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SCIENCE

Geomorphological classification of urban landscapes: the case study of Rome (Italy)

Maurizio Del Monte[a], Maurizio D'Orefice[b], Gian Marco Luberti[c], Roberta Marini[a], Alessia Pica[a] and Francesca Vergari[a]

[a]Dipartimento di Scienze della Terra, Università degli studi di Roma 'La Sapienza', Roma, Italy; [b]ISPRA – Servizio Geologico d'Italia, Istituto Superiore per la Protezione e la Ricerca Ambientale, Roma, Italy; [c]ISPRA – Dipartimento stato dell'ambiente e metrologia ambientale, Istituto Superiore per la Protezione e la Ricerca Ambientale, Roma, Italy

ABSTRACT
The results of a long-lasting geomorphological survey carried out in Rome are summarized. A method aimed at integrating survey data, historical maps, aerial photographs and archaeological and geomorphological literature produced a geomorphological map of the present-day historical centre. The geomorphology of Rome is related to the paleogeographical conditions prior to the founding of the City; they allow us to recognize the stages of landscape evolution of the ancient *Caput Mundi* (Capital of the World). The study area has been affected by continuous man-made changes to the drainage network and to the topographic surface over the last 3000 years. It has forced the authors to develop innovative solutions to undertake effective analysis of the urban environment and the legend of the geomorphological map in this peculiar context. The resulting map is useful for urban planning and archaeological research.

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KEYWORDS
Urban landscape; geomorphological mapping; man-made landforms; multitemporal analysis; Rome

1. Introduction

Rome includes a wealth of well-known historical and cultural sites, as well as a less-known but valuable natural landscape. The geological and natural heritage is, itself, a tourist attraction (Coratza & Giusti, 2005; Gregori & Melelli, 2005; Panizza, 2001; Reynard, 2008; UNESCO, 2005).

Many natural geomorphological features of the *Aeterna Urbs* have been modified by millennia of urbanization, but they are still recognizable amongst popular tourist attractions (i.e. see De Rita & Fabbri, 2009). They currently form a wide and unique worldwide 'man-made layering'.

A geomorphological review of the Roman territory is here presented, based on the results obtained by a 19-year-long geomorphological survey, supported by analyses of many historical, archaeological, cartographic and photographic documents. The first detailed geomorphological map of the central part of Rome ever carried out was thus completed.

The geomorphological map of Rome (Main Map) contains major updates, novelties and re-interpretation of previous data, achieved through an accurate multidisciplinary and multitemporal investigation. In particular, man-made landforms and modifications to the original surface required a special in-depth analysis, as they presented the most challenging investigation and the development of innovative cartographic solutions.

2. Study area

Rome is located on the Tyrrhenian side of Central Italy, west of the Latium-Abruzzi Apennines (Figure 1(a)). The study area corresponds to the *Urbs*, the 'old town' within Imperial Roman walls, continuously inhabited for millennia, and a part of the *Suburbium*, the area between the city and its countryside, called *Agro Romano* (Witcher, 2005).

Features of Rome's ancient history are inscribed not only on monuments, but also on a varied landscape, characterized by hilly, volcanic settings and the Tiber fluvial system, which separates two distinct types of landscape.

On the east side of the Tiber River are the famous Seven Hills: Quirinale, Viminale, Esquilino, Capitolino (or Campidoglio), Palatino, Celio and Aventino, which hosted the first villages in approximately 2000 BC (Del Monte, Fredi, Pica, & Vergari, 2013).

The Seven Hills and other relief (i.e. Pincio Ridge, Parioli and Antenne Mounts; Figure 1(b)) were formed by erosion processes of the Tiber fluvial system, which deepened the distal volcanic plateaus built by Colli Albani and Sabatini volcanic districts. These plateaus, extending, respectively, from south-east and north-west of Rome to the main course of the Tiber (Figure 1), merge in the City's central area. Here, a series of small flat-bottomed valleys, drained by tributaries of the Tiber, separate the Seven Hills; three of them appear

CONTACT Alessia Pica alessia.pica@uniroma1.it
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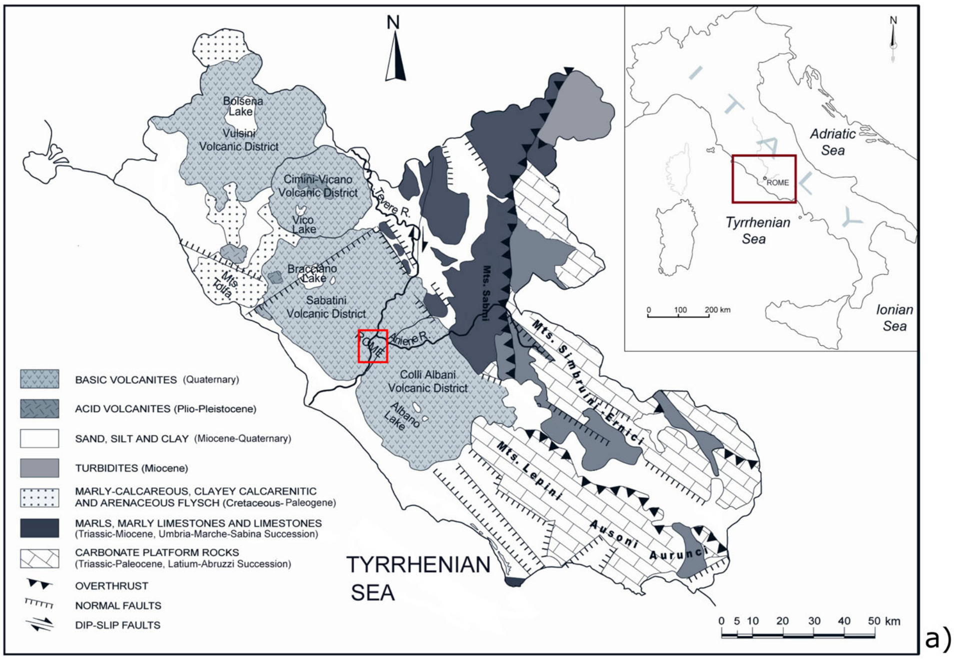

