Geological Field Trips and Maps

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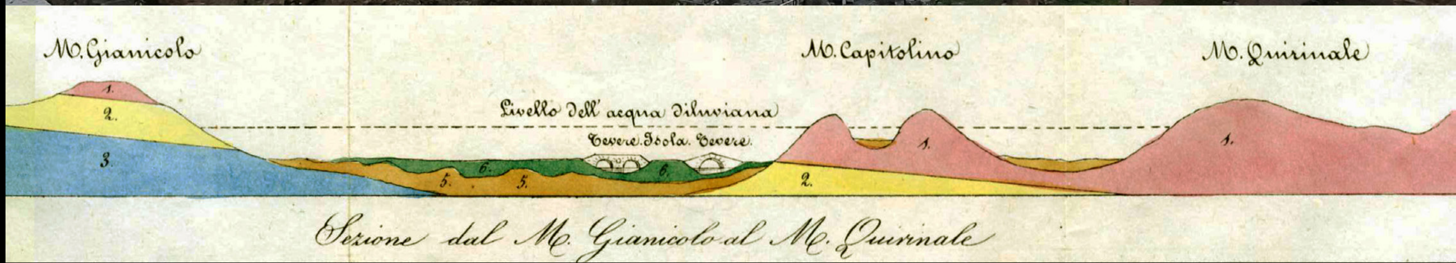

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Rome before Rome: a river among two volcanoes.
Discovering the relationship between the history of the city and the territory

MID-7 Mid-Congress Field Trip of the XXI Inqua Congress "A Mediterranean perspective on Quaternary Sciences", Rome 14th-20th July 2023

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Rome before Rome: a river among two volcanoes. Discovering the relationship between the history of the city and the territory

MID-7 Mid-Congress Field Trip of the XXI Inqua Congress "A Mediterranean perspective on Quaternary Sciences", Rome 14th-20th July 2023

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Cover page Figure: Panoramic view of the Roman Forum from the terrace on the Colle Capitolino on a cloudy day. In the lower part, the geological section of the Rome area, from Monte Gianicolo to Colle Quirinale, by Giuseppe Ponzi (1850).

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INFORMATION

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ITINERARY

Instant“ handbook

Colle/colli = Hill/hills

Ponte = Bridge

Porto = Harbour

Via = Street

Valle = Valley

Rupe = Cliff

Colonna = Column

Piazza = Square

ABSTRACT

The foundation and growth of Rome have been significantly influenced by the geology and geomorphology of the surrounding area. Various factors, including the morphology of the terrain, characterized by the Tiber River, mid-range capacity springs, a secondary drainage system, and plentiful quarries and raw materials for construction, have had a significant impact on the settlement of the city.

This field trip provides an opportunity to follow the geological and geomorphological development of the urban area, which was heavily influenced by two volcanic complexes, the Colli Albani and the Sabatini Mountains, as well as the Tiber River and human activity. The geological and geomorphological characteristics of the surrounding area have played a crucial role in the city's growth and development.

Furthermore, the Tiber River has been critical in providing water for agriculture, transportation, and in defence of the city. The rugged terrain created by the volcanic activity provided ample resources for construction, while the abundance of mid-range capacity springs facilitated the colonization of the city.

The Colli Albani and Sabatini Mountains volcanic complexes, located to the south and north of Rome, respectively, also had a significant impact on the city's expansion. The volcanism in these regions gave rise to the rugged terrain that encircles the city and offers building raw materials.

Over time, the natural landscape has been modified, with the creation of infrastructure, including roads, bridges, and buildings. This field trip provides insight into the geological and geomorphological history of the Rome area and provides an understanding of how these factors influenced the growth and expansion of the city over time.

Keywords: Rome, Tiber River, Colli Albani volcanic complex, Sabatini volcanic district, urban geology, Quaternary, floodings, alluvial deposits, anthropogenic deposits.

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PROGRAM SUMMARY

Meeting point: Ara Pacis Augustae stairway (Largo San Rocco).

Stop MID-7-1: Ara Pacis Augustae
The historical floods of the Tiber River; the disappeared Porto di Ripetta and the ancient hydrometer.
Stop MID-7-2: Piazza di Ponte Umberto I (in front of the Museo Napoleonico)
The riverbed regimentation works, the 19^{th}-century embankments, the changes to the morphology.
Stop MID-7-3: Arco dei Banchi
Flood memorial plaques; the 1277 flood.
Stop MID-7-4: Vicolo del Montonaccio - Monte Giordano
Artificial alterations of the landscape.
Stop MID-7-5: Piazza della Rotonda - Il Pantheon
The lowest point of the Campus Martius; the "temple of all gods", the precious marbles and the "lighter and lighter" dome structure.
Stop MID-7-5.bis (optional): Piazza Colonna
The effects of the earthquake on the Colonna Antonina.
Stop MID-7-6: Piazza della Minerva
An elephant in the centre of Rome; the historical archive of flood traces onto the façade of the Church of Santa Maria sopra Minerva
Stop MID-7-7: Largo di Torre Argentina
Temples from the Republican period; the Roman pavement; the use of tufa and travertine.
Stop MID-7-8: Il Colle Capitolino
The iconic Rupe Tarpea.
Stop MID-7-9: Via della Consolazione
The relationship between alluvial and volcanic units.
Stop MID-7-10: Piazza del Campidoglio
A view of the Roman Forum and the Colli Albani volcano.
Stop MID-7-11: L'insula romana
The raising of the ground surface.
Stop MID-7-12: La Colonna Traiana
The seismic "resilience".

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Stop MID-7-13: Il Foro romano
The Topographic Changes from the Roman Empire to Present Day
Stop MID-7-14: Torre dei Conti
Seismic shaking failure.
Stop MID-7-15: The Palaeoloxodon antiquus
The Colosseum elephant.
Stop MID-7-16: Piazza del Colosseo
Signs from history.

SAFETY

Light clothing, a hat, sneakers or walking comfortable shoes, a light backpack, and water.
Emergency telephone number (NUE): 112

HOSPITALS

Ospedale Santo Spirito in Sassia, Lungotevere in Sassia 1, phone 06 68351
Ospedale Fatebenefratelli, Via di Ponte Quattro Capi 39, phone 06 68371
Policlinico Umberto I, Viale del Policlinico 155, phone 06 49971

ACCOMMODATION

The city of Rome offers a wide range of accommodations which is impossible to list in full. Information regarding tourist services, cultural events, and hospitality on the official tourism website of the City of Rome: https://www.turismoroma.it/en

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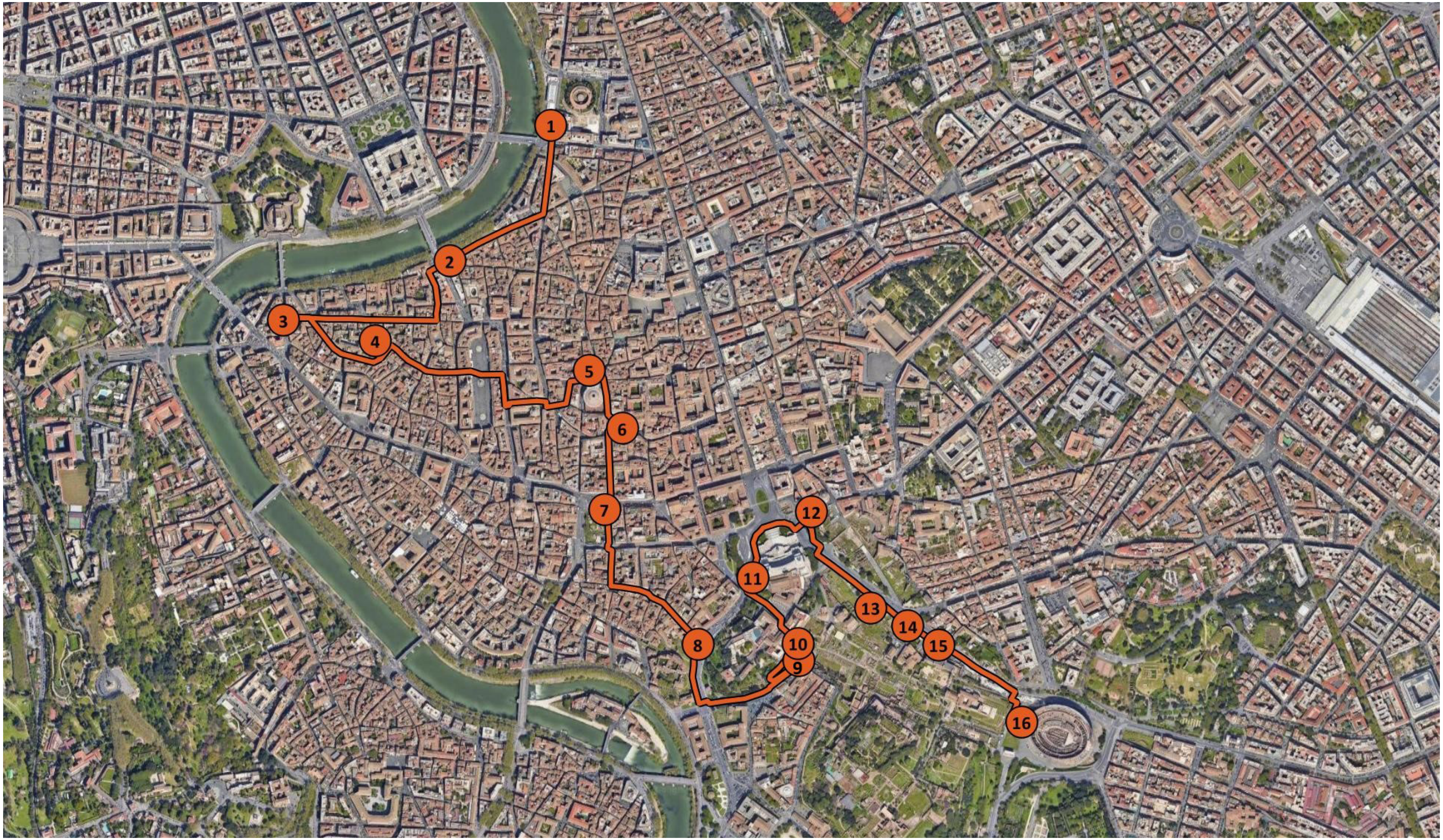

View of the field trip itinerary with location of the stops.

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INTRODUCTION

The foundation and growth of Rome have been largely influenced by the geological and geomorphological environment of the region.
The initial settlers were drawn to the area due to the unique landscape features such as the Tiber River which runs through the tuffaceous terrain, ample mid-sized springs, and a secondary drainage system flowing into the Tiber. Additionally, the area had a rich supply of building materials and raw resources that facilitated urban expansion.
These varied characteristics have been instrumental since the city's foundation on 21st April 753 BC - at least, according to legend - and have played a significant part in shaping Rome's place in Western history.
The city of Rome is situated between two volcanic districts that were emplaced approximately 600 ka and 700 ka ago, (Cioni et al. 1993; De Rita et al., 1996; Faccenna et al., 1995; Funiciello et al., 2002; Funiciello and Giordano, 2008; Giordano, 2008). The volcanic activity in these regions has been predominantly explosive, owing to the presence of potassium-alkaline magma chemistry. Recent research conducted by Funiciello and Giordano (2008) has contributed to a better understanding of the stratigraphic successions and paleoenvironmental history of the urban and regional areas, through the realization of the geological map Sheet n. 374 Roma at 1:50,000 scale (Servizio Geologico d'Italia, 2008).

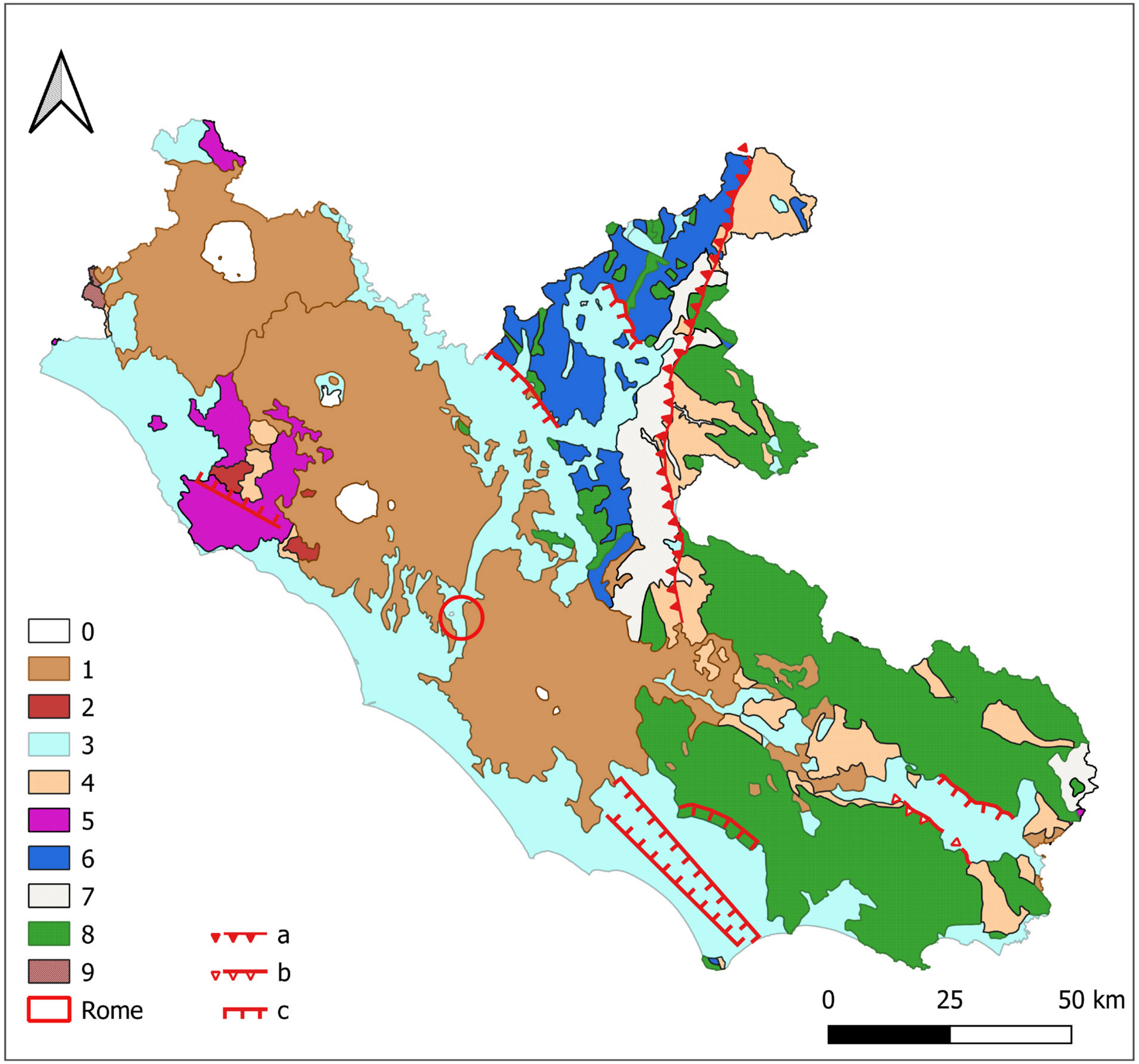

Fig. 1 - Geological sketch of the Lazio region (modified from Cosentino et al., 1993). 0. Lakes; 1. Alkali-potassic volcanic districts (Vulsini Mts., Sabatini Mts., Colli Albani) Pleistocene; 2. Acidic to intermediate chemistry volcanic districts. Pleistocene; 3. Neoallochthonous clastic sediments. Quaternary; 4. Cenozoic flysch; 5. Inner basin, allochthonous complex (Liguridi and Sicilidi) 6. Pelagic sediments of the Umbria-Marche basin, Meso-Cenozoic 7. Lazio-Abruzzo carbonate platform scarp, Meso-Cenozoic; 8. Lazio-Abruzzo carbonate platform, Meso-Cenozoic 9. Metamorphic basement (Romani Mts.). a. Olevano-Antrodoco Thrust; b. Inverse fault and thrust; c. normal fault.

Rome is situated between the Apennine orogenic belt and the Tyrrhenian Sea. The Apennines chain is an ENE vergent fold and thrust belt, which developed between the Upper Miocene and Lower Pliocene (Cosentino et al. 1993). Following the initial compressional phases, a tectonic regime of extension started in the western part of the chain, leading to the formation of a back-arc basin (Fig. 1). The back-arc basement is formed by pre- and syn-orogenic calcareous units. This basement has been identified over a depth range of several hundred to 1,300 metres as evidenced by a deep borehole that was drilled in the Circo Massimo area - the heart of the city - as reported by Signorini (1939) and Argentieri et al. (2019).
The stratigraphic sequence above the deformed carbonate basement comprises clastic marine deposits from the Upper Miocene-Lower Pliocene period. This sequence reflects a facies transition from offshore to continental sedimentation after the Lower Pleistocene. In the Middle Pleistocene, the Latium region underwent an intense volcanic activity from six eruptive districts. This activity had a profound effect on the geomorphology of the area, primarily due to the deposition of numerous pyroclastic density currents. Additionally, Quaternary climatic fluctuations led to corresponding low and high stands, which caused significant morphological changes. Deep river valleys were formed as a result, which were subsequently filled with alluvial deposits.

GEOLOGIC FEATURES OF THE ROME AREA

During the Pliocene, the area surrounding Rome, known as the Campagna Romana, consisted of a complex continental shelf that was submerged under the Tyrrhenian Sea. Various carbonate islands, including the Cornicolani Mountains and Soratte Mount (located to the northeast of Rome), emerged from the sea. The stratigraphic succession of deposits in this area ranges from circalittoral to infralittoral, revealing the gradual evolution of the sea level over time (Fig. 2).
The oldest lithostratigraphic units in Rome are attributed to the Pliocene, and they can be seen on the slopes of Monte Mario, Gianicolo, and Vaticano Hills, as well as in Settecamini, Guidonia, and along the coastline from Civitavecchia to Anzio outside the city. The Pliocene succession found in the city centre has experienced tectonic displacements, identified in the 19^{th} and 20^{th} centuries by various authors such as Ponzi in 1875, Giordano in 1878, Verri in 1915, and De Angelis D'Ossat in 1953. These displacements are interpreted as part of the extensional tectonics now buried under Pleistocene sediments.
The bottom of the outcrop is referred to Monte Vaticano Unit (Funiciello and Giordano, 2008b), or the Marne Vaticane Formation, composed of Pliocene clay and sandy layers from a circalittoral domain deposition (a deep-sea facies). Biostratigraphic studies (Carboni, 1975) have attributed the upper part of the unit to the Piacenzian because of the presence of *Globorotalia emiliana* and *Globorotalia inflata*. In the upper part, the presence of *G. calabra*, with no other marker fossils, could indicate the transition to the Pleistocene.
This geological unit is characterised by an unconformity in relation to the transgressive cycle of the Monte Mario Unit. It is made up of

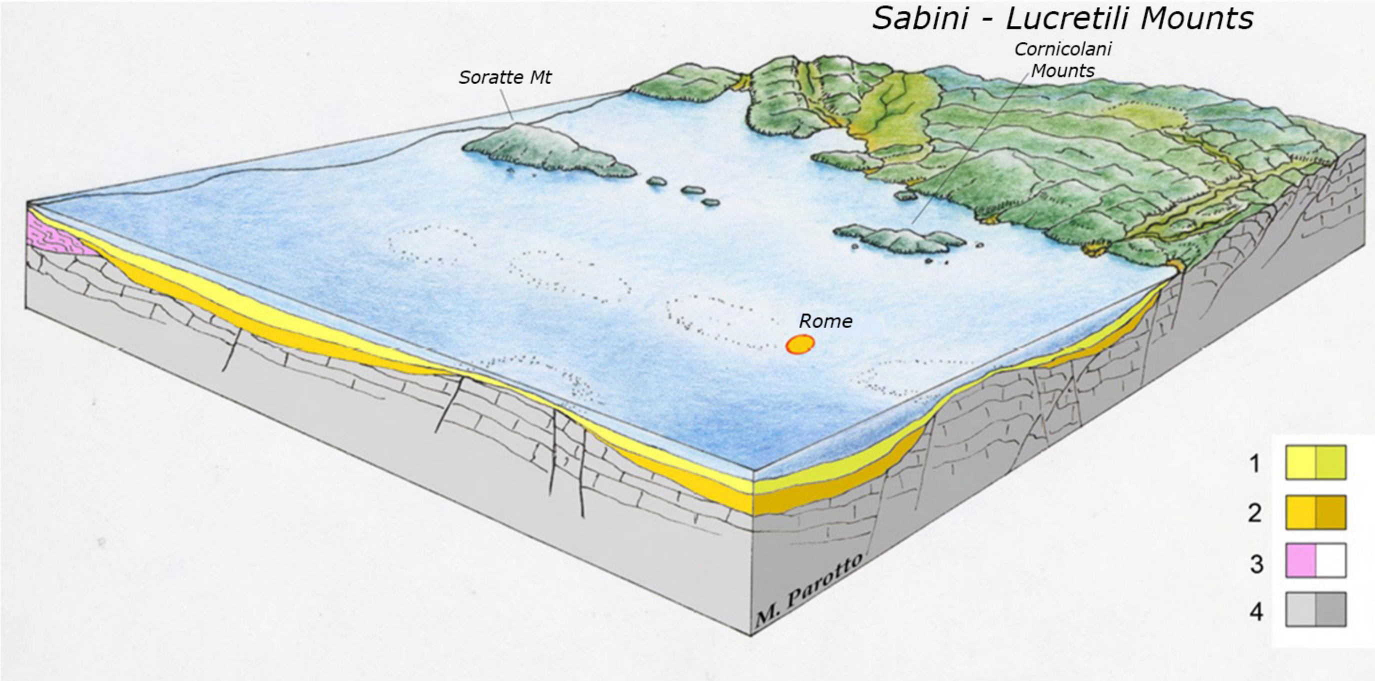

Fig. 2 - Paleogeography of Central Latium in Upper Pliocene - Lower Pleistocene (2.6 Ma).1. Monte Vaticano formation (Lower Pliocene - Upper Pliocene); 2. Neoautochthonous succession (Upper Miocene); 3. Subligurian allochthonous units; 4. Deep marine facies units (facies sabina; from Parotto, 2008).

layers of clay and silt that gradually coarsen into grey-yellowish sand. Its thickness is approximately 60 metres, and it has been dated to the Lower Pleistocene due to the presence of *Hyalinea baltica* and *Bulimina etnea*, which indicate that it was formed in a marine depositional environment.

Due to regional uplift and the dynamic evolution of the paleo-Tiber River delta, the marine environment ebbed away progressively from the east to the west, with the river moving westward and eventually finding its mouth along the current location of Ponte Galeria. The area is now characterised by fluvial and deltaic sediments constituted of conglomerates and sands.

The Ponte Galeria Formation, first described by Ambrosetti and Bonadonna (1967), is the delta system of the ancient Tiber (paleo-Tiber) River. The complete succession of this formation (Funiciello and Giordano, 2008) is approximately 40 metres thick and includes basal fluvial conglomerates, blue-grey clays with *Helicella ericetorum*, beach conglomerates with sandy lens, levels with fragmented remains of *Arctica islandica*, pebble gravels and sands with cross laminations, clays with *Venerupis senescens*, aeolian sands, lacustrine and marshy deposits, and volcanoclastic materials.

This phase was followed by the uplift of the Gianicolo-Monte Mario NW-trending ridge, which redirected the river's flow to the north, running parallel to the coastline and passing east of the Soratte Mount. The eruptive activity of the Sabatini Mountains volcanic complex, located to the northwest, and the Albani Hills volcanic complex (as shown in Figs. 3, 4, and 5) to the southeast, began 600 ka (Sottili et al., 2020) and 700 ka (Giordano, 2008) respectively. As a result, enormous amounts of pyroclastic material estimated to be between 500 and 1,000 km^3 (Mattei et al., 2010) were emitted, significantly altering the development of the plain and river flows.

