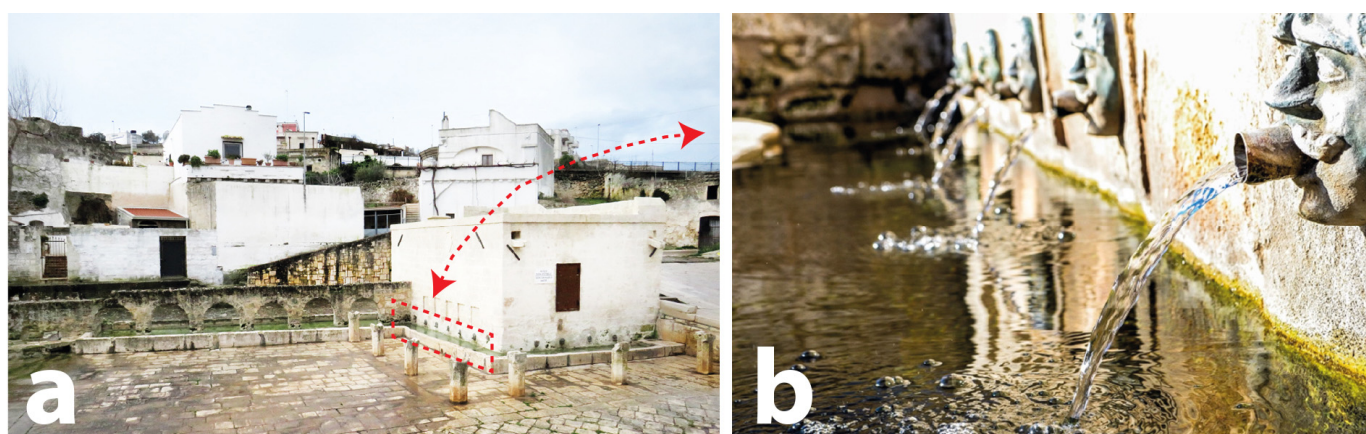


Figure 3. (a) The Mascheroni (Great Masks) Fountain at Laterza. The inset shows the position of the great masks. On the lower left part of the picture, note the presence of an arched structure (see later in the text). (b) Detail of the great masks.

2. Geological Setting of the Area

The rupestrian settlement of Laterza is located on the karst relief known as “Murgia di Matera-Laterza” [53,54] (Figure 4). The Murgia di Matera-Laterza is part of the Murge area, which forms part of the Apulia Foreland, the structural foreland of the Southern Apennines in Italy [55–57] (Figure 2). The exposed rocks of the Apulia Foreland are mainly represented by Cretaceous limestones of an ancient Tethyan Carbonate Platform, the Apulia Platform [57–59] (Figure 2b), which also crop out extensively in the Murgia di Matera-Laterza, where they are assigned to the Calcare di Altamura Formation [60–68]. During Tertiary times these rocks, exposed from the end of the Cretaceous, were faulted [69,70]; this process produced a complex horst and graben system [71,72], later flexed toward the Apennines chain [73,74] (Figure 2c). Due to this westward flexure, the faulted and subsiding foreland (the horst and graben system) progressively became the South Apennines foredeep basin, i.e., the Bradanic Trough, and, during early Pleistocene, was progressively submerged as a result of the relative sea-level rise (induced by the flexural subsidence), transforming the region into a drowning archipelago [75] (Figure 5).

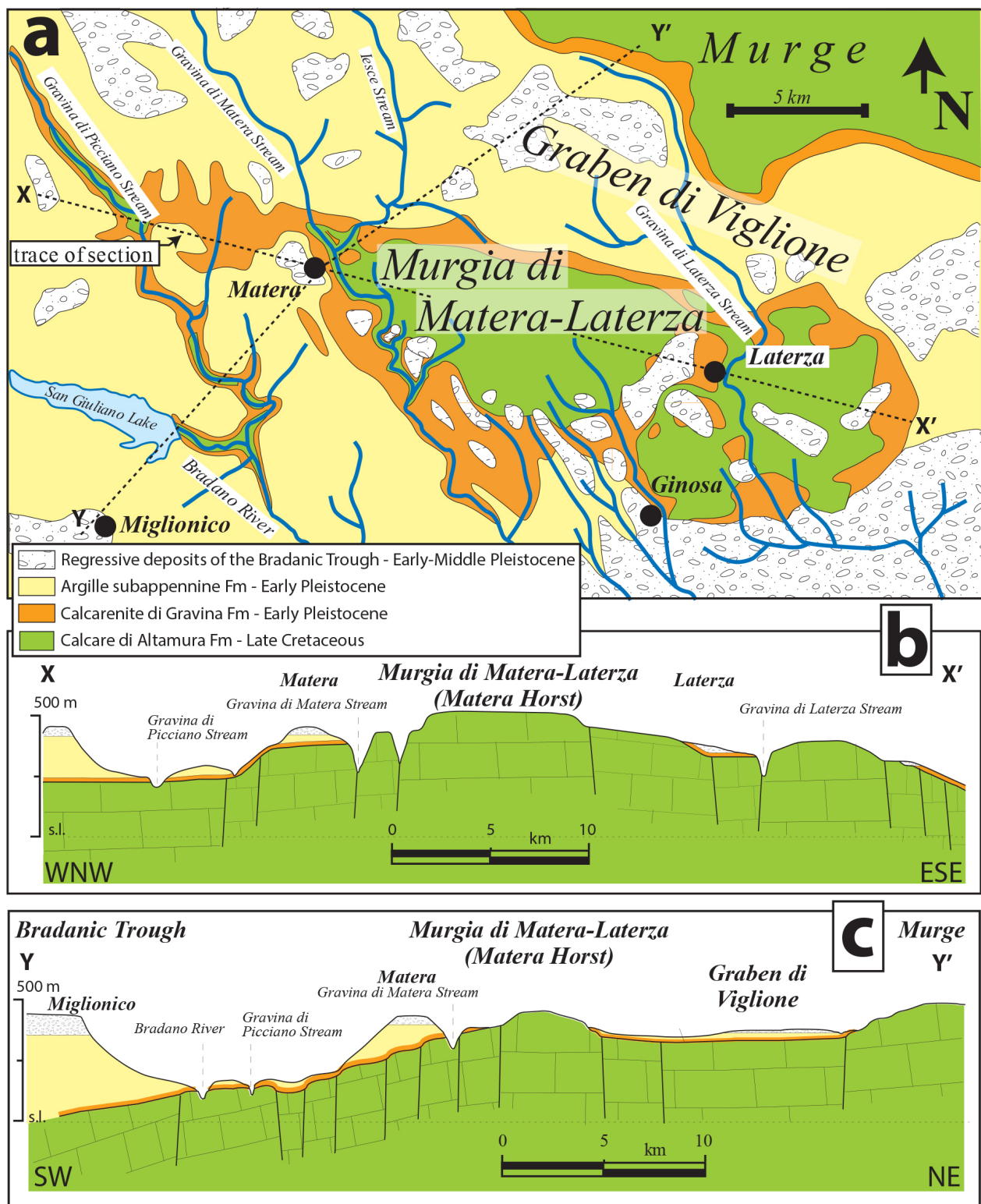


Figure 4. (a) Schematic geological map of the Murgia di Matera-Laterza (Matera Horst) and surroundings [54]. See the inset in Figure 2b for the location. (b) Geological section crossing the horst from WNW to ESE. (c) Geological section crossing the horst from SW to NE. Both geological sections (b,c) highlight how the top of the horst elevates respect to the adjacent areas. Drainage network developed starting from the originally laterally continuous flat surface of the Regressive deposits of the Bradanic Trough (see the legend), without cutting the top of the Matera Horst, more elevated respect to that flat surface.