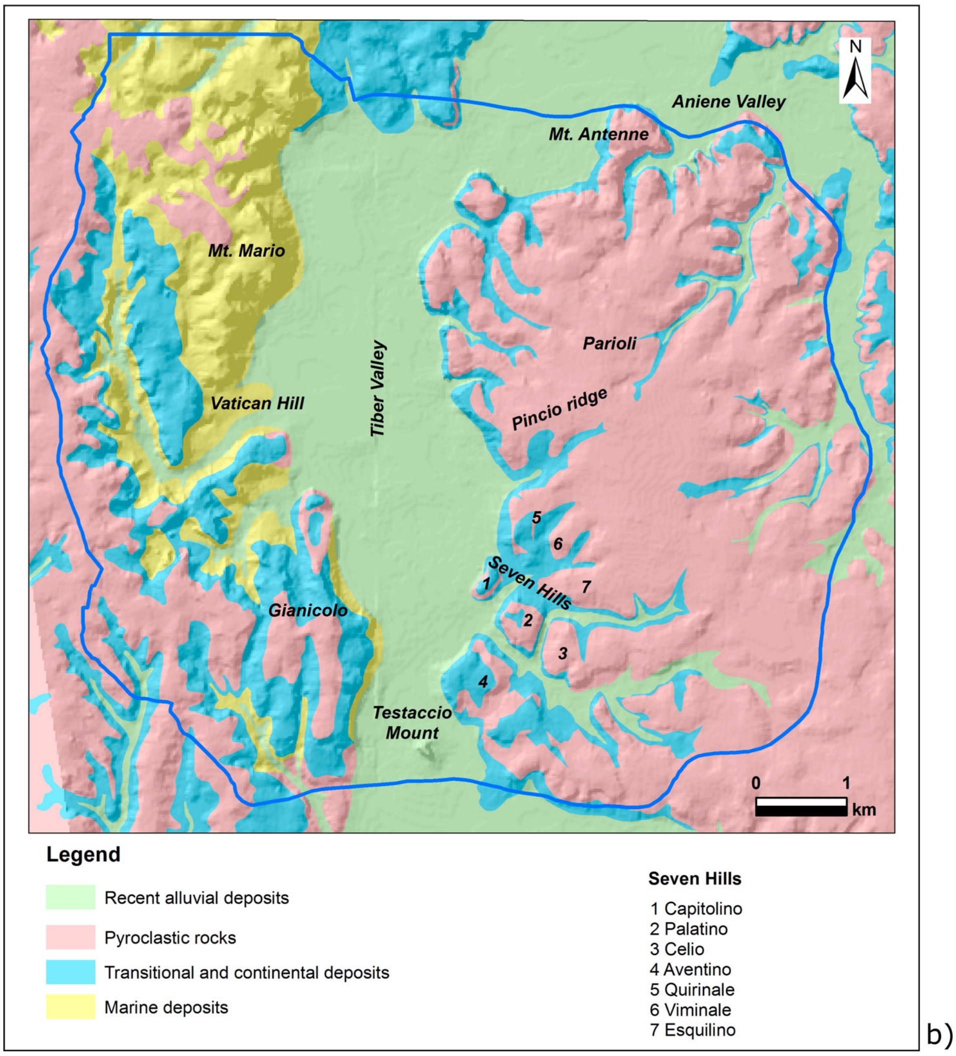

Figure 1. (a) Geological sketch of the Latium region. Modified from Del Monte et al. (2013). (b) Geological sketch of the study area. The geological sketch of Rome city centre was mainly developed comparing the 'Lithostratigraphic map' by Ventriglia (2002) with the geological maps by Funiciello and Giordano (2008) and Marra and Rosa (1995).

Table 1. Correspondence between (a) lithologic units, landforms and deposits of the Main Map and (b) formal (in bold) and informal units of the lithostratigraphic map by Ventriglia (2002) and the geologic map by Funiciello & Giordano (2008).

