

DIGITAL MAPPING FOR ARCHAEOLOGICAL HERITAGE

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Abstract

This essay intends to show the results of a research about Phlegraean Fields, a large zone which extends to the west of the city of Naples, very important from an historical, archaeological and landscape point of view. Surveying and representation methods have been experimented which can read and effectively represent the complexity of areas characterized by the presence of archaeological sites. At the same time, the potential of the techniques of interactive representation including immersive shoots have been verified, with the goal of identifying new methods of spreading knowledge to enhance cultural assets.

Keywords

Archaeological heritage, range-based survey, image-based survey, digital mapping

1. The Phlegraean Fields

The area of *Phlegraean Fields* covers a large zone which extends to the west of the city of Naples, which has been characterized since antiquity by an intense volcanic activity.

Alongside the interest in its geological history, the area of *Phlegraean Fields* is particularly significant for the large number of testimonies of the history of ancient civilizations who settled there, first among all Cuma, the oldest colony of

Magna Graecia, around which an urban-territorial system of great importance developed, that included the port and the commercial city of Puteoli, the military ports of Lucrino and Capo Miseno, the system of imperial villas and Thermal baths of Baia.

To this day, an immense archaeological heritage has been preserved, distributed throughout the territory, which gives evidence of the richness of the civilizations that inhabited it and of the intense urbanization in past ages. This, together with the environmental and landscape aspects, gives form to a heritage which is unique in the world, an archaeological open-air museum that must be enhanced by cultural promotion founded on a project of knowledge.

The numerous archaeological remains distributed throughout the territory witness a prosperous past and the presence of rich civilizations, with their temples, public buildings, markets, villas, spas, amphitheatres, and numerous other buildings, since they were not only seats of important military centres and naval bases, but also areas for pleasure, as it has been handed down to us through many writings dating to the Roman era.



Fig. 1: Francesco Vega, Map of the Gulf of Pozzuoli with part of the Phlegraean Fields, 1770-1780, The National Library "Vittorio Emanuele III", Naples



Fig. 2: Phlegraean Fields, mapping of the archaeological sites of the whole area

All the archaeological sites of this area were mapped and catalogued, thanks to direct surveys, archive researches and consultation of previous studies. Each artifact was linked to data about its typology, its state of conservation and its accessibility, thus creating a database and a system of online cataloguing which can be entered by a web site, both for consulting and for input of data. In addition to the most significant archaeological sites, this research included the study and the analysis of minor archaeological remains, some of which were brought to light through recent excavation campaigns.

2. Cataloguing archaeological remains

All activities began by formalizing working relationships with the bodies in charge of protecting archaeological assets who operate on the territory, in particular with the offices of Cuma, Baia and Pozzuoli of the Superintendence for Archaeological Heritage of Naples, defining specific agreements to study the area as a whole, and later identifying which artefacts to survey,

depending on the need for specific detailed studies of the metric and constructive aspects.

In a first phase, the work of the research group focused on identifying the archaeological remains present on the territory, using direct onsite inspections, searching archives and consulting past studies.

Of fundamental importance was to compare the work with the documentation stored at the archives of the Superintendence for Archaeological Heritage which allowed to define an abacus structured on specific entries, in order to identify the recurrences present on the territory.

A specific symbol was identified for each entry, to make the connotation and localization of the single artefact readily visible and comprehensible within a larger map where the single presences have been progressively shown.

A different colour was established to indicate the specific condition in which the artefacts are found and specifically: above ground, earthed, submerged, not identified (where they were present in the archive catalogues, but not found within the context of the inspections), not