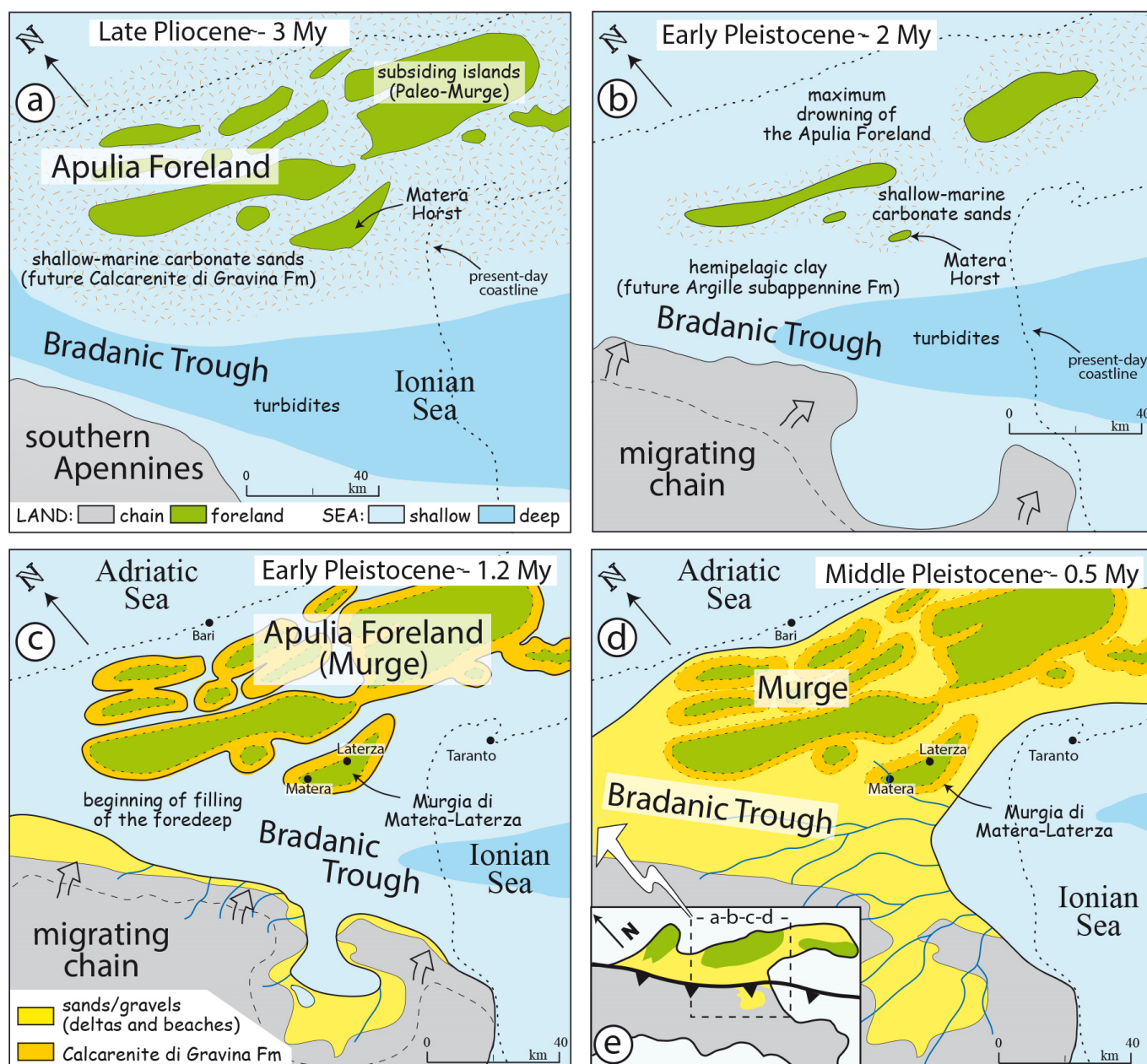


Figure 5. Development of the Murge area and adjacent foredeep basin (Bradanic Trough) during Quaternary times [51,75]. (a,b) Flexure of the Apulia Foreland toward the Apennines caused the return of the sea on the Murge area. In this scenery, the Murgia di Matera-Laterza was a subsidising horst (the Matera Horst), becoming an almost drowned island during Early Pleistocene [54]. (c,d) During late Early and Middle Pleistocene, the subsidence ended, and the region began to uplift. A drainage network developed cutting Quaternary deposits and, on the flank of the foreland, even the Cretaceous bedrock producing those characteristic canyons locally called gravine. (e) Present-day schematic geological setting of the area; the inset shows the position of the area reproduced in the (a–d) pictures.

The Quaternary succession records the progressive drowning of islands during flexural subsidence of the Apulia Foreland: transgressive shallow-marine carbonates deposited on the flank of islands [71,76–78]. These coarse-grained bioclastic sediments, after diagenesis, would have become the soft rocks geologically known as Calcarenite di Gravina Formation [79] outcropping along flanks of the gravine where rupestrian settlements could develop [80]. Both laterally, along the paleoslopes of the island, and upward, these carbon-

ates pass to a relatively deeper marine-clays of the Argille subappennine Formation [62–65]. Clays were subsequently and regressively overlain by sandy–gravelly coastal deposits (Regressive deposits of the Bradanic Trough) which today correspond to coarse-grained deposits on top of clay hills of the area [75,81–83].