Lithologic units of the bedrock in the Main Map (*landforms and deposits*)	Ventriglia (2002) 'Territorio del Comune di Roma Carta litostratigrafica' Scale 1:20,000	Funiciello & Giordano (2008) 'Carta geologica del Comune di Roma' Scale 1:10,000
(*Man-made constructional landforms and deposits*)	Quarry waste deposits, river levees and embankments **da**	Anthropogenic deposits **h** Landfill deposits **h$_1$**
(*Recent alluvial deposits*)	Recent fluvial deposits **qa**	Active fluvial deposits **SFT$_{bb}$** Fluvial deposits **SFT$_{ba}$** Lacustrine deposits **SFT$_{e2}$**
(*Ancient alluvial deposits, terraced*)		**Saccopastore Unit SKP**
	Formazione Fluvio lacustre fl	**Vitinia Formation VTN** **Aurelia Formation AEL**
Pyroclastic rocks, mostly unconsolidated deposits	**Tufo di Villa Senni Avs** **Pozzolana grigia Aps** **Tufo de La Storta Sg**[1] **Complesso delle Pozzolane inferiori Api:** **Pozzolane nere** **Pozzolane rosse** **Tufo di Sacrofano Sl**[3]	 **Pozzolanelle VSN$_2$** (part of: **Villa Senni FormationVSN)** **Tufi Stratificati Varicolori di La Storta LTT** **Pozzolane Nere PNR** **Pozzolane Rosse RED** **Tufi Stratificati Varicolori di Sacrofano SKF**
Pyroclastic rocks, mostly consolidated deposits	 **Tufo lionato Atl** **Tufo rosso a scorie nere Vv**[4] **Tufi antichi Ata** **Tufo giallo della via Tiberina Sn**[1]	**Via Nomentana Unit NMT** **Tufo Lionato VSN$_1$** (part of: **Villa Senni Formation VSN)** **Tufo Rosso a Scorie Nere RNR** **Palatino Unit PTI** **Tor de' Cenci Unit TDC** **Via Tiberina Unit TIB**
Transitional and Continental deposits, with different granulometry and cohesion, including travertine	**Conglomerato giallo** (part of: **Compl. Pozz. Inf.) Api** **Formazione Fluvio palustre fp**	**Fosso del Torrino Formation FTR** **Conglomerato Giallo FTR$_1$** **Valle Giulia Formation VGU**
	Clay, Sand and Gravel Complex **qt**	**S. Cecilia Formation CIL** **Fosso della Crescenza Formation FCZ** **Ponte Galeria Formation PGL**
Marine deposits, mainly sandy sediments with arenaceous interbeds	Grey-blue clayey sand, yellow or red coarse sand, green grey sandy clay and yellow marl deposits with conglomerate layers, Siciliano-Calabriano **Psi**	**Monte Mario Formation MTM**
Marine deposits, mainly clayey-marly sediments alternated with fine sands	Blue clay, marly clay and grey-blue marl deposits with gypsum crystal, Piacenziano **Pm**	**Monte Vaticano Formation MVA**

Notes: Only outcropping units in the study area are included. The stratigraphic order of the units of both the maps is not fulfilled, due to the lithologic aggregations.

today as isolated domes (Aventino, Capitolino and Palatino), the others are small ridges.

On the Tiber's west side, the floodplain ends at the foot of the Mt. Mario-Gianicolo horst. In the same area, reclaimed in the first century BC, the Vatican Hill is located. While Mt. Mario-Gianicolo ridge reaches 139 m a.s.l. and shows an uneven top, the Seven Hills have heights of 50–60 m and flat tops.

Bedrock consists mainly of clay and marl (Pliocene – Early Pleistocene) deposited during an extensional tectonic period that produced several NW–SE-oriented horsts and grabens (Faccenna, Funiciello, & Marra, 1995; Mattei, Funiciello, & Parotto, 2008). Three major marine depositional cycles have been recognized in this period (Funiciello & Giordano, 2008; Marra & Rosa, 1995). The first (Pliocene) included blue clays (Monte Vaticano Formation), while coarser grained sediments of shallower water facies (Monte Mario Formation) were deposited during the second and third cycles (Early Pleistocene) (Figure 1(a), Table 1).

In the study area, these marine deposits reach a thickness of about 800 m. They are overlain by epicontinental deposits of variable thickness (up to 100 m). Some depositional cycles of fluvial-marsh and marine-marginal environments began in the upper part of the Early Pleistocene; flood deposition occurred along Paleo-Tiber and its tributaries. Only the later Paleo-Tiber deposits are located in Rome's historical centre. These units are interdigitated with thick pyroclastic deposits produced by the Sabatini and Colli Albani volcanic complexes (Giordano et al., 2006), in this area ranging in age from 600 to 280 ka (Karner, Marra, & Renne, 2001). Continental sedimentation continued throughout these depositional cycles controlled by eustatic variations (Bellotti et al., 2007; Funiciello & Giordano, 2008; Marra & Rosa, 1995).

The stratigraphic relationships between the volcanic and sedimentary units are complex because the effects of erosion during the lowstands coincided with neotectonic processes and volcanic activity (Belisario et al., 1999; Cattuto, Gregori, Melelli, Taramelli, & Broso, 2005; Ciotoli et al., 2003). The emplacement of volcanic deposits changed the topography and hydrography of the area (Heiken, Funiciello, & De Rita, 2005); the main stream of the ancient Tiber progressively moved towards the Mt. Mario-Gianicolo ridge (Faccenna et al., 1995).

During the Last Glacial Maximum period, at approximately 20 ka, a large drop in sea level (Lamb, 1995) induced intense fluvial deepening. In Rome, the Tiber and its tributaries cut the Plio-Pleistocene bedrock up to 50 m below the present sea level. A subsequent rise in sea level caused a depositional phase; the valleys were filled by up to 60 m of alluvial deposits (Ascani et al., 2008).

Over the last 3 ka, human activities have contributed to a reshaping of all topographic surfaces. The most recent stratigraphic layer overlies flood deposits: it consists of a mixture of alluvium, colluvium and materials from human activity, accumulated throughout Rome's history. This man-made layer covers the historical centre and ranges in thickness from a few metres on hill tops up to about 30 m in valley bottoms (Del Monte et al., 2013; Funiciello & Giordano, 2008; Testa, Campolunghi, Funiciello, & Lanzini, 2008).

3. Methods

The Geomorphological Map of Rome's centre, represented at a 11,000 scale (Main Map), is based on a detailed geomorphological survey and multitemporal analysis of aerial photographs and topographic maps.