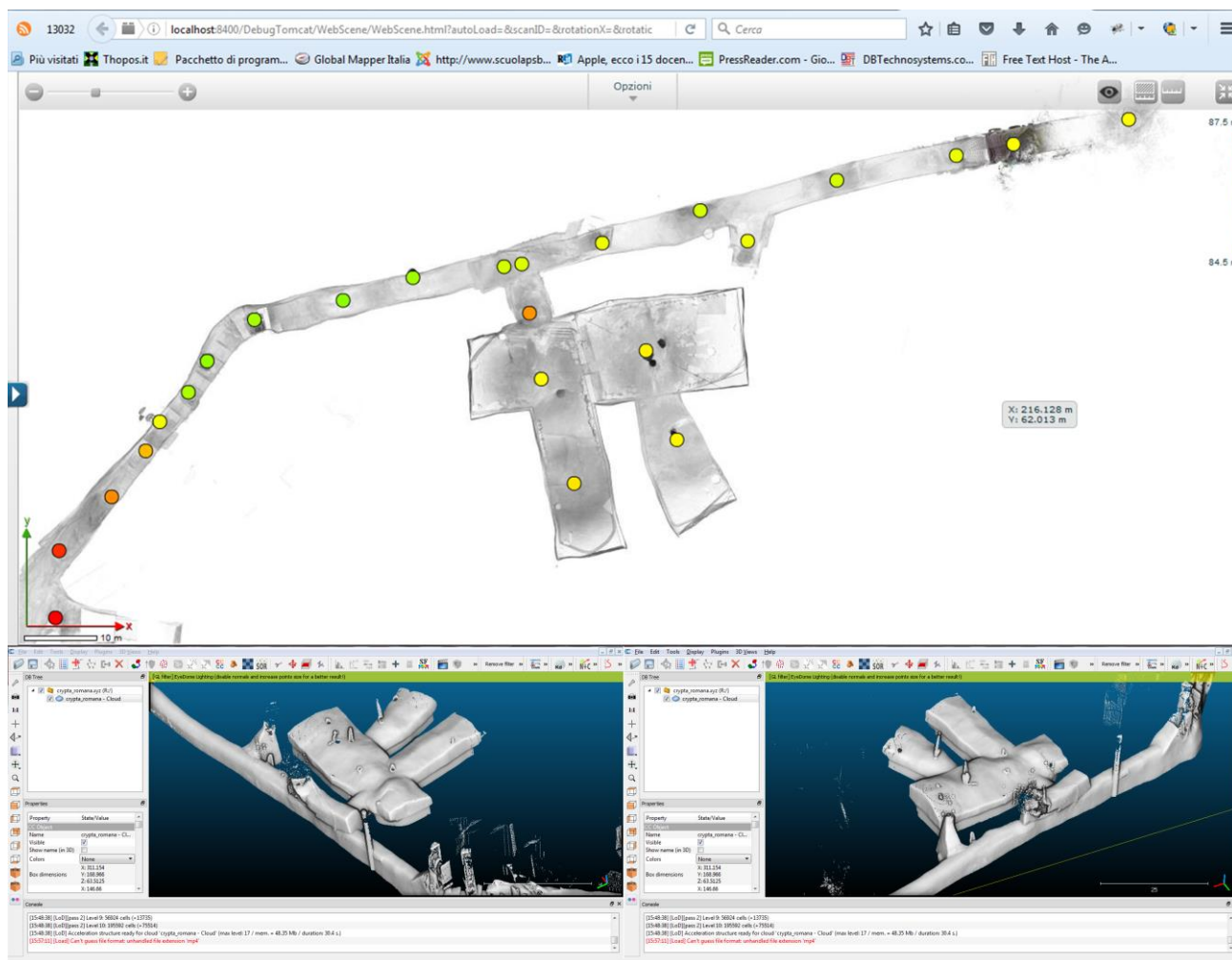


Fig. 3: Cuma, Phlegraean Fields. Roman crypt, visualization and processing achieved by using, respectively, Webshare and Cloudcompare software tools

catalogued (where they were identified on site, but not present in the archive catalogues). The accurate identification was associated to other symbols, relating to construction, to state of preservation and accessibility, differentiating the location into: full accessibility, public property or private property.

Starting from such preliminary analyses, this research became more thorough by surveying some archaeological sites of special interest, properly identified according to their specificity and location, and for which the documentation provided by the bodies responsible for their preservation was incomplete or even absent.

3. Range-based and image-based surveying

Direct and instrumental survey procedures have been used with specific reference to the

technologies with active and passive optical sensors, through a pipeline of the process during the phases of data acquisition and post-processing, by controlling techniques, methods and outputs.

Some criteria were identified to detect the tools to be used to evaluate the dimensions, the smallest detail, the lighting of the object to be examined and also the range of the different devices. The laser scanning data allowed to have dimensional values, to generate ortho-photos, to elaborate three-dimensional models, to extract textures and to produce spherical photos.

Spatial data and colour information allowed to analyse parts and elements of each sample, the quality of surfaces and materials of archaeological remains, thus giving further details.