With the decrease in volcanic activity from both the Colli Albani and Sabatini Mountains, the production of pyroclastic material significantly diminished. Simultaneously, significant changes in the climate affected the erosion processes and landscape development. During the Würmian

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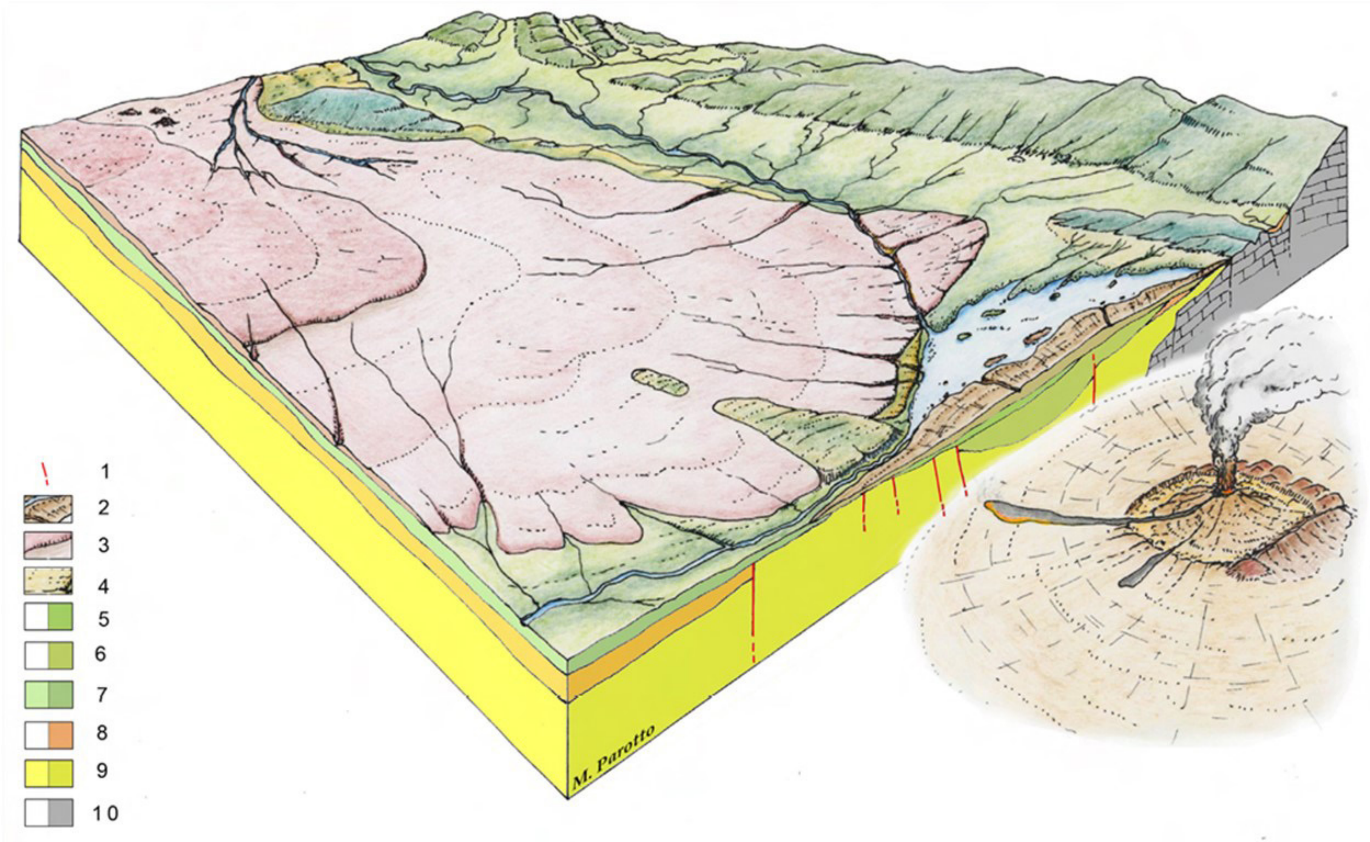

Fig. 3 - Paleogeography of Central Latium in Middle - Upper Pleistocene (780 ka – 120 ka).1. Faults; 2. Volcanic products from the activity of the Sabatini volcanic complex; 3. Via Tiberina yellow tuff; 4. Sedimentary units related to the Tiber River; 5. Fosso della Crescenza formation; 6. Ponte Galeria formation; 7. Monte delle Piche formation (and pre-Pliocene units); 8. Monte Mario formation; 9. Monte Vaticano formation; 10. Meso-Cenozoic carbonatic substratum (from Parotto, 2008).

glacial epoch, the sea level dramatically dropped to a minimum of 120 metres below the current mean sea level. During this period, the Tiber River deeply eroded both the ignimbrite plateau and the underlying Pliocene sands and clays, thus forming numerous reliefs interrupted by deep valleys, including the well-known “Seven Hills”. Throughout the Holocene, the sea level rose, which consequently filled the deeply carved Tiber River valley with gravelly and sandy alluvial sediments, sometimes reaching several dozen metres in depth (see Fig. 5).

The current geomorphology of Rome is defined by a sprawling alluvial plain, which is bounded to the west by the Monte Mario - Gianicolo ridge and extends all the way to the eastern foothills of the Colli Albani volcanic range. In the centre of this plain are the iconic “Seven Hills” that have come to represent the quintessential topography of the Eternal City, familiar to people all around the globe.

The volcanic activity

The geological and geomorphological changes that occurred in the Rome area are strictly connected to the activity of the two Pleistocene volcanoes that encompass the town: the Sabatini Mts. volcanic district and the Colli Albani Volcano.

The Sabatini Mts. volcanic district underwent several phases of activity, as outlined by De Rita et al. (1996) and Sottili et al. (2010) and outlined in Figure 6.

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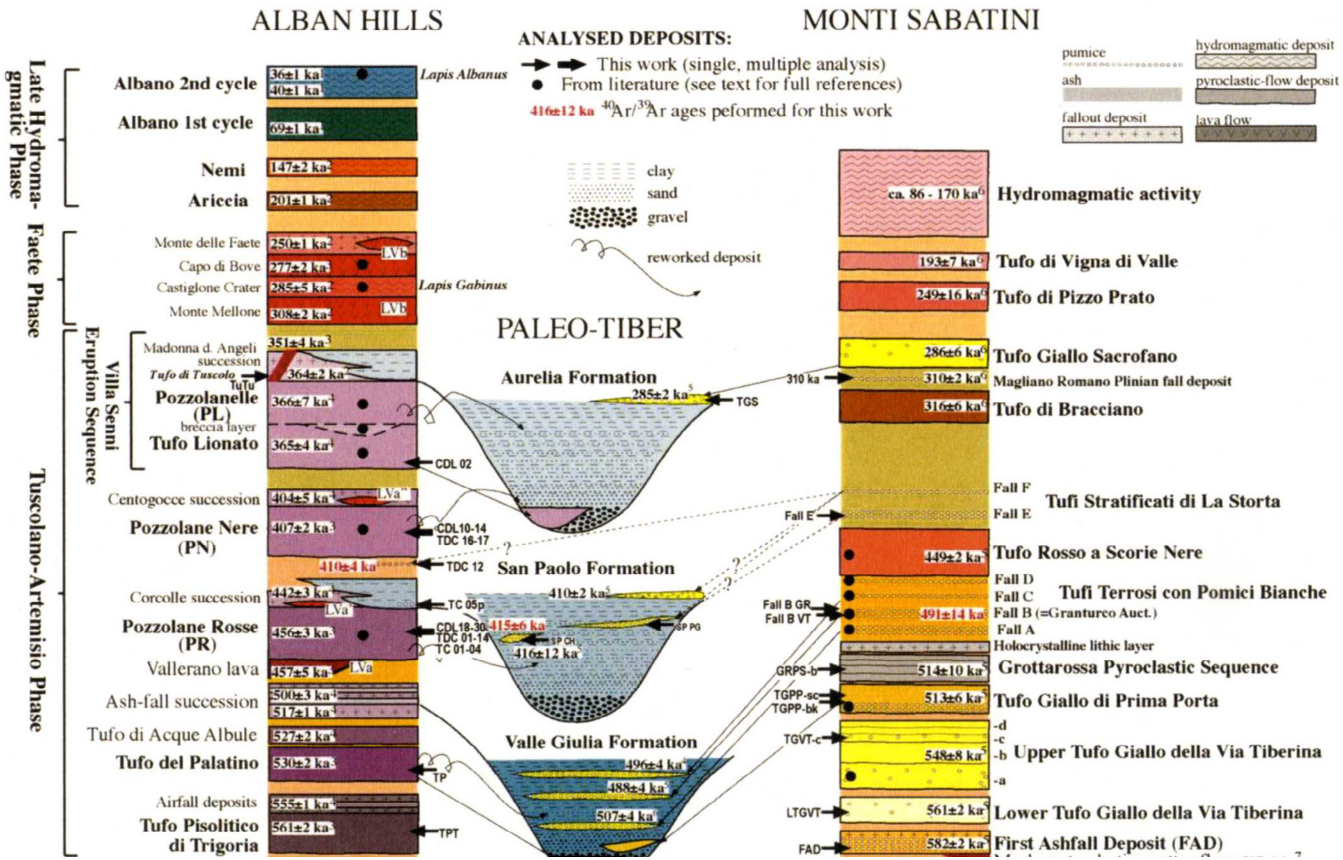

Fig. 4 - Schematic stratigraphy of Colli Albani and Sabatini Mountains volcanic districts (from Marra et al., 2011).

The initial K-rich volcanic activity began around 0.6 to 0.4 Ma near Monte Soratte on the eastern margin of the graben, according to De Rita et al. (1996). The activity later moved westward to the Sacrofano area, and during this phase, sub-Plinian to Plinian fallout and pyroclastic flows were emitted (De Rita et al., 1996). This resulted in the formation of the *Tufo Giallo della Via Tiberina* pyroclastic succession and the *Tufo Rosso a Scorie Nere*, a trachy-phonolitic ignimbrite, which represents the first eruption within the Bracciano Lake region. There were also minor hydromagmatic and effusive activities during this phase (De Rita et al., 1996).

The next activity phase, which took place between 0.3 to 0.2 Ma, was marked by the emplacement of the *Tufo Giallo di Sacrofano* and Bracciano pyroclastic flow eruptions, as well as extensive effusive activity. The Bracciano Lake and Sacrofano depressions were partially formed during this period. Three ignimbrites were also emplaced between 0.28 to 0.17 Ma from fault systems located further north (De Rita et al., 1996).

Between 0.17 to less than 0.08 Ma, hydromagmatic, effusive, and secondary strombolian products were erupted from the eastern margin of Bracciano Lake (Fornaseri, 1985; Di Filippo, 1993). The end of the volcanic activity occurred around 85 ka with the explosive activity of the Baccano eruptive centre, according to Fornaseri (1985) and Di Filippo (1993).

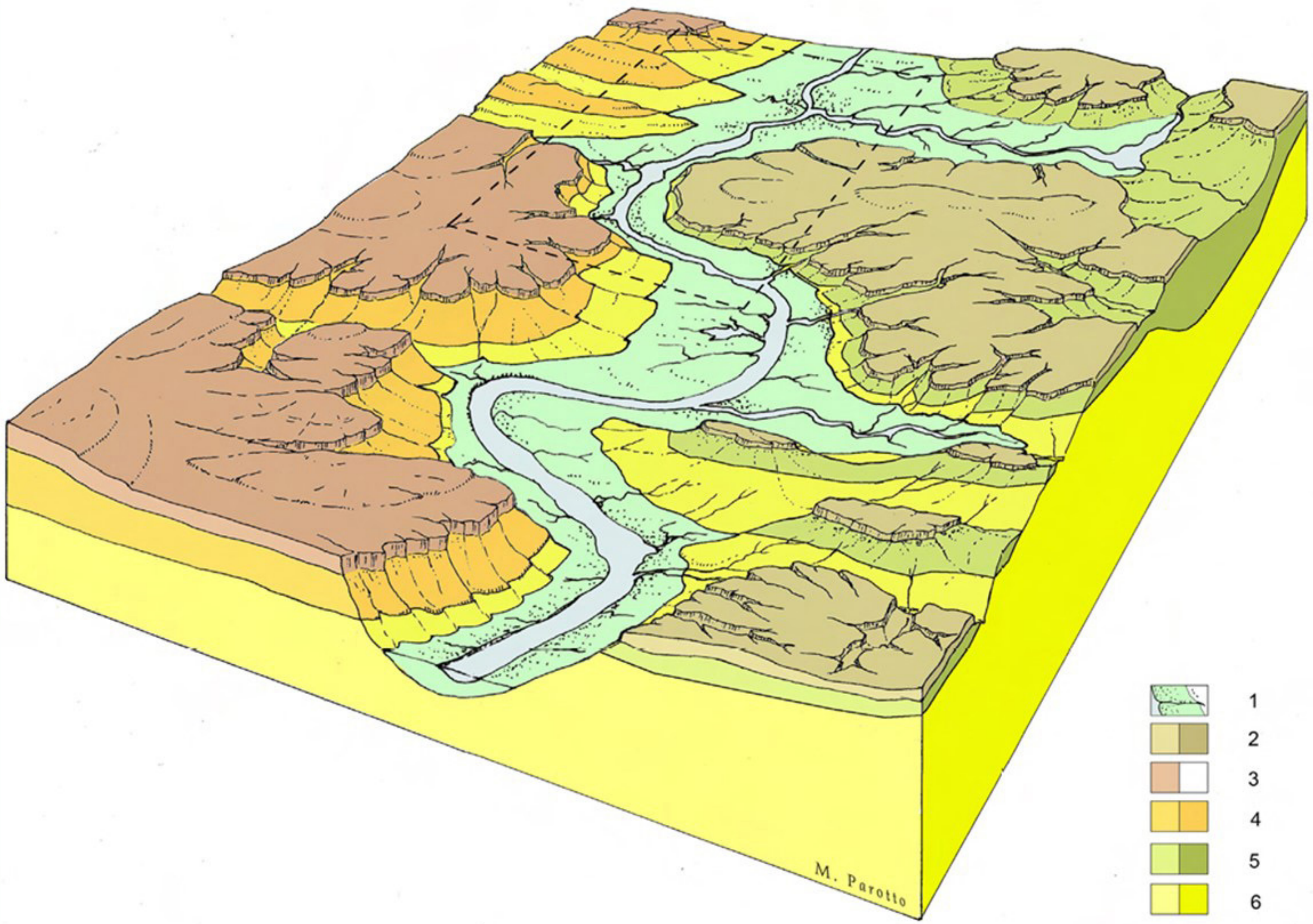

Fig. 5 - Paleogeography of the roman area in Upper Pleistocene – Holocene. 1. Tiber River and its tributaries alluvial deposits; 2. Colli Albani volcanic complex products; 3. Sabatini volcanic district products; 4. Monte Mario formation; 5. Fosso della Crescenza formation; 6. Monte Vaticano formation (from Parotto, 2008).

The Colli Albani volcano

The Colli Albani volcano is situated several kilometres southeast of the central region of Rome, as depicted in Figure 6. Descriptions of the stratigraphic and depositional characteristics are presented in Fornasieri et al. (1963), Alberti et al. (1967), De Rita et al. (1988), updated and detailed in Giordano et al. (2006; 2010) (Fig. 4). The eruption of this volcano can be categorized into three main phases, as reported by De Rita et al. (1988). The first phase, named *Tuscolano-Artemisio* (or *Vulcano Laziale* and *Tuscolano Artemisio Lithosome*, according to Giordano et al., 2006, 2010), which occurred 600-350 ka, was characterized by a significant emission of magma (>280 km^3). This phase was marked by four major eruptions, which produced pyroclastic flows, pumice stones, and lava flows. These materials were deposited over an area of 1,600 km^2, thus creating the "geological floor" of Rome.
The materials were later exploited for building construction. The final eruption, known as Villa Senni formation (Funiciello and Giordano, 2008b), triggered the collapse of the volcanic centre, which is presently recognized as the horseshoe-shaped section that extends from Monte Tuscolo to Monte Artemisio. The Villa Senni eruption also led to the formation of the Tufo Lionato member, which is the central feature of the Sette Colli (Seven Hills), the birthplace of Rome (Faccenna et al., 1995; Giordano et al., 2006; Funiciello and Giordano, 2008b).

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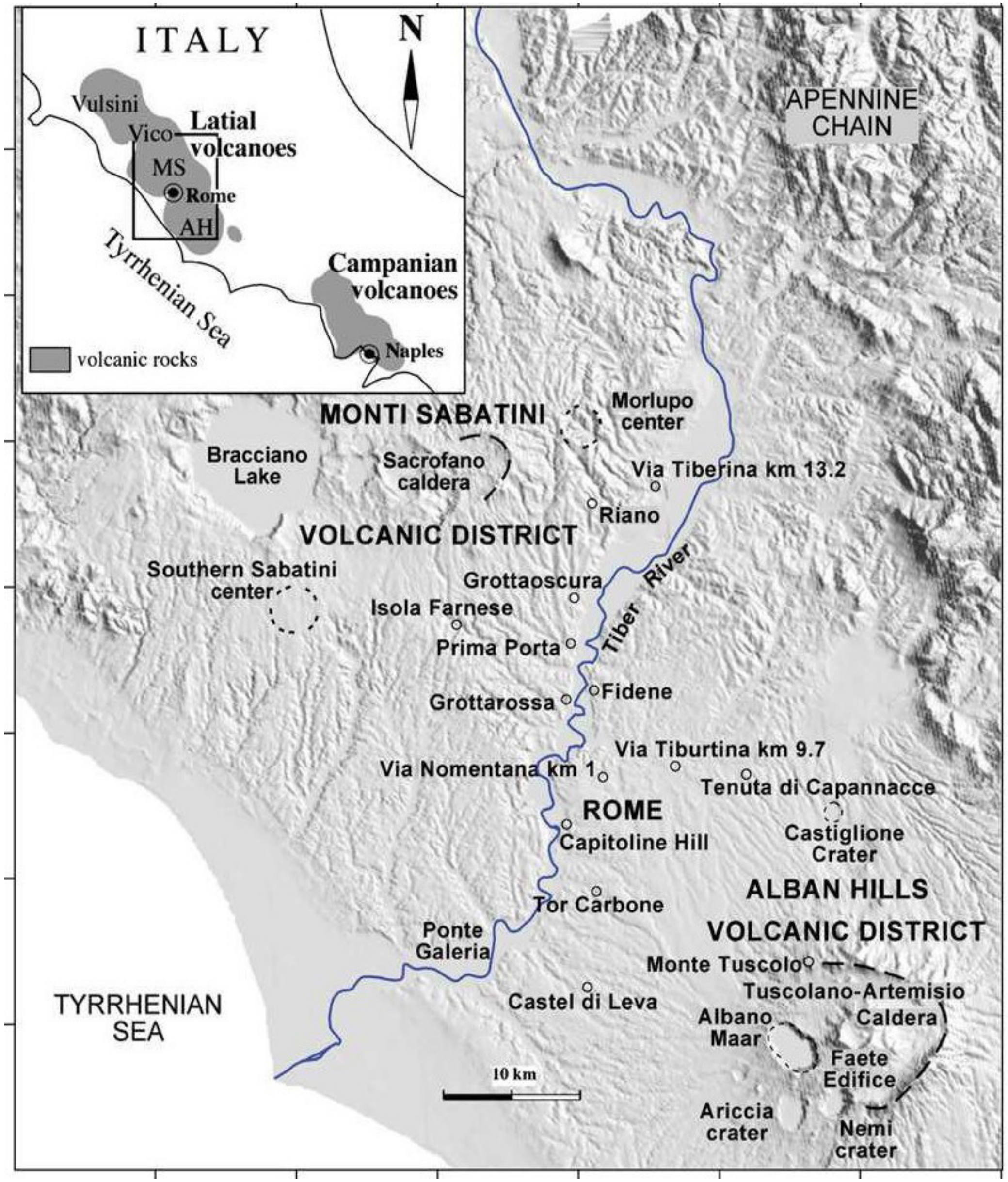

Fig. 6 - Map showing the position of the city of Rome between the Sabatini Mountains (MS) and Colli Albani (AH) volcanic districts (from Marra et al., 2011).

During the second phase, referred to as Faete (Faete Lithosome according to Giordano et al. 2006), which occurred approximately 350-270 ka, volcanic activity resumed within the caldera resulting in the formation of the Faete cone. The activity featured both Strombolian-type explosions and significant emissions of lava flows including the Capo di Bove eruption (280 ka) which covered the north-western flank of the volcano, coinciding with the initial kilometres of Via Appia, commonly known as *Regina viarum* (the Queen of roads). The total volume of erupted magma during this phase is estimated to be 40 km^3 (Giordano et al., 2006; Funiciello and Giordano, 2008b).

The final stage, referred to as Hydromagmatic Via dei Laghi Lithosome (Giordano et al., 2006), occurred approximately 270-20 ka and was characterized by explosive eruptions that resulted in the creation of a sequence of distinct craters. The eruption products from this stage are indicative of explosive events stemming from interactions between magma and water, also known as hydromagmatic or phreatomagmatic eruptions. These types of eruptions are typically brief and give rise to large volcanic landforms known as maars. The eruptions during this stage led to the formation of a series of craters that later evolved into lake basins. The volume of eruptive products produced during this phase is estimated to be around 1 km^3.

Geological deposits of volcanic and volcaniclastic materials in the Ciampino area (Tavolato formation) are believed to be lahars - mudflows that result from the mixture of pyroclastic materials and water during the process of erosion along the slopes of the volcano. Radiocarbon dating of the humic layer beneath the most recent lahar deposits indicates an age of approximately 5 ka (Funiciello et al., 2003).

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GEOMORPHOLOGICAL FEATURES

The urban area of Rome has undergone continuous evolution for thousands of years. It is characterised by landforms resulting from the interplay of tectonic and gravitational movements, surface waters, and human impact.
In the drainage network of the Tiber River, the volcanic plateau has produced steep slopes of the "Seven Hills", while narrow and deep valleys have formed at the edge of the Mt. Mario - Gianicolo ridge on the other side. In the western part of Rome, the lack of vegetation has primarily driven the geomorphological evolution through runoff and gravitational processes (Del Monte et al., 2013).
Throughout history, the urban area has undergone significant changes due to major population fluctuations over a 3,000-year period of occupation (Del Monte, 2018). Human activity has caused erosion and accretion that overlap with natural forms. Mining activities since the VI-V century BC (Cifani, 2008) for tuff and clay extraction produced steep slopes and scarps. Urbanization has layered man-made materials such as waste, building ruins, and landfill materials, intertwined with natural colluvium and alluvium. Landfill materials can reach up to 18 metres in thickness (Funiciello et al., 1995). Consequently, human activities have majorly modified the natural relief.
Giovanni Battista Brocchi (1772-1826), a geologist from Veneto region, described the morphology of the urban area before human presence. His study produced the volume "The Physical State of the Terrain of Rome" (Brocchi, 1820), which includes a "Physical Map of the Terrain of Rome in the Early Times of Its Foundation" (Figs. 7 and 8).

The Tiber River

The Tiber River, previously known as Albula, Thybris, and finally Tiberis, is the primary river in central and peninsular Italy. It has a watercourse of 405 km, making it the third longest Italian river after the Po and Adige. It has a catchment area of 17,375 km^2, which is 5% of the national territory, second only to the Po. With an average annual flow of 324 m^3/s at the mouth, it is the third-largest Italian watercourse after the Po and the Ticino.
The Tiber River passes through four regions: Emilia-Romagna, Tuscany, Umbria, and Latium, eight provinces, and 82 municipalities in the Tiber Valley, including Perugia and Rome. The river's source is located on the slopes of Mount Fumaiolo, at a height of 1,268 m above sea level, near the Balze, a hamlet of the municipality of Verghereto in the Province of Forlì-Cesena, on the side that faces Tuscany.
The Tiber basin has many tributaries and sub-tributaries (Fig. 9), but it receives most of its water from the left bank. The river's main tributaries on the left bank are the Chiascio - Topino system, Nera (which collects water from Velino), and Aniene. On the right bank, the major tributaries are the Nestore, Paglia, and Treja. Rivers on the hydrographic left have a karst character, with constant flow rates, especially the Nera, which is the 7th largest Italian watercourse with a flow rate of 168 m^3/s. In contrast, rivers on the hydrographic right have a seasonal character, with winter flow rates as high as 800 m^3/s and summer low flows.

Fig. 7 - “Physical map of the land of Rome in the early days of the founding of this city” by Giovanni Battista Brocchi, enclosed in the volume “Dello stato fisico del suolo di Roma, memoria per servire d’illustrazione alla carta geognostica di questa città”, published in Rome in 1820. North is on bottom.

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Fig. 8 - Excerpt from Brocchi's Map, with the itinerary of this field trip highlighted. North is on top.

