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THE CAMPANIAN AQUEDUCT STAIRWAY REDISCOVERED

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Abstract
The Phlegraean Fields are a volcanic area W of Naples (Italy). They supported an important ancient settlement, favoured by rich crops and several natural harbours, for both civil and Navy ships. The area lacks fresh water springs, so in Augustean times the *Aqua Augusta Campaniae* was built. It tapped the Serino springs, in the Apennine mountains, and in a 105 km course it supplied several cities and the imposing *Piscina Mirabilis* at *Misenum*, a water tank servicing the Thyrrenian Roman Navy. The city of *Puteoli* was supplied also by the Campanian Aqueduct, a less known but archaeologically intriguing aqueduct. It dates back at least to the I century b. C., but its features could support an origin related to a more ancient settlement. The aqueduct still operated till the beginning of the XX century. The diffusion of the public water distribution network caused the oblivion of its course and accesses. In the framework of an ongoing research project about phlegraean aqueducts, we were able to find the entrance to a stairway placed along the ancient Campanian road. The stairway allowed access to the aqueduct in the past, but its first section was filled with rubbish. We nevertheless explored it and produced a speleological survey. The stairway is not straight but is composed by five sections, is lined in *opus reticulatum,* and reaches a depth of 62 m from the surface, with a 180 m spatial development. Unfortunately it ends with a tuff mud filling, just few meters before reaching the underground aqueduct course. We had the initial rubbish removed in the framework of the national *Puliamo il Buio* (Clean up the Darkness) initiative in 2011. The paper provides the cave description and a brief comparison with some other known cases of stairways reaching ancient underground aqueducts.
Keywords: Phlegraean Fields, Pozzuoli, ancient aqueducts, Roman stairways.

Riassunto
I Campi Flegrei sono un'area vulcanica posta a W di Napoli, caratterizzata da un intenso popolamento antico favorito dal suolo particolarmente fertile e da diverse insenature naturali assai idonee ad un impiego portuale, sia civile sia militare. L'area è priva di fonti naturali di acqua potabile, per cui solo in età augustea vi venne realizzato il tratto terminale e meno conosciuto dell'Aqua Augusta Campaniae, che aveva origine dalle sorgenti di Serino e recapitava le acque a numerose città ed alla maestosa Piscina Mirabilis, funzionale alla flotta militare romana del Tirreno. Il territorio di Pozzuoli era percorso anche dall'Acquedotto Campano, meno noto, ma di grande interesse per le potenziali implicazioni archeologiche. Esso risale infatti sicuramente all'epoca romana, ma le sue caratteristiche topografiche inducono a sospettarne un'origine risalente a popolamenti più antichi. L'acquedotto rimase in funzione fino ai primi anni del XX secolo, ma con l'avvento del servizio pubblico di acqua potabile si perse memoria del suo tracciato e dei suoi accessi. In seguito ad una campagna di ricerche tuttora in corso sugli acquedotti flegrei, abbiamo reperito l'ingresso di una scalinata situata lungo l'antica Via Campana, che permetteva di accedere all'acquedotto. La scalinata si presenta rivestita di opus reticulatum, ma il suo tratto iniziale era intasato di rifiuti urbani. Nonostante ciò, ne abbiamo effettuato l'esplorazione e ne abbiamo steso il rilievo grafico con metodi speleologici. La scalinata, non rettilinea ma costituita da quattro segmenti, raggiunge la profondità di 62 m rispetto al piano di campagna ed ha uno sviluppo spaziale di 180 m. Purtroppo l'estremo è costituito da un riempimento di detrito tufaceo fine di origine alluvionale, che impedisce l'accesso allo speco dell'acquedotto. La parte iniziale della cavità è stata oggetto di un intervento di rimozione dei rifiuti, nel quadro dell'iniziativa "Puliamo il buio". Oltre alla descrizione della cavità, viene effettuato un sommario raffronto con alcuni casi noti di scalinate a servizio di acquedotti ipogei.
Parole chiave: *Campi Flegrei, Pozzuoli, acquedotti antichi, scalinate romane.*

Introduction

The Phlegraean Fields (Fig. 1) are an active volcanic caldera, composed by several craters in an area of about 65 km² in the surroundings of Naples (Campania, southern Italy). Presently, the volcanic activity is limited to fumaroles and thermal springs, but in 1538 a new volcano erupted and destroyed a large area. Main eruptions are dated at 39/35 ky b.p. and 15 ky b.p., while several minor volcanoes erupted in pre-historical times (Rosi, Sbrana, 1987; Orsi et al., 1999; Fedele et al., 2011; Scarpati et al., 2012). The area is affected by bradyseism: a long-period raising and lowering of the land, related to variations in the underlying magmatic chamber. In Roman times the land was at higher elevation than today, so many coastal structures, villas, palaces and harbour structures are presently underwater.

