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SCIENCE

Geo-archaeology of the Roman palaeosurface of *Sena Gallica* (Senigallia, Italy)

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ABSTRACT
Sena Gallica (Senigallia), in the northern Marche region, was the first Roman colony on the Adriatic coast founded at the beginning of the third century BC. This research adopted an integrated approach to different information sources that combines old and new data, archaeological excavations, topographic and geophysical surveys, and geological and geomorphological analyses. The data are managed within a GIS and supported by 3D modelling. One of the results of this work is a map which represents the geomorphological setting of the Roman colony, close to the mouth of the Misa river. The settlement exploited the top-surface of the uppermost Pleistocene–early Holocene coastal fan of the Misa river, now only preserved at the apex sector truncated seaward by wave erosion. The top-surface of the fan apex, in turn, was partly re-incised by stream erosion producing a series of slight topographic mounds, which were selected for the earliest human settlement (V-IV c. BC). Some of the mounds resulted in a protected, slightly elevated, area enclosed by the meandering course of the Misa River and the Sant'Angelo/Penna streams, where the Romans decided to found their colony (284 BC). The tight interaction between human activities and the natural environment has always influenced the development of the town, from the earliest phases to the modern age. This map focuses on the time when the Roman colony was founded, but the combined study in progress allows understanding of the main transformations that occurred during the following centuries.

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Roman palaeosurface; Sena Gallica; alluvial fan; geo-archaeology

1. Introduction

A stratified cultural heritage spanning the last 2500 years is buried beneath the modern town of Senigallia (the Roman *Sena Gallica*) close to the mouth of the Misa river. On this site, where a Celtic population was already living (De Donatis et al., 2012; Lepore & Silani, 2013; Ortolani & Alfieri, 1978; Stefanini, 1991), the Romans established their first colony exploiting a favourable topographic configuration consisting of mounds surrounded by streams, the sea and marshy depressions.

In 2010 the *Senigallia Urban Archaeological Project* was born, promoting the collaboration between the University of Bologna (DiSCi – Department of History and Culture, Section of Archaeology), Soprintendenza per i Beni Archeologici delle Marche, Municipality of Senigallia and the University of Urbino (DiSTeVA – Department of Earth, Life and Environmental Sciences).

Within this project, new multidisciplinary archaeological and geological studies started, providing innovative clues about the evolution of this area, and highlighting strong relationships and mutual influences between natural processes and human activity. Indeed, the archaeological and geological data-set stresses some features of the urban tissue of *Sena Gallica* both constrained by palaeomorphology and/or partly modified by human intervention in Roman times.

In this context, our work focused on reconstructing the natural environment when the Romans settled in this area (284 BC). The map of the Roman palaeosoil (Main Map) is the palaeotopographic reconstruction of the archaeological surface dated 2300 years BP, as attested by archaeological findings (Lepore, 2014; Salvini, 2003). The map's objective is to display, by means of contour lines and shaded relief, the rather irregular natural palaeomorphology of the site and also highlight some traits of the relict hydrographic pattern of the Misa and Sant'Angelo/Penna streams and the position of the Roman coastline.

2. Data and methods

The construction of the geo-archaeological map required the collation of a wide range of data sources, through a combined archaeological–geological–geomorphological approach with continuous feedback among the different data-sets (see the Data Set Map in the upper left corner of the Main Map). These include historical sources (written records, cartographies and maps, historical photos) as well as information from archaeological excavations both

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unpublished and published (Lepore, 2014; Salvini, 2003), hand and mechanical probings, systematic topographic surveys and geophysical prospecting (integrating resistivity, seismic, ground penetrating radar and electromagnetic techniques).

The probings represent important data-sets, which significantly augmented the preliminary desk-based assessment. As a whole, 21 hand probings, 86 mechanical continuous probings and 30 standard penetration tests have been carried out and used in the present research. In particular, the hand probings were accomplished by archaeologists mainly within the cellars of modern buildings, in order to reach greater depths or, in some cases, to validate the results of the geophysical surveys.

