

The Salvennor Project

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Abstract – The integrated use of different methods of survey (photogrammetry, laser scanner 3D, geophysical survey) plays an important role in the Salvennor project (Sardinia). It is used to: outline the extension and, partially, the plan of the monastery related to the San Michele di Salvennor church, otherwise known solely from archive sources; analyse the walls and initiate a virtual reconstruction of the monastic complex; optimise excavation strategies.

Keywords – San Michele of Salvennor, geophysical survey, photogrammetry, laser scanner 3D, excavation.

I. INTRODUCTION (E.G.)

The Salvennor Project aims principally to reconstruct in the *long durée* the landscapes of the homonymous area, located in the territory of Ploaghe (Northern Sardinia: Fig. 1). Today its layout is characterised by the presence of four Medieval churches (San Michele, Sant’Antonio, Sant’Antimo and San Nicola), in close proximity to each other. This has been substantially compromised by works with a considerable environmental impact: a large power station, a main road and a sand quarry (Fig. 2). Thus the objective of the study is to trace a complete framework of this territory and to promote its valorization.

These “sacred markers” are essential indicators for studying population dynamics in the Medieval and highlighting the importance that this territory had at that time (perhaps due to its position and resources).

According to these considerations, besides the macro-scale analysis of the changes of the Salvennor landscape, we have also focussed our studies on San Michele church (Fig. 3). This Romanesque building is in fact a key-site to reconstruct the political-economic system of this territory in the Medieval. The church was related to an abbey, known by archive sources (such as a property register, the ‘condaghe’) [1]; it is composed of a nave and three absides, like the nearby abbey church of the SS. Trinità di Saccargia [2].

II. ARCHAEOLOGICAL DATA (E.G.)

The Salvennor project began in 2014 with archaeological

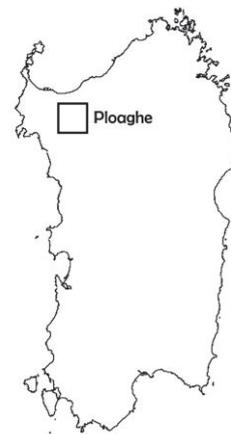


Fig. 1. Location of Ploaghe (SS)

and georadar surveys undertaken to outline the plan of the San Michele monastery.

The archaeological surveys were carried out also in the areas around the other Medieval churches mentioned above. They aimed to verify the extension of these sites and, in particular, possible traces of the Medieval village of Salvennor; this is known by the archive sources and it was presumably located among the churches already indicated.

Our goal was to highlight the presence of other evidence useful to reconstruct the settlement dynamics over time in these areas (Fig. 2).

The areas around the churches of Sant’Antonio and Sant’Antimo were surveyed for detecting the different building phases, as in particular the first one shows evident structural and plan changes.

Unfortunately, maybe for the low conditions of visibility, the archaeological surveys highlighted presence of materials (especially bricks and traces of mortar) only near the church of San Michele.

The GPR survey carried out at south of the church of San Michele allowed to us to recognize the plan of the cloister.

In 2016 excavation carried out to the south of the church confirmed the indications of the geophysical

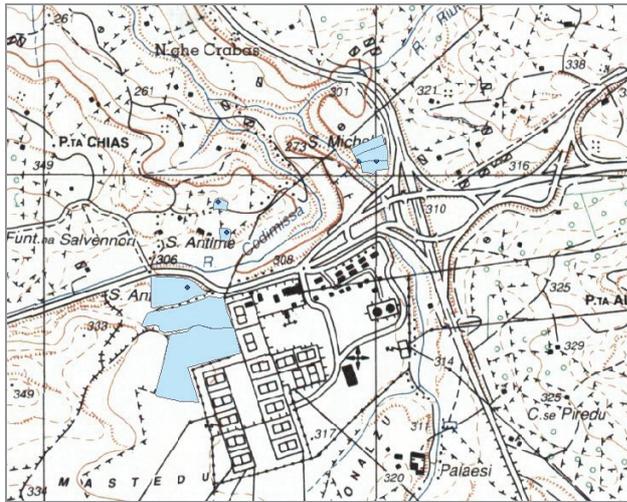


Fig. 2. Medieval churches in the Salvennor valley. The coloured areas were object of archaeological surveys.

surveys. The archaeological researches revealed some walls related to the cloister (the northern wall of the porch) and to other rooms of the monastery uncovered under the collapsed stones.

At the same time we completed the GPR surveys around the church and continued the 3D surveys.