In ancient times the presence of safe harbours, thermal springs and a temperate and fertile land raised attention by Greeks and Romans. About in 725 b.C., Greek settlers founded *Cuma*, one of the most ancient cities in Italy. Pozzuoli is presently the most important town in the Phlegraean Fields. The *Chronicon* of Jerome states that in 528 b.C. *"settlers from Samos*

Fig. 1: the Phlegraean Fields and the Campanian Aqueduct course. In the red circle, the stairway site. In the top-right corner, the Gulf of Naples (from Google Earth, modified).
Fig. 1: i Campi Flegrei ed il tracciato dell'Acquedotto Campano. Nel cerchio rosso il sito della scalinata. In alto a destra: il Golfo di Napoli (da Google Earth, modificato).

founded Dicearchia, which presently is named Puteoli" (Zevi, 1993, p. 11). *Puteoli* quickly grew as one of the most important commercial harbours in Italy, since its position is ideal to control and to manage the wide harbour areas in the Gulf of Pozzuoli
In the last years of the first century b. C. the area was fully exploited with leisure establishments, fisheries, storehouses and with the Roman Navy harbour plants. Many caves were opened in Roman times, as tunnels, aqueducts, water tanks, hot water catchments, steam tubes to warm spas. A major drawback in the Phlegraean Fields was its lack of fresh water. The volcanic land produced just thermal salt springs. In the last decades of the first century b. C., in order to support a growing population and the demanding military and commercial fleets, Romans designed and built the *Aqua Augusta Campaniae,* tapping important springs in the calcareous Apennines. The aqueduct course was mostly underground. Side branches reached the ancient cities of *Pompeii*, *Nola*, *Atella*. The main branch skirted *Neapolis* (the present Naples) and reached *Puteoli*, the *Portus Julius* Navy harbour, the wealthy settlement of *Baia* and the *Misenus* harbour, after leaving a side branch to *Cuma*. Total length of the main branch was about 105 km (Keenan-Jones, 2010). Research on the little-known phlegraean section of the *Aqua Augusta* is ongoing (Ferrari, Lamagna, 2013).
In ancient times, a second aqueduct serviced the Pozzuoli area: the *Campanian aqueduct*. It is even less known than the *Augustean*, but its potential archaeological and historical implications are quite important.

The Campanian Aqueduct
The Campanian Aqueduct is a completely underground water catchment and transportation system. It collected several underground springs in a single course, which ended in the lower part of *Puteoli*, near the harbour. It can be dated back to Roman times, but a more ancient origin has been suggested. The aqueduct still provided water in medieval times. A storm on November 25, 1343, caused a flooding. A restoration was performed in 1343-1346 (Minieri-Riccio, 1877, after Dubois, 1907). In 1538, a new volcano, Monte Nuovo, appeared in the Pozzuoli area. Earthquakes and eruption products ravaged the land and the aqueduct, too. The Spanish viceroy Pedro Álvarez de Toledo designed several restoration actions. In 1540 an inscription celebrated them: PETRVS TOLETVS MARCHIO VILLAE FRANCAE CAROLI V. IMP. IN REGNO NEAPOLITANO VICARIVS, VT PVTEOLANOS OB RECENTEM AGRI CONFLAGRATIONEM … ANTIQVORVM RESTAVRATA PVRGATOQ. DVCTV, AQVAS SITIENTIBVS CIVIBVS SVA IMPENSA RESTITVIT ANNO A PARTV VIRGINIS. MDXL. (Mazzella, 1591).
Further restorations were ordered in 1640 by bishop Martín de León y Cárdenas (Bonucci, 1845; Dubois, 1907; De Criscio, 1881a), in 1695 after a flooding (Sarnelli, 1697) and in 1862-1863 (De Criscio, 1881b). At the time, the Campanian Aqueduct was the only public fresh water source for the city. An

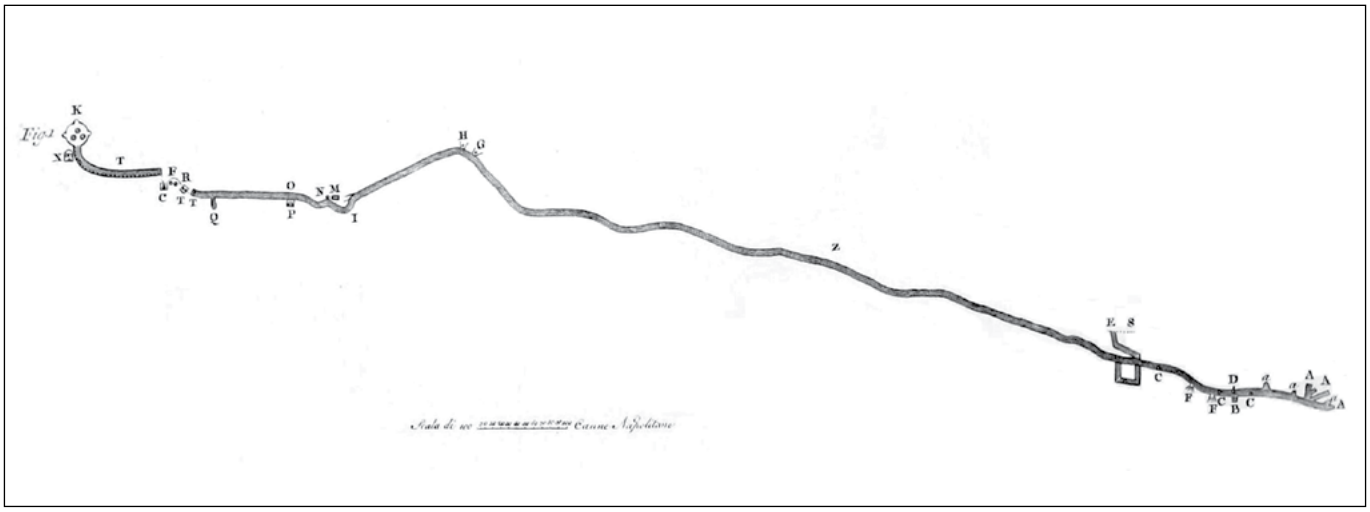

Fig. 2: the Campanian Aqueduct course (Monticelli, 1834). The stairway is in the lower right section (point E). North is approximately on the right. Scale (at bottom) is 100 neapolitan canne long (about 212 m).
Fig. 2: il tracciato dell'Acquedotto Campano (Monticelli, 1834). La scalinata è riportata in basso a destra (punto E). Il Nord è verso destra. La scala (in basso) è pari a 100 canne napoletane (circa 212 m).

