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LANDSCAPE VISUALISATION AND MODELLING

This paper is based on the experience gained in the 'Rome Transformed' project on the eastern Caelian Hill (Haynes, Liverani, Ravasi, Kay 2023). Our aim is to reconstruct the ancient and early medieval topography of the eastern Caelian hill, between the basilicas of S. Giovanni in Laterano and S. Croce in Gerusalemme, in order to understand the urban dynamics of an area crucial both for the interaction between the city and its suburbs, and for the transition between the classical and medieval city.

Compared to more circumscribed projects, we had to face a leap in scale, which implies the difficulty of managing an impressive amount of very heterogeneous data. In fact, it is necessary to integrate different approaches: stratigraphic excavations, architectural surveys, archival data – which, especially in the case of findings from the past, are not rigorously documented – historical cartography, non-invasive geognostic surveys – which have a much higher degree of approximation than an archaeological excavation and, especially in a modern city, are subject to interference and disturbance from more recent phases of life: think of tram lines, underground utilities and sewers. Finally, core drilling, carried out in the past for public and private works of various kinds, or by us specifically for archaeological research, is of great help and can also provide relevant data for paleoenvironmental studies.

Urban life may have significantly altered the geomorphology of the site, but this problem has not always been systematically addressed. We soon realised that a broad approach was needed, going beyond the documentation and visualisation of individual excavations, buildings or monuments. Rather, it is a matter of studying an area which, as such, poses particular problems. In this case, the detailed visualisation of the individual excavation site or building, although important, takes second place to the overall topographical understanding, the reconstruction of its historical evolution and urban dynamics.

It is therefore necessary to start from the palimpsest made up of the geomorphology of the area under study and its sometimes considerable modifications over the centuries. This palimpsest defines the 'conditions of existence' of the topographical and monumental articulation of the city and forms the substratum that directs and conditions all urban and monumental reconstructions, defining the frame of reference and the wider meaning of these transformations. It is therefore necessary to go beyond a purely two-dimensional topography, based solely on the analysis of plans, and instead to integrate the third dimension and thus the stratification of successive monumental and urban interventions.

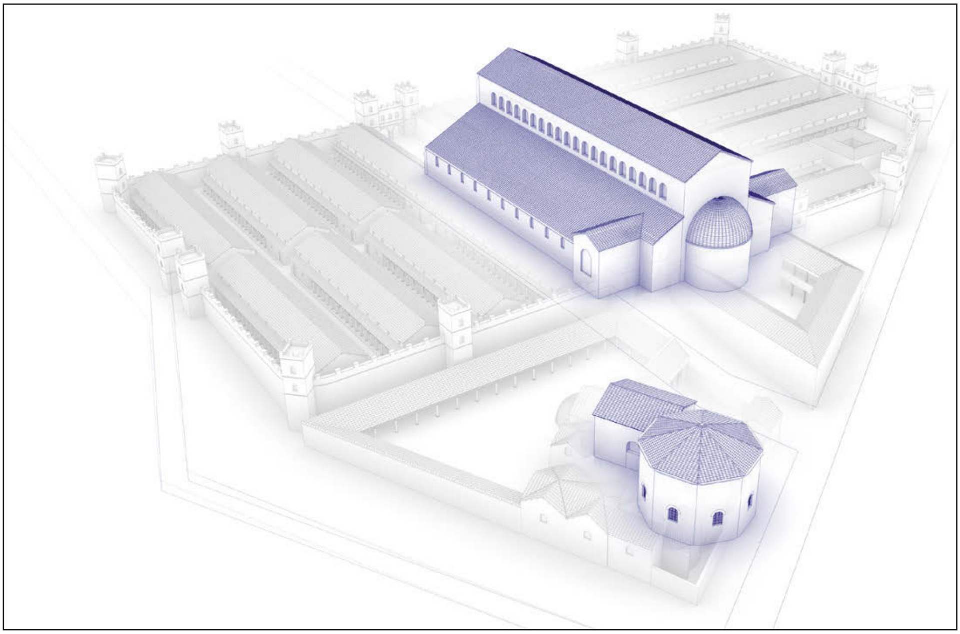

Fig. 1 – Project visualisation ('provocation') showing the Constantinian Basilica's spatial relationship to the *Castra Nova* that previously occupied the same site (Iwan Peverett and Ian Haynes, incorporating a visualisation of the Constantinian Basilica developed by Lex Bosman, Paolo Liverani, Iwan Peverett & Ian Haynes, and work on the baths/Baptistery by Thea Ravasi).