A subsequent phase of regional uplift, which began at least at the Early–Middle Pleistocene transition and is still ongoing [84], led to the emergence of the Murge and the adjacent Bradanic Trough areas, enabling the incision of the drainage network [85–87] (Figure 4). The drainage network was initially developed on the flat surface of the soft sandy and gravelly units (Regressive deposits of the Bradanic Trough), later cutting the underlying clay (Argille subappennine Formation) and coarse-grained carbonates (Calcareniti di Gravina Formation) even reaching the Cretaceous bedrock (Figure 6). Along the flanks of the Murge, as well as on the previously submerged and subsequently buried paleo-islands, the hydrographic network has been responsible for the formation of the distinctive gravine canyons that are characteristic of the region. As suggested by [88], identifying a dominant morphogenetic process for the evolution of the gravine fluviokarst drainage basins remains an open question. Even if generically considered fluviokarst features, the origin of these canyons is debated. Although the Murge area shows some features typical of karst landscapes, it exhibits a well-developed drainage network, formed by a dense dendritic pattern in the headwater zone which evolves into regularly spaced, incised valleys cutting through a staircase of marine terraces moving toward the Adriatic Sea coast [87]. According to [18], a series of valley generations is recognizable, each one of them leading to the internal margin of a marine terrace representing its base level; in this case, morphological features and hydrogeological conditions suggested [18] that sapping processes were responsible for the development of the valley network.

The valley network of the study area developed toward the Ionian Sea, on the other side of the Murge area respect the previous one. Here, the area experienced several morphological cycles from Tertiary times to the Quaternary [85]. During the last stage, a series of marine terraces formed and a drainage system developed, creating both bland valleys and well-defined channels and gorges; the latter streams deeply carve the Cretaceous bedrock and represent the morphological response to the tectonic uplift of the area [89]. According to [54], since the fluvial network took place on Pleistocene covers, later widely eroded, the drainage system represents a good example of superimposition, even if low-order streams and segments of major rivers appear to be structurally controlled. According to [88], in accordance with [54], anomalies of mean local relief and channel steepness, and the distribution of fluvial knickpoints are consistent with a regional uplift affecting the Murge area since Middle Pleistocene, demonstrating that the history of gravine evolution was dominated by fluvial processes. Their analysis reveals that the gravine fluviokarst drainage networks are characterized by well-developed surface drainages, following the typical scaling relationship observed for non-karst bedrock streams [88].

Some of these gravine, the deepest ones of the area, developed cutting the horst/paleo-island corresponding today to the Murgia di Matera-Laterza. Three rupestrian towns, Matera, Laterza and Ginosa, developed on the flanks of these gravine (Figure 7). Each of these towns is characterized by a main historical fountain; in the case of Laterza, it is the Mascheroni Fountain. Moving eastward from the Laterza town, beyond the Murgia di Matera-Laterza, several other gravine incise additional paleo-islands, each one with its own cultural rupestrian history and all of them falling in the Terra delle Gravine Regional Park [90].

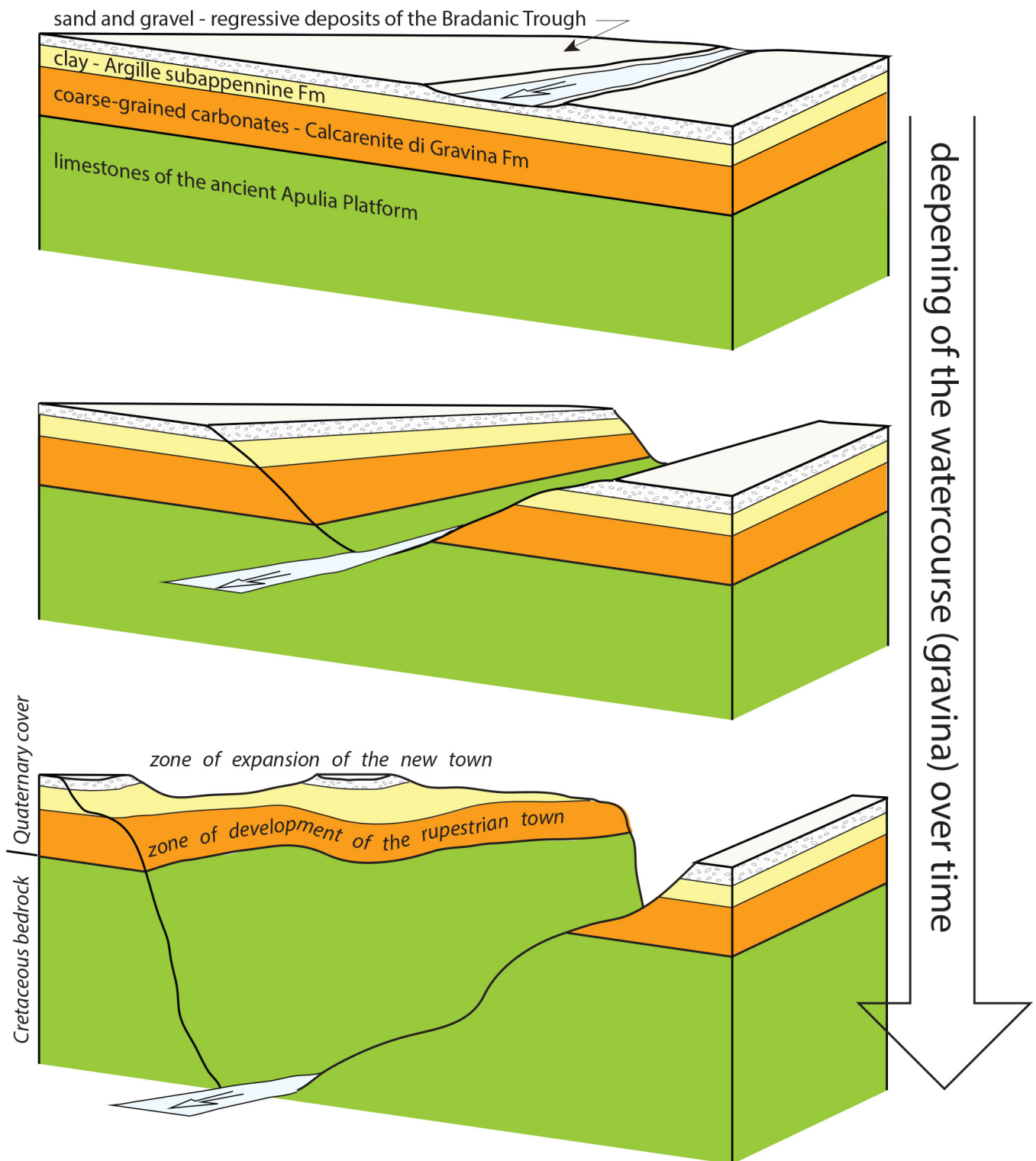


Figure 6. Development of a gravina. The original watercourse developed on the flat top of sandy–gravelly units (Regressive deposits of the Bradanic Trough). The uplift of the area led the river to cut the underlying clay (Argille subappennine Formation) and, on flank of the Murge area, even coarse-grained carbonates (Calcarenite di Gravina Formation) and the Cretaceous bedrock. In this last case, a canyon, locally called gravina, develops. It represents a good example of superimposition, even if tectonic structures and karst features (not highlighted in the scheme) could have controlled small segments of the river course.