official statement dated June 24, 1748, reports: *"the only treasure owned by this public administration is the water from public fountains"* (Annecchino, 1960, p. 278). Badly performed restoration works in 1881 caused a quarrel between the abbot and archaeologist De Criscio and the Municipality of Pozzuoli (De Criscio, 1881b, c, d, e, 1882).

In 1907 the aqueduct still provided water to two public fountains in lower Pozzuoli (Dubois, 1907). With the introduction of modern water networks, the ancient aqueduct was dismissed and completely neglected. Even memories of the entrance sites were lost. We are left with three XIX century descriptions and one dated to the beginning of the XX century.

The naturalist Teodoro Monticelli (1834) abridged a technical report by the water-man Raffaele Di Bello and published a draft plan of the aqueduct (Fig. 2). He was interested in increasing the water provision, so few details about the passages are provided. The total course length was estimated at 12,000 Neapolitan palms (about 3,160 m). The main entrance was through a 150 steps stairway placed along the ancient Campanian road. The upstream course collected several side branches and reportedly reached Montagna Spaccata, 2,700 m to the N. An undetermined difference in temperature among the collected streams is reported, along with the presence of a black oily substance in the water (bacteria ?).

Giovanni Scherillo (1859), canon in Pozzuoli, reported a four miles total length and three upstream branches collecting water from the surrounding craters.

Giuseppe De Criscio, abbot in Pozzuoli and amateur historian and antiquarian, explored the aqueduct in 1880 (De Criscio, 1881a) and again in 1881 after unsuccessful restoration works failed to restore water supply in Pozzuoli (De Criscio, 1881b). Furthermore, he commented Monticelli's and Scherillo's statements and provided a detailed description of the entrance stairway and the upstream course. The stairway was lined in *opus reticulatum*. Up to eight side branches were reported, most of them choked with dirt. Two of them were excavated in recent times. Furthermore, a water source (the *Bolla*) sprang directly from the bottom of the main passage. The total upstream length from the stairway is reported as 430 m. One inspection shaft is mentioned, about 400 m N of the access stairway. It was choked with dirt after few meters. A total aqueduct length of no more than 3 km was provided. About the downstream course, little information is provided. An exploration was performed on December 1, 1881, in order to ascertain the reasons for the interruption of water provision. No description of the passage was provided, just several inspection shafts were mentioned.

Charles Dubois (1907) performed the single archaeological exploration of the aqueduct, at the beginning of the XX century. Since the aqueduct was still in operation, he was just able to investigate the upstream course from the stairway on and the terminal section, near the railway station. Further information was provided by a water-man and by abbot De Criscio. The undergroud depth at the stairway was estimated at 50-55 m. The upstream course and the side branches were the same as in the De Criscio description. No inspection shaft was mentioned. Side walls and roof were lined with *opus incertum* in tuff stones, with vaulted roof. The passages were about 2 m high and 0,7 m wide. The first downstream section, down to Santo Stefano crossing, was similarly lined in *opus incertum*, but the roof was gabled with tuff slabs. No hydraulic lining was observed. The next section, between Santo Stefano crossing and the railway line, had no lining at all; the course was irregular in plan and section. Along the railway, a first section was similar to the uppermost one: walls in *opus incertum* and gabled roof in tuff slabs. The last section was rebuilt in the last third of XIX century.

As a summary, the Campanian aqueduct run underground for a total 3 km in length. Its course was parallel to the ancient Campana road, which connected *Puteoli* to *Capua*. The aqueduct collected water from the underground water table, possibly at the contact between volcanic formations with different permeability. The water collection section was placed under a volcanic plain, Piana Campana, among several volcanic craters. It was divided into several branches. Some of them were obstructed by dirt in the XIX century, while some others were excavated in the same century in order to increase the water flow. The section run at 50 to 60 m depth under the plain. An entrance on the Campana road accessed an *opus reticulatum* stairway which descended to the aqueduct level. The water transport section started at the stairway and it ended near the Pozzuoli harbour. Most of it was lined in *opus incertum* tuff masonry, while the passage roof was covered in an *opus incertum* vault or in a gable made by tuff slabs. A central section, with higher slope, was irregular, winding and unlined. A number of inspection shafts was reported, together with an entrance in the lower part, near the railway station.

A morphologic comparison with the Augustean aqueduct shows a number of differences. The Campanian is a drainage system, quite similar to the *qanat* model; its manufacture is quite rude; no hydraulic lining is present. The Augustean is a water transportation system, built with advanced tunnelling and masonry techniques and with an accurate hydraulic lining.