Monitoring of erosional processes recorded several rapid morphological changes, even over short periods.

To obtain information on morphological changes over longer periods, the geomorphological survey was supported by analysis of aerial photographs taken in the last 80 years, as most changes are a result of anthropogenic activity over the last century. Specifically, the analysis was conducted on photographs by (a) SARA-Nistri (1934), the first complete flight of Rome producing stereoscopic aerial photographs; (b) several Second World War flights by the Royal Air Force (MAPRW, 1943–1944; Shepherd, Leone, Negri, & Palazzi, 2013) and (c) National Flight by GAI (1954). The analysis also integrated non-stereoscopic aerial photos (the photomosaic of Rome (Nistri, 1919)) and more recent stereoscopic material (i.e. ETA, 1951/1958; RER national flight 1988/1989). Most of these were provided by ICCD-Aerofototeca Nazionale (National Aerial Photographic Archive) and analysed at the Laboratories of Earth Science Department of Sapienza University of Rome.

The results of the aerial photo analysis were matched with the geomorphological study of the 'Piano topografico di Roma e Suburbio', a topographic map surveyed in 1907 for the Urbanisation Plan of Rome, and updated in 1924, at 1:5000 scale with a contour interval of 1 m (IGM, 1924). Furthermore, in order to detect previous modifications to the topographic surface, the analysis of historical cartography was conducted using available maps, surveyed with trigonometric methods. In particular, we examined the first edition of *Tavolette* from the Italian Geographic Military Institute (1:25,000 scale, 5 m contour interval; IGM, 1873a, 1873b), and other maps with planimetric precision and without contours. These included the maps by Moltke (1852) and Presidenza del Censo (1839), whilst the *Urbe* map by Nolli (1748) only covers the area inside imperial city walls. In addition, more ancient 'bird's eye' maps were useful to detect some landforms (Dupérac, 1577; Falda, 1676).

For gravitational landforms, the results of aerial photo analysis were integrated with the Landslides Inventory of Rome (ISPRA, 2014) and the webGIS of CERI-Sapienza (Alessi et al., 2014). A number of old papers were also consulted, such as historical books and archaeological papers (i.e. Pinza, 1925; Quilici, 1990) and the archaeological map of Rome by Lanciani (1893–1901), in order to collect information relevant to the geomorphologic characteristics before most man-made modifications. In addition, important information on natural landforms now obscured was obtained from paintings, pictures and interviews with elderly people, who described the most recent modifications. Locally, useful information to detect the thickness of fill deposits was also collected from drilling databases (Rea, 2011; Ventriglia, 1971, 2002) and some geothematic maps, such as the 'Anthropogenic deposit thickness' maps (Corazza & Marra, 1995; Ventriglia, 1971).

The spatial distribution of bedrock was derived from the lithostratigraphic map by Ventriglia (2002), taking into account other geologic maps (Funiciello & Giordano, 2008; Marra & Rosa, 1995) and literature.

The multitemporal analysis of historical and more recent topographic maps was undertaken using a Geographic Information System. The spatial reference of the Main Map and figures is ED50, UTM projection, Zone 33 North.

The analysis of the materials described above has followed a structured procedure, summarized in Figure 2. This procedure represents a methodological proposal on how to approach the geomorphological analysis of an urban environment.

The criteria to recognize and map the landforms are based on those proposed by several authors (Aringoli et al., 2005; Brancaccio et al., 1994; Ciccacci, Del Monte, & Marini, 2003; Del Monte, 1996; Della Seta, Del Monte, & Marini, 2006; Dramis, Gentili, & Pieruccini, 1979; Lupia Palmieri et al., 1998, 2001; Panizza, 1972, 1987; Pellegrini, 2000). Morphological elements were grouped according to genetic criteria; each landform was classified depending on the main type of geomorphic process. As usual, landforms were distinguished as 'active' and 'inactive'; a third column, named 'modified', was added where necessary, to indicate a natural landform still recognizable, even if it appears greatly modified by human activity.