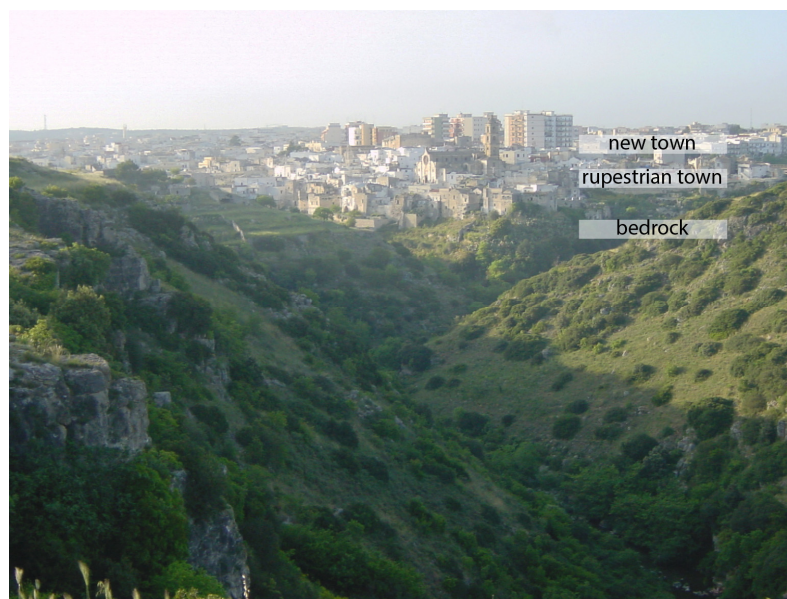


Figure 7. Panoramic view of Laterza town perched on the gravina [91] (taken from $40^{\circ}37'1.42''$ N, $16^{\circ}48'2.52''$ E). Compare with Figure 6.

3. The MurGEopark UGGP and the “Terra delle Gravine” Regional Park: Two Adjacent Protected Areas Closely Linked by Geology

On 17 April 2025, UNESCO named 16 new Global Geoparks, including the MurGEopark (Puglia, Southern Italy) [45]. “The worldwide geological uniqueness of the MurGEopark is that the area is the only in situ remnant of the Adria Plate, the old continental plate almost entirely squeezed between the Africa and Eurasia Plates” and the area could be defined as “the last piece of Adria, the (almost) lost continent” [92,93]. The MurGEopark area comprises: (i) the Northwestern part of the Murge territory, roughly corresponding to the Alta Murgia National Park and where a Cretaceous sector of a wide peri-Tethys carbonate platform (the Apulia Carbonate Platform) crops out, (ii) part of the adjacent Premurge area, where the southwestward lateral continuation of the same platform (flexed toward the Southern Apennines Chain) is covered by the thin Plio-Quaternary foredeep deposits of the Bradanic Trough previously described [92,94,95]. Basically, this description corresponds to the geological setting reported for the Laterza area (see the previous chapter), and can be easily ascribed to the whole Terra delle Gravine Regional Park that is a protected area where landscapes offer a good opportunity to appreciate the linking between geodiversity, biodiversity and cultural diversity present there. The area can be considered the natural extension of the MurGEopark, providing clearer insights into the relationship between geology and human settlements, particularly through the spectacular landscapes shaped by deep gravine. The latter, much explored for having hosted the “rupestrian civilization” [96], simultaneously show cross-sections of the geological evolution of the area probably better appreciable rather than those ones exposed in the wider MurGEopark.

4. The Mascheroni Fountain of Laterza and Its Supply Aquifer

The Mascheroni Fountain is located near one of the main gates of the Laterza old town, close to the ancient walls but outside them [97] (Figure 8), in the middle of a suspended tributary of the Gravina Stream (Figure 9).



Figure 8. Cartography of Laterza at the transition between the 17th and 18th centuries [97]. Note the location of the Mascheroni Fountain outside the town.



Figure 9. The Mascheroni Fountain is located along a suspended tributary of the Gravina Stream of Laterza, at the base of the hill hosting the rupestrian town. "Via Concerie" (literary "Tanneries Street") occupies the bed of the suspended tributary. Base map from Google Earth.

The Mascheroni Fountain and the accompanying system of small pools follow a well-ordered tripartite plan: the first L-shaped pool was used for drinking water (Figure 3b), the second pool, built at the base of the arches of an old aqueduct (see below) (Figure 10; see also Figure 3a), was used for watering animals, and the third pool, which completes the plan, was used as a large washhouse (Figure 10). The residual water ultimately flows into an exposed drain that passes through the vegetable gardens of the Conche locality and converges with the suspended tributary.



Figure 10. The second pool (at the base of the arcs) and the third one (perpendicularly located at the left end of the arcs) of the Mascheroni Fountain, built with blocks coming from the same carbonate soft-rocks dug to create rupestrian houses. The photo was taken from behind the facade reproduced in Figure 3.

The current features of the Mascheroni Fountain can be traced back to 1544, corresponding to its last refacing, as testified by the epigraph on the façade of the fountain; regarding its earliest construction or origin, there are no information or documents that attest to its date or the nature of the distribution work, although a small section of an older and abandoned aqueduct is present in the structure of the fountain [98] (the arcs in Figures 3 and 10). Due to the limited historical documentation describing the Mascheroni Fountain, much of its history has been preserved through local oral tradition. It is generally believed that the water in the fountain came from a surface spring, but the position of the Mascheroni Fountain does not correspond to the location of a main water source and the fountain itself may be a relatively recent structure incorporating the remains of the terminal section of an older aqueduct of Roman facture. In accordance with the Roman hydraulic technology [99], allowing for bringing water to fountains by gravity over long distances through aqueducts, it can be assumed that the series of arches of the ancient disused aqueduct (Figures 3 and 10), by now incorporated in the Mascheroni Fountain with an aesthetic function only, testify to the presence of an older feeding conduit.

Our investigations focused on the water supply system that today feeds the distribution structure. Water does not come from the surface runoff but from an intercepted aquifer

hosted in the dug soft rocks, and it is carried through an underground conduit, of which the structural integrity has been severely compromised in several places by tree root penetration. The conduit is partially excavated into the same soft rock that hosts the rupestrian town and vaulted; it extends approximately 500 m below “Via Concerie” (literary: Tanneries Street), from the Mater Domini Sanctuary area to the Mascheroni Fountain [100,101] (Figure 11).



Figure 11. Satellite view of the Via Concerie area, from the Mater Domini Sanctuary to the Mascheroni Fountain. The white line highlights the route of the underground conduit connected to collection tanks A, B, and C. Collection tank D shows no connection to the underground aqueduct compared with Figure 9. Base map from Google Earth Pro (7.3.6.10201 (64-bit); date of acquisition of the base image: 7 July 2018).