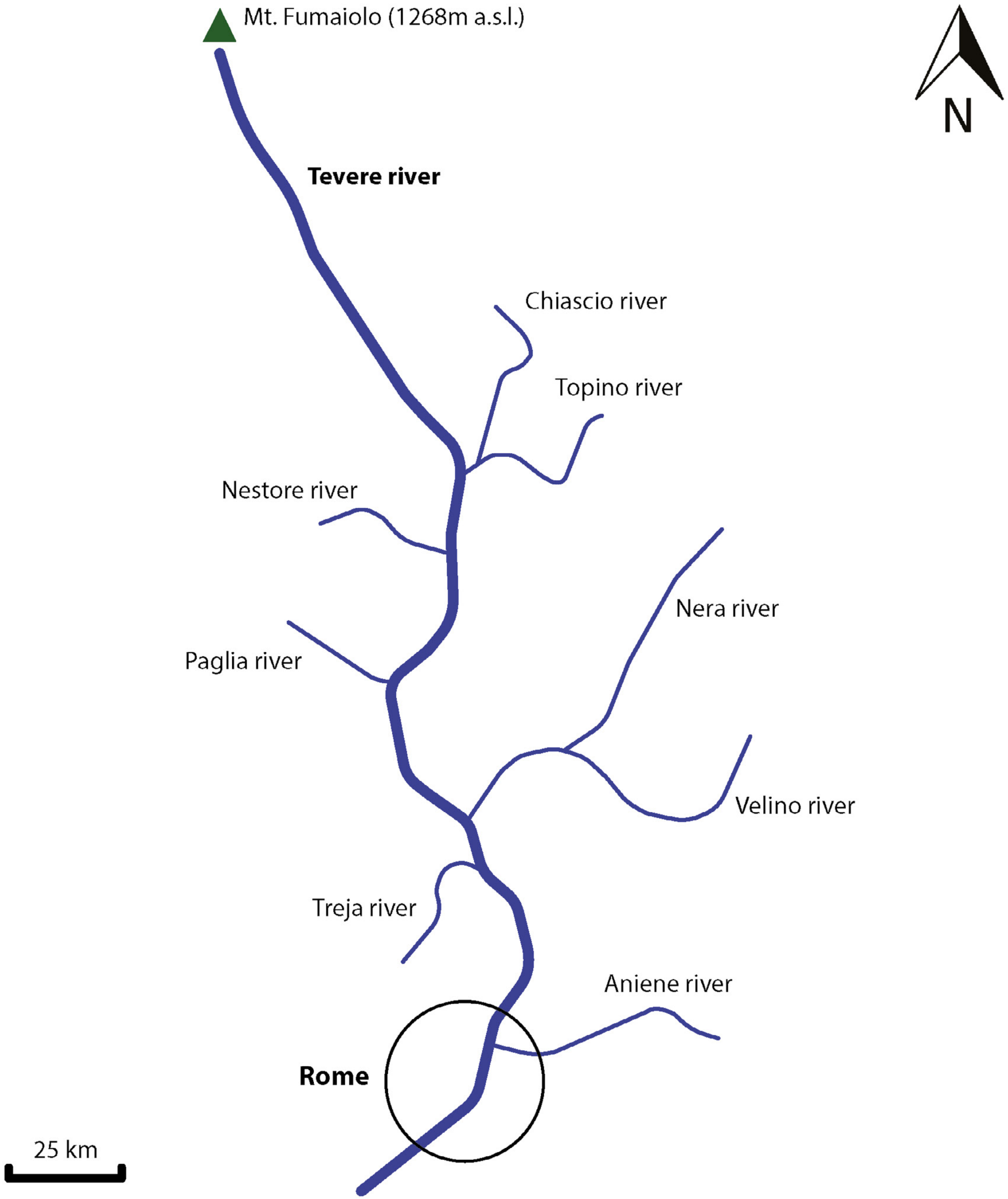

Fig. 9 - Pattern of the course of the Tiber River and its main tributaries.

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ITINERARY

Stop MID-7-1: Ara Pacis Augustae

Coordinates: 41°54'20.08"N - 12°28'31.37"E
Topic: The historical floods of the Tiber River; the disappeared Porto di Ripetta and the ancient hydrometer

The historical floods of the Tiber River

The vicissitudes of the city of Rome, from its founding in 753 BC to the present day, are closely related to the Tiber's strength. In the urban stretch are visible the traces left in the bridges, churches, and houses of the historic centre by the impetuous passage of the waters, evidenced by numerous plaques and inscriptions placed in the memory of the most devastating flooding of the river (Natalini, 1877; Celani, 1895; Di Martino and Belati, 1980).
The Tiber has an average flow rate of about 240 m^3/s, and a hydrographic height of about 6.64 m, which is modest compared to major European rivers, but can increase tenfold during major floods. It is estimated that in the flood of December 24, 1598, the largest ever recorded, the river flow reached 4,000 m^3/s (as comparison, the average flow of the Nile is about 3,000 m^3/s).
During the history of Rome, civil authorities had to choose between the alternative of accepting the risk related to periodical inundations or separating the city from the river by floodwalls, in a radical way. Different choices were made throughout history.
Based on the flow rate, floods are considered:

- ordinary, 10 to 13 m, between 800 and 1,500 m^3/s (return time about once a year).
- extraordinary, 13 to 16 m, between 1,500 and 2,000 m^3/s (return time about every two years).
- exceptional, above 16 m, over 2,000 m^3/s (return time about every 34 years).

Before the construction of the floodwalls, the embankments and collectors, the sewers discharged directly into the river, and during a flood the Tiber used to behave in the following ways: when the flood level exceeded 12 m, the waters leaked out of the manholes in the lower parts of the city, causing the floods "by effusion" (e.g., at 12.13 m in Via della Fiumara in the Ghetto, at 12.88 m in Piazza dell'Orso, at 12.98 m in Piazza della Rotonda and Pantheon, at 13.12 m in Via di Ripetta; Bencivenga et al., 1995; 1999).
When the level exceeded 16 m flood was called "by current", in this case, the Tiber would leave the riverbed and propagate out of Ponte Milvio following via Flaminia, entering in Porta del Popolo, Via del Corso, Via del Babuino, and Via di Ripetta. Another flood stream followed the slopes of Monte Mario and re-joined at Castel Sant'Angelo, creating a swirling flow.

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At the entrance to the city the Tiber's riverbed narrows, forcing the waters to rise and accelerate. Moreover, in the past along the Tiber path, many artificial narrowing were present in the riverbed such as bridges, mills, and buildings (Figs. 10 and 11).

Fig. 10 - The characteristics of the Tiber River in the city centre before the regimentation works (Pescatori sul Tevere a Castel Sant'Angelo, James Anderson, 1870)

Fig. 11 - View of the left bank of the Tiber River before its embankment; the building with the balcony in the foreground is Palazzo Altoviti, 1887.

Tito Livio (59 BC – 17 AD) and Quinto Orazio Flacco (65 BC – 8 BC) mentioned floods that afflicted Rome in several documents (Frosini, 1965). Other incomplete mentions of flood events during the imperial age and the Middle Ages, up to the 12th century, are available. An analysis of the documents shows no events reported in the period between the year 860 AD and 1180 AD, possibly due to a gap in the documentation or to the climate change (medieval climatic optimum) that occurred during that period (Figs. 12 and 13).

Since the XIII century, marble plates, often placed on church facades have been marking the highest points reached by the flood. Many plates survive until today (Di Martino and Belati, 1980): the oldest one is exhibited in the Museo di Roma in Palazzo Braschi. The second plate, dated 1277, was on the facade of the church of the Santi Celso and Giuliano, now moved under the Arco dei Banchi (see stop 3).

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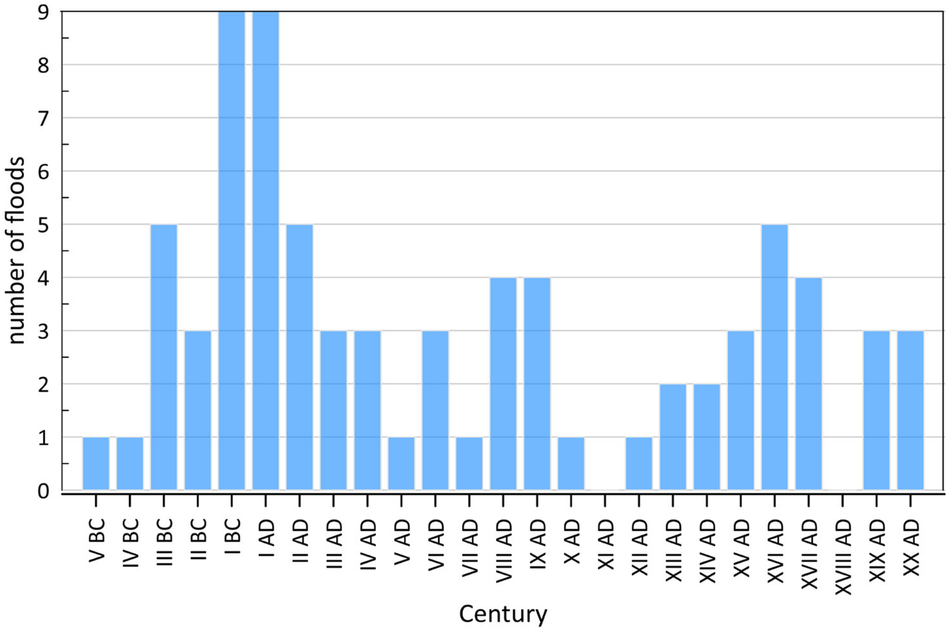

Fig. 12 - Frequency of Tiber's floods in Rome in the last 25th centuries. The low frequencies during the X-XII centuries are possibly related to a gap in the documentation or to the climate change (medieval climatic optimum).

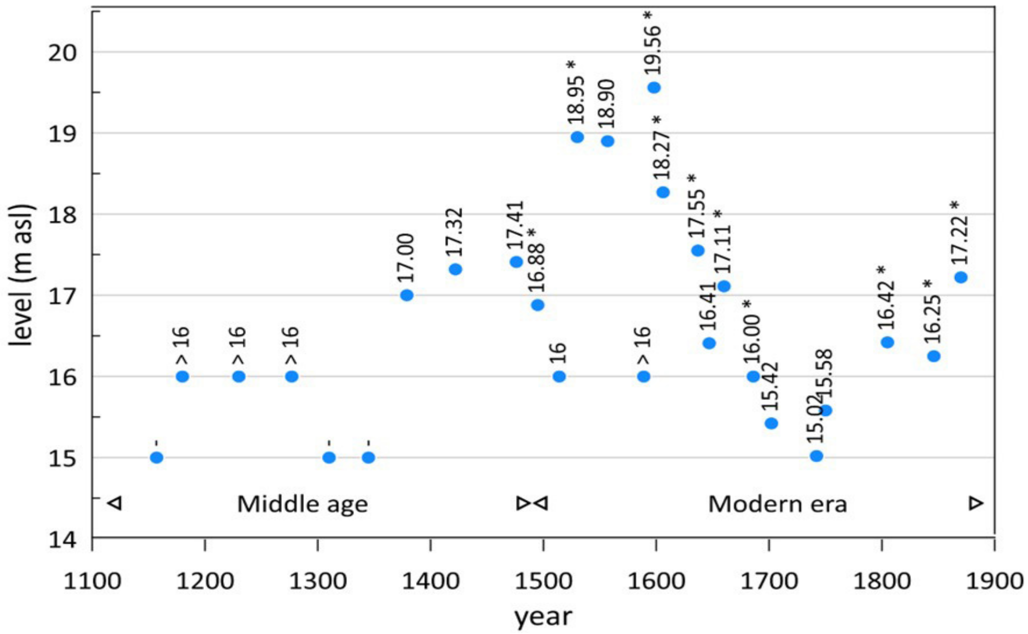

Fig. 13 - Levels of flooding greater than 15 m of the Tiber River in Rome from the XII to the XIX century (from Frosini, 1965; Di Martino and Belati 1980; Bencivenga et al., 1999). Asterisk indicates floods whose levels are reported on the Ripetta hydrometer.

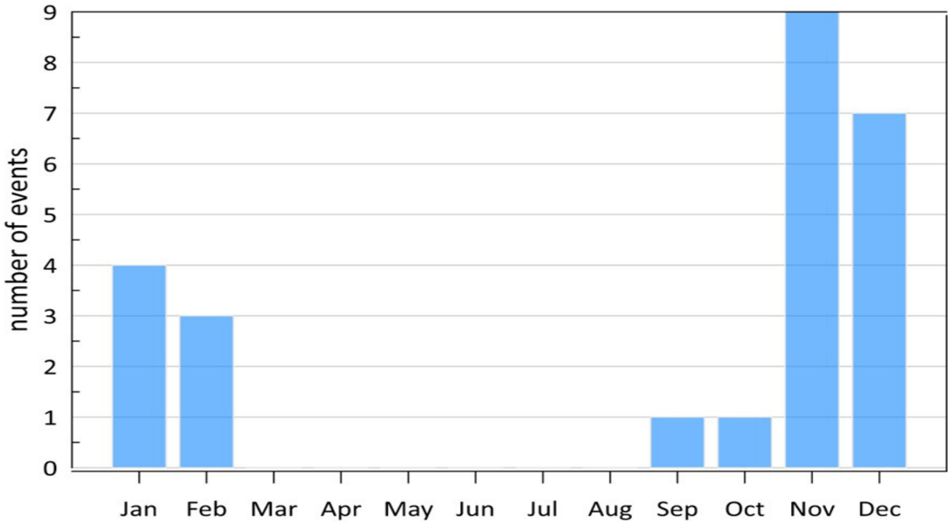

Fig. 14 - Number of flood events related to the monthly period.

Since the XV century, chronicles have been more frequent, detailed, and reliable, also due to the diffusion of moveable-type printing.

Many floods occurred in the XVI century (Fig. 12), most likely related to the beginning phase of the cold climate period known as the "Little Ice Age" (XVI-XIX centuries). On Christmas eve of 1598, Rome experienced its most terrible historical flood. The water reached 19.56 m at the hydrometer of Ripetta (Frosini, 1977, Remedia et al., 1998), 3.70 m above the ground level at Santa Maria sopra Minerva, and 5 m at Piazza Navona.

It must be noted that the XVI century had been a period of large expansion for the city, with many new constructions narrowing the section of the Tiber River. During the subsequent two centuries, weak floods occurred probably linked to the Little Ice Age (Di Martino and Belati, 1980). Three

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large events took place in the XIX century (1805, 1846, and 1870). Since 1900, 28 extreme floods took place, the most relevant are those that occurred in 1900, 1915, and 1937. Nowadays, the available information is more accurate than before thanks to the meteorological network and to the hydrometers placed in specific points of the city (as the hydrometer of Ripetta, moved in 1893 near the Cavour bridge; Berti et al., 2004).

The "disappeared" Porto di Ripetta

The Porto di Ripetta, or Porto Clementino, was the river commercial port of Rome, located in the area in front of the San Girolamo dei Croati Church.

In the early XVIII century, Pope Clement XI approved a project for the construction of a monumental new harbour, equipped with quays, stairways, and squares (Cilli, 2018).

The project was entrusted to the architect Alessandro Specchi, who also designed the staircase of Trinità de' Monti, with the collaboration of Carlo Fontana. The Porto di Ripetta was inaugurated on August 16th, 1704, for its construction bare materials from the Colosseum were used.

Fig. 15 - Panoramic view of the Porto di Ripetta reproduced from a copper incision by Alessandro Specchi, 1704 (from Ministero dei Lavori Pubblici, 1924).

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The port was an example of late Baroque architecture, characterised by two wide curved stairways, which connected the docks to the street level. In the centre there was a hemicycle (Fig. 18), where a fountain was placed to water pack animals used in the transport of merchandise and to tow boats.

Since the Porto di Ripetta was inaugurated, flood levels were marked on the two travertine columns that adorned it (Fig. 18). The harbour was buried because of the hydraulic regulation works carried out in the late 1800s (Segarra Lagunes, 2020). The fountain and the two columns were moved to the close Piazza del Porto di Ripetta.

The Ripetta hydrometer

The first hydrometric station in Ripetta has been operating since 1782, and it provided information on flood levels. It was formerly located in the Porto di Ripetta and consisted of five segments placed at different heights, along which were reported the water level and the date of the flood occurrence (Figs. 16 and 17).

The first hydrometer was replaced in 1821 by a new stone hydrometer (Ministero dei Lavori Pubblici, 1924).

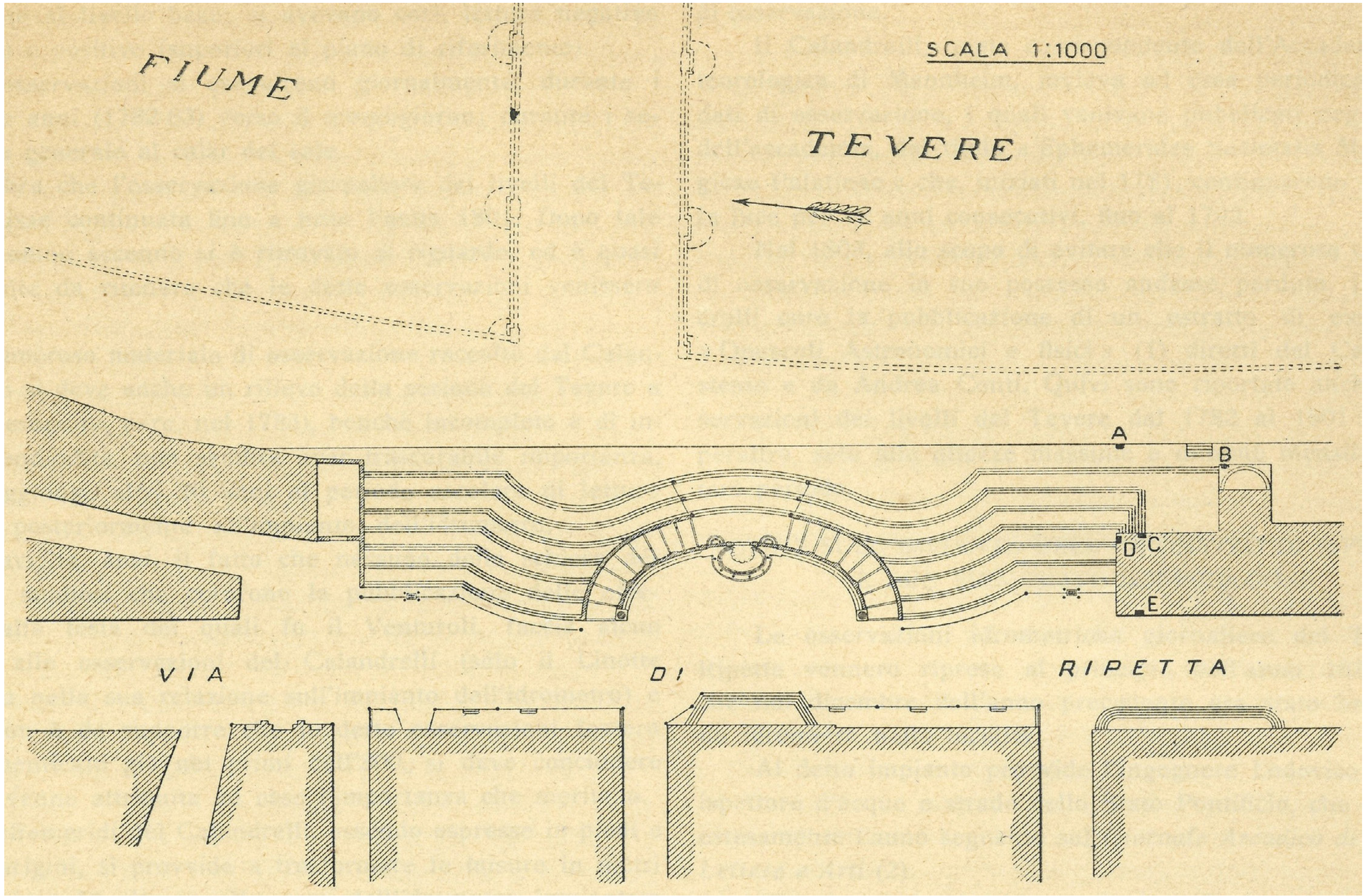

Fig. 16 - The first hydrometer at Ripetta harbour, divided into 5 segments (from A to E), placed in 1782 (from Ministero dei Lavori Pubblici, 1924).

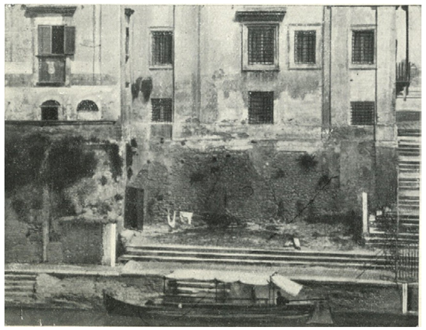

Fig. 17 - The first three sections of the old hydrometer in a photo from 1886 (from Ministero dei Lavori Pubblici, 1924).

Fig. 18 - One of the two columns in Piazza del Porto di Ripetta with indications of the floods of 1805, 1495 and 1660.

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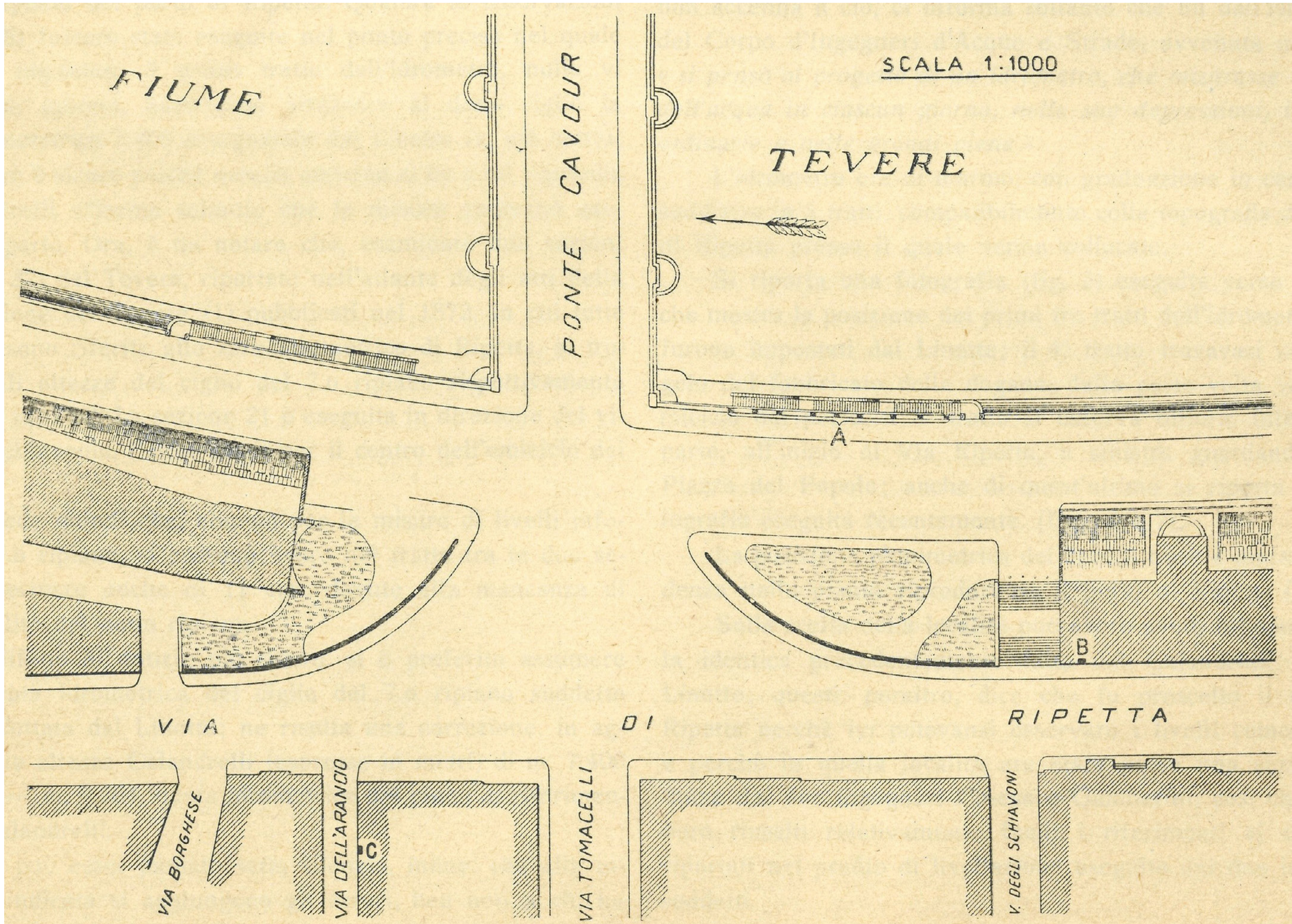
◄ Fig. 19 - The upper part of the Ripetta hydrometer located on the right side of the Church of San Rocco.

▼ Fig. 20 - The Ripetta hydrometer after the construction of the embankments: A - along the staircase leading from the Lungotevere to the bank; B - the upper part of the old hydrometer, on the Dogana Vecchia building. After the building was demolished, this section was moved to the side of the Church of San Rocco (from Ministero dei Lavori Pubblici, 1924).



After the demolition of the harbour, the only remaining part of the hydrometer was the tallest one (E in Fig. 19) placed on the wall of a house near the Tiber bank. When the house was also destroyed, the hydrometer was moved to the wall of the San Rocco church where it still stands today (Fig. 22). The lowest part of the hydrometer was placed on the river wall along the stairs leading from Lungotevere in Augusta to the riverbank, under Ponte Cavour (A in Fig. 20).

In 1893, with the construction of the walls, a new hydrometer with a mechanical recording was activated.

Nowadays, the level is measured with an electronic system, located on Ponte Cavour.