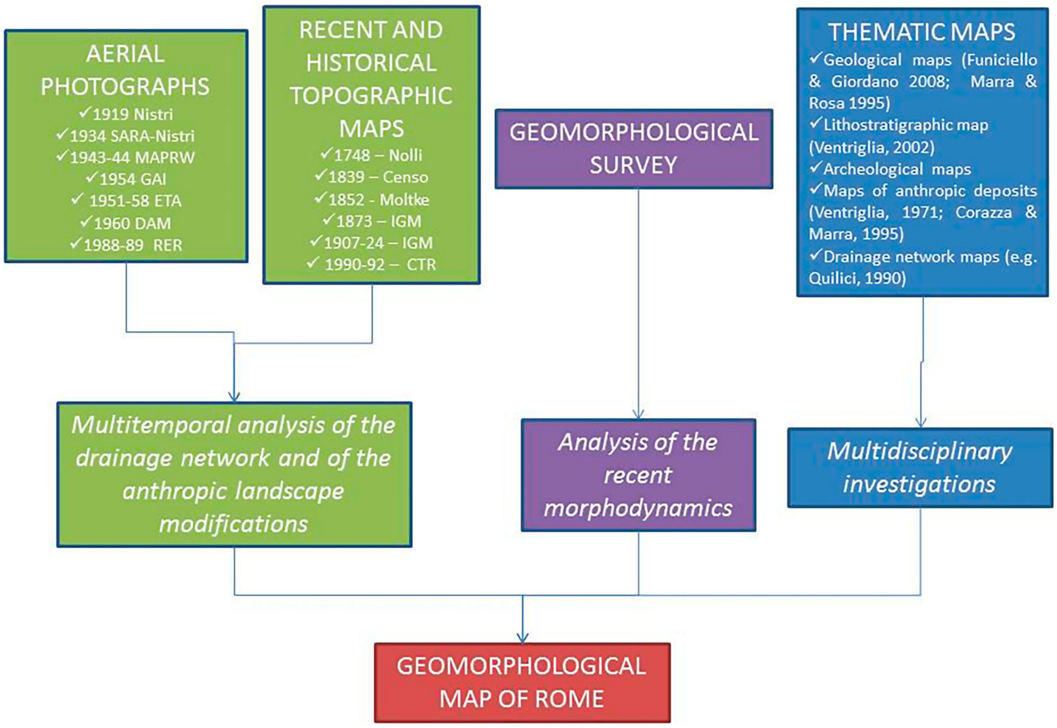

Figure 2. Flow chart summarizing the methodology used for the production of the Main Map. Only a partial list of the examined literature sources is shown.

Due to an extraordinary variety of man-made modifications, the legend of landforms and anthropogenic processes has been significantly improved and integrated, attempting where possible to record the previous erased morphology.

4. Results

The natural landscape in which Rome has developed was primarily moulded by fluvial processes. Polygenetic, structural and gravitational forms are also widespread; in addition, many landforms were modified or created by human activities.

Man-made landforms and modifications to the original surface required in-depth discussion, as they presented the most challenging investigation. Specifically, the following rules were adopted:

(1) man-made landforms were included in this category when they completely erased the natural morphology (in this case, an indication of the previous morphology was given, if possible);
(2) natural landforms modified by man, but still recognizable, were grouped in the original morphogenetic process category, adding a special column to the legend, named ‘modified’.

4.1. Natural and modified fluvial landforms

Most of the hydrographic network is currently affected by linear erosion, even if the major streams are subject to erosion control and drainage management.

A series of narrow and deep valleys cut the western and eastern slopes of Mt. Mario-Gianicolo ridge. Small trough-shaped valleys are common and indicate geomorphic evolution by both fluvial and gravitational processes. Runoff plays an important role in shaping unvegetated areas. Gully and rill erosion, as well as subsurface erosion (due to tunnelling and piping), are effective on clay outcrops and clayey soils and very effective on anthropogenic deposits, even on shallow slopes.

The eastern part of the study area is generally characterized by a substructural surface, formed by Quaternary volcanic activity. The volcanic plateau was subsequently deeply cut by the Tiber and its tributaries (Figure 3): the seven historical hills of Rome were shaped by fluvial erosion of the Tiber drainage system in the upper part of the Pleistocene and the Holocene, and then partially reshaped by man in the last part of the Holocene. After a depositional phase during the Holocene the valleys acquired their current flat floors.

In the City centre, the largest of the tributaries on the east side, the ancient Murcia Valley stream (*Velabrum*), formed a straight, flat-floored valley with steep slopes, now occupied by the *Circus Maximus* stadium (Figure 1(b)). The channel direction was structurally influenced; the ancient stream flowed into the Tiber counter-flow, supporting the Tiberina Island genesis (Del Monte et al., 2013).

Several ancient valleys have no topographic evidence, being completely filled by anthropogenic deposits, such as the upper Fosso di S. Agnese valley, close to the top of Pincio ridge, and other tributaries of the Aniene River (Fosso della Città Universitaria; Fosso