While the conduit acts simply as a channel, water collection takes place through three tanks and referred to as Tank A (Veteri Source), Tank B, and Tank C (Figures 11 and 12). The Veteri source consists of a primary chamber approximately 6 m wide, 8 m long, and 7 m high (Figure 12A). The lower part is excavated into the rocks, while the upper 2 m consists of ashlar masonry. Within this chamber, a 1.5 m wide by 2 m high basin collects water. The two additional water collection basins (points B and C in Figure 11) are located in smaller tanks and are connected to the main conduit by side channels (Figure 12B,C). All these basins intercept an aquifer locally hosted in the lower part of the outcropping Calcarene di Gravina Formation and collect water in a conduit feeding the Mascheroni Fountain. All along the route, it is possible to identify the cleaning wells of the structure, which connect the conduit to the surface. The hydraulic system comprises vertical wells too, connecting the surface to the conduit itself (Figure 13).

A fourth basin is located outside the fountain system (point D in Figure 11), in a cellar (Figure 12D). Although located near the adduction conduit of the Mascheroni Fountain, this tank is hydraulically independent and not physically connected to the main channel but fed by the same aquifer hosted in the Calcarene di Gravina Formation, i.e., in the same rock–mass hosting the rupestrian settlement of Laterza.

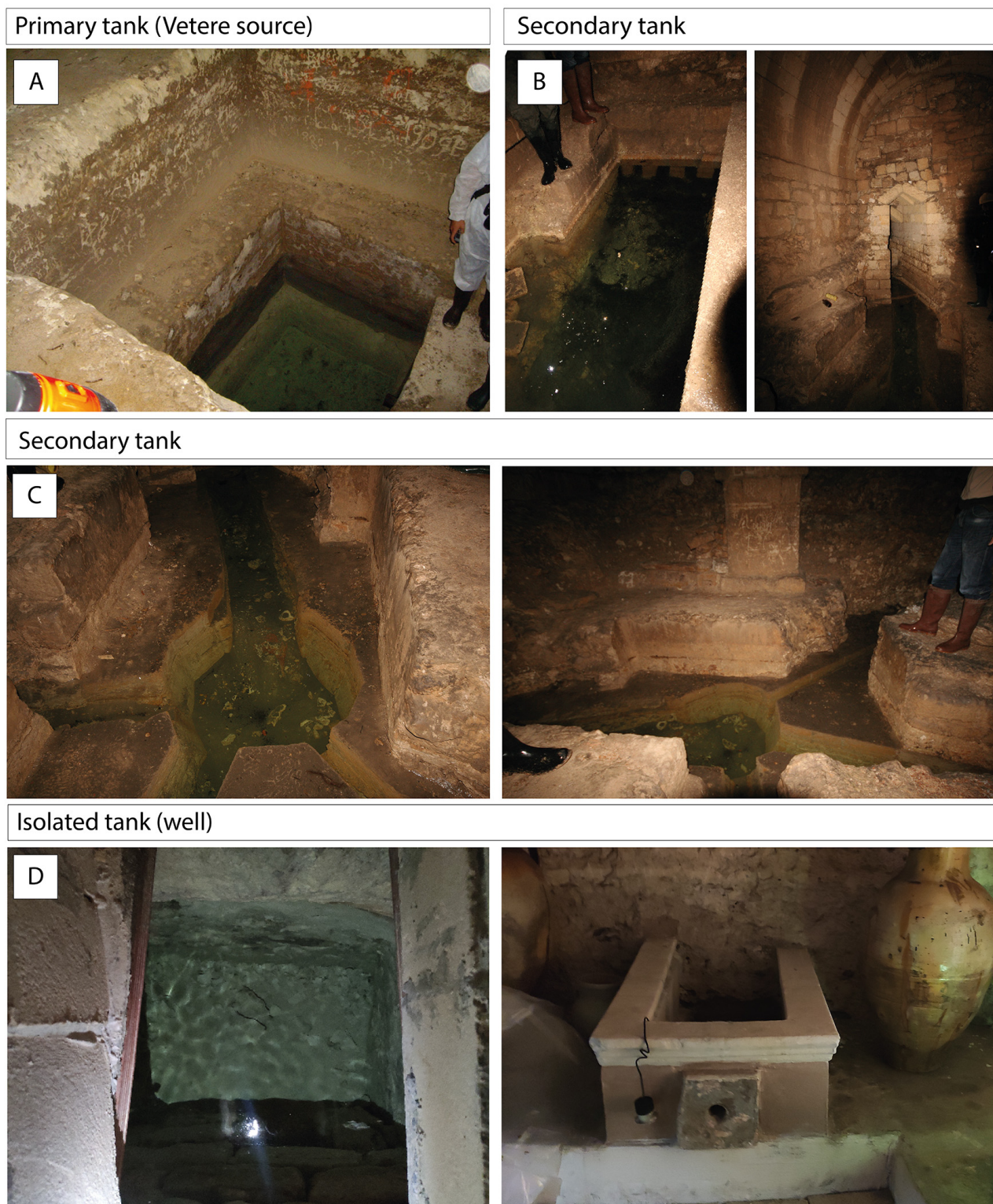


Figure 12. Visual documentation of the underground conduit system (the conduit is carved directly in the calcarenite; the building blocks used to construct some parts of the conduits and the vaults of the underground structure come from the same kind of calcarenite). (A) The Vetere source, the main collection tank, and the primary intake structure of the aqueduct. (B) The secondary collection tank (on the left) and the side conduit connecting it to the main underground channel (on the right). (C) Views of tank C and the associated underground distribution network, which links this node to the principal conduit of the aqueduct system. (D) Views of tank D, highlighting its structural characteristics. (Pictures of Nicola Zilio).