Leaving the staircase of the Ara Pacis Augustae, we walk towards Via della Scrofa. On the left, on the wall of a palace in Via dell'Arancio, there is a small marble plate that records the level of 16.42m, reached by the Tiber River during the flood of February 2nd, 1805. A few metres away there is a hydrometer installed by the Hydrographic Commission established in 1866 at the Ministry of Agriculture, Industry, and Commerce after the Unification of the Kingdom of Italy. This

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hydrometer is a duplicate of the hydrometric gauge of Via di Ripetta and it was intended to improve hydrometric readings thanks to the chromatic scale.
Another hydrometer is located at Palazzo Corsini alla Lungara, the headquarters of the Accademia dei Lincei.
The walk proceeds along Via della Scrofa until Via di Monte Brianzo, the second on the right.
Following the road, after a slight ascent, we arrive in Piazza di Ponte Umberto I. From the terrace, in front of the entrance to the Napoleonic Museum, looking back to Via di Monte Brianzo, we can see an XIII century building, whose entrance is about 4 metres below the actual Lungotevere, indicating the former road level before the urban transformation occurred in the late 19th - early 20th centuries.

Stop MID-7-2: Piazza di Ponte Umberto I (in front of the Museo Napoleonico)

Coordinates: 41°54’9.39”N - 12°28’24.83”E
Topic: The riverbed regimentation works, the 19th-century embankments, the changes to the morphology.

The hydraulic regulation of the Tiber River

Exceptional floods represented a real calamity, causing flooding, damage, collapse, and casualties, which were followed by plagues and famine.
After the floods, scientific treatises were written and measures were studied, but they remained on paper.
After the flood which inundated the city of Rome on December 28th, 1870, with a height of 17.22 m, the construction of the Tiber embankments became necessary. A Commission established by the Ministry of Public Works was engaged to choose the intervention to be adopted. The Commission analysed in detail three of the many proposed projects:

- A first proposal, by Professor Alessandro Betocchi, a member of the Commission, consisted of the construction of a straightening (*drizzagno* in Italian) to be built in the river stretch between Ponte Milvio and the Santo Spirito Hospital, downstream of which a widening of the riverbed was planned.
- A second project by Engineer Raffaele Canevari, also a member of the Commission, consisted in the widening and equalising the width of the riverbed in the urban section and in eliminating part of the existing obstructions, such as the remains of the structures of ancient bridges, mills, or even the Tiber Island.
- The third proposal was made by Engineer Carlo Possenti, chair of the Commission. His project focused on the urban section of the Tiber and the work consisted in the cleaning of the riverbed by the remains of ancient structures, widening the main bottlenecks, and increasing the span of some bridges. Possenti, with the aim of reducing the height of floods in the city, proposed to carry out “three cuts of the

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total length of 7,085 m to be operated by straightening in the three meanders that the course of the Tiber presents downstream of Rome". It should be noted that the main of the three cuts in the project also included the abandonment of the so-called Spinaceto meander, south of the city.

Of the three projects, the Commission approved the one proposed by Canevari, which specifically included the following:

- construction of a slab at Ponte Milvio.
- Embankment of both sides of the Tiber from the Sassi di San Giuliano, at the height of the present Ponte Flaminio, to the city.
- Removal of obstructions and ruins present in the riverbed and construction of embankments (so-called *muraglioni*) in the urban section up to the height of 1.20 m above the presumed crest of a flood-like that of 1870; width of the riverbed of 100 m between the tops of the walls; suppression of the left branch at Isola Tiberina.
- Demolition of the Ponte Rotto with the reconstruction of a new bridge and addition of a span at Ponte S. Angelo.

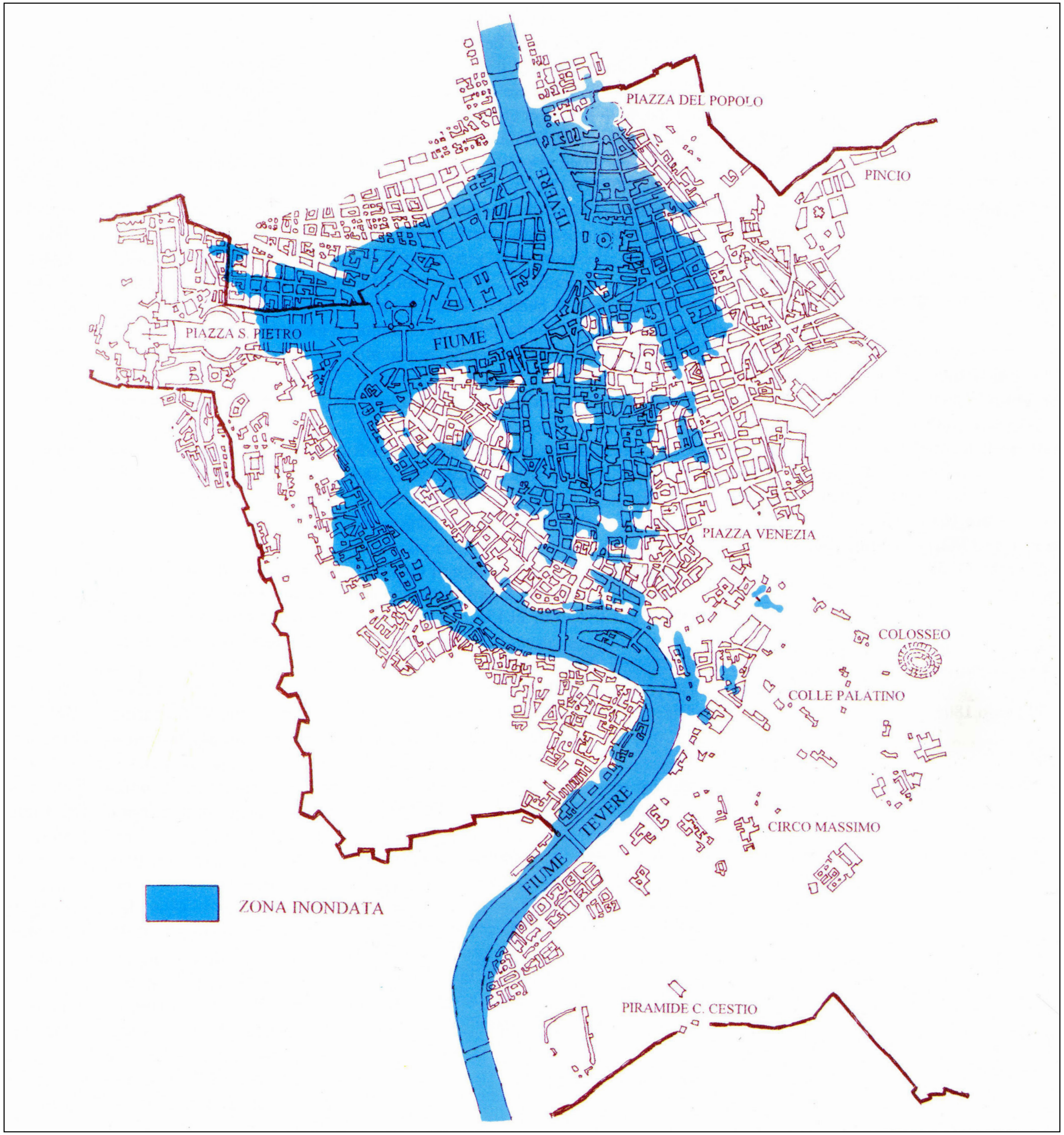

Fig. 21 - In blue the area of the city of Rome inundated by the flood of 1870 (from Bencivenga et al., 1999).

- Construction of two collectors parallel to the banks and embankment of the left bank up to the height of St. Paul's Basilica.
- The intervention, therefore, consisted in regularising the river course and was carried out in the Ponte Margherita – Ponte Sublicio section on the right bank and in the Ponte Matteotti (present) – Ponte Sublicio section on the left bank. The work is about 8 km long and involved profound urban changes in the areas of Campo Marzio, Ponte, Regola, S. Angelo, Ripa, Borgo, and Trastevere.

The work, planned by the Commission in 1871, only began in 1875 through a proposed law promulgated by Giuseppe Garibaldi, which identified the interventions for the hydraulic protection of the city as works of public interest. Garibaldi himself, during the parliamentary debate, presented his own project that called for the detour of the river along a bend outside the city, passing through the eastern and southern sectors, and the construction of river rectifications in the downstream part of Rome.

The Canevari project was financed with 60 million liras (about 260 M€ today) and was subject to numerous modifications during its execution; it is worth of note that the project flooding was that of the 1870 flood, which was estimated at 17.22 m. The Canevari project was completed in 1926, and during those years some major floods occurred: on December 2nd, 1900 (16.17 m), on February 15th, 1915 (16.08 m). The one in 1900 caused a section of the retaining wall to fall at the height of the present-day Lungotevere dei Vallati, but overall, no flooding occurred, thus confirming the validity of the project.

Fig. 22 - Works for the construction of embankments and quays along the Tiber, 1883.

Since the end of the XIX century, no flooding events comparable to the past have occurred.

The highest flood after the building of the hydraulic regulation of the Tiber occurred on December 17, 1937.

Many things occurred to this success: a generalised reduction of the mean seasonal rainfall and, consequently, of the flow rate (Bersani and Bencivenga, 2001) but also the large quantities of water used for farming and industrial activities.

In addition, a major contribution to flood reduction comes from the realisation of the Spinaceto straighten in 1940 (Pantaloni, 2016; 2020) (Fig. 23), the Castel Giubileo (1951), Nazzano (1956) and Gallese (1961) weirs, and the Corbara (1959-1963) (Autorità di Bacino del Fiume Tevere, 2005) and Alviano (1964) dams.

Conversely, these large reservoirs have the defect of retaining some of the sediment transported by the river, which prevents the growth of the river delta and the necessary beach nourishment, resulting in severe coastal erosion of the beaches of Ostia and Fiumicino observed over the last 40 years (Berti et al., 2004).

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Left the footpath in front of the Museo Napoleonico, we cross the road in the direction of Via degli Acquasparta.

Continuing along the smallest alley of the city (Vicolo di San Trifone), turning right our walk continued along Via dei Coronari, one of the most attractive and picturesque roads of the city, in which there are numerous stores selling antiques, jewelry, and precious marbles. It owes its name to the medieval vendors selling rosary beads (*corona* in Italian) and holy images to pilgrims in transit on the way to St. Peter's Basilica.

At the end of the street, which after the square is named Vicolo del Curato, we arrive at Via del Banco di Santo Spirito, turning left. On the right side of the street is an archway connecting Via del Banco di Santo Spirito to Via Paola.

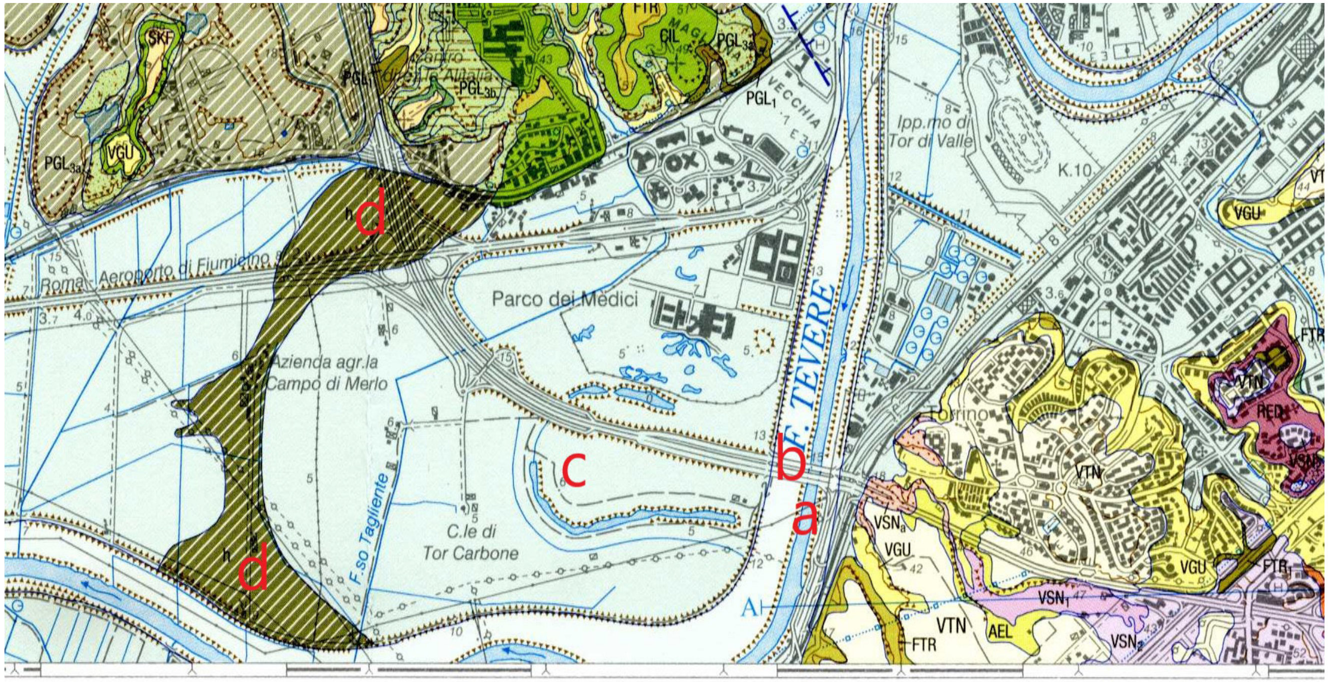


Fig. 23 - Extract from Geological Map of Italy 1:50.000 scale – Sheet 274 Roma (Servizio Geologico d'Italia, 2008). a = Spinaceto straighten; b = Ponte di Mezzocammino; c = abandoned meander; d = excavated material backfills area (from Pantaloni, 2016).

Stop MID-7-3: Arco dei Banchi

Coordinates: 41°54'1.85"N – 12°27'59.65"E
Topic: Flood memorial plaques; the 1277 flood.

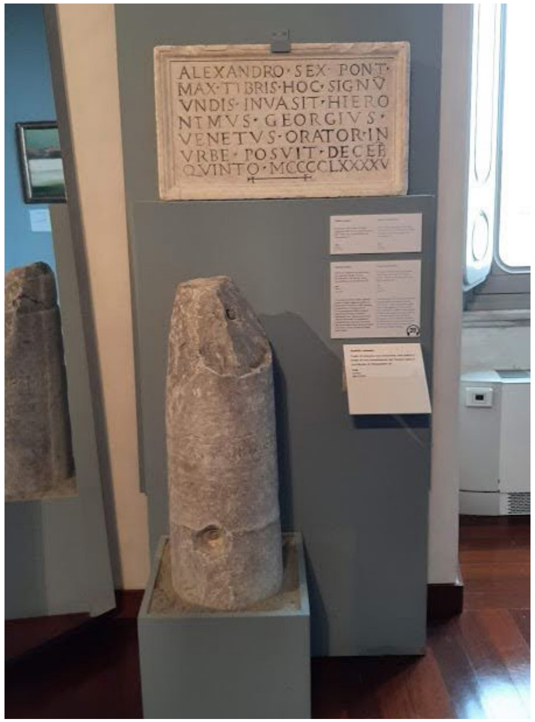
Under the arch, indicated on the outside by a marble plate, is one of the oldest inscriptions relating to a flood of the Tiber: that of November 7th, 1277. The flood level is indicated by a horizontal line placed immediately below a supporting iron bracket (Di Martino and Belati, 1980; Bersani and Belati, 2010) (Fig. 24).

The white marble slab is rectangular, very tall, and narrow, 176 x 35 cm in dimension. The epigraph states:

Fig. 24 - The marble slab at Arco dei Banchi: the horizontal line marks the water level of the 1277 flooding. Note in the upper part a posthumous inscription dated 1640.

HUC TIBER ACCESSIT SET TURBIDUS HINC CITO CESSIT ANNO DOMINI MCCLXXVII IND VI M NOVEMB DIE VII ECCL A VACANTE.	Here the Tiber arrived, but turbid, from here it soon withdrew in the year of our Lord 1277, sixth indiction, seventh day of November, while the Church was vacant.

Originally, the slab was located under the porch of the church of Santi Celso e Giuliano, which was in Piazza di Ponte; the original flood level was, therefore, different from the one reported.
The oldest column relative to a Tiber flood is in the Museum of Rome in Palazzo Braschi (Fig. 25) (Di Gioia, 1998). The flood of January 26th, 1180, is reported by the following inscription:



PONT(IFICATU), DO(M)P(N)I. ALEX(ANDRI). III. P(A)P(AE). ANNO XX (I) [INDICTION] XII [I]. ME(N)SE. IAN(UARII) / D(IE). XXVI. HUCUSQ(UE) CREVIT FLUM(EN). [ANNO DOMINI AB] IN(CAR) N(ATIO)NE. M.C.LXXX	In the twentieth year of the pontificate of Alexander III Pope, in the XII announcement, in the month of January, on the twenty-sixth day, the river grew up until here, in the year 1180.

The column with the inscription was recovered on March 16th, 1886 “in a wall of the demolitions of the Piazza della Chiesa Nuova house, precisely meeting the facade of the Church” during the demolition work of some old buildings for the opening of Corso Vittorio Emanuele II (Bersani and Belati, 2010). The same authors believe that both the column with the 1180 inscription and the plaque with the 1277

Fig. 25 - The column relative to the flood of January 26, 1180, located in the Museum of Rome in Palazzo Braschi. In the upper part, a plate reporting the level of the 1495 flood.

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inscription in the Arco dei Banchi were part of the portico of the ancient Romanesque Basilica dei Santi Celso e Giuliano, which overlooked the Tiber opposite Castel Sant'Angelo, much damaged by the 1488 river flood and demolished (Di Martino and Belati, 1980) in the early 1500s by Pope Giulio II for the enlargement of the Canale di Ponte (the present Via del Banco di Santo Spirito).

We turn back onto Vicolo del Curato and, after a few dozen metres, turn right at the second onto Via di Panico, walking until you reach a small apron, on the left, with the entrance to a magnificent residence: Palazzo Orsini Taverna. Alongside this building, following Via di Monte Giordano, we come to a steep slope, on the left: Vicolo del Montonaccio.

Stop MID-7-4: vicolo del Montonaccio - Monte Giordano

Coordinates: 41°53'58.46"N - 12°28'11.00"E

Topic: Artificial alterations of the landscape.

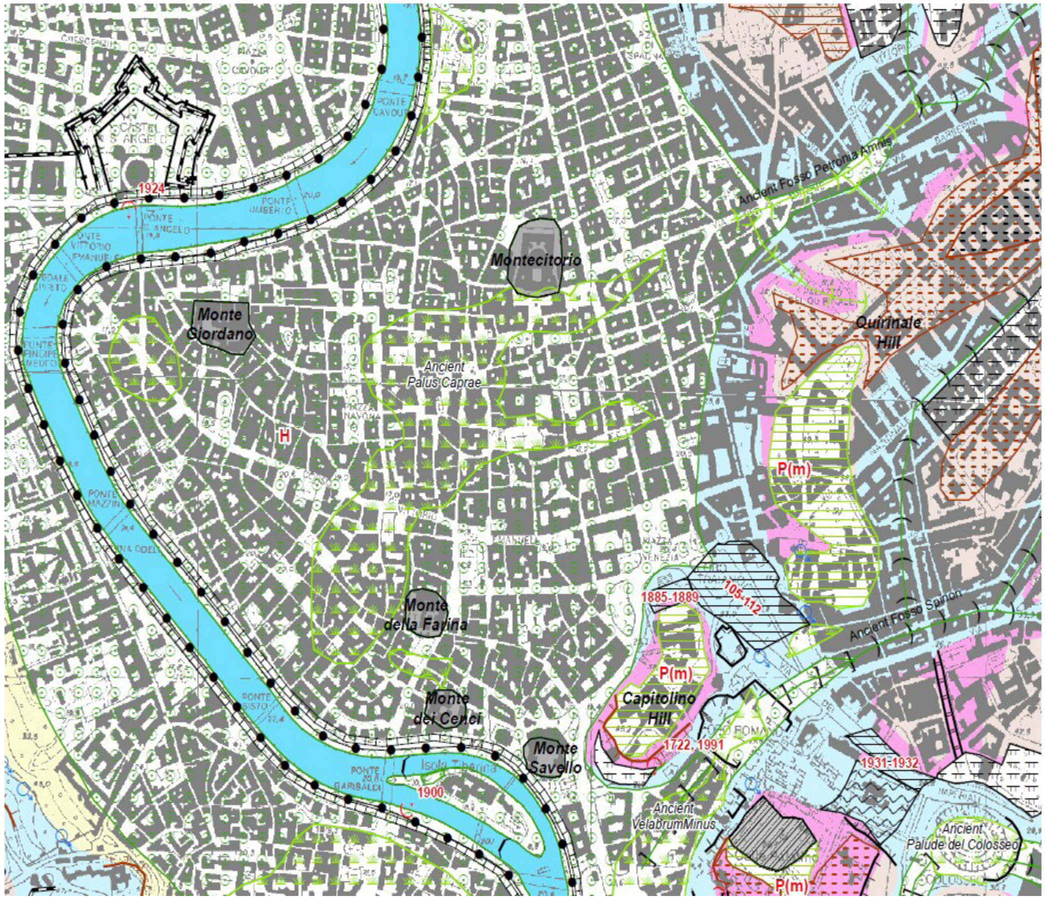

Fig. 26 - Excerpt from the Geomorphological Map of Rome for the Campo Marzio area (from Del Monte et al., 2016), which highlights the presence of various anthropic reliefs, including Montecitorio, Monte Giordano, Monte della Farina, Monte dei Cenci, and Monte Savello.

In the middle of the river plain lies the unexpected elevation of Monte Giordano. Along with Montecitorio (which houses the Italian Parliament), Monte Savello, and Monte Testaccio, it bears witness to the human ability in altering the morphology. The maximum elevation of Monte Giordano was measured at Vicolo del Montonaccio, standing at 6 metres above the surrounding ground level (24 metres above sea level, Vergari et al., 2021). The origin of the hill can be traced back to medieval times; it was mentioned by Dante Alighieri in the early 14th century in the Divina Commedia (Canto XVIII of the Inferno, 25-33), where it is referred to as the "mountain" from which pilgrims came on their way to the church of San Pietro before crossing the Tiber at Castel Sant'Angelo. Some scholars speculate that Monte Giordano may have been formed from the debris of a fortress destroyed by Roberto il Guiscardo during the 12th century, while others believe it is made up of deposits from the ancient fluvial harbour *Statio marmorum* of "Tor di Nona."

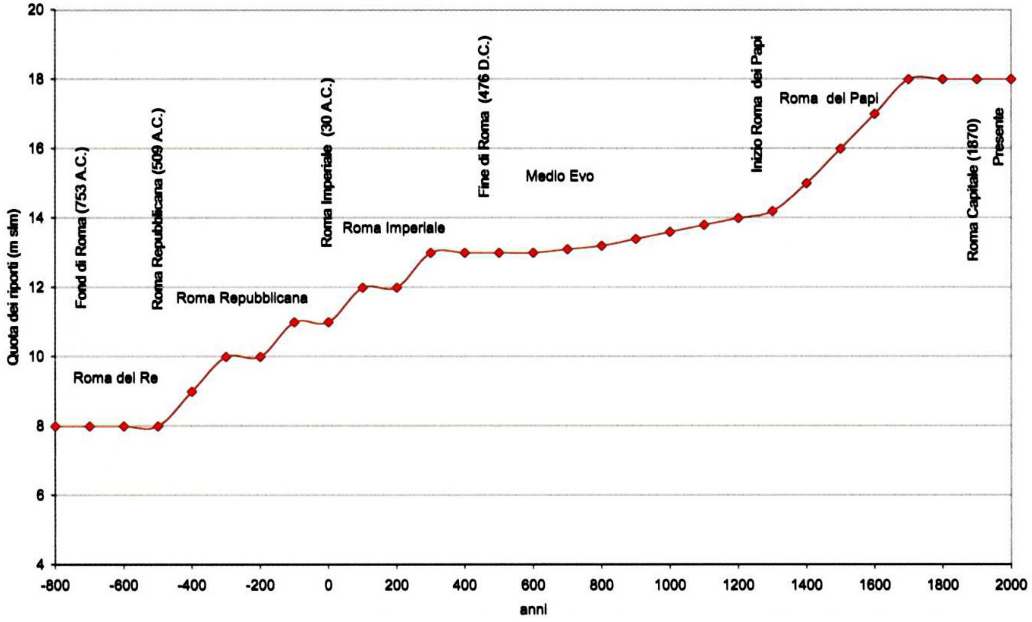

Fig. 27 - Model of the progressive "thickening" of backfill covers in the Campo Marzio area over time, which was caused by alluvial deposits from the Tiber River and the accumulation of rubble and ruins from the ever-changing city of Rome. Different rate of thickening is associated to the different expansion/regression phases of the urban fabric (Funiciello et al., 2008b).

Over the centuries, the ground level of Rome has steadily risen due to deposits from the Tiber floodings and cycles of construction and destruction of buildings. In the Campo Marzio area, the topographic surface is now 0-20 metres above the original level, which can be now observed through several "windows" (such as the Diocleziano circus, the "insula" at the base of the Capitolium Hill, Largo di Torre Argentina, the Foro Romano area, San Vitale, and others, as depicted in Fig. 28).