The above-mentioned characteristics produced various, tentative and little-supported datings and interpretations for the Campanian aqueduct. The fact that the whole aqueduct has been unreachable for the last century forbade more detailed research and checking of past statements. Monticelli (1834) apparently suggested a possible Greek date, similarly to the Bolla aqueduct in Naples. Bonucci (1845) stated a late Empire datation. Scherillo (1859) tentatively dated the Campanian aqueduct to Roman times, before the Augustean aqueduct. Beloch (1879) considered both the Bolla in Naples and the Campano in Pozzuoli as greek-roman 'without doubt'. De Criscio (1881a) criticized Monticelli's and Scherillo's suggestions. He then attributed the Campanian aqueduct to the medieval age, due to the rough building characteristics (*op. cit.*, pp. 65-68). Dubois (1907) reviewed the previous

hypotheses and agreed with Beloch about a Classic age datation. A more detailed statement was awkward: due to the rougher structure in comparison with the Augustean aqueduct, he suggested an earlier, at least Republican age. Johannowsky (1993) stated that the Campanian aqueduct was built between the II and the I century b.C.

Finally, several authors erroneously attributed some ancient hydraulic sections in Pozzuoli to the Campanian aqueduct. Dubois attributed both a section of aqueduct under the Flavian amphitheatre (Dubois, 1907) and a section near the Annunziata crossing to the Campanian. However, land elevation in both places (44 m a.s.l. at the Annunziata crossing, 39 m a.s.l. near the amphitheatre; elevations from the maps enclosed in *Puteoli*, 1993) is much higher than the Campanian aqueduct elevation (<15 m a.s.l. at the Campana stairway). Unfortunately, the attribution was carried on in several subsequent publications (e.g. Maiuri, 1955, 1958). In our opinion, elevation, position and building characteristics of the Flavian amphitheatre aqueduct section are compatible with the Augustean aqueduct system. We estimated the amphiteatre section elevation at 35 m a.s.l. (Ferrari, Lamagna, 2012, which reports also some elevations of nearby Augustean aqueduct sections). Angela Gallottini performed a comprehensive study about Piscina Cardito, a water tank system composed by two separate tanks, located W of the Flavian amphitheatre in Pozzuoli. She suggested the western tank was fed by the Campanian aqueduct (Gallottini, 1996). As already mentioned, land elevation (47 m a.s.l. near Piscina Cardito) is much higher than the expected Campanian aqueduct elevation. In order to cope with these apparently contradictory data, the German engineer Mathias Döring supposed a second Campanian aqueduct, later in time and higher in elevation than the original one (Döring, 2007). As far as we know, no evidence of this second aqueduct is reported.

The stairway

The most peculiar element in the Campanian aqueduct is the access stairway. It is placed at the junction between the drainage section and the water transport section. The stairway was described by Monticelli, De Criscio and Dubois. Monticelli (1834) simply reported about a small locked door on the Campana road, which accessed a 150 steps stairway. At 200 palms depth (53 m), the main aqueduct course was entered.

Dubois (1907) description looks like an abridged version of the De Criscio one (1881a), with little supplemental information. The entrance door was placed at about 100 m from Croce di Campana, toward San Vito, on the right side of the Campana road, amidst Roman sepulchres. The stairway, about 58 m deep, was lined in *opus reticulatum*. The passage width varied between 0,6 and 0,75 m. Accordingly to De Criscio, the vault was in masonry, while Dubois reported a gabled roof in tuff slabs. The stairway turned five times; over the third turn, a vertical shaft opened on the vault, choked with dirt after few meters. Some inscriptions are reported, marked on wall stones. After the fifth turn, steps were replaced by a gently sloping passage, lined in *opus incertum* (Dubois) and covered with gabled tuff slabs (De Criscio) or flat stones (Dubois). The passage lenght was estimated at about 10 m (De Criscio) or about 20 m (Dubois). The passage entered the Campanian aqueduct just under the stairway entrance through a small platform, 3 m long and 1,5 m wide.

Recent explorations

Our research on the Campanian aqueduct started in 2008. The head of the Pozzuoli office of the Naples Archaeological Superintendency, Ms. Costanza Gialanella, suggested the investigation of a well whose curb opens near the San Vito burial area, placed along the ancient Campanian road. We abseiled the well using normal caving single rope techniques. It is 55 m deep but the bottom is filled with dirt and debris. No connection with the Campanian aqueduct was evident (Ferrari, 2009). We soon realized that no part of the Campanian aqueduct was actually known and explorable. However, the stairway entrance topographic reference in De Criscio and Dubois was quite accurate: «about 100 m [north] of Croce di Campana». The ancient Campana road is still open to the traffic. The road is lined with private houses and crop lands, mainly vineyards. Croce di … is a typical toponym related to a road crossing where a stone cross was standing. Unfortunately, the Naples-Rome railway, built in 1927 across the Campana plain, caused important changes in the road network and in local names. Nevertheless, on March 20, 2010, a reconnaissance on site by one of us (Ms. Lamagna) with the support of local residents revealed a square hole in the road right wall, nearly hidden by wild vines. The hole allowed access to a small covered passage, nearly filled with dirt, rocks and garbage (Fig. 3). On March 31 the first penetration was performed, with the support of the caver Ms. Elena Rognoni. Some garbage was removed, so as to reveal a sloping passage, neatly lined in *opus reticulatum*. We quickly reached the stairway bottom and we produced a preliminary photographic documentation. On May 7th we showed the stairway to Ms. Costanza Gialanella, together with Ms. Elena Rognoni and the caver Mr. Berardino Bocchino. On July 11 we collected data for the cave survey. Finally, on September 17, 2011 we organized a clean-up event in order to remove the garbage in the initial part of the stairway. Presently the entrance is closed in order to avoid further garbage dumping and possible danger to untrained visitors.