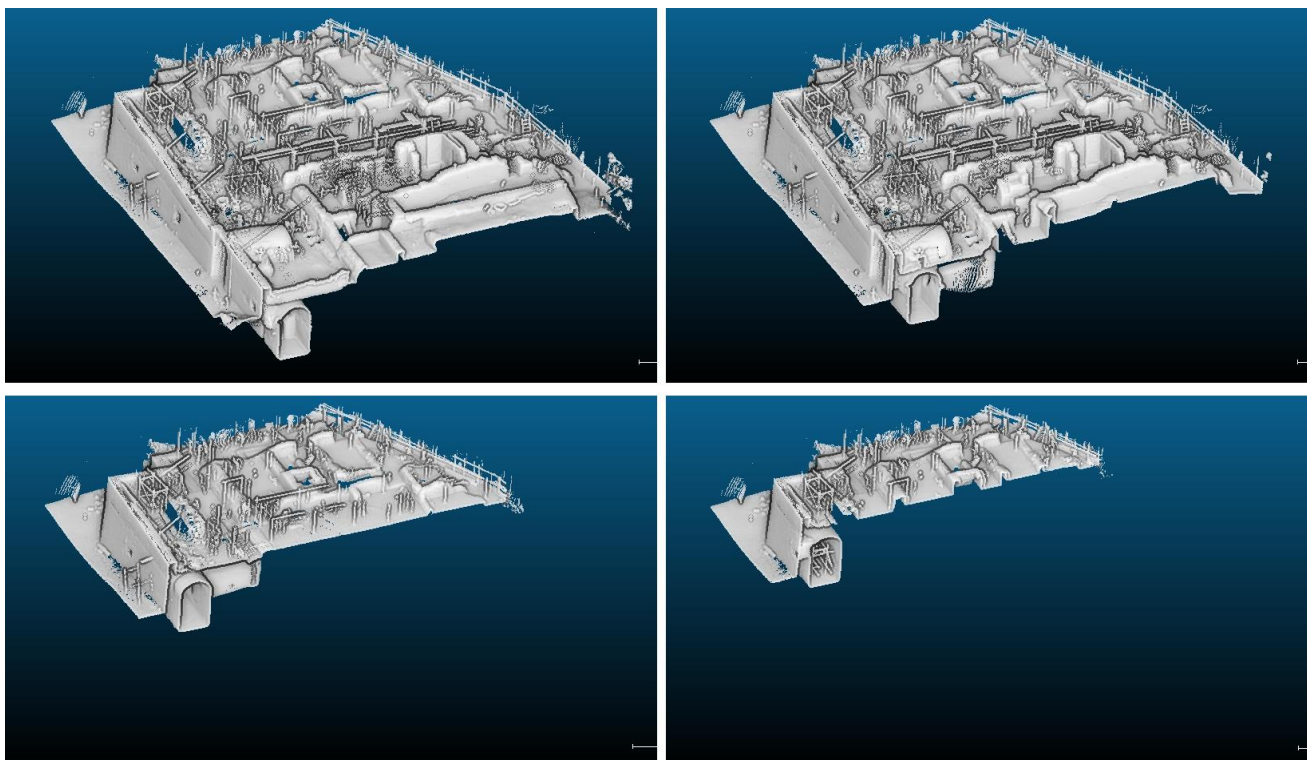


Fig. 4: Cuma, Phlegraean Fields. Roman villa, point cloud in *CloudCompare*

The research was carried out by a group of researchers of the Architecture Department and the Interdepartment Centre of Urban Eco Research of Naples University Federico II which for many years has been focusing on the study and documentation about architectural and archaeological heritage in Campania.

The study of *Phlegraean Fields* area included the survey of a Roman villa discovered near the Lake of Averno, located in a particularly significant position from the landscape point of view. Time returned a great part of its structure, except a portion collapsed in the underlying slope, and still today the hill on which it is located offers a wonderful view on what, in Roman age, was the ancient port and which changed into a lake after the eruption of Monte Nuovo.

This survey was performed in February 2013 under the supervision of Superintendence for Archaeological Heritage of Campania, by using a modulation laser scanner of CAM2 Focus3D phase which allowed to execute 50 scans for the survey of the above ground parts and of the underlying cisterns.

Since they were performed shortly after the end of the excavation of this artifact and before some safety works of structures, the metric investigations served as a documentary evidence

of the conditions of these places at the time of their discovery. In this sense, laser scanning was particularly suitable for producing a virtual cast of this villa, immediately allowing the necessary restoration and conservation works.

The results of this work and the comparison with similar exemplifications in the territory enabled to make assumptions about the artifact reconstruction. Furthermore the laser scanner allowed the three-dimensional reconstruction of underground spaces thanks to the reflectance values stored in the point clouds.

The same technology was used for the survey of Cuma Roman Crypt, a tunnel excavated in the tuff at the base of the Monte di Cuma with a west-east orientation and composed by four variously inclined straight sections, whose unusual profile was influenced by the presence of some spaces already existing at the time of its construction and by the need to create a direct connection between Cuma forum and the Portus Iulius.

The laser scanning was a particularly appropriate technology, considering the strong irregularity of the location which shows significant dimensional and morphological variations and does not allow any discretization according to recurring elements or recognizable geometries.