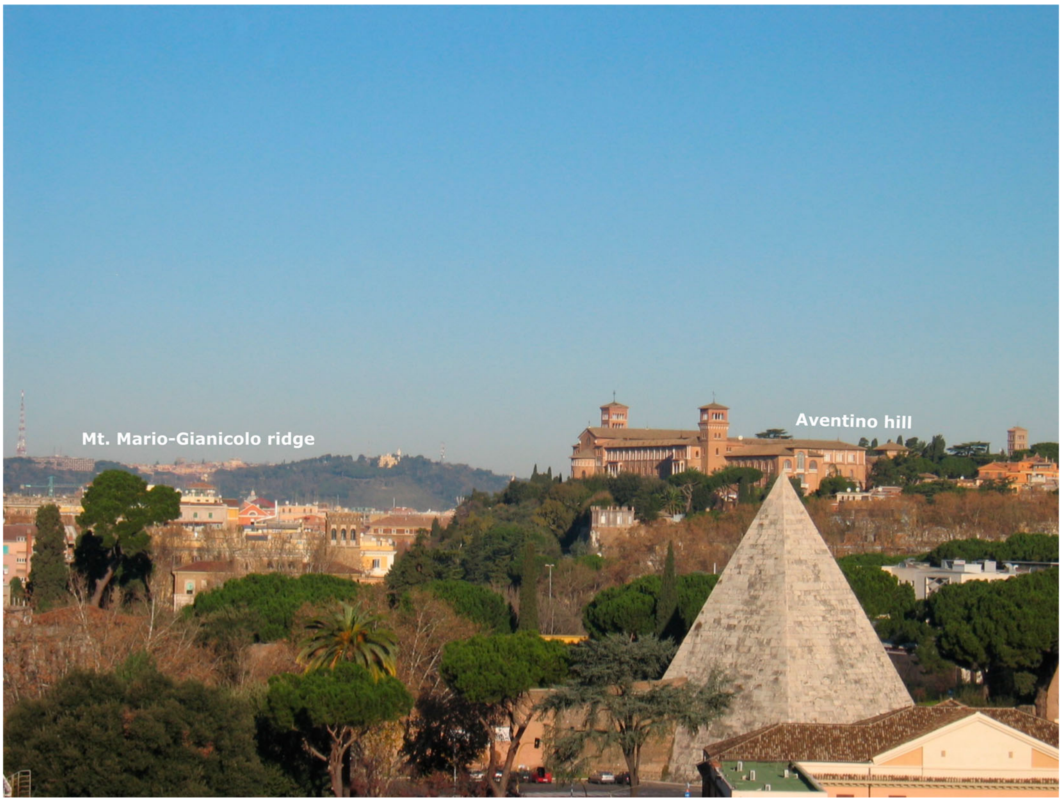

Figure 3. On the right, the southern slope of Aventino, one of the 'Seven Hills' that has steep slopes and a flat top, overlooking the floodplain of the Tiber. The landscape on the West side of the Tiber (left, in the background) is characterized by the Mt. Mario-Gianicolo ridge, which is higher, rugged and frequently subjected to landsliding. In the foreground, the only ancient pyramid surviving in Rome (built about 2000 years ago).

di San Lorenzo: Luberti, 2014). Some left-tributaries have flat-floored valleys due to anthropogenic deposits more than fluvial ones, so they were classified as 'modified' fluvial landforms.

Moreover, the analysis of ancient topographic maps and other literature (Corazza & Lombardi, 1995; Quilici, 1990) have highlighted the presence of landforms otherwise unrecognizable, much as the alluvial fan north-west of the Tiber alluvial plain, and ancient marshy areas southwards. Finally, the geomorphological survey allowed us to recognize Middle Pleistocene alluvial terraces.

4.2. Natural and modified structural landforms

During the Middle Pleistocene the volcanic materials of Sabatini and Colli Albani volcanoes covered the entire area, generating a large ignimbritic plateau that gave rise to a flat summit surface. During the peak sea level lowstand, fluvial erosion cut this structural surface.

The outliers (such as the Seven Hills) were once part of a large mesa; their tops preserve some remains of structural surfaces, surviving only in limited portions of the study area. In some areas of the city centre (i.e. Termini and Esquilino), a large flat surface is the result of centuries of human activity, which produced a wide and thick layer of fill deposits. Such evidence, provided by archaelogical and borehole data, suggests the introduction of the 'modified substructural surface' landform.

The structural and substructural surfaces are often bounded by scarps shaped by various weathering and denudation processes. In the eastern area, many scarps overlooking the Tiber alluvial plain (Capitolino, Aventino and Pincio hills) have polygenetic origin: erosion started by fluvial incision along the lines of tectonic weakness. In the western area, several scarps follow boundaries between volcanic and the underlying clayey and sandy units. Some stream elbows (i.e. Aurelia Valley) indicate a tectonic control on drainage network development. Finally, the area is also characterized by many rounded and flat ridges, isolated by fluvial incision; the main ridge (Mt. Mario) is a structural horst.

4.3. Gravitational landforms

A lot of scarp edges and landslide deposits have been identified in the study area, many of them according to the Landslide Inventory (Alessi et al., 2014; ISPRA, 2014), and mapped with a temporal reference, when known. They were caused by flows, slumps, falls and toppling. The last two are present on the more cohesive outcrops, while the slumps and mud-flows often occur in areas with clay, sand and clayey sand outcrops (Figure 4). Deformation features induced by creeping

Figure 4. Rock topple which occurred in via dell'Ongaro, Monteverde neighbourhood, in March 2015.

have also been identified on natural or modified surfaces with low slopes.

Landslides are widespread in the western part of the study area, and particularly on the slopes of Mt. Mario (Bozzano, Martino, & Priori, 2006). A number of landslides occur where the slope gradient is high (>20%) and clay and sand outcrop.

Several flows are developing in areas of moderate slope gradients (8–10%) and sometimes occur within older landslide deposits. Although smaller than other landslide types, they may cover long distances.

The east side of the Tiber has low amplitude relief, which reduces the possibility of landslide development. Mass movements, especially falls and topples, are located mainly on the steeper slopes of the fluvial valleys. They have also affected the travertine deposits outcropping along some vertical slopes of the Parioli Mounts (Amanti, Cesi, & Vitale, 2008, 2012; Carrara, Chiessi, & D'Orefice, 2012). Several small landslides are affecting artificial embankments or reshaped scarps; these gravitational deposits are rapidly removed, embankments reconstructed and scarps strengthened.

Several landslides have been mapped using a specific point symbol, if they are very small or characterized by uncertain limits but certain occurrence.

4.4. Man-made landforms

The study area has been greatly affected by a variety of human activities beginning in ancient times. The signs of these activities are superimposed and juxtaposed with those caused by natural processes.

Rome has hosted stable settlements since the Bronze Age. During the Roman age, the population grew up to 1 million people and the urbanized area, the *Urbs*, became larger than the area included in the Imperial Walls (Witcher, 2005). After decay of the Roman Empire, part of the Urbs and the suburban area were abandoned; later, they hosted cropland and rural settlements until the 1960s.

Mining activities, currently inactive, started in the sixth to fifth century BC (Cifani, 2008) and produced numerous caves with straight scarps and step-like slopes. In addition, a dense network of underground cavities were dug to extract material for construction, particularly lithic tuffs (*tufi litoidi*) and unconsolidated pyroclastic deposits (*pozzolane*), to distribute and collect waters and to build underground cemeteries (*catacombe*). Furthermore, underground cavities are related to the presence of buried spaces, such as remains of buildings (Crescenzi, Piro, & Vallesi, 1995; Ventriglia, 1971). More recent changes to the topographic surface are due to open-pit mining for clay extraction (i.e. Inferno and Balduina valleys). These activities are related to the construction of new buildings (Amanti, Troccoli, & Vitale, 2013; Funiciello & Testa, 2008), since Rome became the capital of Italy (nineteenth century).