Funiciello et al. (2008b) modelled the rate of the thickening of the filled land in the Campo Marzio area (Fig. 27) based on the analysis of borehole cores. The highest rate of thickening (i.e., the raising of the "floor") was recorded during the periods of maximum expansion of Rome, while a decline in the rate of thickening between 400-1200 reflects the demographic crisis in Rome after the fall of the Western Roman Empire in 476 AD.

Testa et al. (2008) presented a digital elevation model (DEM) before and after anthropic land reworking (Figs 28a and 28b).

We turn left onto Via di Monte Giordano and then take the second right onto Vicolo delle Vacche, a quintessential Roman alleyway that leads to Piazza del Fico on the right. The road continues straight into Via della Pace and Via di Tor Millina, where a medieval fortified tower stands at the intersection with Via di Santa Maria dell'Anima. Crossing the street onto Via di Sant'Agnese in Agone, we arrive at Piazza Navona, one of the most magnificent squares in Rome, commissioned by Pope Innocent X (Giovanni Battista Pamphili 1574-1655). The shape of the square follows that of the ancient Roman Domitian Stadium.

At the center of the square stands a Baroque masterpiece: the Fountain of the Four Rivers, designed by Gian Lorenzo Bernini in 1651 on direct commission from Pope Innocent X. The fountain depicts the giants standing for the four great rivers in the four continents: the Nile in Africa, the Gange in Asia, the Danube in Europe, and the Río de la Plata in America. These rivers represent the four corners of the known world at that time.

The fountain's marble giants are arranged on a travertine shoal amidst a scene of carved grottoes decorated with exotic plants, flowers, and animals. Seven animals surround the fountain: a horse, a sea monster, a serpent, a dolphin, a crocodile, a lion, and a dragon. The Ganges is depicted carrying a long oar, representing the river's navigability. The Nile's head is draped with a loose piece of cloth, indicating that at the

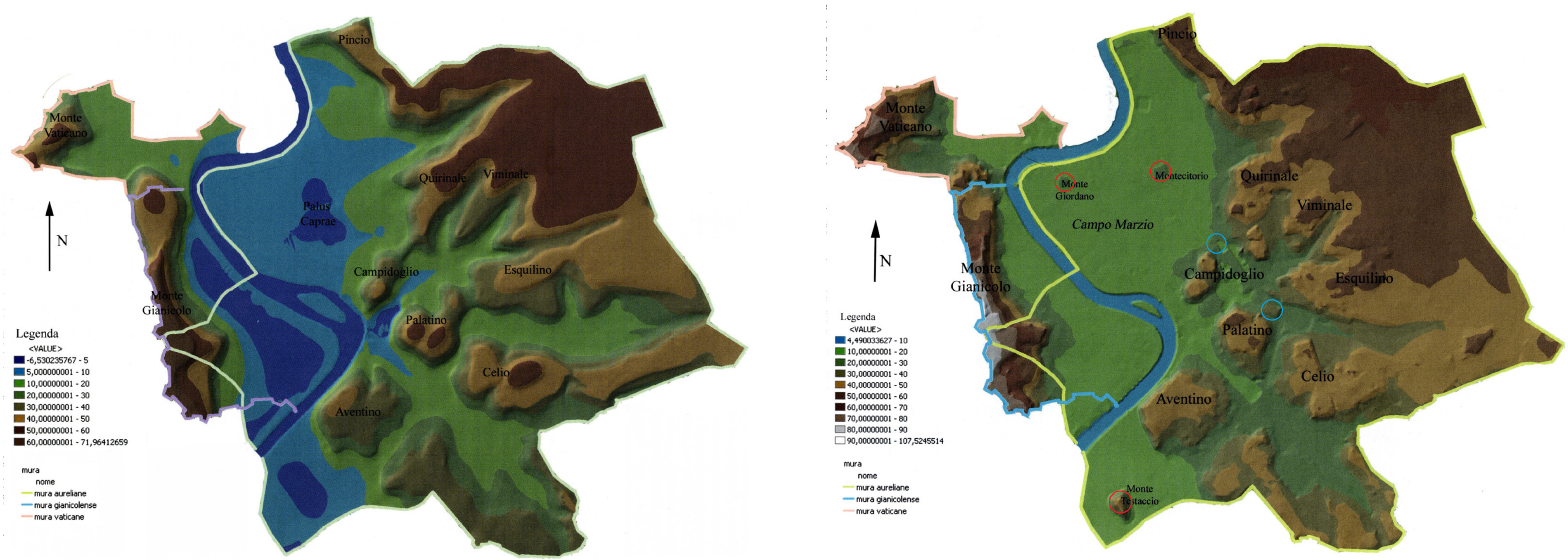

Figure 28 - Digital elevation model of the Roma area before the development of the town (top) and after (end of XX century; Testa et al., 2008). The latter figure identifies "windows" in the landscape where the ancient floor is visible a few metres below the current ground level, with red circles highlighting the most relevant sites of terrain removal (Colonna Traiana and Velia Hill).

time, nobody knew exactly where the Nile's source was. The Danube touches the Papal coat of arms as it is the largest river closest to Rome. Finally, the Río de la Plata God is depicted as sitting on a pile of coins, symbolizing the potential riches that America could offer Europe. This remarkable work of art by Gian Lorenzo Bernini can also be interpreted as a powerful metaphor, where each River God is seen in a state of awe, as they bow in front of the central tower. The tower is exemplified by a slender Egyptian obelisk, representing the Papal power, and crowned with the Pamphilj symbol of a dove. To finance the cost of the fountain, the pope imposed a tax on bread, which resulted in a reduction of the weight of the loaves.

As we walk down the Corsia Agonale, we arrived at Piazza Madama, right in front of Palazzo Madama, which serves as the Senate of the Italian Republic. At number 2 of the square, we notice a commemorative plate for the flood of 1495, that here reached 1.80 m above the ground level. Moving on, we cross the road at the designated crosswalk and proceed along Via degli Staderari, where we come across the Piazza Sant'Eustachio fountain. During excavations in 1985, a basin from the Roman imperial period was discovered in the courtyard between Madama and Carpegna

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Fig. 29 - Anonymous, XVII century, “Ansicht der Piazza Navona in Rom”, oil on canvas (from Wikimedia Commons).

palaces. The basin was originally a monolith of Egyptian granite from Aswan and belonged to a Neronian-Alexandrine bath complex that once existed in the area. The pool was reduced to eight fragments and underwent complex restoration work. It measures 5.30 metres in diameter and weighs about 25 tons, while the base was crafted from a block of Carrara marble, weighing 8.5 tons. In honor of the 40th anniversary of the promulgation of the Republican Constitution, the Senate gifted the fountain to the city of Rome in 1987.

As we continue along the road, we soon arrive at the beautiful Piazza di Sant’Eustachio, where we are greeted by the stunning Chiesa di Sant’Eustachio on our left. On the right side of the church, we can see a plaque that records the devastating flood of December 5, 1495 (Figure 30), similar to the one we saw earlier in Piazza Madama. This plaque indicates a flood level of approximately 2.10 metres, which shows that the street level has decreased by about 0.30 metres from Corso Rinascimento.

We continue our journey by taking via della Dogana Vecchia, then turning right onto Salita de’ Crescenzi, which will lead us to the Piazza della Rotonda. This square is surrounded by typical Roman mansions and features a beautiful fountain made of African bigio marble, adorned with masks and dolphins from which water gushes out, surmounted by the small obelisk of Ramses II. However, our attention is inevitably drawn to the majestic ancient Pantheon, which dominates the square.

Fig. 30 - The plate on the right side of the Chiesa di Sant’Eustachio, recording the flood level of December 9, 1495.

Stop MID-7-5: Piazza della Rotonda

Coordinates: 41°53'56–69"N - 12°28'36.49"E
Topic: The lowest point of the Campus Martius; the "temple of all gods", the precious marbles and the "lighter and lighter" dome structure.

The Pantheon is situated at the lowest point of the Campus Martius; its name comes from the Ancient Greek words "pan" meaning "all" and "theos" meaning "gods". This temple holds great historical and architectural significance. The construction began in 27 BC by Marcus Vipsanius Agrippa, who was the son-in-law and collaborator of Emperor Augustus. The temple was a crucial part of Augustus' efforts to turn the city into a respectable capital of the empire. Such urban and architectural transformations and improvements were recognised by the historian Svetonius, who wrote "Augustus found Rome in brick and left it in marble".
The external features of the temple include a trabeation, that bears the following inscription:

M. AGRIPPA. L. F. COS. TERTIUM. FECIT	Marcus Agrippa, son of Lucius, consul for the third time, made

The Pantheon's pronaos, made up of 16 monolithic columns 13 metres high, acts as a link between the outside and inside of the temple. Eight columns are made of grey granite from Elba Island and eight of pink granite from the Mons Claudianus quarry in Egypt. They are adorned with Corinthian capitals made of white marble. The pilasters at the doorway are made of *Marmor thasium*, from Thasos island in the Aegean Sea, and the jambs and capitals at the door are made of *Marmor Lunense* (*Carrara antico*, from the Fantiscritti quarry in Carrara, Italy). The pavement of the doorway is made of *Marmor Chium* (called *Affricano rosso*), a greenish-brown stone with large red stains and traces of shells (Pullen, 2018).

The ancient marble of the Pantheon

Inside the Pantheon, one can observe a vast collection of ancient marbles that represent the splendour of ancient Rome. These marbles, brought from all parts of the empire, were originally intended to demonstrate the dominance of Rome over the Mediterranean. The seven niches in the Pantheon at first represented the seven deities connected with the worship of the planets such as the Sun, Moon, Venus, Saturn, Jupiter, Mercury, and Mars. Many of the marbles have been spoiled and/or replaced over time; even the original aediculae, now converted into sacred altars, have been heavily remodelled during the Renaissance with the replacement of even the original columns. Nevertheless, the large monolithic columns that support the dome in *Giallo antico* (*brecciato*) are still original. This stone came from Numidia, today's Tunisia, and is the largest column in the world of *Giallo antico*. We are therefore looking at the original decorative apparatus commissioned by the emperor Hadrian (76-138 AD; Figure 31).

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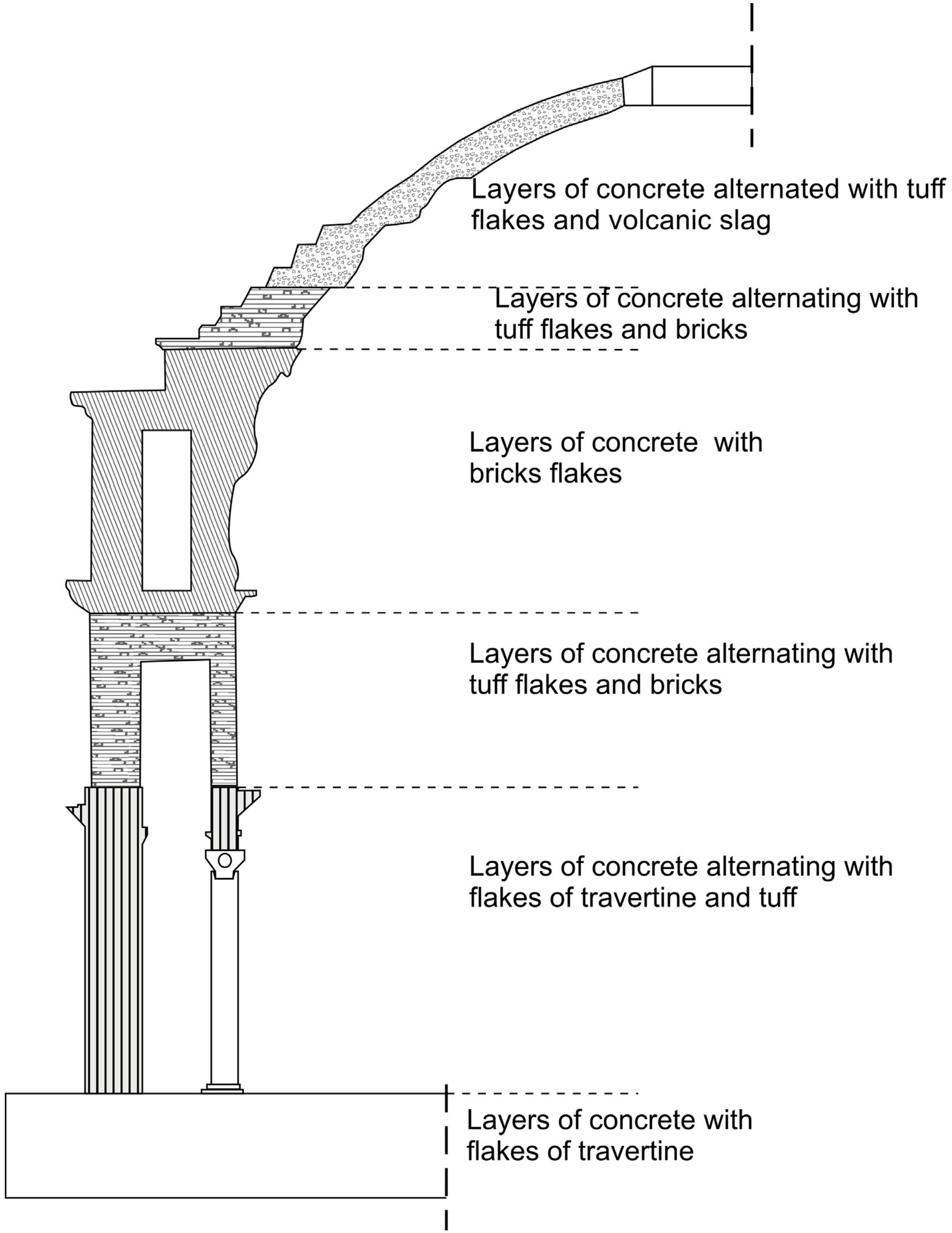
Fig. 31 - The white marble on the floors is Docimian marble. Used in combination with other marbles, the white colour of the Docimian marble is dominating the floors.



Pantheon's dome

The main characteristic of the dome is the progressive decrease in density, from bottom to top, of the building materials. The dome's structure consists of a mixture of Roman pozzolana, (*Pulvis Puteolana* after Pozzuoli the city from which this material originated), combined with water (a Portland-cement-like mixture), and it is remarkable for its hydraulic property, eliminating the need to dry out like lime mortar, in fact, this compost results hydraulic and has been even used for underwater construction (Mark and Hutchinson, 1986). The dome's lowest portion is made of a mortar of travertine and tufa layers, while the middle part is composed of a mortar that mixes tufa pieces and broken tiles or bricks. The uppermost level of the dome is a mix of pumice aggregates that allows for a decrease in density up to the dome's oculus (Masi et al., 2018; Fig. 32). However, the data about the Roman concrete formula that can be found in the literature are not complete.

Stop MID-7-5 bis (optional): Piazza Colonna

Coordinates: 41°54'3–03"N - 12°28'47.99"E
Topic: The effects of the earthquakes on the Colonna Antonina.

Starting from Piazza della Rotonda, we head northeast along Via degli Orfani and continue to Piazza Capranica and Via in Aquiro until you reach Piazza Montecitorio, which houses the Italian Parliament. Take a right turn and we continue along Via della Colonna Antonina to arrive at Piazza Colonna.

Fig. 32 - Schematic structure of the Pantheon's Dome.

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In the centre of the square stands the Colonna di Marco Aurelio, also known as the "*Colonna Antonina*" The column in the past had been erroneously attributed to Antoninus Pius, an error discovered in 1704, when excavating in the Montecitorio area, the remains of the real Antonine column were discovered.

The column was erected between 176 and 192 AD to commemorate Emperor Marco Aurelio's victories over the Marcomanni, Sarmatians, and Quadians populations who were established north of the middle course of the Danube.

The Colonna Antonina stands at a height of 29.62 metres (equivalent to 100 Roman feet), with an additional 12.50 metres for its plinth. It is decorated with bas-reliefs and follows the proportions of Traiano's Column.

Compared to Traiano's Column, however, the Colonna Antonina's drums are conspicuously dislocated as they were twisted as a result of the strong earthquakes in 847 AD and 849 AD (Fig. 33; see also stop 16).

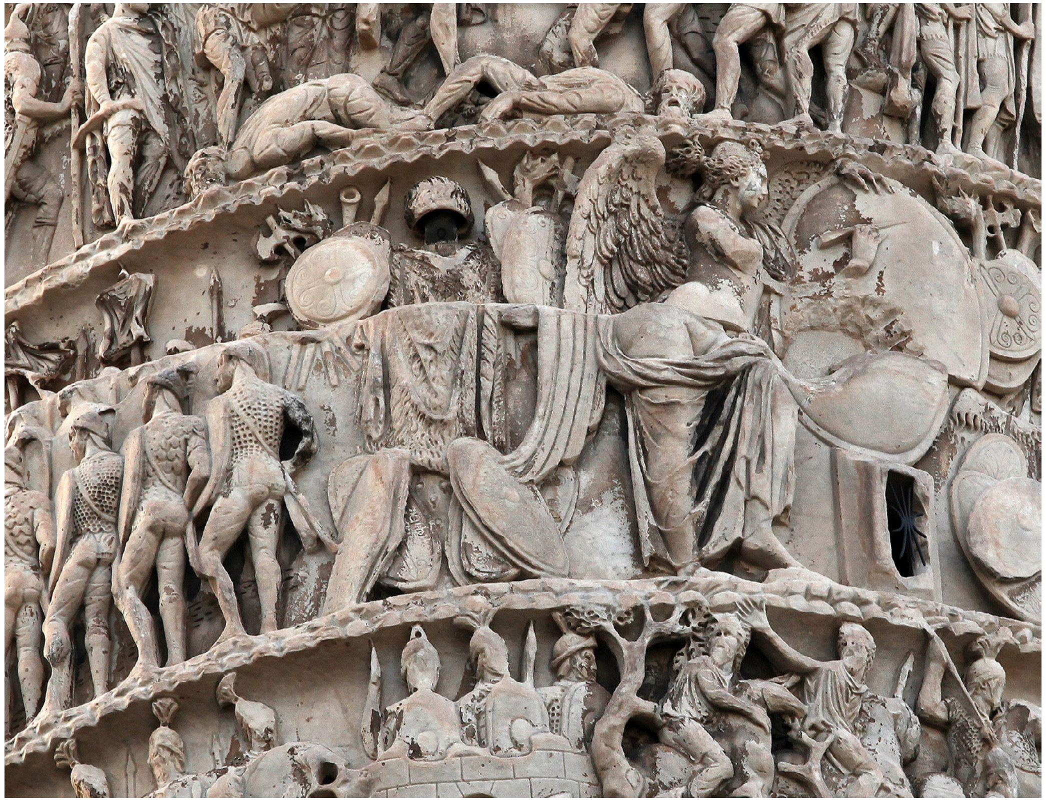

Fig. 33 - The 10-cm dislocation visible at about half height of the Marco Aurelio column; note the displacement of the wings and shield of the winged victory.

This difference can be attributed to the different seismic impedance of the substrates upon which they are built. The seismic amplification phenomena, caused by a resonance effect, were indeed not observed in the Traiano Column, which is situated on a consolidated substrate. This phenomenon was observed in the Colonna Antonina, which rests on alluvial deposits with a resonance frequency of about 2 Hz (Fig. 49; Funiciello et al., 2004).

In 1589 AD, in the fourth year of his pontificate, Sisto V, Pontifex Maximus, restored the miserably deteriorated and damaged column to its original form, as reported at the base of the column:

SIXTVS V PONT MAX / COLVMNAM HANC / COCLIDEM IMP / ANTONINO DICATAM / MISERE LACERAM / RVINOSAMQ PRIMAE / FORMAE RESTITVIT / A. MDLXXXIX PONT IV	This historiated column dedicated to Emperor Antonino, miserably deteriorated and damaged, Sisto V, Pontifex Maximus restored to its original form. 1589 AD, in the fourth year of his pontificate

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Stop MID-7-6: Piazza della Minerva

Coordinates: 41°53'52.28"N - 12°28'39.80"E
Topic: An elephant in the centre of Rome; the historical archive of flood traces onto the façade of the Church of Santa Maria sopra Minerva

After leaving Piazza della Rotonda, we walk along the left side of the Pantheon and proceed uphill on Via della Minerva. On the right-hand side, below the boundary wall, we can observe a walking surface from the Roman era located at the base of the temple, which is several metres below the current street level. This is indicative of a significant period of anthropogenic elevation, possibly dating back to the medieval era.
Continuing our path, we arrive at Piazza della Minerva, which features the famous "little elephant" surmounted by an Egyptian obelisk from the 4th century BC, the positioning of which was designed by Gian Lorenzo Bernini in 1667. The inscription on the base reads:

SAPIENTIS AEGYPTI INSCULPTAS OBELISCO FIGURAS AB ELEPHANTO BELLUARUM FORTISSIMA GESTARI QUISQUIS HIC VIDES DOCUMENTUM INTELLIGE ROBUSTAE MENTIS ESSE SOLIDAM SAPIENTIAM SUSTINERE	Whoever here see the signs of the wisdom of Egypt carved on the obelisk, supported by the elephant, the strongest of beasts, understand this as proof that a strong mind is needed to support a solid sapience

The obelisk, made of pink granite and adorned with hieroglyphs on all four sides, stands about 5.50 metres tall, and its top reaches a height of 12.70 metres above the ground. As such, it is smaller than all other obelisks in Rome. Originally located in the Egyptian city of Heliopolis, it was transported to Rome under Domiziano during the first half of the 1st century AD to adorn the Temple of Isis in the Campo Marzio (Iseo Campense). In 1665, it was discovered in the gardens of the Dominican convent, near the church.
The elephant sculpture was commissioned by Pope Alexander VII, who asked several artists to submit proposals. The Dominican priest Domenico Paglia, residing in the Dominican convent to the left of the church, submitted two designs, both of which were rejected. The Pope wanted the statue to evoke the virtue of Divine Wisdom, which is common to the Egyptian deities of the Iseo (Isis, Minerva, and Maria), thus recalling the original dedication of the site. An anecdote suggests that Bernini placed the elephant with its rear end facing the Dominican monastery, with its tail snaking to the left. This exposed its clenched and tensed buttocks, forming a highly indecent greeting that would confront the Dominicans every time they looked out onto the square. The elephant also looks like he is smiling from certain angles, while enacting this permanently impolite salute.

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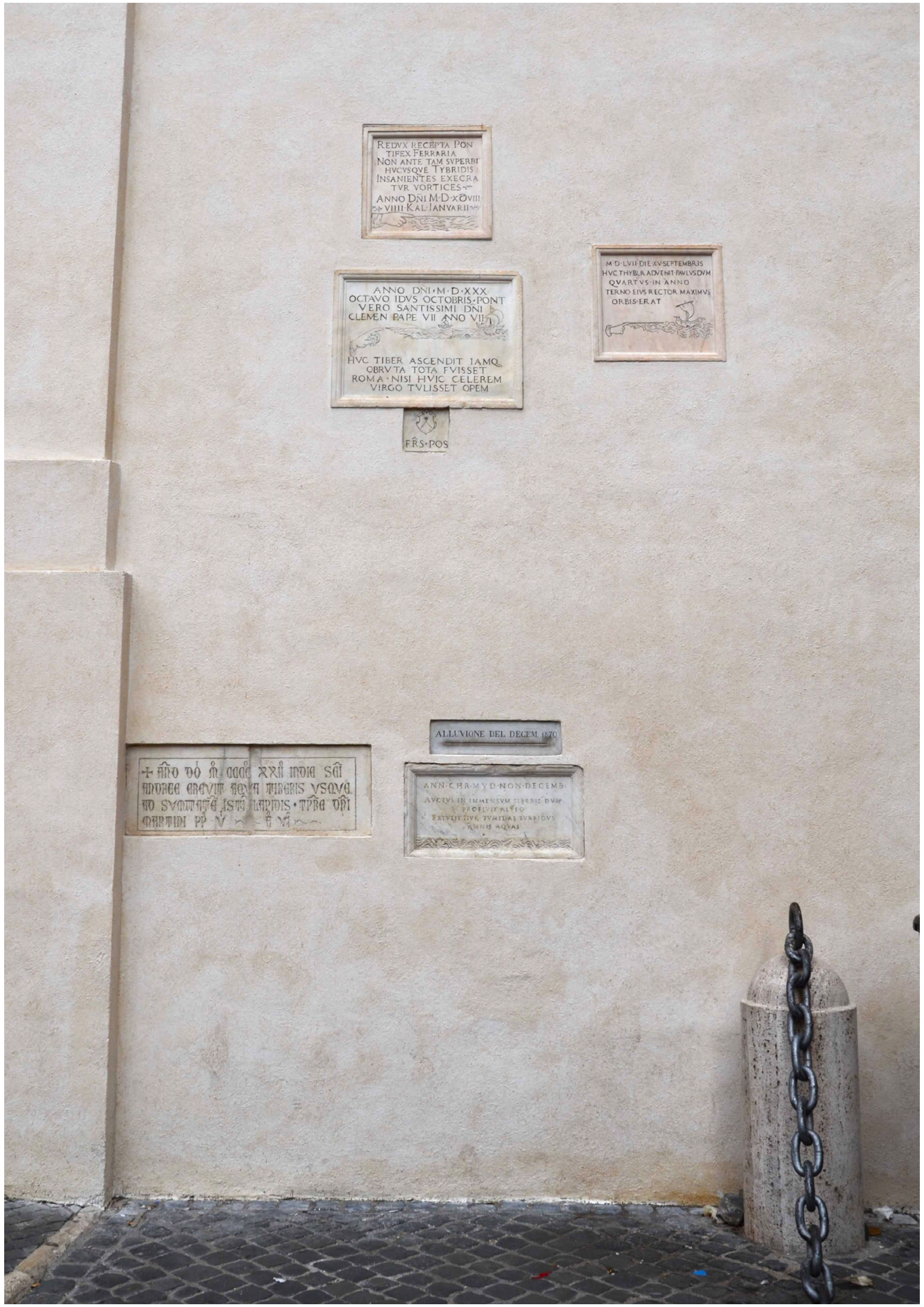

In the square is located the Gothic Church of Santa Maria sopra Minerva, built by the Dominican Friars in 1280 and completed in 1453. The church houses the relics of Santa Caterina da Siena, the patron saint of Europe, and the remains of the famous painter Beato Angelico. On the right side of the façade of the Church of Santa Maria sopra Minerva, there are 6 plates that preserve, in their original position, the indication and inscriptions related to some of the most important floods that have struck the city of Rome throughout history (Fig. 34).