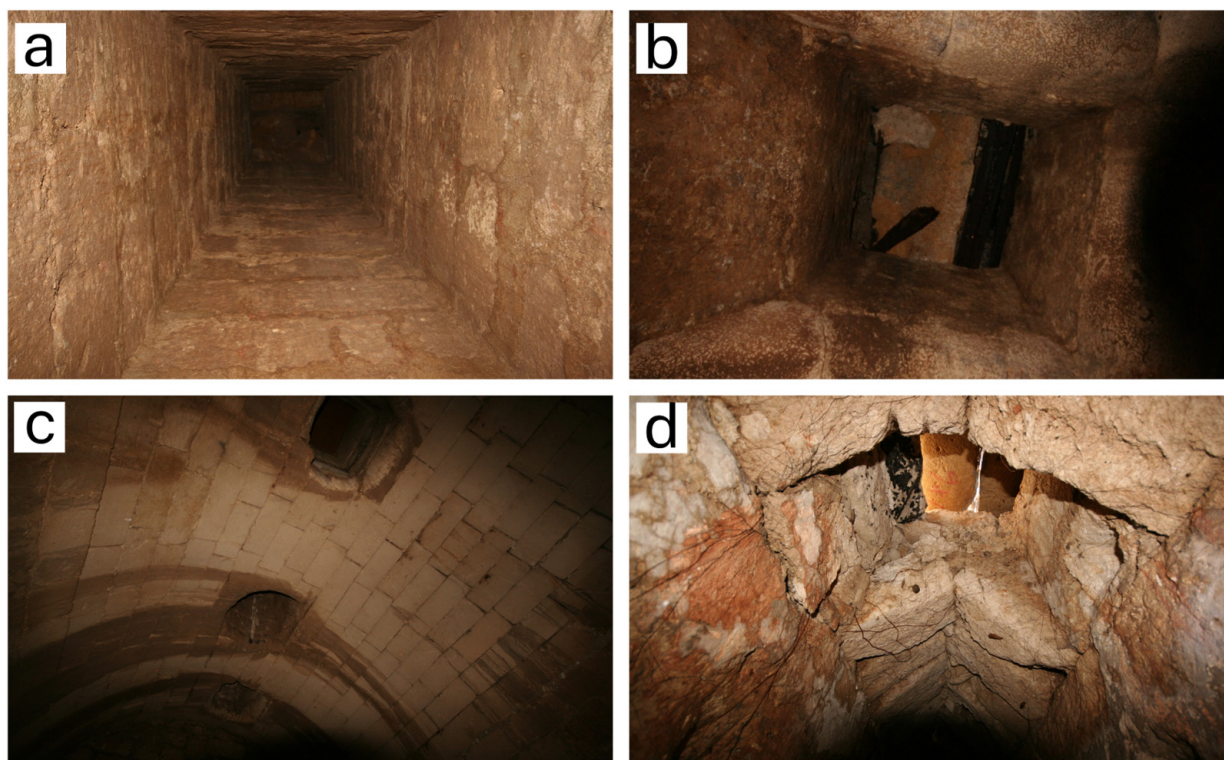


Figure 13. Details of the vertical shafts that connect the surface to the underground conduit: (a) the shaft in the Sanctuary Mater Domini area; (b) the shaft in the middle of the Via Concerie area; (c) the two shafts in the vaulted ceiling of the secondary tank; (d) the shaft near the Mascheroni Fountain area. (Pictures of Nicola Zilio).

5. Discussion

5.1. The “Hidden” History of the Mascheroni Fountain and Its “Qanat”: Some Help from Geology

The occurrence of shallow aquifers in the Murgia di Matera e Laterza area is strictly linked to the regional stratigraphic framework. These aquifers are hosted in the upper part of the Quaternary succession, where porous sandy/gravelly deposits overlie impermeable clays (see stratigraphic features in Figures 6 and 14a). In such a context, fountains were fed by springs located at the boundary between porous deposits and underlying clay, namely above the rupestrian towns hosted in the “diggable” soft rocks of the Calcarene di Gravina Formation, located below clay (Figure 6), as at Matera [49]. At Laterza, even if the contact between the clays and the overlying porous deposits can be seen above the rupestrian old town, like upstream of Via Concerie, exposed data suggest that water was not collected from that position. By contrast, the presence of an aquifer inside the Calcarene di Gravina Formation indicates the likely presence of an aquiclude at the base of the formation itself, i.e., at the boundary with the underlying Cretaceous karstified limestones. In the surroundings of Laterza, some outcrops show that this boundary is characterized by the presence of a palaeosol, corresponding to a terra rossa horizon (Figure 14), i.e., residual clays due to karst processes developed on the Cretaceous bedrock before the sedimentation of Calcarene di Gravina Formation; assuming that this feature occurs below the rupestrian town of Laterza, the presence of this impermeable horizon enables the Calcarene di Gravina Formation to act as an aquifer. Regionally, the spot presence of this kind of palaeosol below the Calcarene di Gravina Formation was highlighted by [71,77,78]. This geological context determines a peculiar hydrostratigraphy in the Laterza area, allowing the presence of a suspended aquifer in the lower part of the formation (Figure 14a). The suspended shallow aquifer hosted below the old settlement of Laterza could be partly compared to

that described at Acquaviva delle Fonti and Corato towns where groundwater is accessed by wells and may temporarily emerge during the main rainfall events [102–105].