Most parts of the study area were definitively urbanized in the 1950s, when the city's population growth generated the development of vast neighbourhoods, and a dense network of roads and railways. The new buildings and road network required sub-horizontal surfaces, produced by filling ancient valleys and terracing slopes (Figure 5). Among the most significant anthropogenic changes are the excavation of the saddle between the Capitolino and Quirinale hills, in Roman times, and the removal of Velia hill (Figure 6), located between the Palatino and Esquilino, in 1932 (Insolera, 2001). Construction activities and other historical events, in addition to earthquakes, floods and subsidence (Berti et al., 2004), have covered the surface of the historical City centre several times, producing a continuous layer of materials made up of the remains of collapsed buildings, rubbish and the ruins of ancient temples and monuments mixed with colluvium and alluvium. The Tiber River embankments, built in the last century, now protect the city centre from flooding.

In many valleys (i.e. Fosso di San Lorenzo), core drilling data have shown several metres of alluvial deposits containing the remains of human activity, demonstrating the high rate of erosion for first-order stream channels during the historic age (Luberti, 2014).

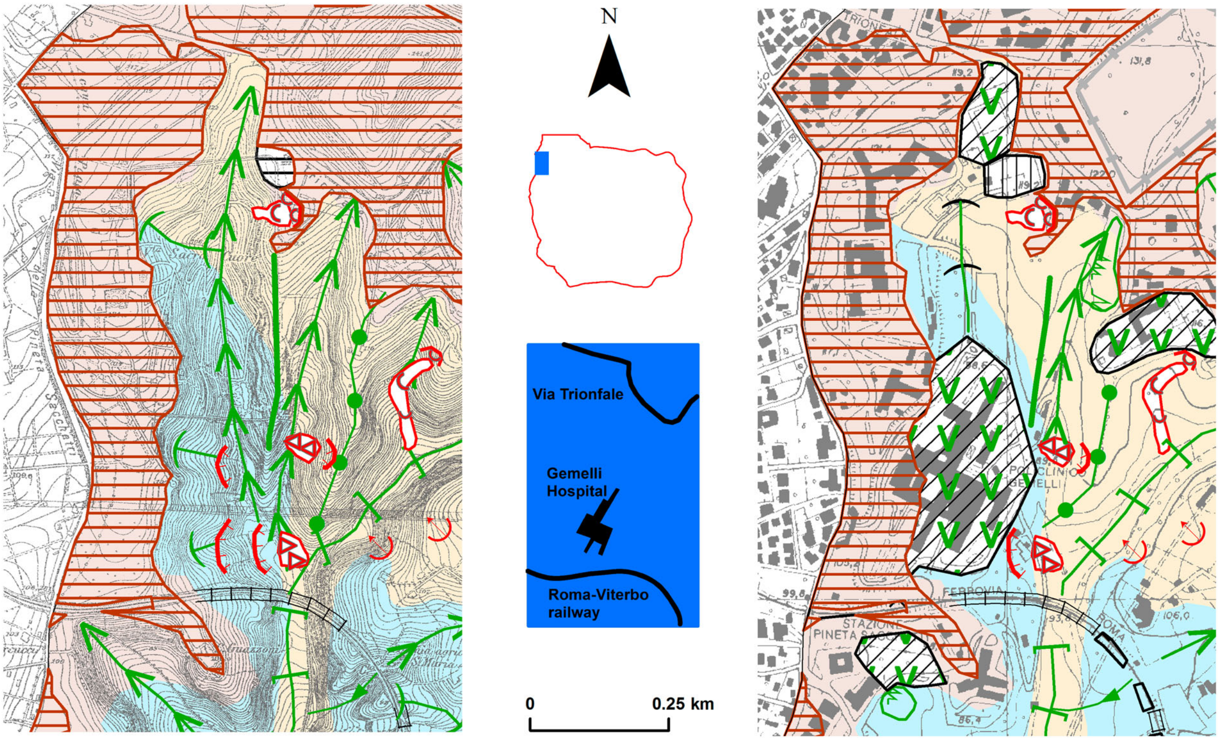

Figure 5. Multitemporal analysis of the anthropogenic modifications of the drainage network and landslide processes that occurred in the Gemelli Hospital area. In (a) the rural landscape in 1924 (IGM Piano Topografico di Roma); in (b) the present-day situation (CTR Lazio 374060–374070). This area is characterized by several valleys that have been heavily modified due to urbanization; some of them were previously affected by landslides. The figure highlights that in 1924 the selected area was characterized by natural landforms, including fluvial valleys (green), landslides (red) and structural surfaces (brown). Currently some man-made landforms (black) have been superimposed on natural landforms, such as filling material in ancient valleys; other natural landforms were partially buried and reduced in extent. A more detailed description of the landforms represented can be found in the legend of the Main Map.

Human activity has also created artificial hills. A well-known example is Testaccio Mount, which reaches 48 m a.s.l. (the same height of Aventino and Palatino). This hill was created by the accumulation of so-called «*Cocci*» (shards), fragments of broken amphorae of the ancient Romans. On the Tiber alluvial plain, several other man-made mounds appear as small hills (e.g. Montecitorio).