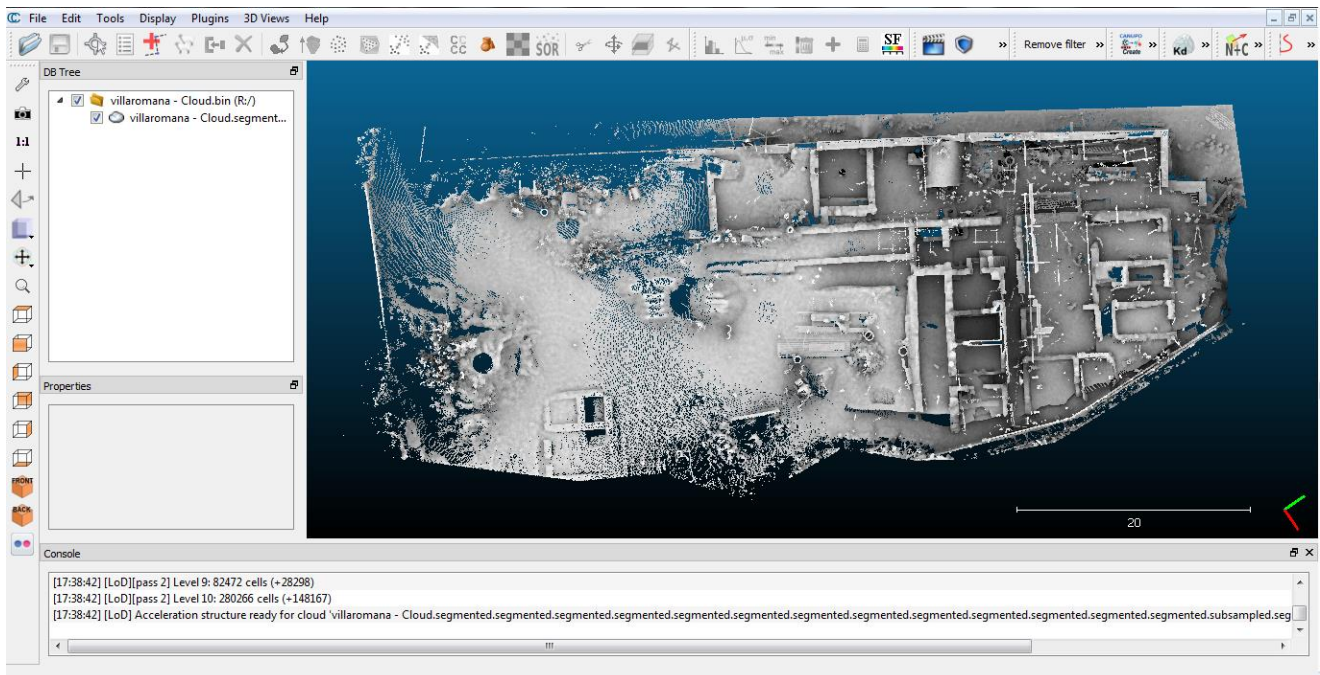


Fig. 5: Cuma, Phlegraean Fields. Roman villa, processing in *CloudCompare*

This route also showed remains of ancient places and two great cisterns of Roman time, as well as ruins of a cave basilica and early Christian tombs. It was possible to identify and register some skylights which effectively illuminate the space along the way and the areas of collapses taking place over the centuries.

For the survey of the Roman Crypt 36 scans were performed by using as a reference spherical and chessboard targets. Speed and pace of rotations have been previously set up by determining scanning resolution, that is the density of the grid of points observed at a certain distance and the quality of acquired data, typically higher for slower rotations. Therefore these two parameters also determined the duration of each single scan as equal to 7 minutes. During acquisition this instrument archived the distance and the horizontal and vertical angles of each point, also obtaining the reflectance of the surface hit by laser.

Scans have been subsequently registered in a single point cloud giving the real conformation of the space, allowing the complete digital reconstruction of this location and producing a new documentation of the condition of these places.

Since these are archaeological studies, particular care has been taken to representation phase, by giving the building materials of

surveyed spaces to different scales, focusing on the copy of all the tracks on surfaces.

Similarly, laser scanning was used for surveying two cisterns of Roman era located within the municipality of Bacoli between the Aragonese Castle and the port of Miseno, whose reading is strongly compromised by the presence of recent structures and whose remains have been overwhelmed over time by other buildings which have upset their original arrangement.

This survey was performed through 30 laser scans providing data of the whole artifact, whose processing allowed the representation of a 3D model able to illustrate the different periods of building and the virtual reconstruction of the original configuration.

In addition to these experiences, this research also deals with the study of other archaeological sites in Phlegrean area such as the Temple of Venus and the Temple of Diana in the archaeological park of Baia, the Cuma Acropolis, the ancient lighthouse of Capo Miseno, the infrastructures of port of Bacoli and many other significant artifacts such as the Arco Felice Vecchio, the monumental door which was the entry to Cuma, built in the I century A.C. to enable the passage of the via Domitiana through the monte Grillo.

For the survey of the Arco Felice Vecchio and considering the artifact dimension, the presence of a dense vegetation and the difficult terrain of

these places, a careful survey project was necessary to identify where targets had to be located.

At present the Arco has a high arch having on its top remains of other structures whose original form is documented in the drawings of the great travellers of the eighteenth century. In fact the *Phlegraean Fields* were one of the most important stages of the Grand Tour, because this territory offers singular attractions from the scientific and historical point of view and allows to see impressive natural phenomena caused by volcanic activity and, at the same time, to closely study important archaeological sites by documenting them through particularly interesting representations.

4. Mapping digital data

Acquired data were entered in an on-line system for remote use. In this respect, this work illustrates how to manage the Webshare application by Faro, configured after the Tomcat installation by Apache, to enable data

visualisation and virtual use of the detected space, by describing the ways of archiving the different scans and the methods for on-line access. This application allows to virtually investigate and visit surveyed areas, usable through panoramic views and overview maps. These products not only can be subject to verification and control procedures but also to measurements, thus obtaining an archive of information useful for further investigations. Effectiveness of panoramic views have been verified, by testing new methods for visualising and using collected data, able to effectively render the complexity of archaeological sites.

Therefore an interactive map (*Matchmed*) was created to give information at different levels, opening the way to new readings of these places, even through the comparison and the compared data reading.