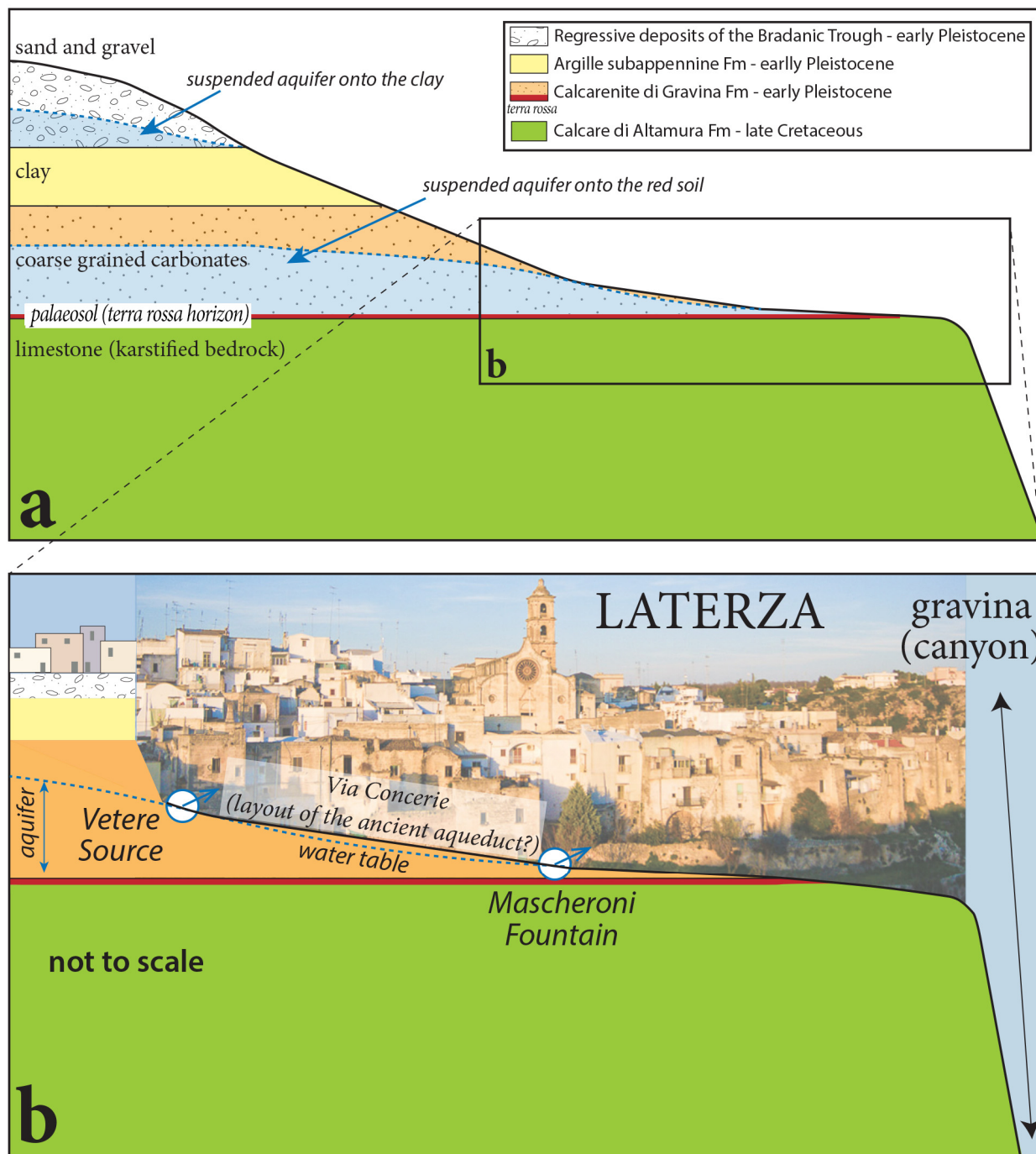


Figure 14. (a) Schematic and simplified geological section showing the hydrostratigraphy along the flank of the gravina at Laterza. Note the possibility in the area to have two suspended aquifers. (b) Detail of the suggested position of the two original springs along the tributary (now corresponding to Via Concerie) of the Gravina Stream. Compare this scheme with the position of the fountain along the tributary highlighted in Figures 9 and 11, on whose left side developed the old rupestrian town. See the text for the discussion about the interception of the water table.

Since ancient times, the rich presence of water in Laterza has played a decisive role in the growth and development of local activities such as leather tanning and the prestigious majolica ceramics [97,106]. It is evident that both activities necessitate the availability

of running water rather than collected water and are usually located below a spring or fountain, not above it, as is instead observed in Via Concerie at Laterza. As described above, the fountain catchment system consists of a conduit, excavated at the bottom and vaulted on top, supplied by a network of catchment tanks for groundwater collection and featured by several vertical wells connecting the surface to the conduit itself (Figures 12 and 13). In accordance with [100,101,107], the system is comparable to a “qanat”, i.e., a system of gently sloping tunnels connected to the surface with a series of vertical shafts and dug from the base of a slope until a hidden water table is pierced, allowing groundwater to flow freely and continuously without energy input [108,109]. The qanat system was performed in regions featured by arid climates to ensure a reliable water supply in human settlements and to provide irrigation; originally it developed in ancient Persia; later, it was introduced to Arabia and then across the Mediterranean region by the Arabs, first into North Africa and then to Southern Spain [110,111] and even in Southern Italy [112,113].

There are no documents or records attesting to the first construction date or the nature of the distribution work of the Mascheroni Fountain. Nevertheless, a small section of an older aqueduct, now abandoned, is present in the structure of the fountain (Figures 3 and 10). This suggests that the old aqueduct probably transported water in a different way from the current system.

Geology, offering reasonable hypotheses, could help describe the “hidden” history of the Mascheroni Fountain, its qanat and its “phantom” aqueduct. The geological evolution of the area led the Gravina Stream of Laterza to deeply cut even the Cretaceous rocks, producing a drainage network; along Via Concerie, the watercourse of a tributary reached the Cretaceous bedrock downstream of the Mascheroni Fountain without deepening in the Cretaceous limestones; by contrast, it incised deeply into the Calcarene di Gravina Formation, most probably locally touching the shallow water table of the aquifer hosted in the Calcarene di Gravina Formation itself (Figure 14b). It could be assumed that the water table skimmed the topographic surface at the bottom of the tributary, now corresponding to Via Concerie, in two places: one is the area where the Vetere source is now located, and the other was a bit downstream (a few meters away from the third pool) respect to the present position of the Mascheroni Fountain (Figures 11 and 14b).

According to [114], “supplying life’s most basic daily need, freshwater sources were likely the earliest sacred sites”; therefore, the Vetere source, which is effectively incorporated in the Mater-Domini Christian Sanctuary, is a sacred place corresponding to the emergence point of the aquifer and most likely was a sacred place even before Christianity. While more conjectural, the idea that a second emergence point existed downstream from the Mascheroni Fountain gains plausibility when considering that the area has long hosted vegetable gardens, cultivations that would have required a constant and dependable freshwater supply. As described in a previous chapter, the residual water that today reaches the Mascheroni Fountain feeds the gardens and forms a shallow pond (a puddle) before infiltrating the fractured Cretaceous rocks that crop out a few dozen meters downstream of the fountain, in the last stretch of the tributary.

The aqueduct of Roman facture was likely built to collect water from the Vetere source toward an old fountain/pool located in the same place as the present-day Mascheroni Fountain (Figure 14b); in this way, clean water could run down to the old fountain or pool, of which the overflow may have also supplied the shallow pond. The absence of cisterns below the fountain, which were instead so widespread in the nearby rupestrian town of Matera, most likely was due to the presence of fractured Cretaceous limestones very close to the topographic surface. This type of bedrock is not suitable for digging cisterns to store water, which in the old town of Matera is collected in very large cisterns dug in the Calcarene di Gravina Formation and sealed with plaster [43,115–117]. The excavation

of some cisterns was reasonably attempted downstream from the Vetere source, where the Calcarenite di Gravina deposit was a bit thicker. In this instance, the excavation was conducted to a depth that reached the aquifer, and the presence of a continuous water supply made further excavation of the cisterns unnecessary. Applying the qanat technique (culture), the various small cisterns were connected, from the Vetere source to the other natural point of exit of the water table (the pond), substantially following the roof of the aquifer. The latter and the new collector channel that touched it were slightly lower than the channel of the old aqueduct, now made useless by the new system.

5.2. Enhancement of the Mascheroni Fountain

According to the conceptual framework developed by [118], a natural locality where groundwater-related phenomena (such as springs, aquifers, or underground galleries) that exhibit exceptional scientific, ecological, educational, cultural or aesthetic values due to their genesis, hydrodynamic functioning, and spatial uniqueness is a geosite that could be defined a hydrogeological heritage site. There are several interconnected factors that support this claim and make the Mascheroni Fountain a site of significant importance.

The primary factor is the availability of a water resource in a karst environment, characterized by a scarcity of surface water [119]. Indeed, the Murge region hosts a deep and very large karst aquifer [120], but the availability of (little) water close to the topographic surface is controlled by specific stratigraphic characteristics linked to the sedimentary cover of the Cretaceous bedrock [121]. At Laterza, the hydrostratigraphic availability of a shallow aquifer is located within the Calcarenite di Gravina Formation (a permeable, coarse-grained unit) thanks to the (hypothesized) presence of an impermeable terra rossa horizon at its base. Such conditions, which determine the presence of exploitable aquifers below towns, are known on the Adriatic side of the Murge region, but are uncommon (unique) below rupestrian towns, particularly in the Murgia di Matera-Laterza area.