Depressions filled by man-made materials were mapped as depositional anthropic landforms where the thickness of anthropic deposit is over 5 m and hides the depression. They were distinguished, based

Figure 6. Excavation work on Velia Hill in the 1930s: (a) view from the Colosseum to NW, the Capitolino Hill and the Vittoriano are in the middle background, the Basilica di S. Francesca Romana in the upper left corner of the picture; (b) view from the Basilica di S. Francesca Romana to SE, to the Colosseum.

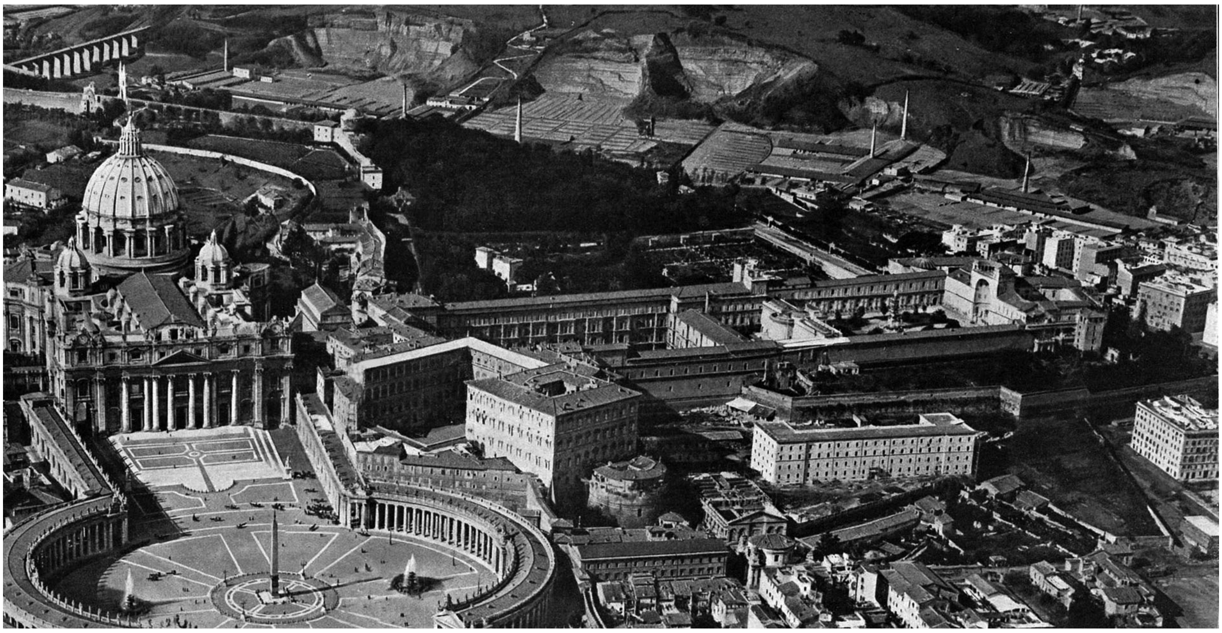

Figure 7. The clay quarries still visible behind the basilica of St. Peter in 1911 were active between the mid-1800s and the 1930s. Clay was used for brick production, which is emphasized by the presence of furnaces whose chimneys are visible in the picture (Insolera, 1985). These quarries have been mapped as abandoned quarries (see the Main Map).

upon the original landform, in 'filling material covering' (a) an ancient valley (Figure 5), (b) an abandoned quarry (Figure 7) and (c) a previous anthropogenic excavation due to building activity or other purposes.

A special case of man-made deposit is the anthropogenic deposit over 15 m high on the previous flat top of Palatino Hill (Di Luzio, Bianchi Fasani, & Bretschneider, 2013). This deposit causes a landform similar to the previous one: a Middle Pleistocene alluvial terrace, today completely hidden by human activity.

Finally, between the man-made landforms, the ancient Roman walls and related moats (buried or not) were also mapped, and now form monumental features characteristic of Rome's landscape.

5. Conclusion

The geomorphological survey carried out over several years in Rome allowed the description of the geomorphological evolution of the study area. The ancient *Caput Mundi* (Capital of the World) includes many well-known historical and cultural sites, but also peculiar geomorphological features and typical natural landscapes.

The survey resulted in a geomorphological map of the city, which aimed at highlighting the connections between the area's history, urban planning and geomorphological processes. The peculiarity of the analysed territory, affected by continuous man-made changes over the last 3000 years, has forced the authors to develop innovative solutions to undertake the analysis of the urban environment as well as their cartographic representation. The analysis of the urban environment required a method for integrating survey data, historical aerial photos and maps and archaeological as well as geological, geothematic and geomorphological literature. The methodological proposal contributes to a national (Lucchetti & Giardino, 2015) and international (Rodrigues, Machado, & Freire, 2011) approach to urban environmental analysis. The legend concerning anthropogenic landforms has required remarkable additions when compared to the current standards, as the symbology derives from the analysis conducted in this heavily urbanized area. The results obtained highlight a significant landscape transformation.

To conclude, it can be stated that this is the first reconstruction of the geomorphological characteristics of the whole historical centre of Rome. The Main Map will also be useful for urban planning and archaeological research. The landform inventory, including landslides and floods, has additional and potentially useful implications for hazard zonation.

Software

Esri ArcGIS was used to create the original geodatabase and to produce the Main Map, including improving the map graphics and adding the extra data and figures on the map.

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ORCID

Maurizio Del Monte http://orcid.org/0000-0002-9564-3548
Alessia Pica http://orcid.org/0000-0003-2877-1619
Francesca Vergari http://orcid.org/0000-0002-5552-0797

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