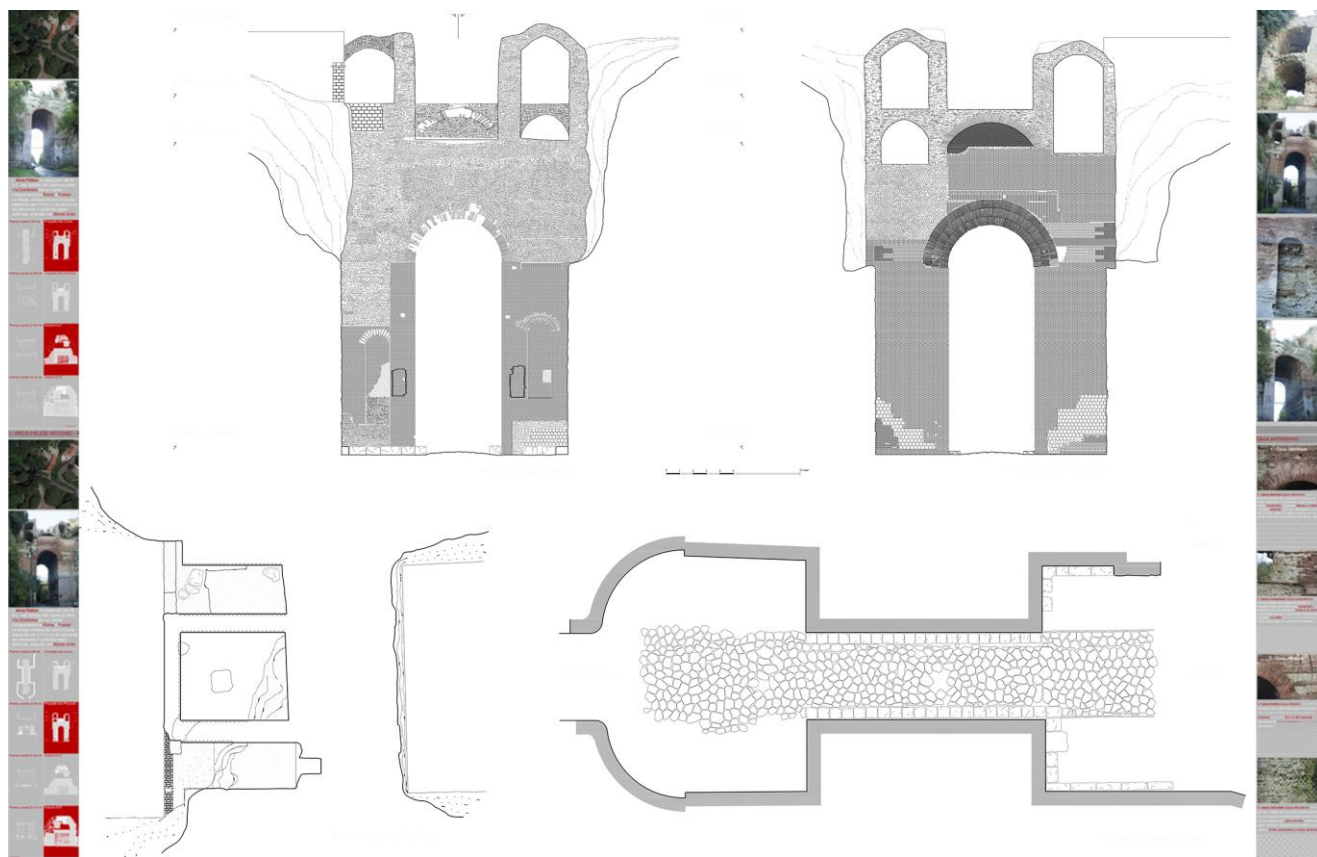


Fig. 6: Cuma, Arco Felice Vecchio, plan and sections. Drawings by Marcella Contiello. Thesis in Architectural survey: *Nuove metodologie per il rilievo del patrimonio archeologico: l'Arco Felice Vecchio a Pozzuoli*. Supervisors: Prof. Arch. R. Catuogno, Prof. Arch. A. di Luggo.