In order to understand the significant relationships between the various urban elements, it is not enough to reconstruct the topography at a specific historical moment, but it is necessary to follow its diachronic evolution in order to identify the constraints that the earliest phases impose on the later ones. A simple example in the Lateran area is the succession between the Severan phase of the *Castra Nova* of the *Equites Singulares* with the adjacent baths and the Constantinian phase of the Lateran Basilica with its Baptistery. The position of the Baptistery, behind the Basilica and 6 m lower, would remain incomprehensible if one did not take into account, on the one hand, that the Baptistery used the Baths – probably linked to the *Castra Nova* – and, on the other hand, that during the Easter liturgy the celebrant with the catechumens, leaving the Basilica for the Baptistery, walked along what in the Severan period was the external continuation of the *Via Principalis* of the *Castra Nova* (Fig. 1).

There are many cases where the reconstruction of the orography and its evolution can radically change our ideas. In our area, for example, we know that the Caelian Hill has undergone profound changes since ancient

Fig. 2 – Paolo Anesi, *View of the Lateran from East* (oil on canvas, 18th cent.), Diocesan Museum of Milan.

times. We need only think of the construction of the Aurelian Wall, which resulted in the damming of a valley, with problems for the drainage of the water and important consequences for the stability of the wall itself. Downstream, in the area of the watercourse that flows under the Lateran, known as the Marrana, there was considerable silting up, as can be seen from the difference in level between Aurelian's and Honorius's Asinaria Gate, and as confirmed by the underground excavations just outside the walls. Other serious interventions were carried out in modern times, with the levelling of Mount Cipollaro, SW of S. Croce in Gerusalemme, and the alteration of the slopes of piazza S. Giovanni, which at the beginning of the 18th century was still marked by an abrupt drop in height caused by the substructures of the *triclinium* of Pope Leo III, as can be seen in the views of the time (Fig. 2). Finally, in modern times, large quantities of topsoil were dumped behind the Aurelian Wall, only partially removed in recent years for conservation reasons.

For an accurate reconstruction of this complex history, it is necessary to develop a methodology that does not rely on rough intuitions, but that defines a uniform procedure for the entire area of investigation. Hence the need for an environment in which it is possible to incorporate evidence of a very heterogeneous nature, as I mentioned at the beginning. This environment must be structured in such a way as to be able to provide data in accordance with the FAIR principles (Findable, Accessible, Interoperable and Reusable) and to