The lowest plate reports the flood that occurred on December 5th, 1495, which reached an elevation of 16.88 m asl in Ripetta, the same as the plates in Corso Rinascimento and on the façade of the Church of Sant'Eustachio. Although it did not reach exceptional levels, this flood is highly documented in the chronicles as one of the most dramatic and catastrophic.

The second plate refers to the flood of November 30th, 1422, which reached the level of 17.32 m asl. According to legend, it was caused by the mercenary leader Braccio di Montone, who, driven out of Rome by the troops of the mercenary leader Francesco Sforza, broke the threshold of the Piediluco lake, which feeds the Nera River and then the Tiber.

A few centimetres higher, there is the plate that records the 1870 flood, which holds the most records in the city. This flood occurred on December 27th, only three months after the city was annexed to the Kingdom of Italy and a few months before Rome became the new capital of the state. The coincidence of these events triggered a fierce political debate over the measures to be taken to protect the city from flooding (see stop 2) (Di Baldassarre et al., 2017).

Fig. 34 - The right side of the façade of the Church of Santa Maria sopra Minerva with 6 plates recording the most important floods that afflicted Rome. Of significant note is the height of the 1598 flood, which reached 3.70 m from street level.

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Fig. 35 - Piazza della Rotonda inundated during the flood of December 28, 1870 (painting of Alessandro Faure, 1870, Beni Storici e Artistici, Catalogo Generale dei Beni Culturali).

Fig. 36 - The Ostia meander cut, captured from a balloon in 1911 (from Shepherd, 2006).

The plate recording the October 8th, 1530 flood, which reached a level of 18.95 m asl, is 1.73 cm higher. The 16th century was the most disastrous period for floods, with as many as five exceptional floods occurring in just 100 years, averaging one every 16 years. This phenomenon was caused by huge urban development and changes to the riverbed.

Just 27 years later, the city of Rome was hit by another great flood. At 10 p.m. on Tuesday 14th September 1557, a flood of exceptional intensity submerged a large part of the city, causing the collapse of buildings and the ramparts of Castel Sant'Angelo and causing damage not only in the city but also along the entire course of the river, including the areas upstream of Rome, in the Umbria region (Di Martino and Belati, 1980). The flood level reached is estimated at 18.90 metres.

Downstream of the river, almost at the mouth of the Tiber, a meander was cut during the flood near the ancient Roman city of Ostia Antica, where the Castello di Giulio II had been built, thus rectifying the course of the river in that stretch (Bersani and Bencivenga, 2001; Shepherd, 2006; Fig. 36).

On the evening of December 24th, 1598, as the city was preparing to celebrate Christmas, the waters of the Tiber rushed down, catching Romans by surprise as they found themselves trapped in their homes for several days. In addition to the lack of food provisions, the city also suffered from a shortage of water, as it was not possible to draw water from wells or fountains for several months. The flood caused massive damage to houses and buildings. The railings of Ponte Sant'Angelo and Ponte Sublicio collapsed as they were overtopped by the floodwaters, and dozens of buildings between the Torre di Nona and Ponte Sant'Angelo collapsed, resulting in the deaths of prisoners locked up in ground-floor jails. The flood also affected the Santo Spirito Hospital, and a plaque placed on a brick column still commemorates it.

But the most serious damage caused by this event, which can still be seen today, was the collapse of the Ponte Emilio (or Ponte di Santa Maria), just downstream from the Tiber Island, Rome's first masonry bridge, built in 179 BC and thereafter known as the *Ponte Rotto* (broken bridge; Fig. 37).

Figure 37 - The remains of the Ponte Emilio, now commonly known as "Broken Bridge", destroyed by the flood on Christmas Eve of 1598.

Fig. 38 - The plaques on the facade of a medieval building in Via di Santa Maria de' Calderari indicate the level of the 1598 flood.

The Jewish Ghetto area was heavily affected by the same flood, as it was exposed to the flood wave and densely populated. Plaques indicating flood levels are absent in the area but can be found in the immediate surroundings, such as Via di Santa Maria de' Calderari (Fig. 38).

A popular version suggests that the fountain in Piazza di Spagna, designed by Pietro and Gian Lorenzo Bernini and located at the foot of the Spanish Steps, may have been inspired by a boat that ran aground on the square during the flooding of the Tiber in 1598 (Fig. 39).

The plaque on the façade of the Church of Santa Maria sopra Minerva currently stands at a height of approximately 3.70 metres above street level, which suggests the exceptional nature of the most significant flood that hit Rome (Fig. 40). Studies estimate the flood level to be 19.56 metres asl and the discharge rate to be around 4,000 m^3/s.

After leaving Piazza della Minerva, continue along Via dei Cestari to reach Largo di Torre Argentina. Cross the street and observe the significant archaeological area from the Republican age.

Fig. 39 - The fountain in Piazza di Spagna, known as “La Barcaccia”, depicts a boat aground, that according to the popular version was brought there by the flooding of the Tiber in 1598.

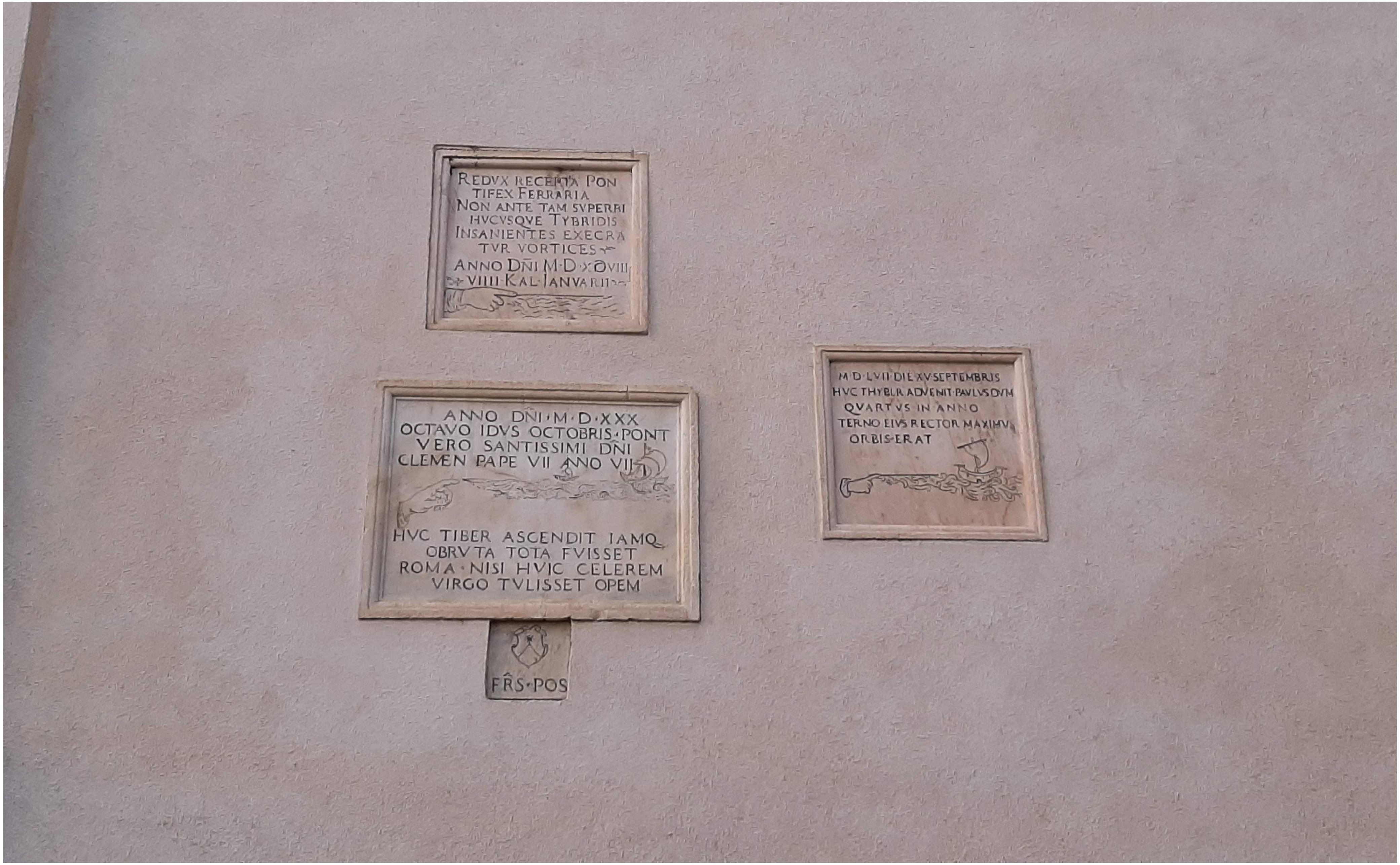

Fig. 40 - The three highest plaques commemorate the floods of 1530, 1557, and 1598.

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Stop MID-7-7: Largo di Torre Argentina

Coordinates: 41°53’43.54”N - 12°28’37.95”E
Topoic: Temples from the Republican period; the Roman pavement; the use of tufa and travertine

The archaeological site of Largo di Torre Argentina (known as the “sacred area”) is an important historical site located in the centre of the square. The site was discovered in 1926 during building works, and excavations continued until the 1970s. The archaeological area includes the remains of four temples of the middle and late Republican age. The history of the complex is very articulated, as both floor and base of the temples have been progressively raised over the centuries. Archaeologists have reconstructed the phases of the realization of the complex, dating them with a good accuracy. A total transformation took place when the floor was raised by about 1.40 m, probably after a fire like the one in 111 BC. On that occasion a unique tuff floor was created. Currently, the road level stands 5-6 m above the “republican” level, so looking down at the archaeological site means looking across the centuries.

We continue towards the south along the pedestrian street of Via S. Nicola dei Cesarini and we arrive in Piazza dei Calcarari, dominated by the medieval Torre del Papito. This square was built in 1938 by the widening work of Via delle Botteghe Oscure. However, the origins of the place name ad Calcararia can be traced back to 1023 when, in the area between the church of San Carlo ai Catinari and the Chiesa delle Stimmate, there were numerous furnaces for chalk manufacturing produced from the marble extracted from ancient Roman monuments.

Fig. 41 - Largo di Torre Argentina archaeological site, a “window” that allows us to see the republican Rome of XX centuries ago characterized by different levels of temples’ foundations.

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Fig. 42 - The Rupe Tarpea cliff constitutes the SW border of Campidoglio Hill. The cliff results from the erosive processes, mainly linked to surface water activity, set on a rather resistant lithology (Tufo Lionato).

At the zebra crossing that cut Via Florida - Via delle Botteghe Oscure we continue in Piazza dell'Enciclopedia Italiana and then in Via Paganica. Entering by the ancient northern entrance of Ghetto of Rome, we arrive in Piazza Mattei, dominated by the graceful presence of the Renaissance

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Fontana delle tartarughe. We turn left and follow Via dei Funari that runs alongside the ghetto until Piazza di Campitelli, which continues with Via Montanara.
Then we arrive in Via del Teatro di Marcello and in front of us the Campidoglio reveals itself.

Stop MID-7-8: Il Campidoglio (the Capitoline Hill)

Coordinates: 41°53’28.91”N - 12°28’57.77”E
Topic: The iconic Rupe Tarpea

The Campidoglio is built upon the cliff of *Rupe Tarpea*, which is one of the most iconic places and symbols of Rome. The *Rupe Tarpea* records a part of the geological and volcanological evolution of Rome, in fact, it is constituted by the ignimbrite products of the Colli Albani volcano, located a few kilometres SE of Rome. In particular, the Rupe Tarpea core is composed of the Tufo Lionato deposit, which is the lowest unit of the Villa Senni Formation. The eruption has been dated at about 350 ka ago by different authors and techniques (Radicati Di Brozolo et al., 1981; Bernardi et al., 1982; Karner and Renne, 1998; Karner et al., 2001). The name “Lionato” comes from the lion’s fawnskin, red-yellowish as the ash matrix. The colour is due to the intense process of zeolitization that gives to the tuff a particular resistance to erosion (De Rita and Fabbri, 2009).

The Tarpeian cliff is related to a legend that hands down the memory of ferocious struggles between the Sabines (who settled on the Quirinale) and the Romans (who instead lived on the Palatino) to ensure control of the Campidoglio, which culminated in the famous episode of the Tarpea betrayal. She was the daughter of the commander of the Campidoglio garrison and would have opened the gates to the Sabine invaders in exchange for “bracelets”. Instead of thanking her, the Sabines would have killed her, burying her under shields. Tarpea was originally the tutelary divinity of the hill (mons Tarpeius is the name of one of the two peaks of the Campidoglio) and the name of Rupe Tarpea was always attributed to the southern cliff of the hill: from here, in memory of the crime of Tarpea, those guilty of treason and other serious crimes against the state were thrown.
Continuing down Via del Teatro di Marcello until the traffic light intersection, we turn left and follow Vico Jugario. This street corresponds to the ancient vicus Jugarius (where the poet Ovidio lived) which, running under the outermost slopes of the Campidoglio, connected the Foro Romano to the Foro Olitorio.
At the Rampa Caffarelli there was the entrance to the lower floor of the latomie that pass through the entire Campidoglio. These were tuff quarries used most of the Middle Ages and until the 19th century.
We continue toward Piazza della Consolazione, with the magnificent Church of Santa Maria della Consolazione, and we arrive in Via della Consolazione, at the base of the Campidoglio and facing the south-western side of the Foro Romano.

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Stop MID-7-9: Via della Consolazione

Coordinates: 41°53'31.43"N - 12°28'59.56"E
Topic: The relationship between alluvial and volcanic units

In Via della Consolazione is exposed a geological section at the base of the Campidoglio Hill (Figs. 43 and 44). According to Funiciello and Giordano (2008b) at the base outcrops an alternation of fluvio-palustrine deposits, which are composed by gravel and sand facies with volcanic elements. This is evidence of an ancient Tiber River valley. Above these deposits lie pyroclastic units belonging to the Colli Albani Complex, represented by a phreatoplinian-type eruption sediments whit a thickness of 2 metres. This part is named Tufo Lionato, so called because of its reddish colour (De Rita and Fabbri, 2009).
The Tufo Lionato was emplaced 350 ka ago by the largest volume, the caldera-forming eruption of the Colli Albani. It has been the most widely used building stone in the Roman area for its favourable geomechanical characteristics (De Rita and Fabbri, 2009).
The succession is topped by fluvial deposits of the Aurelia Formation, related to the high stand of the sea level which lasted until about 320 ka ago (Funiciello and Giordano, 2008a; 2008b).
From this stop, we proceed uphill along Via Monte Tarpeo, which leads us to Piazza del Campidoglio. Before reaching the top of the Campidoglio, a stop on the terrace is necessary to have an overview of the Foro Romano.

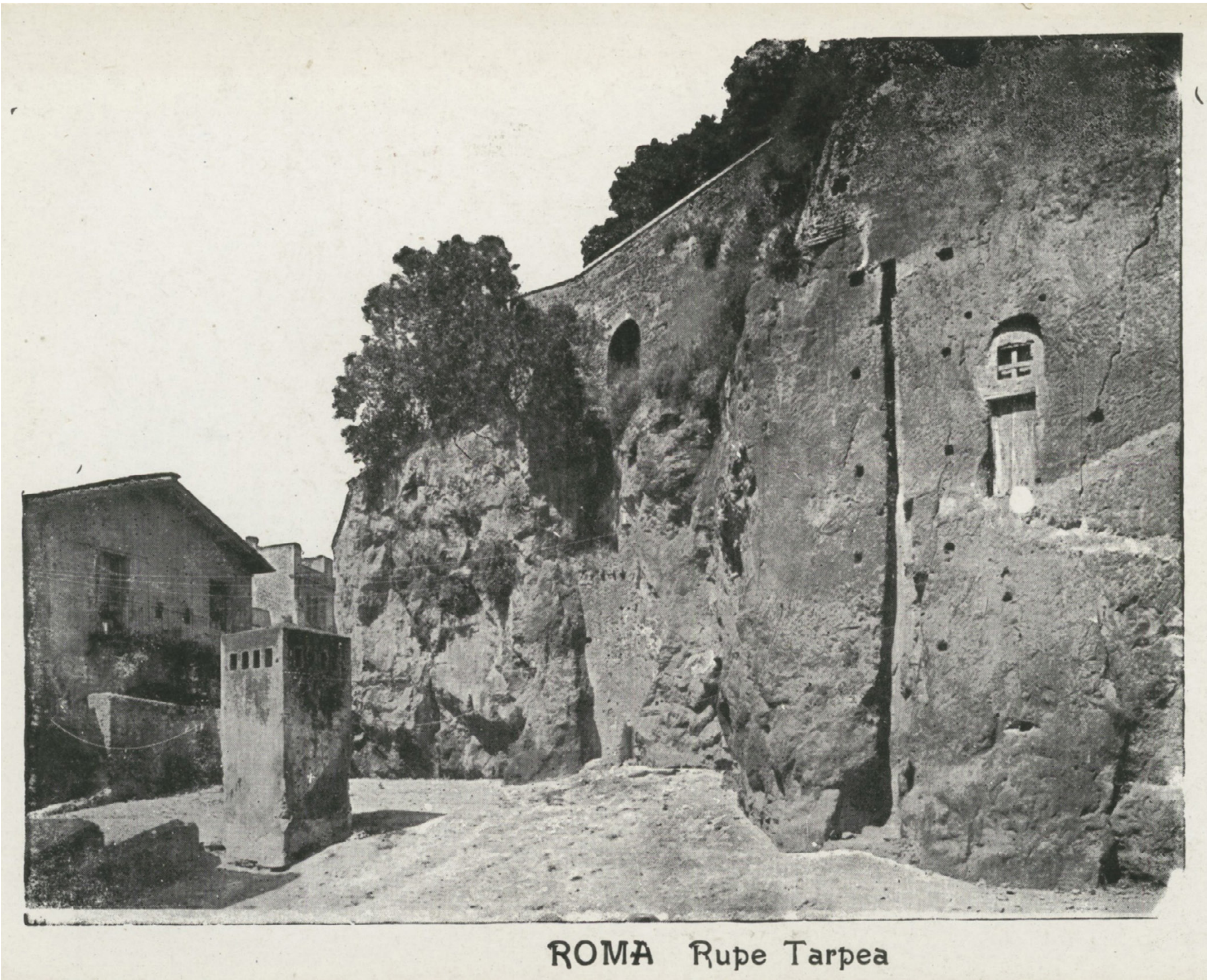

Fig. 43 - Rupe Tarpea in Rome, postcard, 1920.

Fig. 44 - Outcrop in Via della Consolazione. Fluvial deposits of the Aurelia formations lie on pyroclastic units belonging to the Colli Albani Complex.

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Stop MID-7-10: Piazza del Campidoglio

Coordinates: 41°53’35.95”N - 12°28’58.57”E
Topic: a view of the Roman Forum and the Colli Albani volcano

The geological evolution of the Roman Area can be understood and reconstructed by some elements that can be found in the geological evidence of Campidoglio. The Campidoglio Hill is composed of rocks mainly produced by the volcanic activity of Colli Albani, a volcanic complex located in the southeastern sector of Rome. Upon the cliffs deposits of pyroclastic flows are visible, such are the deposits of middle or large-volume ignimbrites. The emplacement formed the flat topography which was engraved by the fluvial activity. This process dissected the plateau and formed several relatives high, known as the famous seven hills of Rome.
The Campidoglio has an altitude of about 45 m a.s.l. with a flat summit and steep cliffs, but the present-day morphology is partially due to human activity. The negative morphology on the top, between the *Arx* and the *Capitolium*, has been filled for the realisation of the Campidoglio square. The space for the construction of the Forum of Cesar was obtained separating the Campidoglio from the Quirinale. Further changes in local topography were accomplished by the emperor Traiano for the realisation of the forum of Traiano and the Colonna di Traiano (Fig. 45).

Fig. 45 - Human changes of topography. The Forum of Caesar as an example (Di Zuffe - Opera propria, CC BY-SA 3.0 - Wikipedia).

From Piazza del Campidoglio we descend along the Cordonata Capitolina, the staircase leading to Piazza Venezia. At the end of the steps, we notice two Egyptian basalt lions, from whose mouths water pours into two basins. The lions come from the Iseo Campense, the temple built by Domiziano in the Campo Marzio in honour of the Egyptian gods Isis and Serapide. When the Acqua Felice was brought to the Capitoline Hill in 1587, the lions were adapted as fountains by placing two travertine basins in front of them.
On the top of the Capitoline Hill, on the North-eastern side, stands the imposing and austere mass of the Basilica di Santa Maria in Aracoeli, built on the site of the ancient Roman temple of Giunone Moneta and where – according to tradition – the Sibilla Tiburtina would have predicted to Augustus the coming of the Son of God (Haec est Ara Primogeniti Dei, i.e., “this is the altar of the firstborn son of God”).
The barbarians of Brenno arrived to invade ancient Rome. Until then only the Campidoglio was resisting, and when the barbarians tried to infiltrate during the night, some geese sacred to Juno began to cackle, attracting the attention of the sentinels.
Thanks to these geese, Rome was saved, and Juno was called Moneta (from the Latin monere, which means “to admonish, to recall”) in memory of the call of the geese.
A mint was created next to the sanctuary, and for this contiguity the money produced was called *moneta*, a word that passed as such into Italian, and with a slight modification (moneda) into Spanish, moneie (old French), and money (English).
Proceed to the right on Via del Teatro di Marcello. After a few metres, stop in front of the Insula dell’Aracoeli complex.

Stop MID-7-11: Insula dell’Ara Coeli

Coordinates: 41°53’38.85”N - 12°28’55.66”E
Topic: The raising of the ground surface

At this stage, the remains of an insula, or Roman rent house, the most common form of dwelling in imperial Rome, are visible. The building was spared by the demolition works that affected all the slopes of the Capitoline Hill in the 1930s. The insula consisted of at least five floors, which are still preserved today. On the ground floor, the *tabernae* (shops) are visible; the upper floor, the mezzanine, was used as the dwelling of the manager of the *taberna*. Other floors are preserved above, connected by an internal staircase dating back to medieval times. The lower floors, with large rooms, were reserved for the richer people, while the upper floors, of lesser value, were for the plebs.
The building, built in *opus latericium* in the 2nd century AD, borders a wall in *opus reticulatum* that probably belonged to an arrangement of the Capitol in the 1st century AD.
The Roman insula could accommodate around 380 people and bears witness to the fact that, despite its proximity to the monumental area of Imperial Rome, right on the slopes of the most important and sacred hill of the city, the plebeians still lived in uncomfortable conditions.

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Interestingly, the Roman ground level is now about 8 m above the present-day level, indicating a significant artificial elevation of the ground (Fig. 46).

We continue past the imposing Vittoriano building, the so-called Altar of the Fatherland, dedicated to the first king of united Italy, Victor Emmanuel II. The building, completed in 1911, is made of Botticino marble, extracted from quarries in the Brescian municipalities of Botticino and Rezzato. For the construction of the monument, 40,000 m^3 or 110,000 tonnes were transported to Rome.

Fig. 46 - The second floor of the Insula dell'Ara Coeli, today positioned at the street level. In the middle is visible a frescoed lunette of the Church of San Biagio del Mercato (12th century).

Stop MID-7-12: Colonna Traiana

Coordinates: 41°53'44.97"N-12°29'3.36"E
Topic: The seismic "resilience"

The Colonna Traiana (Column of Trajan), erected in 113 AD, commemorates Emperor Trajan's conquest of Dacia (present-day Romania and Moldavia). Its spiral bas-relief illustrates key moments of the territorial expansion in 55 different scenes, depicting Dacians and Romans fighting, negotiating, or dying in battle. Historians have studied these bas-reliefs to gain insights into Roman clothing, weaponry, and battle tactics. The monument comprises 18 Carrara marble drums, each weighing around 40 tonnes, with a diameter of 3.83 metres. Originally, a bronze statue of Trajan stood atop the column (Fig. 47).