The stratigraphic information was entered into a geographic information system (GIS) database linked to the Regional Technical Map of the Marche Region (scale 1:2,000), based upon heights above the present sea level. The data-set analysis and interpretation allowed identification of a stratigraphic level consisting of homogeneous, compact and plastic clay, dark brown in colour (with frequent coal remains) at the top, overlying greyish silty–clayey to sandy alluvial sediments. This level, identified as a palaeosoil and supplemented by archaeological findings, demonstrates the earliest Roman presence (third century BC) on the site, and is therefore regarded as the reference height for the first settlement's activities by the Roman colonists. The same layer was further recognised and characterised within archaeological digs carried out between 2011 and 2014 in several areas of the modern town, where it was also identified by geophysical prospection (resistivity and seismic techniques).

The GIS-based analysis allowed modelling of the Roman palaeosurface (hereafter called simply 'palaeosurface)' which has been reconstructed in terms of morphology and altitude as a DSM (digital surface model). Specifically, the DSM was obtained by subtracting all the depths related to the first Roman period from the ground level. Consequently, the heights of the palaeosurface with respect to present sea level were calculated.

The current sea level is also presented as it allows an immediate visual comparison with the modern topography. In this respect, it is worth emphasising that, in the whole north-Marche area, where the study area sets, since Roman times relative sea level (combining eustatic, isostatic, tectonic components) has experienced minimal variation (Antonioli et al., 2009; Lambeck, Antonioli, Purcell, & Silenzi, 2004) despite a notable sedimentary seaward shifting of the shoreline.

The adopted 'total approach' led to the combined use of a wide range of non-invasive geophysical survey methods. For the ground penetrating radar (GPR) mapping, an IDS RIS MF Hi-Mod 1 system was widely employed, equipped with a dual frequency 600–200 MHz array antenna. The seismic prospection was carried out using a SARA Electronic Instruments SR04 EDUGEO seismograph, while the resistivity surveys were achieved with a resistivity meter with a 72 multi-electrodes. Although not entirely suitable for urban areas, a geomagnetic technique was also tested; a GEM Systems GSMP-35 optical potassium magnetometer-gradiometer integrated, in some cases, with a GSSI EMP-400 profiler multi-frequency electromagnetic system was used.

Within the integrated analysis, geotechnical tests and geophysics played a relevant role in interpreting the archaeological deposits and natural setting on which the town was founded. GPR has been widely used for mapping streets, squares and buildings of the modern town, providing information on the buried stratigraphy and favouring the discovery of buried structures and infrastructure (as in the case of via Baroccio). Resistivity and seismic systems support the description of the natural morphology, including the palaeomeandering of the Misa River and the detection of the ancient coastline.

As an urban historical context, the *Senigallia Urban Archaeological Project* acquires relevance from a methodological perspective in terms of 'preventive archaeology' in a living town. In effect, in this kind of environment the importance of the evaluative process is unquestionable but is more complex than in a rural context. Urban deposits are unfortunately not usually susceptible to geophysical or electronic surveys; however, working in a living historic town provides others favourable conditions not often available in the countryside, as the existence of a collective historical memory and the work of modern contractors that can be collated and form important contributions to the map of underground deposits (Carver, 2009, pp. 347–356). The operations carried on within the presented project perfectly fit this condition and so support the use of geophysical techniques alongside other data sources. In our case, the preliminary geophysical surveys demonstrated the 'quality' of the deposits, in terms of their depth and preservation, but at the same time underlined the limits of the non-invasive techniques for analysing a living historic town, with complex stratification. Data interpretation needs to be integrated with a deeper historical knowledge of the urban site, which considers the most recent urban history, possibly augmented with geotechnical surveys and stratigraphic inspection. Among current projects of archaeological impact assessment in urban environments, the London Crossrail project (http://www.crossrail.co.uk/) exemplifies this integrated approach. In Italy, relevant experience of urban archaeology was demonstrated at Pavia (Hudson, 1981) and, more recently, in Pisa (Anichini, Fabiani, Gattiglia, & Gualandi, 2012), in both cases starting from the integration of many different data-sets.

Data analysis was performed using Esri ArcGIS 10.2. Depth data represented by points (probings) or 3D polylines (sections) were interpolated using the algorithm 'Topo to Raster' within the ArcGIS toolbox. This is an iterative interpolation technique specifically designed for modelling the morphometry (Allen, Green, & Zubrow, 1990).

3. Map description

The map of the palaeosurface (Main Map) shows an irregular morphology consisting of slight mounds and depressions confined between the two main incisions of the Misa river (arrowed blue line) in the northern and western sectors and by the Penna stream (arrowed violet line) in the southeastern area. The streams (arrowed lines) are interpreted with different positions according to both their relative dimensions (Misa channel diversion) and the changing morphology (S. Angelo-Penna channels). The sharp deepening of the palaeosurface to the northeast indicates the Roman coastline (dotted blue line).