Cave description

The entrance (point A in plan, Fig. 8, and in section, Fig. 9) is placed along the Vecchia Campana road in the municipality of Pozzuoli, 145 m NNE from the Croce di Campana cross, at 77 m a.s.l. elevation (Naples Province Technical Map, scale 1:5,000).

The first section (A-B) 5 m long, is directed toward ESE. It was nearly chocked by garbage (Fig. 3). The inner masonry is rough; in the visible areas no lining is present. A modern stone wall closes the entrance bottom half.

At point B a sharp left turn is present, under a small

Fig. 3: garbage in the cave entrance (photo G. Ferrari).
Fig. 3: i rifiuti all'ingresso della cavità (foto G. Ferrari).

Fig. 4: typical cross-section at point C (photo E. Rognoni).
Fig. 4: sezione tipica al punto C (foto E. Rognoni).

tuff arch originally hidden by garbage. The next section (B-E) is a 69 m long sloping passage, with 20° average dip. The floor is cut in the rock with no lining, with worn steps. A good *opus reticulatum* lines the walls, with many evenly spaced lamp niches. The passage width and height vary slightly (0,70 to 0,77 m width, 1,90 to 2,20 height). The passage top is vaulted, in *opus caementicium*, with traces of the wooden board marks on the concrete (Fig. 4). At C, the garbage filling ends; on the vault impost, two larger than usual niches are present. At D there is a small wall collapse. Point E is reached, where the stairway turns right, at 24 m depth. The masonry at the turn is tuff blocks *opus vittatum*.
The next section (E-F) goes SE with a 16.5° dip, still lined in *opus reticulatum*. After 12,5 m there is a third turn, again to the right, at 29 m depth (point F). Again, the masonry at the turn is in *opus vittatum* (Fig. 5). On the tufa blocks, several writings are visible. On the roof, a square vertical shaft opens, lined in *opus vittatum,* with footholds. It is closed at about 10 m height.
The fourth section (F-H) goes SSW, 66 m long, with a 20° average dip. The wall lining is irregularly alternated in *opus reticulatum* and *vittatum*. The floor is deeply eroded by flooding waters, evidently from the shaft at F. Flooding water caused the formation of 2 m deep pot-holes; erosion removed most rock supporting the wall masonry, so the masonry often overhangs (e.g. point G). The floor in the second half of this section is less eroded than in the first half. A short vault section is gabled with tuff slabs. The last 7 m turn slightly left with respect to the general direction of this section, with a higher 27° dip. Steps in the rock floor are preserved.
A fourth turn is reached (point H), again to the right and lined in *opus vittatum*, at 53 m depth. Several inscriptions mark the wall stones. The shaft in the roof is immediately closed by rock debris. After the turn, the floor is again deeply eroded. The next section (H-L) is 27 m long; it is oriented toward W with a constant 0,71 m width. The vault in the first half (point I) is in *opus caementicium*. High in the left wall, a deep niche crosses the wall thickness. At point J, a wall collapse in the *opus reticulatum* exposes the masonry section and the background rock (Fig. 6). The floor is still eroded. At 60 m depth, a third shaft opens in the roof, closed after 1,6 m. Further traces of water flooding are present. In the last section, 8 steep steps are present. After them, the vault lowers (point K) and the shape becomes gabled, made by thick tuff slabs. The floor is chocked by a mud deposit, with a small water pool.
The end point (L) is a tight squeeze between the horizontal floor deposit and the slightly sloping roof gable tiles (Fig. 7). The walls show traces of water levels up to 2 m above the present deposit level; the walls are lined with mud. This area is nearly under the entrance, 62 m deep and at 15 m a.s.l. elevation. Accordingly to De Criscio (1881a, p. 63), few meters are left before the junction with the actual Campanian Aqueduct passage. Unfortunately, a century of no maintenance caused the deposition of the thick mud deposit, which blocks any further exploration.

Fig. 5: right-turn at point F (photo E. Rognoni).
Fig. 5: la svolta al punto F (foto E. Rognoni).

Fig. 6: wall masonry collapse at point J (photo B. Bocchino).
Fig. 6: distacco parietale al punto J (foto B. Bocchino).

Clean up the World / Clean up the Darkness

Legambiente is a national environmental association; it is structured on local *circles*. Yearly, it organizes an event aimed at employing volunteers in cleaning sites over all Italy. The event is called *Puliamo il Mondo* (Clean-up the world); it provides nation-wide coverage to local events organized by local circles. The national caving association Società Speleologica Italiana cooperates with the event, organizing a cave-specific version. The *Puliamo il Mondo* cave side is called *Puliamo il Buio* (Clean-up the Darkness). In 2011 the Naples Archaeological Superintendency, the Municipality of Pozzuoli, the Legambiente Circle in Pozzuoli and the Campanian Speleological Federation agreed to cooperate in an event at the Campanian stairway. The objective was the removal of the garbage in the entrance. On September 17, 2011 few cavers and archeologists entered the cavity and brought garbage to the entrance, where Legambiente volunteers and local residents handed it to Municipality garbage collectors on a small truck. The event resulted in about 700 kg of garbage removed (Fig. 10), in a renewed public interest in the site and in the recovery of a local cultural heritage. The aqueduct was an important public resource till 100 years ago, property of the Municipality of Pozzuoli. However, the work is far than completed: about two cubic meters of earth and stone blocks are left. We plan to organize a second event, with the objective to complete cleaning and to allow an easy access to researchers and possibly to the public.