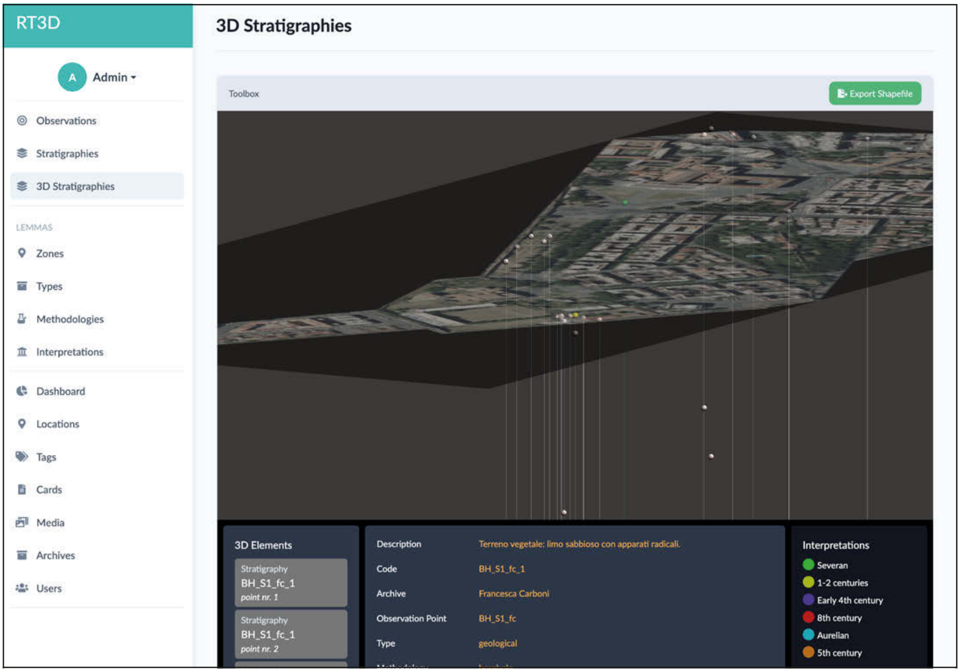

Fig. 3 – The RT3D environment.

constitute a working tool capable of gradually integrating new acquisitions in a dynamic manner. To meet these requirements, Margherita Azzari, together with Vincenzo Bologna and the LabGEO laboratory team in the department SAGAS, developed a software solution and created a tool capable of managing stratigraphic data. The first generation of this tool was called RT3D (‘Rome Transformed 3D’) (Bologna, Azzari 2023) (Fig. 3).

It is an open software, built on open libraries. RT3D makes it possible to collect and compare data obtained from different surveying methods and to retrieve geometric information to be translated into entities (points, lines, polygons) that can be managed in a GIS environment to generate Digital Terrain Models (DTM) (Fig. 4). Data input is performed using batch tools capable of processing large volumes of data. Import scripts load datasets based on an Excel (XLS, XLSX) or CSV structure whose fields have been defined considering the specific characteristics of each data acquisition and storage mode adopted by the different project teams. After software processing and validation, data can be exported as ArcGIS shapefiles and processed in a 3D GIS environment. Information from literature, archival sources, historical cartographies, excavation reports, structural analysis and non-invasive surveys

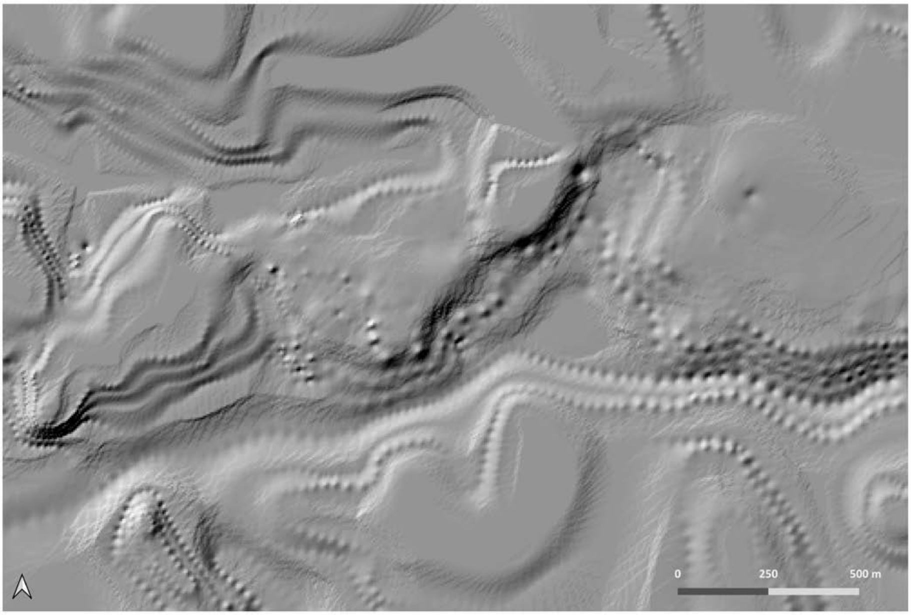

Fig. 4 – Digital Terrain Model of the study area during the Severan period. Reconstructive hypothesis based on data from literary and archival sources, historical cartographies, structural analysis and non-invasive surveys. The image shows the surface generated using the Inverse Distance Weighted (IDW) interpolation method, which allowed the z-values of the fiducial points to be preserved, before the final smoothing operation.