The construction of the column involved a partial cutting of the Quirinal Hill towards the Capitoline Hill, resulting in the lowering and levelling of the original topographical surface. According to tradition, the depth of the excavation was approximately the same height as the column, around 40 metres including the basement (Pollen, 1874; Fig. 48).

From an architectural standpoint, Trajan's Column is identical to the Colonna di Marco Aurelio (or Colonna Antonina), located in Piazza Colonna, which was erected about eighty years later (180-193 AD) and is located 800 metres away. While Trajan's Column remains perfectly intact, the Colonna di Marco Aurelio was twisted by the strong earthquakes that occurred in 847 AD and 849 AD, as evidenced by the dislocated drums (see stop 1.5.bis). The different response to the earthquakes is thought to result from differences in the bearing terrains: the Colonna di Marco Aurelio was built on soft, recent alluvial deposits, while Trajan's Column was built on harder volcanoclastic conglomerate and sandstone deposits from the Middle Pleistocene-Santa Cecilia formation (see Fig. 49).

The 847 earthquake also heavily damaged the Colosseum (see stop 15), while the 849 earthquake caused the collapse of the Meridian or Solar Clock of Augustus, whose gnomon, consisting of an obelisk, now stands in Piazza di Montecitorio.

Fig. 47 - Drawing of the Column of Trajan by Etienne Duperac in 1575.

Continuing along Via dei Fori Imperiali, which was inaugurated in 1932 as Via dell'Impero (the construction of this wide road led to the destruction of entire medieval quarters), we see the monumental remains of the forums of Caesar, Augustus, Nerva, Trajan, and Peace on either side of the street. The street gets its current name from these forums. The Flavian Amphitheatre, or Colosseum, forms the scenic backdrop to this street. The Trajan Forum, visible on the left side of the street, had an enormous square paved with white marble from Luni, which was removed in medieval times. The Forum is surrounded by arches made of pavonazzetto marble and granite (Funiciello et al., 2004). The Forum retained its former magnificence until at least the 8th century when it was destroyed by an earthquake in 801 AD that caused many structures to collapse, which were later used as building materials (Guidoboni, 1989).

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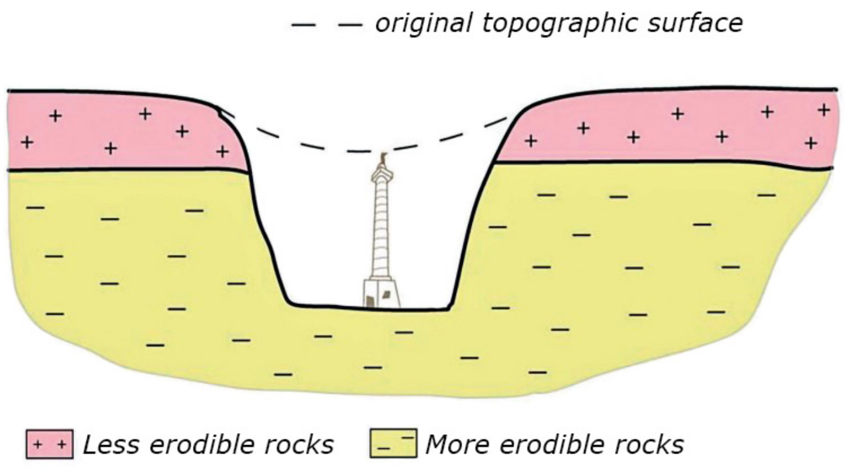


Fig. 48 - The height of Trajan's Column corresponds approximately to the depth of the excavation made to remove the saddle that connected Colle Capitolino to Colle Quirinale (dotted line). Today it corresponds to Via dei Fori Imperiali. The diagram also indicates the different types of rocks found in the excavation: less erodible rocks are represented in pink, more erodible rocks are shown in yellow (from Del Monte, 2018).

Stop MID-7-13: Il Foro romano

Coordinates: 41°53'36.74''N – 12°29'9.37'' E
Topic: The Topographic Changes from the Roman Empire to Present Day

The marshy and inhospitable valley of the Roman Forum (Fig. 50) served as a necropolis between the 11th and 10th century BC for the early inhabitants of the surrounding hills. According to Tacitus, Tito Tazio added the plain of the Forum and the nearby Campidoglio Hill to the first nucleus of Rome founded by Romulus on the Palatine. At the centre of the Forum stood the *Lacus Curtius*, a mysterious pit or pool surrounded by brooks and marshes. Legend has it that a noble Roman named *Marcus Curtius* sacrificed himself by leaping into the swamp at the behest of an oracle. One area of the Forum was never drained and gradually shrank until it became a basin.

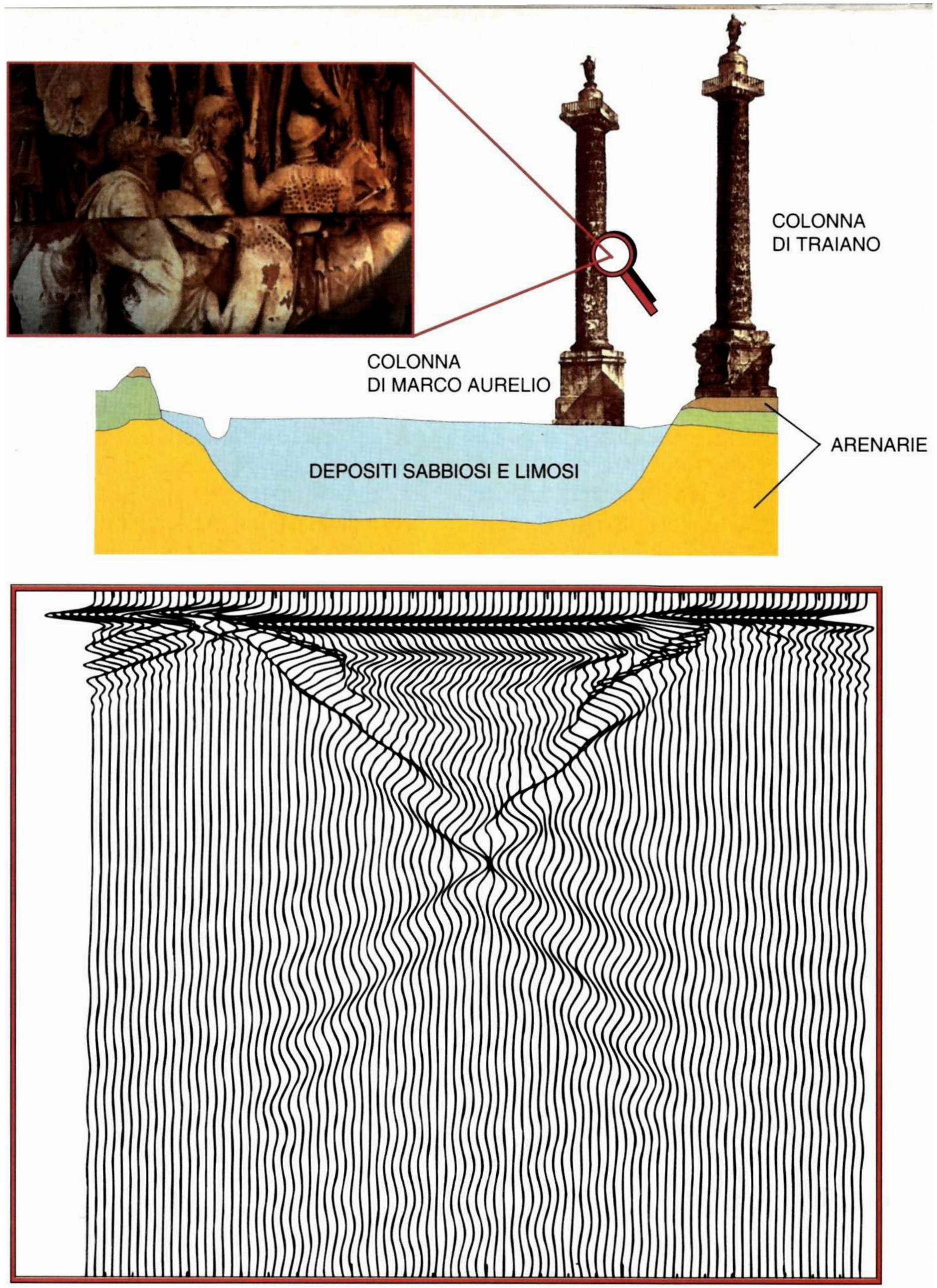
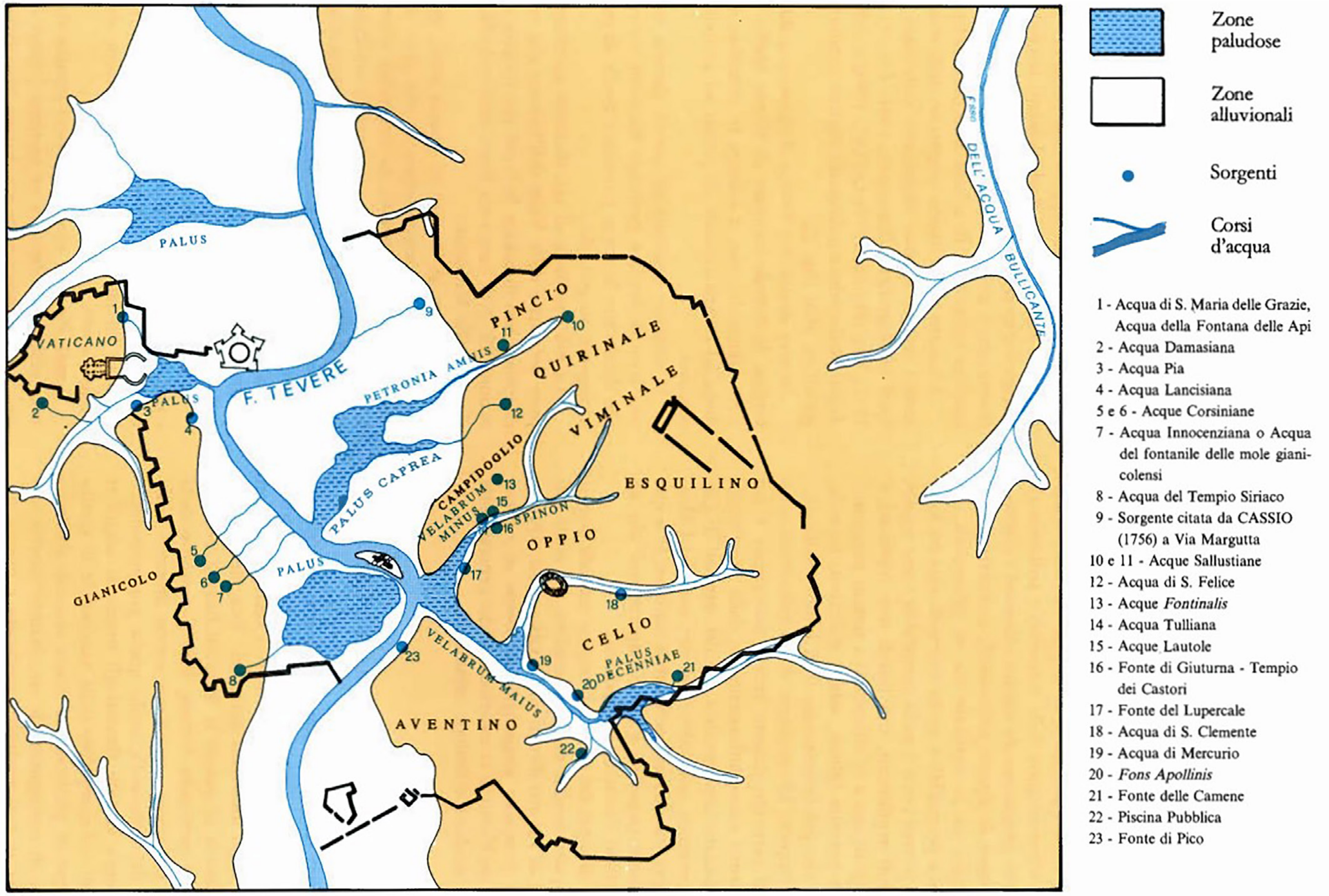


Fig. 49 - The syntethic earthquake visualizes the Campo Marzio site effects on seismic wave amplification (from Funiciello and Rovelli, 1998).

From the 9th century BC until the first half of the 1st century BC, the area gradually became occupied by houses, including the residence of the famous writer Cicero. In 54 BC, Julius Caesar initiated the construction of the Forum, which was inaugurated on September 26th, 46 BC, and completed by Emperor Augustus in 29 BC. During the Imperial age (1st to 5th centuries AD), the Forum was damaged by fires and restored, until the 5th-6th centuries when it was abandoned and demolished for the purpose of recovering building materials.
In the 9th century, the area was transformed into gardens, vineyards, and small buildings. The central area, which was no longer drained, became occupied by swamps (known as *i pantani*). In 1577, Etienne Du Pérac reproduced the area of the Roman Forum in his *Nova urbis Romae descriptio* (Fig. 51), which shows the presence of a small pond area named *Lacus Curtius*.
In the 16th century, the owner of the land where Caesar's Forum was located reclaimed the swamp and started a significant urbanization project, founding the Alessandrino district. However, in October 1931, the Fascist regime demolished the district to build the new *Via dell'Impero* (now



◀ Fig. 50 - Original hydrographic features and location of springs in the historic centre of Rome (from Corazza and Lombardi, 1995).

▼ Fig. 51 - Excerpts from the Nova urbis Romae descriptio (Duperac, 1577) with the area of the Roman forum. Note the presence of the Lacus Curtius at the foot of the Capitoline Hill.

known as Via dei Fori Imperiali), to showcase the "splendor of the new Empire". This project also involved the demolition of buildings on the slope of the Campidoglio.

Stop MID-7-14: Torre dei Conti

Coordinates: 41°53'36.79"N - 12°29'16.29"E
Topic: Seismic shaking failure

The Torre dei Conti is a three-stage medieval tower built in the XIII century over the ruins of the Tempio della Pace, destroyed by an earthquake that occurred in the II century BC and covered by travertine slabs retrieved from the Foro Romano.
Over the centuries several earthquakes struck the tower, in particular the 1349 one. It was one of the most disastrous earthquakes in Italy with its epicentre in Central Apennines (Galli et al., 2022). In particular, the effects on the city of Rome were so great that the poet Francesco Petrarca wrote: "Rome has been shaken by an unusual tremor, so severely that since its foundation, which dates back over two thousand years, nothing like it has ever happened".
The tower became uninhabitable and was abandoned until 1620 when it was rebuilt. Further earthquakes followed in 1630 and 1644. Other renovations, with the construction of the reinforcing counter forts, were carried out by Pope Alexander VIII at the end of the 17th century. The vulnerability of this structure to earthquakes is related to the presence of unconsolidated sediments of the Fosso del Velabro just below the structure, the path of Via Cavour. Note that the Torre dei Conti is located at the edge of the palaeovalley, in proximity of the bedrock (Fig. 52).

Fig. 52 - The actual remains of the Torre dei Conti.

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Stop MID-7-15: The Palaeoloxodon antiquus

Coordinates: 41°53'30.24"N - 12°29'24.04"E
Topic: The Colosseum elephant

In 1932, during the realisation works of Via dell'Impero (currently Via dei Fori Imperiali, in Fig. 53) that were carried out to unearth the Fori, the medieval Alessandrino quarter was demolished, whose historical interest was considered negligible compared to one of the ancient monuments that would re-emerge. This work also entailed the demolition of the Collina Velia, located a few hundred metres from the Colosseo, between the Colle Palatino and the Colle Oppio. During the excavations, a complete skull with the tusks of a *Palaeoloxodon antiquus* was found (Fig. 54).

Fig. 53 - The area of the Colosseo and today's Via dei Fori Imperiali around 1900. Note in the background the volcanic complex of the Colli Albani.

Fig. 54 - The discovery of a skull of *Palaeoloxodon antiquus* in 1932 during works for the construction of Via dell'Impero (today Via dei Fori Imperiali).

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The news caused quite a stir and was reported by all the newspapers of the time. On May 24th, 1932, the "Giornale d'Italia", published an article with the following headline: "The remains of a prehistoric elephant in the excavation next to the Colosseo".

In charge of the discovery of the *Palaeoloxodon* remains was Gioacchino De Angelis D'Ossat who, along with the younger Carlo Alberto Blanc, were the researchers who most contributed to the advancement of knowledge in the field of vertebrate faunas during the period at the turn of World War II.

"On May 23rd, 1932, at the intersection of Via del Colosseo and Via Gaetana Agnesi, one of the most remarkable discoveries took place, consisting of the remains of the base of the aedicule of the compitum Acili, [...]. In the same month of May occurred the notable discovery of the skull of *Palaeoloxodon antiquus*, which was a stimulus for the geological study of the entire area covered by the works made by Gioacchino de Angelis d'Ossat (see De Angelis D'Ossat, 1935). He dwelt on one of the most complete geological sections unearthed during the works, which remained standing near the site of the most important fossil finds, almost like a wreck leaning against the sack wall flanking the Venere e Roma temple. The morphology of the sites, in particular the natural conformation of the Velia heights and the saddle between the Campidoglio and the Quirinale, was reconstructed by De Angelis D'Ossat in a series of studies in the 1930s and 1940s and has been fully confirmed, with some re-dimensioning, in more recent studies".

After the investigation by De Angelis D'Ossat, the Elephas fossil was lost and forgotten. They were recently found at the Municipal Depot and, after restoration, were exposed at the Exhibition "Rome, the City of Science" held at the Palazzo delle Esposizioni from October 2021 to February 2022 (Rufo and Papi, 2022).

After the discovery and the clamour that the news had in the press, the Roman people believed to recognise in the *Palaeoloxodon antiquus* of the Fori Imperiali, rather than the fossil remains of an animal from the past, that of a victim of the Colosseo bestiary.

Few images remain to us of that find. The need to complete the road, a symbol of the twenty-year period, did not allow filmed recordings of the event (Fig. 55).

Few people know that during the excavations of the Vittorio Emanuele II monument, at Piazza Venezia, the skeleton of an elephant was also found at a depth of 14 metres. Due to the cost and the extension of the excavation, however, the remains of the fossils were left buried, now unrecoverable (Antonioni, 1970; Manni, 2001).

Fig. 55 - The skull of *Palaeoloxodon antiquus* found during excavations in Via dei Fori Imperiali has been restored and exhibited, after nearly 90 years, at the Palazzo delle Esposizioni in Rome on the occasion of the exhibition “The Science of Rome: past, present and future of a city” in 2021-22.

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Stop Mid-7-16: Piazza del Colosseo

Coordinates: 41°53’23.16”N - 12°29’28.21”E
Topic: Signs from history

Discover the signs of history at the Colosseum, also known as the Flavian Amphitheatre. This ancient Roman monument is the largest amphitheatre in the world, capable of accommodating between 50,000 to 87,000 spectators. It is considered the most impressive and iconic symbol of ancient Rome and was included in the UNESCO World Heritage list in 1980.

The Colosseum was constructed during the Flavian dynasty and was built on the eastern edge of the Roman Forum. Vespasian began its construction in 70 AD, and it was completed by Titus in 80 AD. The building has an elliptical shape with a perimeter of 527 metres, and its axes measure 187.5 and 156.5 metres, respectively. The arena inside measures 86 by 54 metres, with a surface area of 3,357 square metres. The current height of the Colosseum is 48.5 metres, although it originally stood at 52 metres.

The monument is made of blocks of welded scoria, known as Sperone, from the Colli Albani volcano and Tivoli travertine. These were fixed together with metal holders, and originally the Colosseum was covered with white marble plates. The columns of the Summa Cavea arches are made of Marmara marble from Turkey. Visit the Colosseum and experience the magnificence of ancient Rome.

The Amphitheater was constructed in a valley between the Velia Hill, the Opium Hill, and the Caelian Hill, where an artificial lake was dug by Nero for his *Domus Aurea*, as mentioned by the poet Martial. The lake was situated along the Fosso Labicano Creek. It suffered significant damage from fires and lightning, but as early as 442 or 443 AD, restorations following earthquakes were recorded in the *Corpus Inscriptiones Latinarum*. Further restorations were carried out in 470 AD and after the earthquakes of 484 AD, as noted in the base of the statues of Decio Mario Venanzio Basilio (CIL, VI, 32094; Jones et al., 1992; Fig. 56), which were placed at the Triumphal Gate of the Colosseum.

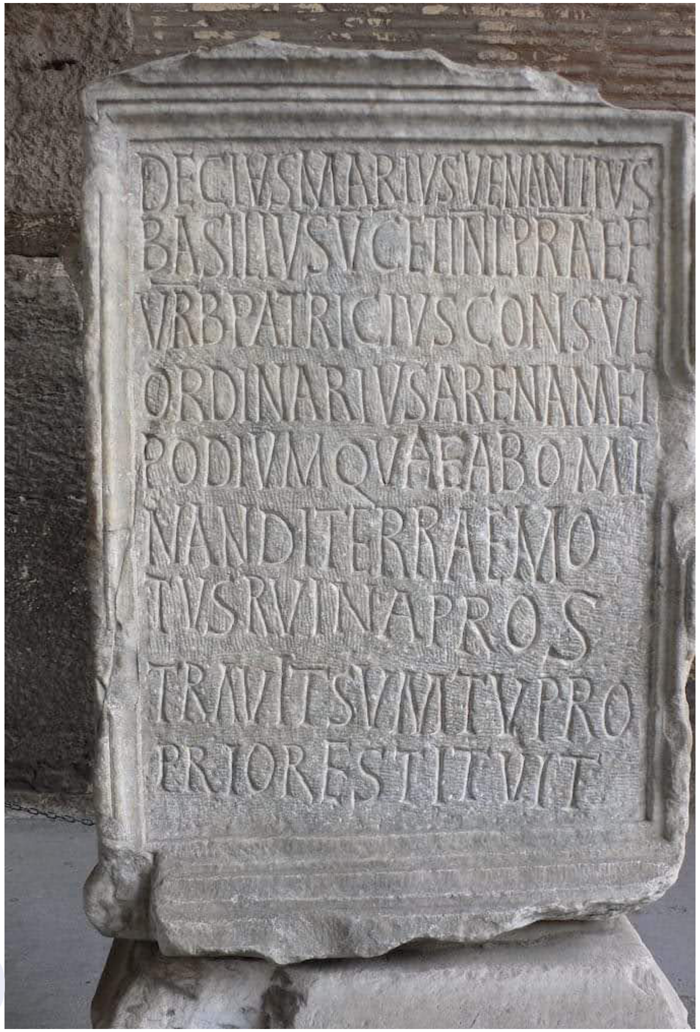

Fig. 56 - Base of the statue of Decio Mario Venanzio Basilio with indications of restoration after the earthquakes of 443 and 484 BC (see Funiciello et al., 2006).

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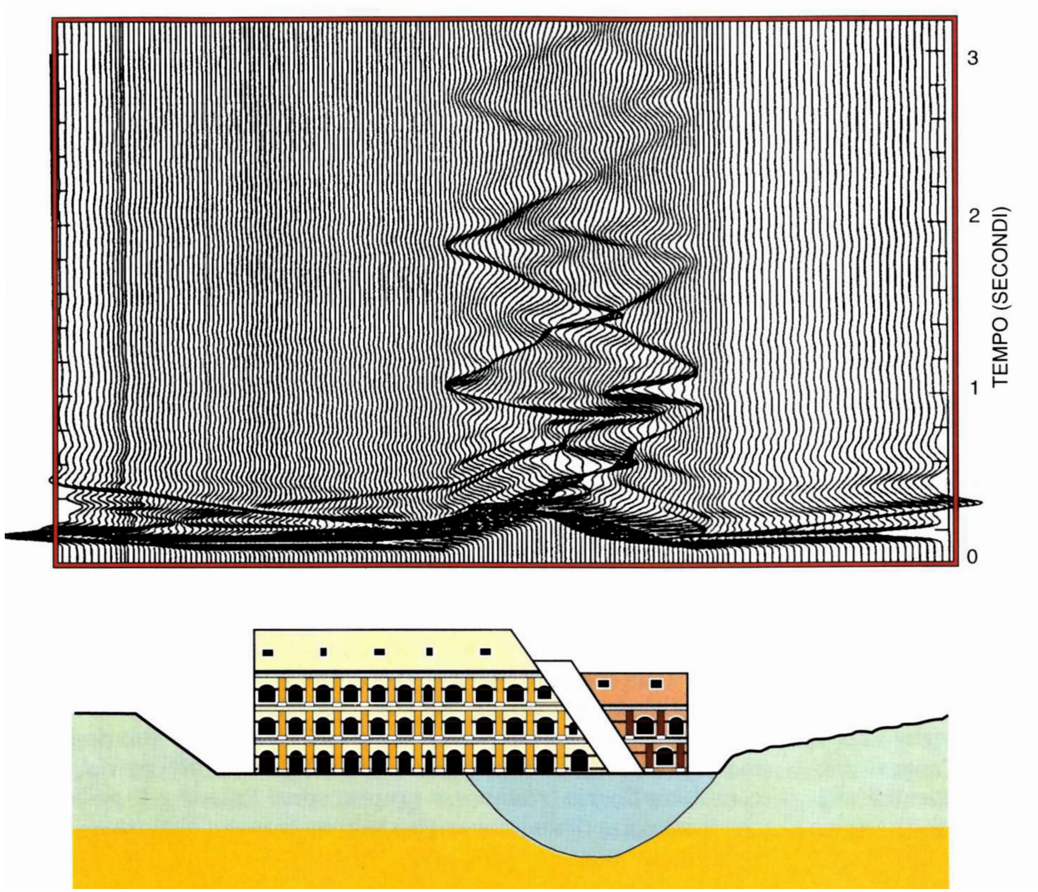
DECIVS MARIVS VENANTIVS BASILIVS V[IR] C[LARISSIMVS] ET INL[VSTRIS] PRAEF[ECTVS] VRB[I] PATRICIVS CONSVL ORDINARIVS ARENAM ET PODIVM QVAE ABOMI NANDI TERRAEMO TVS RVINA PROS TRAVIT SVMTV PRO PRIO RESTITVIT	(Statue of) Venantius, consul and senator clarus Decio Mario Venanzio Basilio, prefect of the city, patrician, ordinary consul, restored at his own expense the arena and podium that the disaster of a dreadful earthquake had demolished



After the fall of the Roman Empire, the Colosseo was abandoned, leading to rapid structural deterioration. This was due to several factors, including earthquakes (such as the 847 AD event and the 1349 earthquake that caused the partial collapse of the southern sector of the third ring) and the practice of using the Colosseo as a quarry for building materials (as depicted in Fig. 57). The partial collapse could be attributed to the different properties of the bearing terrains. The Colosseo was built on two different terrains: half on the bedrock composed of pre-volcanic conglomerate and sand (known as Santa Cecilia formation) and half on the Fosso Labicano thalweg. The seismic impedance contrast between the bedrock and the unconsolidated alluvial sediments of the Fosso Labicano caused significant damage and led to the partial collapse of the external ring.