The irregular topography between the Misa and Penna courses can be interpreted as the result of a rather complex, polyphase geomorphologic evolution starting from a former low-relief coastal fan formed in the uppermost Pleistocene–early Holocene at the Misa river-mouth. Nesci, Savelli, and Troiani (2008) and Calderoni et al. (2010) highlighted the presence of relict fans at the north-Marche river-mouths and outlined their geomorphologic characteristics and evolution. Troiani and Della Seta (2011), by means of geostatistical topographic reconstructions, constrained the former extent and relief of the same fans. According to Nesci, Savelli, and Troiani (2012), the low-grade convexity of the Misa fan depends on fine-grained sediment supply which, in turn, accounts for the predominance of pelitic units within the hydrographic basin. Like other north-Marche coastal fans, the Misa fan was largely dismantled by wave erosion during the Holocene sea-level rise, and is today preserved at its apex only, which roughly corresponds to the position of the Roman settlement of *Sena Gallica*. The preserved fan apex terminates seaward against fairly low wave-cut scarps, which attest to the partial erosion of the primary fan; the low height of the scarp, in turn, directly relates to the low relief of the Misa fan. The overall position of the scarps is related to the Holocene maximum marine ingression (roughly 3–5 ky BP). Minor oscillations of the shoreline occurred during the relatively long period from the maximum flooding to the Roman settling, and most likely accounted for lesser modifications of the scarp itself as well as the local development of multiple seaward-facing escarpments. Regardless of such minor remoulding, several authors attest to the position of the 'Roman shoreline' based on both geomorphological and archaeological evidence (Coltorti, 1991, 1997; Curzi & Tonnarelli, 1991; Dall'Aglio, 1991; Elmi, Fanucci, Nesci, Beer, & Pignocchi, 1994; Elmi, Colantoni, Gabbianelli, & Nesci, 2001). At present, throughout the north-Marche area, except for two actively retreating rock cliffs (Colantoni, Mencucci, & Nesci, 2004), a 500 to more than 1000 m-wide sedimentary coastal plain separates the preserved fan apex and related wave-cut scarps from the shoreline.

The surface of the fan-apex sector, preserved by wave erosion, has been partly dissected by both the Misa river and other minor channels, also favoured by the low fan-relief. A topography characterised by mounds (preserved patches of the previous fan), separated by depressions (abandoned and active channels) thus developed behind the seaward-facing wave-cut scarps. Specifically, such complexity is relevant for explaining both the buried scarp shown in the *Interpreted Roman urban plan* (dotted black line with triangles) and the subsurface palaeosurface topography northeastwards of the same scarp. Despite its low-relief, some minor streams developed across the seaward, wave-cut margin of the fan. According to the evolution model proposed for the northernmost Metauro river-mouth (Nesci et al., 2008), they lengthened upslope by headward incision, further dissecting the fan apex to form the paths where both natural and anthropogenic causes will subsequently drive the S. Angelo and Penna channels. Similarly, some minor channels starting from the Misa banks could lengthen onto the fan apex, further contributing to shape the irregular topography beneath and around the settlement area.

Such geomorphological change, achieved in the uppermost Pleistocene–early Holocene, necessarily influenced the human settlement choices both for the former pre-Roman occupation and, then, for the Roman colony (Silani, 2015). In fact, the site was naturally defended by stream channels, close to the seashore and was also suitable as a harbour as the Misa river-mouth was likely open seawards and relatively deep (Coltorti, 1991, 1997).

The *interpreted Roman urban plan*, see the Main Map (lower left corner), blending the archaeological data with geomorphological insights, presents a schematic reconstruction of the first planning layout of the Roman colony of *Sena Gallica.* The recent archaeological discovery of a pre-Roman domestic building (V-IV c. BC) in Via Cavallotti, which attests a hitherto unknown human occupation which pre-dates the foundation of the Roman colony, appears perfectly coherent with the palaeosurface topography displayed by the map. Indeed, it is placed on a slight mound of the coastal fan facing to the west on the external bank of a Misa river meander and protected against modification of the shoreline (Lepore, Ciuccarelli, et al., 2012).