Comparison with other stairways

Information on some known stairways related to ancient hydraulic systems is provided.

- *Aqua Augusta Bononiae* (Bologna, Emilia-Romagna; Demaria, 2010): an aqueduct built in Augustean age provided water to Roman *Bononiae*. The aqueduct tapped water from a river in the Apennines. It run underground for about 18 km with several tunnels. Two stair accesses are reported. The first one was destroyed in 1861. Just information from Calindri (1781) is left, with additions by Gozzadini (1864). A six or seven steps flight of stairs entered a small room, 3 m square, where a passage aimed in the direction of the aqueduct, about 200 m distant. The second stairway was described by Gozzadini (1864) but Demaria (2010) provided modern detailed information. It is a 324 steps stairway, 110 m long and 66 m deep. The walls are not plastered and the vault is in concrete. The stairway is absolutely straight.
- *Aqua Alsietina* (Rome, Latium): the *Aqua Alsietina* was a 33 km long aqueduct. It tapped water from *Lacus Alsietinus* (presently Lake Martignano), north of Rome (Frontinus, 11). The aqueduct was built on about 2 b.

Fig. 7: the present end of the stairway (photo B. Bocchino).
Fig. 7: il punto estremo della cavità (foto B. Bocchino).

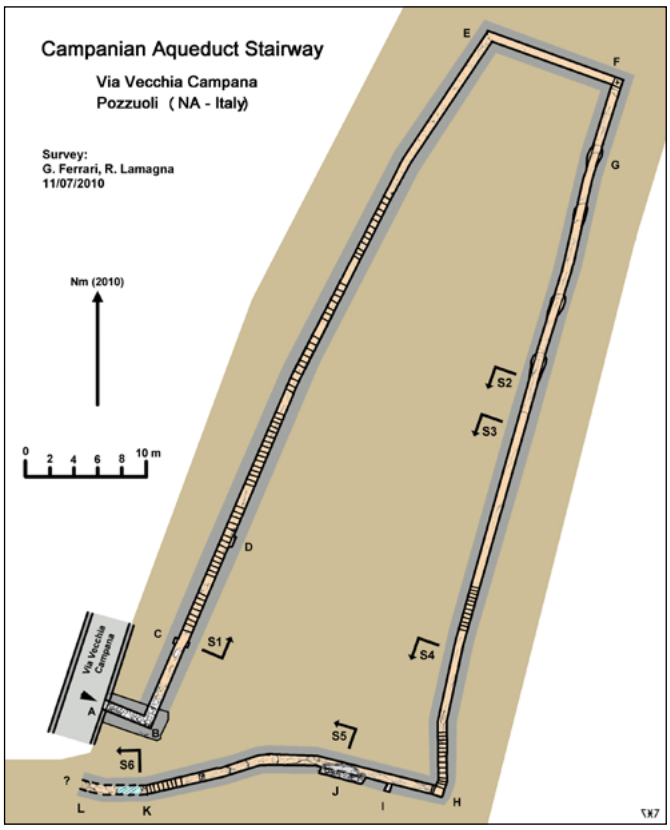

Fig. 8: the cave plan.
Fig. 8: pianta della cavità.

C., during the reign of emperor Augustus. In 1824, ANTONIO NIBBY (1837, V. 1, pp. 139-140) explored a 90 steps stairway near Osteria Nuova (Rome). It was 45 m long and 21 m deep, lined in *opus reticulatum* and *opus signinum*. A side passage collected water from Lacus Sabatinus (presently Lake Bracciano). NIBBY suggested the stairway was used by the water-men to check the Aqua Alsietina level. In case of insufficient flow, they would open the sluice of the channel from Lacus Sabatinus. Its water would fall down the steps, and for this reason they were lined with *opus signinum*. ASHBY (1935) found a ramp in the area, but it looked related to the Aqua Paola, with little traces of antiquity. Unfortunately, the Alsietina stairway is presently lost (VITTORIA CALOI & GIORGIO PINTUS, pers. comm.).

- *Praeneste* (Palestrina, Latium; CASTELLANI et al., 1993): *Praeneste* aqueduct collected some surface springs placed some 3 km NNE of the city. It is tentatively dated to the end of the II century b. C. A 1800 m long tunnel pierced a relief, so as to avoid a long course along the hill slopes. The tunnel excavation proceeded from the two entrances to a middle meeting point, but several side branches are present. Most of them are closed by walls. The single documented branch begins with a 6 m long horizontal passage, nearly orthogonal with respect to the main tunnel. After a left turn, a raising stairway is present. The floor is covered with sinter pools. A landslide chokes the stairway after 15 m. Digging signs on the walls show that the passage was excavated from the main tunnel upward. It looks like the stairway, and possibly the other walled ones, were realized in order to ease the main tunnel excavation and then they were closed. This means the stairways were not intended as maintenance accesses.

- *Aqua Virgo*, Pincio, Villa Medici (Rome, Latium; LOMBARDI, GERMANI, 2014): *Aqua Virgo* was another Augustean aqueduct. It was built in 19 b.C. to bring water to Rome through a 20 km long underground course. Under the Pincio hill, the aqueduct runs 25 to 35 m below the surface. LOMBARDI & GERMANI (2014) mention three stairways in the area, one straight with 118 steps and two winding ones. Several authors (e.g. Canina, Lanciani) considered the straight stairway as Roman, but Lombardi & Germani established it was executed in the XVI century. Similarly, one of the winding stairways was probably executed between 1576 and 1587.