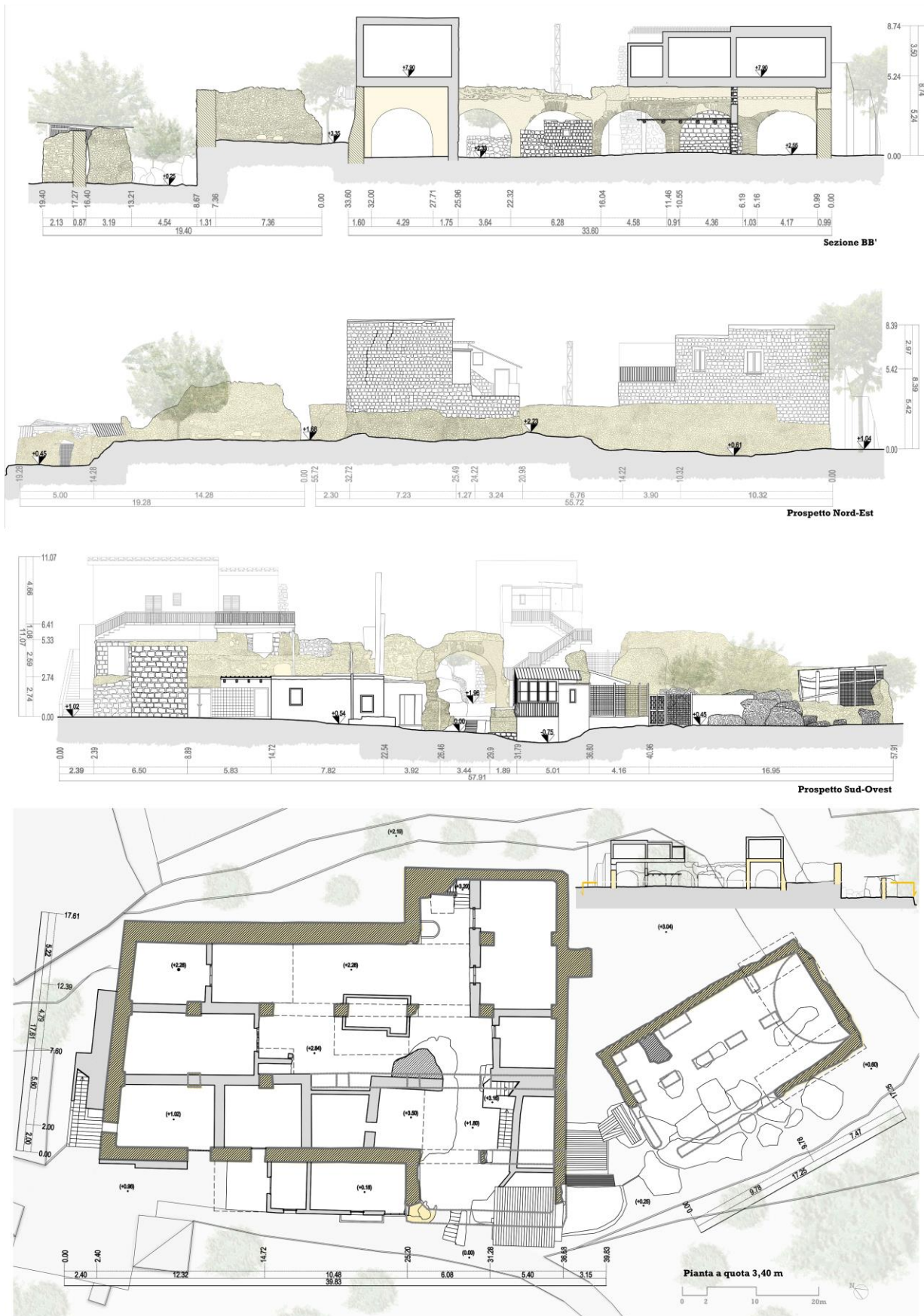


Fig. 7: Bacoli, Phlegraean Fields. Trippitello cisterns, plan and sections. Drawings by Jacopo Munzù. Thesis in Architectural survey: *Traces and signs of the past in the Phlegraean Fields. Laser scanner survey of Trippitello cisterns.* Supervisors: Prof. Arch. A. Lugo, Prof. Arch. R. Catuogno.