Similarly, the earliest Roman occupation (beginning of the third century BC, prior to the colony foundation) attested by the new archaeological digs in Via Baroccio, opted for a former low-relief mound in the southwestern part of the dissected fan, within an area not settled before. This first occupation took the shape of a *subdivo* sanctuary, which was intentionally based on a strategic position, not only for its height, but also because this point was the only one accessible by land, probably exploiting a pre-existing road axis (Lepore, de Marinis, Belfiori, Boschi, & Silani, 2012).

Also the urban walls, built by the Romans when the colony was founded (284 BC) and attested by the archaeological excavation in via Baroccio, fit with the geomorphological reconstruction of the area, exploiting a defensive element of the Misa river or, as in the case of the Penna stream, partially modifying the natural hydrographic pattern. During this first phase, the eastern side of the colony was probably naturally fortified by the sea (Lepore, 2012).

The former irregular morphology was progressively flattened and adapted to the needs of an earlier urban plan, as revealed by the land reclamation works attested by the investigation under the theatre 'La Fenice' (Figure 1) (Lepore, Mandolini, Silani, Belfiori, & Galazzi, 2014).

The buried scarp (dotted black line with triangles in the *Interpreted Roman urban plan*) see the Main Map, lower left corner, reconstructed by geomorphological and geophysical surveys (Figure 2), allows us to hypothesise that, in the earliest phase of the colony, the urban layout extended up to this natural boundary. Today this scarp is roughly retraced by the main street of the modern city, Corso 2 Giugno. Further confirmation is the relative lack of archaeological evidence dating between the third and second centuries BC, over which, instead, the early medieval and medieval city was settled. The discovery of an *in situ* boundary stone/altar under the sixteenth-century Rocca Roveresca represents an important sacred sign of the boundary between urbanised and natural space and that presumably matched the seaward termination of the coastal hinterland at that time. Moreover, the irregular morphology displayed by the map permits us to recognise the possible location of the Roman port, which, most likely, exploited the

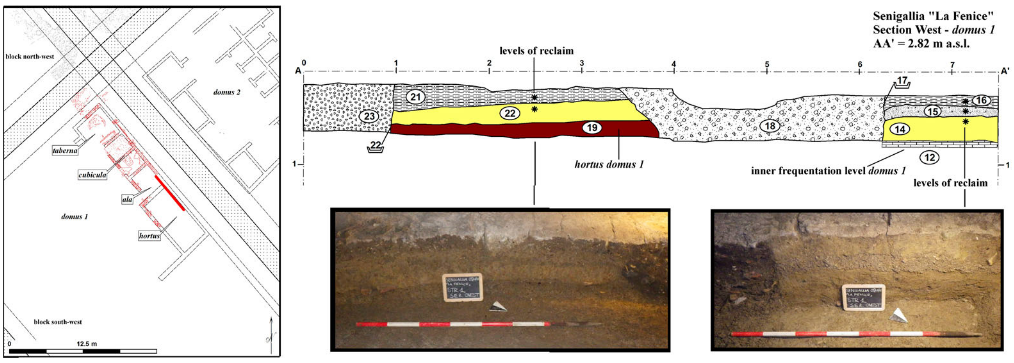

Figure 1. Archaeological excavations under the Theatre 'La Fenice'. (a) Map and location of the section (red line); (b) The section shows several levels of reclaim, achieved to prepare the area for building; (c) facies of reclaim.