- Fucino emissary (Abruzzo; BURRI, 2005): the emissary was initiated in 41 d. C., under Emperor Claudius and completed in the II century A. D., under Hadrian. The emissary, 5650 m long, ceased functioning about in the VI century. In 1854 prince Torlonia started restoration and enlargement of the emissary. FABRETTI (1683) reported eleven slipways; two of them were forked. BURRI (2005) mentions nine, but some of them were excavated during the Torlonia restoration. All slipways are straight and with no masonry or lining. In some of them, traces of steps are visible. Most slipways cross vertical shafts. In several cases, the slipway turns around the shaft square section (CANINA 1840). A special feature is related to the slipway which pierced deep below the ridge (Discenderia Maggiore). After reaching the main tunnel, the slipway continues in a horizontal passage which runs few meters above the main tunnel. It is intended as a reference passage to guide direction and elevation of the main tunnel in the deepest part of the work.

- Albano and Nemi emissaries (Latium): the Albano lake emissary was traditionally executed at the beginning of the IV century b. C. (LIVY, V, 15 ss.). It is about 1450 m long (CARDINALE *et al*., 1978). Engravings by PIRANESI (1762) show a longitudinal section of the emissary. A long forked stairway is reported. It begins high above the emissary upper entrance and it runs several hundred meters deep beneath the volcanic ridge. However, PIRANESI himself admits he modeled

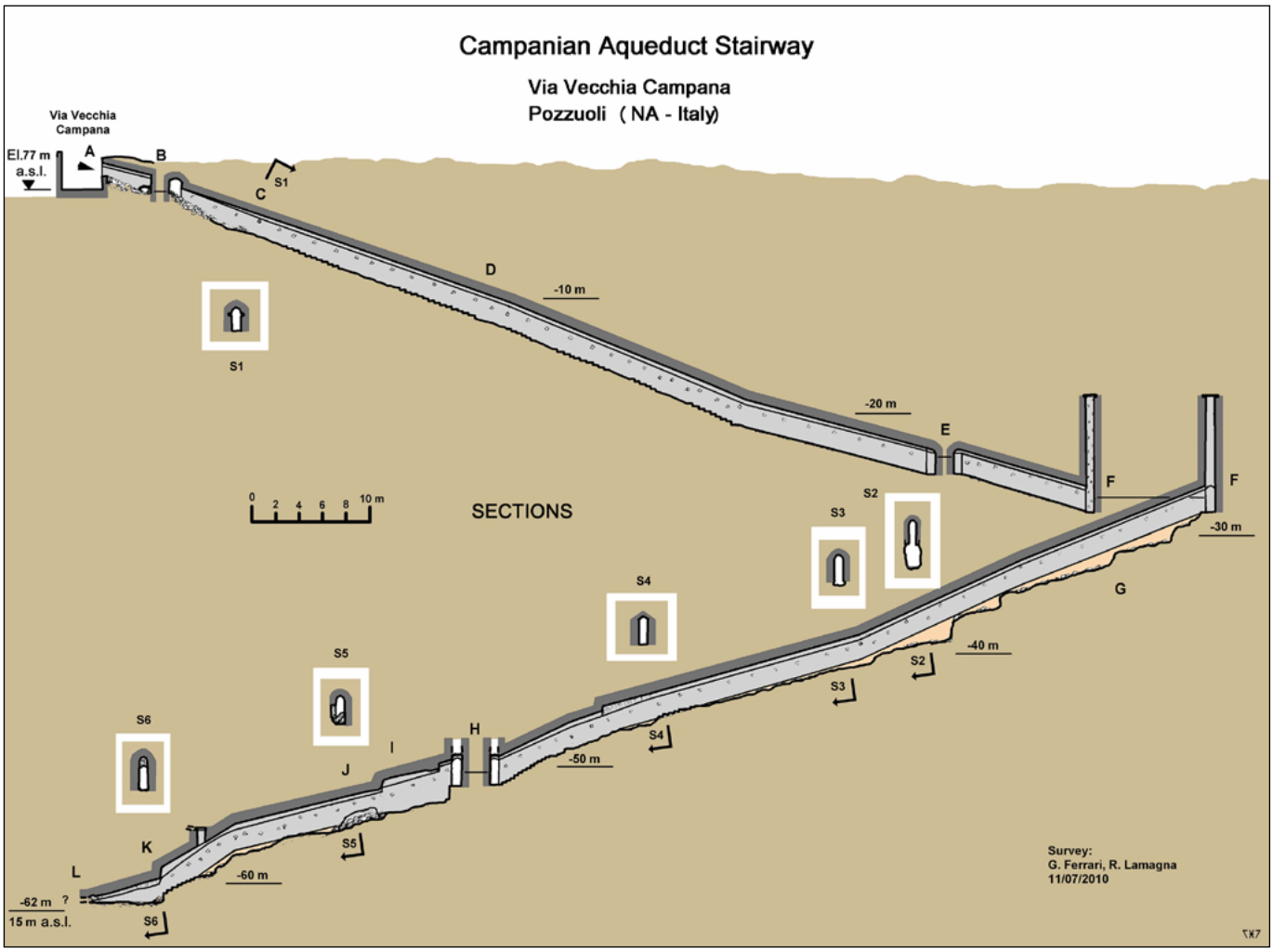

Fig. 9: the cave sections.
Fig. 9: le sezioni della cavità.

his representation of the Albano emissary on the Fucino emissary structure (Castellani, Dragoni, 1991). Modern explorations of the Albano emissary show no hint of a stairway (Cardinale et al., 1978; C. Galeazzi, pers. comm., 2014). On the other hand, the Nemi emissary, 1650 m long, shows several walled accesses to side branches (Castellani, Dragoni, 1991), similarly to the *Praeneste* aqueduct. A couple of them look like stairways executed in order to ease main tunnel digging and then de-functionalized after completion.