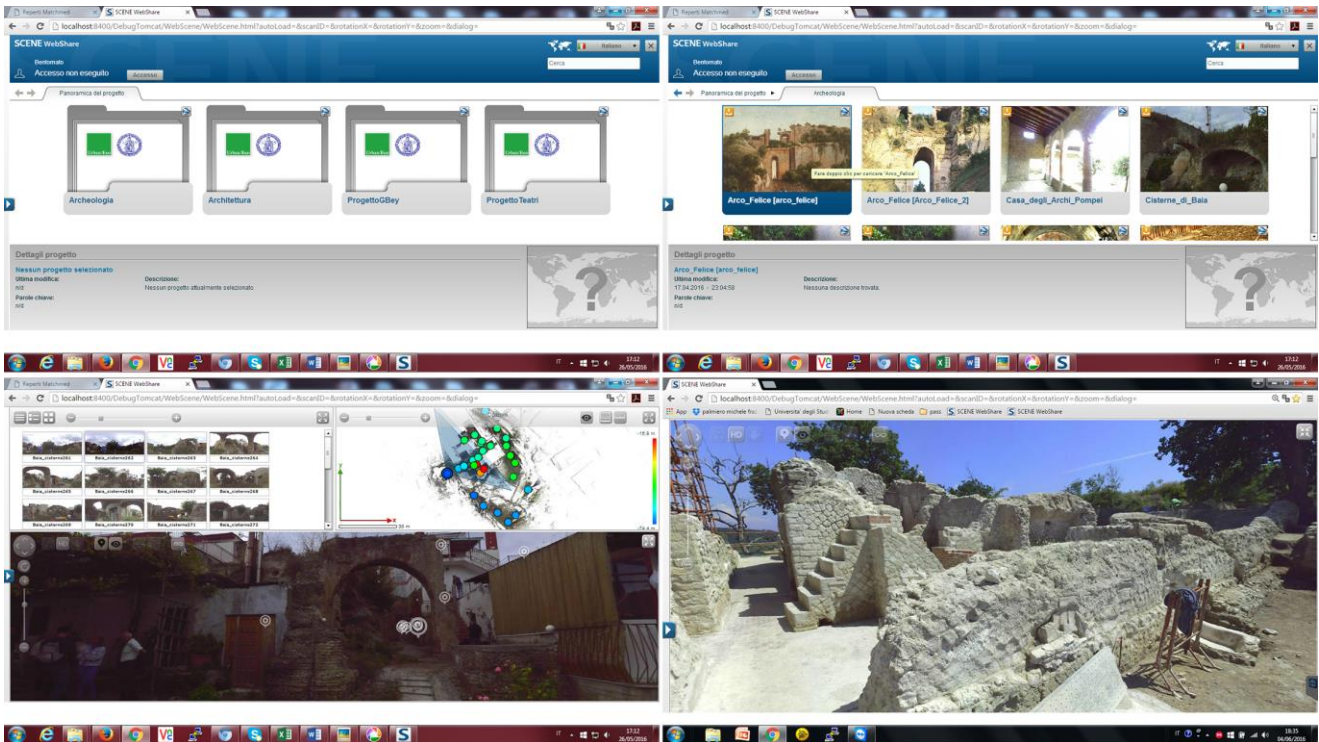


Fig. 8: WebShare screenshots about Trippitello cisterns (Bacoli) and Roman villa (Cuma)

The interactive map *Matchmed* is based on the computerized cataloguing of the surveyed sites, and data have been entered according to a previous recognition. This cataloguing uses specific symbols able to find the characteristics identifying each site. A sheet including identification data, geographic coordinates, photographic documentation and a short description was prepared for each site.

This system is based on the *Wordpress* platform (*CMS* open source), conveniently extended to implement the functional specifications. This platform allowed to create a *CRUD* (*Create, Read, Update, Delete*) and the modular nature of *Wordpress* enabled to develop specific plugin to manage the geolocation of finds, the export of information in Excel format and the presentation of multimedia content.

The *Matchmed* platform allows to browse within the study and to perform queries according to specific typologies of information such as pictures, videos and graphics, as well as according to tags such as state of conservation and accessibility.

It should be noted that not only this system allows to access previously entered information, but it is also open to further contributions, with different levels of accessibility, since it is a web-

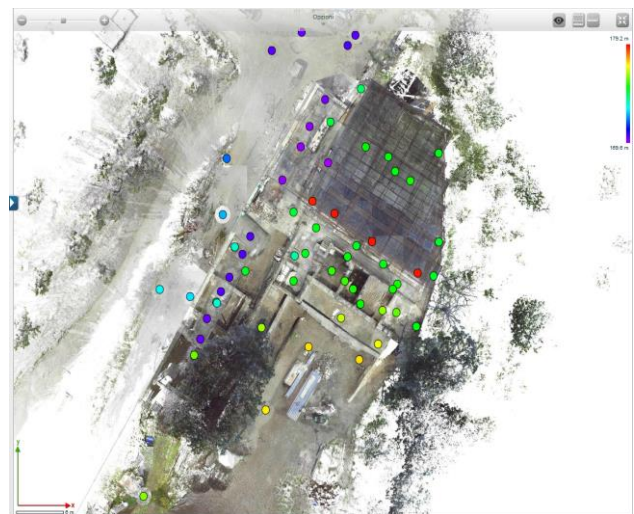


Fig. 9: WebShare screenshots about Roman villa (Cuma)

container site and an updatable over time database, with the possibility to enter additional data progressively through specific sheets.

It is possible to request a visualization on map of any kind of find and to obtain both geographic and graphic data for each find.

A further implementation is expected which allows an interaction with apps for mobile devices both for using and for entering data to be sent to server according to input, consultation and research formats.