The other relevant factors to determine the importance of the site include the architecture, structure, and history of the water collection system, the strategic location of the Mascheroni Fountain, and its role in supporting the development of the local community in pre-modern times. These elements provide a solid foundation to suggest that the Mascheroni Fountain site, including the feeding aquifer, the Vetere source, and the qanat system, as a whole can be considered a hydrogeological heritage site [122,123]. Exemplary applications of this designation are provided by several case studies in the world [113,124–126].

To support the importance of the Mascheroni Fountain as geosite/hydrogeological heritage site, a further area of investigation concerns the impact of human activities on water quality, as well as the implications of climatic change on the availability of water resources over time and across different seasons [127]. A resource such as that offered by the Mascheroni Fountain has been in continuous operation for at least five hundred years, but may be impacted by climate change and could be particularly vulnerable being at the base of the (old and new) town of Laterza and located along one of the main tributaries of the Gravina Stream. An exhaustive examination of the chemical characteristics of the water, with particular reference to the predominant pollutants, could facilitate the formulation of strategies for its potable quality and/or for the utilization of the resource to irrigate vegetable garden and to collect and storage excess of water.

Despite the lack of data on water quality, it is still important to valorize the site for educational and geotouristic purposes [48,100,101,122,123]. In fact, explaining the presence of a small local aquifer can facilitate the understanding of the water cycle and, by introducing historical arguments, can allow for a discussion of the importance of correct management of this precious resource for sustainability purposes.

6. Conclusions

Laterza is a small town characterized by a previous old rupestrian settlement, i.e., an underground town dug in a soft rock mass. Several rupestrian towns developed in the region on the flanks of canyons locally known as gravine. Two geological (stratigraphic) conditions were favorable for the development of rupestrian towns: the presence of easily diggable rocks on the canyons flanks, which allowed the excavation of cave dwellings, and the availability of water. The watercourses flowing at the bottom of the canyons are ephemeral streams, with only sporadic water flow. Therefore, the inhabitants of the rupestrian towns of the Southwestern Murge area should have had other sources of water, and historical fountains are often witnesses of springs located above rupestrian towns. This was determined by the development of the hydrographic network of this area, which has progressively incised the local Quaternary succession, i.e., from the top downward, sands and gravels, clays, and the underlying soft-rock masses (hosting rupestrian towns), before reaching fractured Cretaceous limestones of the bedrock. This stratigraphic arrangement, where highly permeable sands/gravels overlie impermeable clays, created favorable conditions for the presence of an aquifer above the lithologic boundary. Consequently, as exemplified in Matera, groundwater emerges feeding: (i) fountains located above rupestrian towns, and (ii) cisterns inside the same towns.

By contrast, Laterza shows a different kind of aquifer and a different system of water outflow. The aquifer is located below the old rupestrian town, inside the dug soft rock rather than above it. At Laterza the water table is located below the topographic surface, touching it along a street occupying the bottom of a tributary of the main river course, i.e., the gravina which characterizes the city landscape. The presence of an aquifer in the lower part of the soft-rock mass suggests the presence of an aquiclude at the boundary with the underlying fractured Cretaceous limestones, a geologic feature recognized in other areas of Murge.

The Mascheroni Fountain at Laterza is the present-day witness of the local presence of a water source. Not much historical data are available about the development through time of the fountain, but a reasonable hypothesis on its history comes from geology. The presence of a shallow water table, touched by the bottom of a river course now corresponding to a street ending at the fountain, initially led to the construction of an aqueduct fed from a sacred source located where the aquifer slightly emerged; later, the same aquifer was used through a short qanat, an underground hydraulic system intercepting the hidden groundwater. These hydraulic systems now have only a historic value, but at least until the first half of the last century, they were a precious tool to make water, an essential resource, available to everyone. The presence of small local aquifers could prove to be strategically important, as climate change, which is being observed in a dramatic manner, could result in the necessity of this forgotten resource.

The idea of sustainability and the opportunity to raise awareness among citizens about the finiteness of resources should push decision makers to use the Mascheroni Fountain again as a water source for some public uses, provided that thorough technical and environmental studies first confirm the feasibility and long-term sustainability of such uses. This could be an attractive and driving topic in the context of the holistic approach required in a UNESCO Global Geopark, such as the MurGEopark, and in the Terra delle Gravine Regional Park.

Author Contributions: Conceptualization, F.B., L.S. and M.T.; investigation, F.B., D.B. and F.C.; data curation, F.B., D.B. and F.C.; writing—original draft preparation, F.B., L.S. and M.T.; writing—review and editing, F.B., L.S. and M.T.; visualization, F.B., L.S. and M.T.; supervision, F.B. and M.T.; project administration, L.S. and M.T.; funding acquisition, L.S. and M.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the following: (i) The HORIZON EUROPE SEEDS (to M. Tropeano) “S63—Patrimonio naturalistico e turismo culturale ed escursionistico in aree protette (pa.na.c.e.a.) Divulgazione dei concetti di “sviluppo sostenibile” e di “conservazione e gestione della geo/biodiversità” nel Parco Nazionale Alta Murgia, aspiring UNESCO Global Geopark”. Codice Identificativo Progetto S63, CUP H91I21001670006; (ii) PhD grants (to F. Bellini) “Valorizzazione del ‘capitale naturale geologico’ a fini turistici (geoturismo) del Parco Nazionale Alta Murgia (candidato Geoparco UNESCO) e realizzazione di piattaforme e siti digitali dedicati ai visitatori e alla comunità degli smartworkers” [“Enhancement of the ‘geological natural capital’ for tourism purposes (geotourism) of the Alta Murgia National Park (UNESCO Geopark candidate) and creation of platforms and digital sites dedicated to visitors and the community of smartworkers”], in collaboration with the Everywhere TEW Company, aimed at identify geotouristic routes linking geosites of broad interest; (iii) the project (to V. Festa) “GeoSciences: un’infrastruttura di ricerca per la Rete Italiana dei Servizi Geologici—GeoSciences IR” (codice identificativo domanda: IR0000037); CUP: I53C22000800006. Piano Nazionale di Ripresa e Resilienza, PNRR, Missione 4, Componente 2, Investimento 3.1, “Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione” finanziato dall’Unione Europea—Next Generation EU; (iv) PRIN Project 22 D.D 104 del 02/02/2022: “Abrupt Lithofacies Variations IN the stratigraphic record: proxies for environmental and climate changes—ALVIN” financially supported by the European Union (Next Generation EU-PRIN22-ALVIN-2022APF9M2-CUPH53D23001500006—RUOR M. Tropeano).

Data Availability Statement: No new data were created.

Acknowledgments: The authors are grateful to three anonymous reviewers whose suggestions helped improve the manuscript and to the AE.

Conflicts of Interest: The authors declare no conflicts of interest. Filippo Bellini and Domenica Bellini are brother and sister. This doesn’t and didn’t create any conflict of interest, as their activities fall within different fields.

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