- *Aqua Augusta Campaniae* – M. Paterno (Campania; Abate, 1862, 1864): the above-mentioned *Aqua Augusta Campaniae* was a 105 km long aqueduct (Keenan-Jones, 2010). It was built in the last decades of the I century b. C. Its course was mostly underground. In at least two cases, it crossed mountain ridges through long tunnels. The M. Paterno tunnel was 1903 m long (Abate, 1864). The tunnel was provided with several shafts. The deepest one was 104 m deep. Two straight slipways connected the shaft with the surface; they were 2 m high and 0,9-1,25 m wide, with no lining. No steps are mentioned. The lower and longer one connects also with a second shaft near the entrance. As in the Albano emissary, this feature could imply a procedure to bring underground the aimed alignment. On the other side of M. Paterno, a third slipway is present. It was 2 m high and 1,5 m wide, with a 30° dip. The slipway reached the main tunnel. An upward shaft and a downward one were present in the slipway.

Discussion

The main result is in the actual rediscovery and exploration of the stairway. Its characteristics are unchanged with respect to De Criscio description, apart from the garbage in the entrance and the floor erosion in the F-K section. Here, the *opus reticulatum* roman masonry self-stands, without support from the bottom rock. This is a further demonstration of Roman masonry reliability. Unfortunately, the bottom mud filling prevents exploration of the aqueduct. Maximum depth is 62 m, that is, the Campanian aqueduct is expected to flow at less than 15 m a.s.l. This information could drive further research on inspection shafts and attribution of hydraulic structures in lower Pozzuoli.

The *opus reticulatum* implies a Roman manufacture of the stairway wall masonry. Dubois (1907, p. 274) attributed the *reticulatum* to imperial age. This statement still appears reasonable, due to the overall high masonry quality in a place not intended to be in public sight. More detail is impossible to provide. A careful analysis of masonry, concrete and inscriptions is required. On the other hand, the rough lining and covering in the terminal section could be a hint of an older manufacture. Again, a careful analysis of

the junction between different wall techniques could provide interesting information. The masonry variation implies some questions: is the stairway contemporary to the aqueduct ? Does the *opus reticulatum* pertain to a restoration action ?
The stairway opens near the junction of the collecting section and the transport section of the aqueduct. Reasonably, it was designed as an easy way to access the collecting section for monitoring purposes. Digging and maintenance actions could have been performed with less effort through vertical shafts. However, De Criscio (1881a) mentioned just one shaft in the collecting section, chocked with dirt. On the other hand, three pits open on the Campana road N of the stairway, in front of the San Vito burial area, in places different from the De Criscio one. They were not mentioned by Monticelli, De Criscio or Dubois. The single explored pit nearly reaches the Campanian aqueduct depth (Ferrari, 2009) but present information suggests an early XX century manufacture.
Comparison with other known stairways related to ancient hydraulic systems shows that the Campanian aqueduct stairway is connected to a water collecting system and it shows several turns, while other stairways are straight and they are connected to water transport systems. Most of them were designed as features needed to execute long tunnels (Aqua Augusta Bononiae, Praeneste, Fucino, Albano (?), Aqua Augusta Campaniae).
The many turns represent the most striking feature in the Campanian stairway. The presence of vertical shafts in at least two of the turns can provide hints at the techniques employed in the stairway execution. The shaft at point F was 29 m deep, there is evidence it still collects important amounts of flood water. The shaft at point H was 53 m deep. The stairway direction and slope change considerably just before point H. This could suggest a misalignment in digging directions.
A final consideration about maintenance, restoration and management of the underground water table: in XVI-XIX centuries the aqueduct was considered a critical resource for the municipality. Several restoration actions were performed to assure water provision. The aqueduct was neglected in the past 100 years. No maintenance produced a choking which presently stops further exploration. However, flood water still flows through the stairway, the shafts and the aqueduct, to unknown destination. A priority step toward the restoration and exploitation of the stairway would consist in avoiding any further water flow at least in point F shaft. As it is well-known in management of underground spaces, artificial cavities could cause structural failures on the surface, especially where water flow is concerned. On the other hand, detailed knowledge of voids is critical in designing and applying precautionary measures. Furthermore, both legal and illegal waste dumping areas were established on lands which are expected to contribute to Campana plain water table. Exploration of the ancient Campanian aqueduct could provide extremely important information on this issue too.
Next steps could be:

Fig. 10: rubbish removed from the entrance (photo U. Potenza).
Fig. 10: rifiuti solidi rimossi dall'ingresso (foto U. Potenza).

- the completion of entrance cleaning and the installation of a reliable door, in order to avoid further garbage dumping;
- the execution of a detailed archaeological and structural research on the stairway, especially on the masonry, the upward shafts and the wall inscriptions;
- the removal of the terminal mud filling, in order to provide access to the aqueduct;
- the identification and the exploration of the inspection shafts still open along the ancient Campana road, in order to possibly gain further accesses to the aqueduct;
- the design and the execution of a restoration and exploitation plan on the stairway and possibly the aqueduct.

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