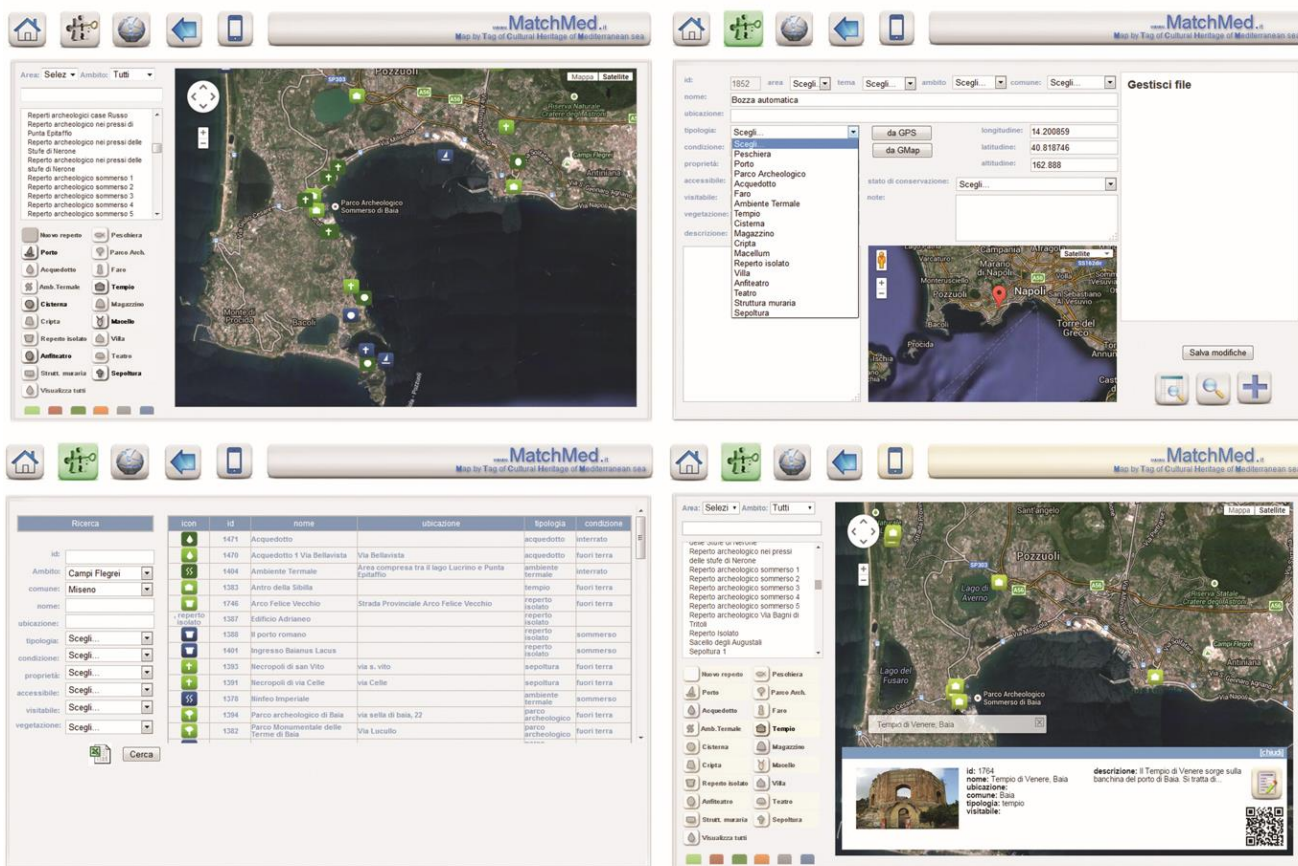


Fig. 10: Matchmed screenshots, mapping archaeological heritage in Phlegraean Fields

5. Conclusions

Spreading knowledge in Internet and introducing new methods of use of the archaeological assets can trigger an implicit process of growth and territorial promotion.

However, these actions must avail of the cross promotion of ideas between sectors, companies and individuals, starting with a creative action which requires tangible interaction between the players who work on the ground, to give life to a continuous process of construction of new knowledge.

In this sense, it is appropriate to combine innovation based on the conscious use of new technologies with the history of the places, focusing on a renewed method of “creating”

culture and on the awareness of the value of the cultural asset as a unifying element and catalyst, able to trigger a virtuous circle of territorial development.

What is necessary is a renewed way of becoming acquainted with the archaeological heritage of Phlegraean Fields and this is possible starting with its knowledge and spread in Internet, promoting an action which is aimed at identifying in it the strategic axis of a model of development. Culture has indeed an essential role to play since it is the depository of tacit knowledge, of the conventions and of the behavioural models which lie at the basis of what identifies a territory and can therefore generate richness and employment, with positive effects on the entire local community.

REFERENCES

- Bruno, F., Bruno, S., De Sensi, G., Luchi, M. L., Mancuso, S., & Muzzupappa, M. (2010). From 3D reconstruction to virtual reality: A complete methodology for digital archaeological exhibition. *Journal of Cultural Heritage*, 11(1), 42-49.
- di Luggo, A., Campi M., Catuogno R., & Zhao W. (2010). New applications of laser scanner survey in Architecture. In *Proceedings of The 2nd International Symposium on Architecture Heritage Preservation and Sustainable Development* (pp. 211-214). Tianjin, CN: AHPSD.
- di Luggo, A., & Catuogno. R., (2015). Innovazione della conoscenza e valorizzazione dei beni culturali. In Giovannini M., Arena M., Raffa P. (Eds.) *Costruzione di un Atlante del Patrimonio Culturale del Mediterraneo, Conoscenza, Comunicazione, Governance* (pp. 568-587). Napoli, IT: La Scuola di Pitagora editrice.
- Guttentag, D. A. (2010). Virtual reality: Applications and implications for tourism. *Tourism Management*, 31(5), 637-651.
- Migliari, R., (2002). *Frontiere del rilievo. Dalla matita alle scansioni 3D*. Roma, IT: Gangemi.
- Panvini, P., (1838). *Il Forestiere alle antichità e curiosità naturali di Pozzuoli, Cuma, Baia e Miseno*, Napoli, IT.
- Rua, H., & Alvito, P. (2011). Living the past: 3D models, virtual reality and game engines as tools for supporting archaeology and the reconstruction of cultural heritage—the case-study of the Roman villa of Casal de Freiria. *Journal of Archaeological Science*, 38(12), 3296-3308.