can be processed. Each layer produced by a GPR survey, for example, can be represented by a raster in which anomalies are displayed using a colour scale based on the Mhz response of the anomalies detected by the instrument. Each layer can be exported in .dat format, representing each point with its x,y,z coordinates and corresponding bandwidth in MHz. RT3D will import the points with a bandwidth considered significant for the generation of the phase DTMs. This data can then be compared with data from other sources in a 3D environment. This allows hypotheses to be formulated.

The imported data is converted into a GIS geometry called Multi-PointZ, which relates multiple PointZs to each other. This ensures that the roof and bed elevation information is maintained for each of the stratigraphic layers. In the 3D viewer, the data is visualised as points connected by segments, allowing the acquired element to be visually identified in three-dimensional space. The interpretation can be repeated for each individual point of a feature (borehole, stratigraphy, point cloud, etc.).

Fig. 5 – A 3D rendering of the Lateran area during the Severan period. The surface model was created using the IDW method in ArcGIS pro, then imported into ArcGIS City Engine and into Twinmotion for rendering. The building in the foreground was created using 3D Studio Max (Iwan Peverett & Thea Ravasi) and imported into Twinmotion.

Once the data interpretation is complete, the RT3D database points can be exported in ESRI shapefile format, which is compatible with all GIS processing programmes. The files can be imported directly into ArcGIS and contain not only the geometries but also the table with all the stratigraphic information. The spatial matrix generated in this way contains all the essential data entered the system to elaborate the interpretative hypotheses, and can be refined, modified and updated on the basis of further research and discoveries.

The methodology adopted for the creation of surfaces at different times involves the interpolation in a 3D GIS environment of a raster data set and data organised in shapefiles (Fig. 5). Each landscape component (translated into points, lines or polygons) must therefore be correctly geolocated (x, y, z). It is clear how the availability of many data from different sources, evenly distributed over the survey area, will allow the creation of a reliable model. The DTMs produced by the various methods (IDW, kriging, cokriging, spline, triangulation with linear interpolation, global and local polynomials, etc.) thus constitute documented hypotheses. In any case, they will be able to provide the basis for the visualisation of the topography of each of the macro-phases identified by the project, to support the historical-topographical reconstruction by integrating the 3D models of the buildings, infrastructures and environmental information into the visualisation, but they will also be valuable for communicating and disseminating the hypotheses and the scientific results.

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ABSTRACT

The contribution draws on the experience gained within the Rome Transformed project on the Eastern Caelian hill, reserving a with more general attention to problems of method. The spatial dimensions of the project pose problems including – but at the same time going beyond – those normally addressed for the visualization of individual surveyed structures. Two points seem crucial: 1) the transparency of metadata and paradata; 2) the tension between too much or too little prescriptive models or ontologies. Visualizing a territory poses peculiar problems; we have several examples in the past, but normally the reconstruction of ancient orography on which to place surveyed structures is not explicitly thematized. The territory imposes a leap in scale in the size and management of the data; forms the palimpsest on which to arrange the views of the individual sectors or structures into which it is divided; defines the 'conditions of existence' of topographical and monumental articulation; must consider the effects that older phases impose on later ones. Visualization of a territory is not only a way to present to the scientific community and the wider public in a concise manner the results achieved. Such an approach poses the need to work in an environment in which it is possible to progressively incorporate evidence of a very heterogeneous nature such as archival data, geognostic surveys of different types, surveys using traditional techniques or 3D scanning, and core drilling. The organisation of such heterogeneous data within a single software becomes essential for their subsequent processing. It was therefore necessary to design an application able to

manage in a single three-dimensional environment the data produced while maintaining the associated information (metadata and paradigms) in order to allow them to be compared and at the same time guaranteeing full interoperability with the GIS environments in which the modelling activity is carried out.