Fig. 57 - The syntethic earthquake visualizes site effects in the area of the Colosseo on seismic wave amplification (from Funiciello and Rovelli, 1998).

collapses took place during the earthquake of 1703, which had its epicentre in L'Aquila with an intensity of X and was felt in the city with an intensity of up to VII. Subsequently, a significant amount of the debris was utilized for the construction of the Ripetta Harbour in 1704 (refer to stop 1; Fig. 59).

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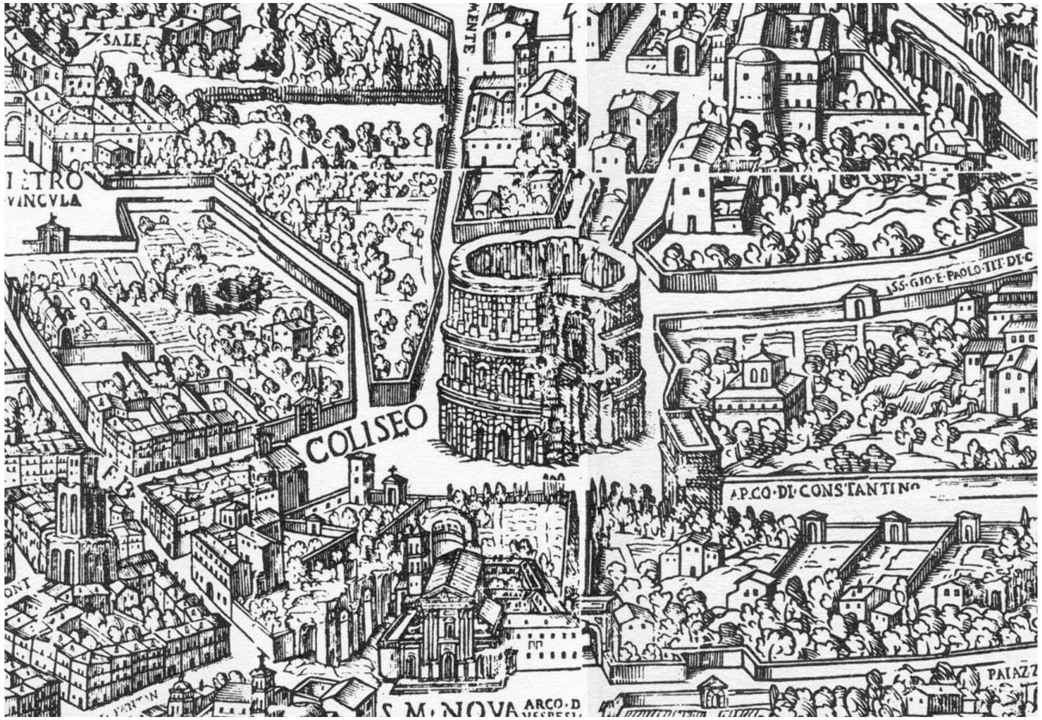

Fig. 58 - The Colosseo depicted in a map of a medieval Rome.

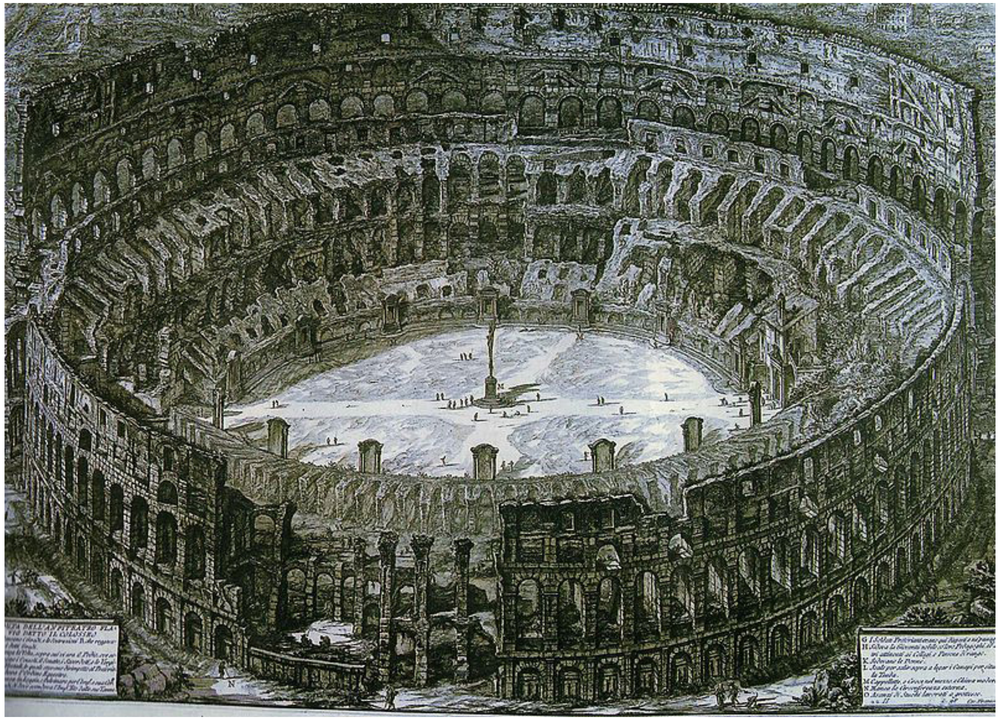

Fig. 59 - The Colosseo with Stations of the Cross. Engraving by Giovanni Battista Piranesi, 1750 circa.

REFERENCES

Alberti A., Dragone F., Fornaseri M., Scherillo A., Lipparini T., Gioria C. (1967) - Note illustrative della Carta Geologica d'Italia in scala 1:100.000, F. 150 Roma. Servizio Geologico d'Italia, Roma.

Aldrete G.S. (2006) - Floods of the Tiber in Ancient Rome. Johns Hopkins University Press, Baltimore. 338 pp.

Ambrosetti P. and Bonadonna F.P. (1967) - Revisione dei dati sul Plio-Pleistocene di Roma. Atti Accad. Gioenia Sci. Nat., 18, 33-70.

Antonioni L. (1970) - Roma inizio di secolo. Cronache vissute della Roma Umbertina. Ed. Mediterranee, Roma, 246 pp.

Argentieri A., Capelli G., Mazza R. (2019) - The "Circo Massimo" borehole (Rome 1939), a site of the geological memory. Italian Journal of Groundwater, 8(4), 79-83, https://doi.org/10.7343/as-2019-444.

Autorità di Bacino del Fiume Tevere (2005) - Ipotesi di regolazione dei deflussi ai fini del governo delle piene nel bacino del Tevere. 3: Sistemi idraulici di riferimento (Sistema Corbara–Castel Giubileo). 96 pp., https://www.abtevere.it/sites/default/files/datisito/rel_gen_3_corbara_castelgiubileo_pl.pdf.

Bencivenga M., Di Loreto E., Liperi L. (1995) - Il regime idrologico del Tevere, con particolare riguardo alle piene nella città di Roma. In: Funiciello R. and Amanti M. (Eds.). La geologia di Roma: il centro storico. Mem. Descr. Carta Geol. d'It., 50, 125-172.

Bencivenga M., Di Loreto E., Liperi L. (1999) - Piene storiche del Tevere a Roma. L'Acqua, 3, 17-24.

Bersani P. and Bencivenga M. (2001) - Le piene del Tevere a Roma dal V secolo a.C. all'anno 2000. Presidenza del Consiglio dei Ministri, Dipartimento per i Servizi Tecnici Nazionali, Servizio Idrografico e Mareografico Nazionale, Roma, 100 pp.

Bersani P. and Belati M. (2010) - La più antica iscrizione di un'inondazione del Tevere a Roma. L'Acqua, 5, 55-58.

Berti D., Esposito E., Giusti C., Luberti G.M., Piccardi L., Porfido S., Violante C., Vittori E. (2004) - Geological setting, hazards and urban growth in some historical towns in Italy. Post-Congress Field Trip P64, 32nd International Geological Congress, Florence, Italy, August 20-28, Mem. Descr. Carta Geol. d'It., 63, https://www.isprambiente.gov.it/en/publications/technical-periodicals/descriptive-memories-of-the-geological-map-of/field-trips-guide-books-from-p55-to-pw06-1.

Bonadonna F.P. and Bigazzi G. (1970) - Studi sul Pleistocene del Lazio, VIII; datazione di tufi intertirreniani della zona di Cerveteri (Roma) mediante il metodo delle tracce di fissione. Boll. Soc. Geol. It., 89(4), 463-473.

Bonini F.M. (1666) - Il Tevere incatenato, ovvero l'arte di frenar l'acque correnti. Per Francesco Moneta, Roma, pp. 462.

Brioschi F. (1876) - Le inondazioni del Tevere in Roma. Salvucci, Roma, 101 pp.

Brocchi G.B. (1820) - Dello stato fisico del suolo di Roma: memoria per servire d'illustrazione alla carta geognostica di questa città. Stamperia De Romanis, Roma, 281 pp.

Carboni M.G. (1975) – Biostratigrafia di alcuni affioramenti pliocenici del versante tirrenico dell'Italia centrale. Geologica Romana, 14, 63-85.

Celani E. (1895) - Alcune iscrizioni sulle inondazioni del Tevere. Bollettino della Commissione Archeologica Comunale, 23, 283-300.

Cifani G. (2008) - Architettura Romana Arcaica, Edilizia e società tra Monarchia e Repubblica. L'Erma di Bretschneider. Biblioteca Archaeologica, 40, 404 pp.

Cilli F. (2018) - Porto di Ripetta: quando i romani navigavano sul fiume. Olmata, Roma, 141 pp.

Cioni R., Laurenzi M. A., Sbrana A., Villa I. M. (1993). $^{40}Ar/^{39}Ar$ chronostratigraphy of the initial activity in the Sabatini Volcanic Complex (Italy). Boll. Soc. Geol. It., 112(1), 251-263.

Conticelli S., Francalanci L., Manetti P., Cioni R., Sbrana A. (1997) - Petrology and geochemistry of the ultrapotassic rocks from the Sabatini Volcanic District, central Italy: the role of evolutionary processes in the genesis of variably enriched alkaline magmas. J. Volcanol. Geoth. Res., 75(1-2), 107-136.

Corazza A. and Lombardi L. (1995) - Idrogeologia dell'area del centro storico di Roma. In: Funiciello R., La geologia di Roma: il centro storico. Mem. Descr. Carta Geol. d'It., 50, 179-211.

Cosentino D., Cipollari P., Di Bella L., Esposito A., Faranda C., Giordano G., Gliozzi E., Mattei M., Mazzini I., Porreca M., Funiciello R. (2009) - Tectonics, sea-level changes and palaeoenvironments in the early Pleistocene of Rome (Italy). Quaternary Res., 72(1), 143-155.

Cosentino D., Parotto M., Praturlon A. (1993) - Lazio: 14 itinerari. Guide Geologiche Regionali. Società Geologica Italiana, 5. BeMa, Milano. 377 pp.
De Angelis D'Ossat, G. (1936) - Il sottosuolo dei Fori Romani e *l'Elephas antiquus* della Via dell'Impero. Bull. Comm. Arch. Com., 63, 5-34.
De Angelis D'Ossat G. (1942) - Elefanti nella regione romana. L'Urbe, 7/8, 1-14.
De Angelis D'Ossat G. (1953) - La geologia del Monte Vaticano. Studi e documenti per la storia del Palazzo Apostolico Vaticano, 1(1), 1-53.
De Rita D. and Fabbri M. (2009) - The Rupe Tarpea: the role of the geology in one of the most important monuments of Rome. Mem. Descr. Carta Geol. d'It., 87, 53-62.
De Rita D., Di Filippo M., Rosa C. (1996) - Structural evolution of the Bracciano volcano-tectonic depression, Sabatini Volcanic District, Italy. Geol. Soc. Spec. Publ., 110(1), 225-236.
De Rita D., Funiciello R., Parotto M. (1988) - Geological map of the Colli Albani volcanic complex. Progetto Finalizzato Geodinamica CNR, Rome.
Del Monte M. (2018) - La geomorfologia di Roma. Sapienza Università Editrice, Roma, 220 pp.
Del Monte M., Fredi P., Pica A., Vergari F. (2013) - Geosites within Rome City center (Italy): a mixture of cultural and geomorphological heritage. Geogr. Fis. Din. Quat., 36(2), 241-257.
Di Baldassarre G., Saccà S., Aronica G.T., Grimaldi S., Ciullo A., Crisci (2017) - Human-flood interactions in Rome over the past 150 years. Advances in Geosciences, 44, 9-13.
Di Filippo M. and Toro B. (1993) - Gravimetric study of Sabatini area. Sabatini volcanic complex. Quad. Ric. Sci., 114, 95-99.
Di Gioia E.B. (1998) - La più antica iscrizione medioevale sull'inondazione del Tevere. In: Cimino e Nota Santi. Corso Vittorio Emanuele II tra urbanistica e archeologia: Storia di uno sventramento, Electa, Napoli, 128-131.
Di Martino V. and Belati M. (1980) - Qui arrivò il Tevere. Le inondazioni del Tevere nelle testimonianze e nei ricordi. Multigrafica Editrice, Roma, 236 pp.
Duperac S. (1575) - I vestigi dell'antichità di Roma raccolti et ritratti in perspettiva. Lorenzo della Vaccheria, Roma.
DuPérac E. (1577) - Nova urbis Romae descriptio. https://www.nga.gov/accademia/en/maps/Duperac-Nova-urbis-Romae-descriptio.html.
Faccenna C., Funiciello R., Marra F., Rosa C. (1995) - Caratteri geologico-stratigrafici. In: Funiciello R. and Amanti M. (Eds.). La geologia di Roma: il centro storico. Mem. Descr. Carta Geol. d'It., 50, 17-118.
Fornaseri M. (1985) - Geochronology of volcanic rocks from Latium (Italy). Rendiconti della Società Italiana di Mineralogia e Petrografia, 40(1), 73-106.
Fornaseri M. Scherillo A., Ventriglia U. (1963) - La regione vulcanica dei Colli Albani: vulcano Laziale. Bardi, Roma, 560 pp.
Frosini P. (1965) - Il Tevere e la difesa di Roma dalle inondazioni. L'acqua nell'agricoltura, igiene ed industria: organo ufficiale dell'Associazione idrotecnica Italiana, 2, 25-39.
Frosini P. (1977) - Il Tevere, le inondazioni di Roma e i provvedimenti presi dal governo italiano per evitarle. Accademia Nazionale dei Lincei, Roma, 323 pp.
Funiciello R., Corazza A., Marra F. (1995) - Carta dello spessore dei terreni di riporto, in Caratteri geologico stratigrafici della città di Roma. Mem. Descr. Carta Geol. d'It., 50, tav. 13.
Funiciello R., Giordano G. (2008a) - La nuova carta geologica di Roma: litostratigrafia e organizzazione stratigrafica. In: Funiciello R., Praturlon A., Giordano G. (Eds.). La geologia di Roma. Dal centro storico alla periferia. Mem. Descr. Carta Geol. d'It., 80, 39-85.
Funiciello R., Rovelli A. (1998) - Terremoti e monumenti in Roma. Le Scienze, n. 357, maggio 1998, 42-49.
Funiciello R. and Giordano G. (a cura di) (2008b) - Note Illustrative della Carta Geologica d'Italia alla scala 1:50.000, F. 374 Roma, S.EL.CA, Firenze, 158 pp.
Funiciello R., Giordano G., De Rita D. (2003) - The Albano maar lake (Colli Albani Volcano, Italy): recent volcanic activity and evidence of pre-Roman Age catastrophic lahar events. J. Volcanol. Geoth. Res., 123(1-2), 43-61.
Funiciello R., Giordano G., De Rita D., Barberi F., Carapezza M.L. (2002) - L'attività recente del cratere del Lago Albano di Castelgandolfo. Rend. Lincei, 13(3), 113-143.
Funiciello R., Heiken G., De Rita D., Parotto M. (2006) - I Sette Colli. Guida geologica a una Roma mai vista. Raffaello Cortina Editore, Milano, 328 pp.
Galli G., Galderisi A., Messina P., Peronace E. (2022) - The Gran Sasso fault system: Paleoseismological constraints on the catastrophic 1349 earthquake in Central Italy. Tectonophysics, 822, 229156, https://doi.org/10.1016/j.tecto.2021.229156.

Giordano F. (1878) - Condizioni topografiche e fisiche di Roma e Campagna Romana. Tipografia Elzeviriana, Roma, 86 pp.
Giordano G. (2008) - I vulcani di Roma: storia eruttiva e pericolosità. In: Funiciello R., Praturlon A., Giordano G. (Eds.). La geologia di Roma. Dal centro storico alla periferia. Mem. Descr. Carta Geol. d'It., 80, 87-95.
Giordano, G., De Benedetti, A., Diana, A., Diano, G., Gaudioso, F., Marasco, F., Funiciello, R. (2006) - The Colli Albani mafic caldera (Roma, Italy): stratigraphy, structure and petrology. J. Volcanol. Geoth. Res., 155(1-2), 49-80.
Giordano G., De Benedetti A.A., Diana A., Diano G., Esposito A., Fabbri M. (2010) - Stratigraphy and volcano-tectonic structures of the Colli Albani volcanic field. In R. Funiciello and G. Giordano (Eds.), The Colli Albani Volcano. Special Publication of IAVCEI, 3, 43-97.
Guidoboni E. (1989) - I terremoti prima del Mille in Italia e nell'area mediterranea. Storia, archeologia, sismologia, SGA Storia Geofisica Ambiente, Bologna, 765 pp.
Heiken G., Funiciello R., De Rita D. (2005) - The Seven Hills of Rome: a Geological Tour of the Eternal City. Princeton University Press, Princeton, 288 pp.
Jones A.H.M, Martindale J.R., Morris J. (1992) - The Prosopography of the Later Roman Empire, Cambridge University Press, 218 pp.
Lugli G. and Gismondi I. (1949) - Pianta di Roma Antica. https://geoportale.cittametropolitanaroma.it/cartografia-storica/20/41/roma-antica-2
Manni R. (2001) - The elephants in Rome: history, legends and anecdotes. The World of Elephants - International Congress, Rome 2001, 397-401.
Mappa della antica città di Roma (1870) - Noveau Larousse Illustré (Larousse XIXs. 1866-1877).
Mark R. and Hutchinson P. (1986) - On the structure of the Roman Pantheon. The Art Bulletin, 68(1), 24-34.
Marra F. and Rosa C. (1995) - Stratigrafia e assetto geologico dell'area romana. Mem. Descr. Carta Geol. d'It., 50, 49-112.
Marra F., Florindo F., Karner D.B. (1998) - Paleomagnetism and geochronology of early Middle Pleistocene depositional sequences near Rome: comparison with the deep-sea $\delta^{18}O$ record. Earth Planet. Sci. Lett., 159(3-4), 147-164.
Masi F., Stefanou I., Vannucci P. (2018) - On the origin of the cracks in the dome of the Pantheon in Rome. Engineering Failure Analysis, 92, 587-596.
Mattei M., Conticelli S., Giordano G. (2010) - The Tyrrhenian margin geological setting: from the Apennine orogeny to the K-rich volcanism. In: The Colli Albani Volcano, Funiciello R. and Giordano G. (eds), Special Publication of IAVCEI, 3, 7-27.
Ministero dei Lavori Pubblici, Servizio Idrografico, Sezione di Roma (1924) - Fiume Tevere. L'Idrometro di Ripetta. Pubbl. N.6(2), Servizio Idrografico, Roma, 40 pp.
Natalini P. (1877) - Studi sul Fiume Tevere. Giornale del Genio Civile. Tip. Genio Civile, Roma, 73 pp.
Pantaloni M. (2016) - 1940: the Tiber River length shortened for 2700 m. Acque Sotterranee - Italian Journal of Groundwater, 5(4), https://doi.org/10.7343/as-2016-244.
Pantaloni M. (2020) - Il drizzagno di Spinaceto e l'ansa morta del Tevere (Roma). Mem. Descr. Carta Geol. d'It., 106, 233-244.
Parotto M. (2008) - Evoluzione paleogeografica dell'area romana: una breve sintesi. Mem. Descr. Carta Geol. d'It., 80, 25-39.
Petronio C. and Sardella R. (1999) - Biochronology of the Pleistocene mammal fauna from Ponte Galeria (Rome) and remarks on the Middle Galerian faunas. Riv. It. Paleont. Strat., 105(1), 155-164.
Ponzi G. (1875) - Dei Monti Mario e Vaticano e del loro sollevamento. Atti R. Acc. Lincei, 2, 545-556.
Pollen J.H. (1874) - A Description of the Trajan Column. Spottishwoode, London, 181 pp.
Pullen H.W. (2018) - Handbook of ancient marbles. Gangemi editore, Roma, 256 pp.
Remedia G., Alessandroni M. G., Mangianti F. (1998) - Le piene eccezionali del fiume Tevere a Roma Ripetta. Università degli Studi de L'Aquila, Dip. di Ingegneria delle Strutture, delle Acque e del Terreno (DISAT n.3).
Rufo F. and Papi S. (2022) - La scienza di Roma. Passato, presente e futuro di una città. Azienda Speciale Palaexpo, Roma, 192 pp.
Segarra Lagunes M.M (2020) - Il Tevere e Roma: Storia di una simbiosi, Gangemi, Roma, 428 pp.
Shepherd E.J. (2006) - Il rilievo topofotografico di Ostia dal pallone (1911). Archeologia Aerea, 2, 15-38.
Servizio Geologico d'Italia (1967) – Carta Geologica d'Italia alla scala 1:100.000, F. 150 Roma. Stab. L. Salomone, Roma.
Servizio Geologico d'Italia (2008) – Carta Geologica d'Italia alla scala 1:50.000, F. 374 Roma. APAT, Roma.

Signorini R. (1939) - Risultati geologici della perforazione eseguita dall'A.G.I.P. alla Mostra autarchica del Minerale nel Circo Massimo di Roma. Boll. Soc. Geol. It., 58, 60-63.

Sottili G., Palladino D. M., Marra F., Jicha B., Karner D. B., Renne P. (2010) - Geochronology of the most recent activity in the Sabatini Volcanic District, Roman Province, central Italy. J. Volcanol. Geotherm. Res., 196(1-2), 20-30.

Testa O., Campolunghi M.P., Funiciello R., Lanzini M. (2008) - Il problema dei riporti e le modificazioni della forma originaria (Backfill covers and the original shape of the city of Rome). Mem. Descr. Carta Geol. d'It., 80, 145-168.

Verri A. (1915) - Cenni spiegativi della Carta Geologica di Roma pubblicata dal R. Ufficio Geologico su rilevamento del Tenente Generale A. Verri. Istituto Geografico De Agostini, Novara, 56 pp.

Database

Corpus Iscritiones Latinarum - https://cil.bbaw.de/

EDCS Epigraphik-Datenbank Clauss / Slaby - http://db.edcs.eu/epigr/epi_einzel_it.php?p_belegstelle=CIL+06%2C+32086&r_sortierung=Belegstelle

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