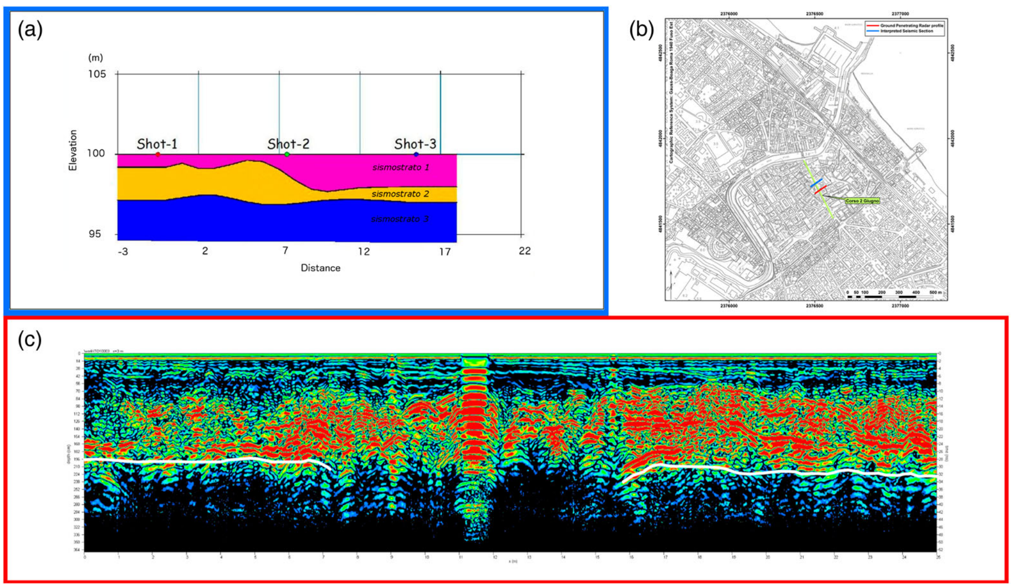

Figure 2. Geophysical survey in Corso 2 Giugno. (a) Map and profiles location; (b) Interpreted seismic section; (c) Ground Penetrating Radar profile. Both systems show a sharp deepening of the Roman palaeosoil in correspondence of the actual main street of the town, interpreted as a buried ancient scarp.

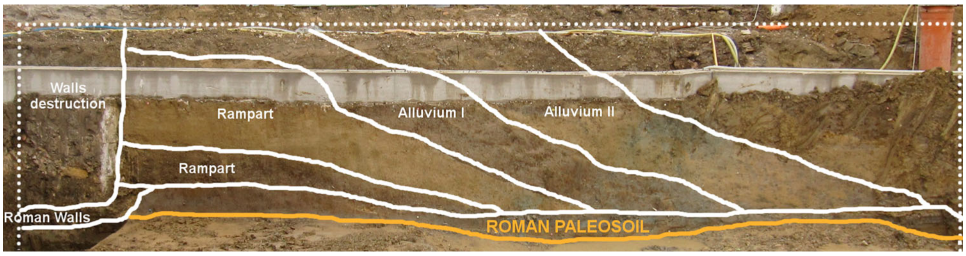

Figure 3. Archaeological dig at via Baroccio (north section). The Roman palaeosoil is clearly recognisable. It is also possible to distinguish the cut for the foundation of the walls of the colony, the relative ramparts and the alluvial deposits of the Misa river following the spoliation of the circuit wall.

outlet of an ancient diversion of the Misa channel within a small cove adjacent to the Misa river-mouth.

The close connection between human activity and geomorphology is also confirmed by evidence from the Middle Ages, when the dismantlement of the Roman circuit walls that bordered the Misa river caused subsequent floods within the urban area, as widely attested by the archaeological excavation in Via Baroccio (Figure 3).

4. Conclusions

The coupling of subsurface geological and geognostic data with evidence from archaeological excavations at *Sena Gallica* allowed both a detailed reconstruction of the Roman palaeosoil and the production of profiles (*Sections* Main Map. The position of the reconstructed sections is indicated on the Data Set Map.) displaying the vertical arrangement and distribution of post-Roman deposits.

The map of the Roman palaeosoil, besides stressing an irregular morphology, slightly undulating and dissected by relict channels, underscores the following important topics:

(1) The reconstructed Roman planned layout strictly depends on the palaeogeomorphology of the site.
(2) Important drainage modifications exploit pre-existing natural features (e.g. slight topographic depressions), in order to improve the defensive system of the urban area.
(3) The present main street (Corso 2 giugno) matches a buried scarp which represents the maximum expansion of the inhabited area when the colony was founded.
(4) Since the dismantling of the Roman walls in the Middle Ages left a large part of the urban territory defenceless against floods, post-Roman overflow events and related deposits combined with continuous human intervention caused the raising of the soil, thus leading to the present topography of the urban area (palaeosoil surfaces in *Sections*).

Given the wide range of information provided by the map, it can be used not only as a reference for further archaeological studies but also for detailed geological forward modelling (i.e. seismic microzoning). Moreover, in sites like Senigallia where natural hazards (e.g. floods and earthquakes) are high, information derived from this kind of map is of the utmost importance for land-use planning and risk assessment.

Software

The map was produced using Esri ArcGIS 10.2.

Disclosure statement

No potential conflict of interest was reported by the authors.

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