The San Michele church was subject to considerable restoration over time, which hinders the stratigraphic analysis of the walls. Another aim of the research is to identify the composition of the walls and the different building phases by the combined use of GPR technology and 3D survey.

III. METHODS AND RESULTS

A. The geophysical survey (V.P.)

A Ground Penetrating Radar survey (GPR) has been carried out in the outside part of the San Michele church, with the aim to individuate buried structures and to better define the monastery shape.

The church lies on a small plateau made of Quaternary basaltic rocks mostly weathered. This last character has allowed radar wave penetrating up to 2.5 m depth.

The survey was conducted in five areas using an I-Mod2, IDS with integrated 200 and 600 MHz antennas carried by a trailer with a wheel encoder system. The defined survey grid was of 1x1 meter size.

Data acquired have been processed using GRED (IDS licensed) and the following processing sequence:

1) 200 MHz Antenna: Move start time (SOIL_SAMPLE), Background removal (CLEAR_X 0 10), Vertical bandpass filter TD (FILTER_FIR_Y 130 1500), Smoothed gain (STC_SMOOTH 2), Linear gain (STC_LIN 2);

2) 600 MHz Antenna: Move start time (SOIL_SAMPLE), Background removal (CLEAR_X 0 10 Vertical bandpass filter TD (FILTER_FIR_Y 200 2600),



Fig. 3. San Michele di Salvennor church (photo taken by G. Saturno).

Smoothed gain (STC_SMOOTH 2), Linear gain (STC_LIN 2).

Images have been processed in order to obtain C-scan three-dimensional data. Where needed images were also color processed to better enhance some of the imaged features.

Five are the investigated areas simply named from 1 to 5 (Fig. 4).

Results

Area 1

The survey carried out to the south of the church has indicated the presence of clear radar anomalies. These are made of two quasi-continuous rectangular features that archaeologists have interpreted as the church cloister. They occur a depth of 0.60 m and can be followed down for about 50 cm. Cloister dimension are 35x25 m. Inside the

cloister a 1x1 m radar anomaly has been interpreted as the water well (Fig. 4).

Area 2

Well-imaged radar anomalies have been encountered at the depth of 0.65 m and followed up to 1.5 m. The L-shape 6x6 m anomaly has been interpreted as the portico of the abbey (Fig. 4).

Area 3

A rather complicate radar anomalies pattern makes the interpretation of the more external part of the surveyed area complicate. At depth of 0.5 m, GPR the anomalies interpretable as walls. Their pattern, however, is relatively scattered resembling rooms or closed spaces. These features could be related to ruins of a not defined functionally space (Fig. 4).

Area 4

The GPR survey conducted adjacent to the northern wall of the nave has imaged at depth of 0.6 m until 1.5 m an almost square structure of about 3x3 m. This could be tentatively interpreted as the bell tower of the abbey (Fig. 4).

Area 5

The GPR conducted outside of the church apse has not

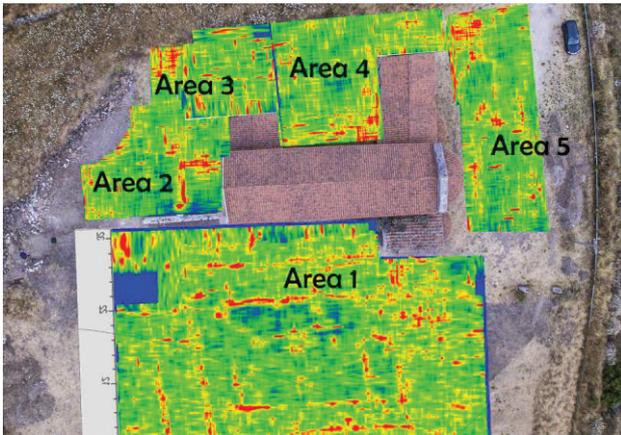


Fig. 4. San Michele di Salvennor church: geophysical survey

imaged many anomalies. The too scattered and not continuous structures present at depth comprised between 0.6 and 1 m can be interpreted as rocks block present below the ground floor of the church. However, in the north-eastern part of the surveyed area the radar anomalies encountered may be interpreted as buried walls (Fig. 4).

B. The photogrammetry and laser scanner 3D survey (L.S.)

To investigate the architecture of the church the following survey methods have been adopted: the survey; the stratigraphic analysis of the walls; the virtual reconstruction of the monastery by different technologies of measurement and 3D modelling.

The survey of the church has been carried out using a total station, a TLS and photogrammetrical images acquired both from the ground and using an UAV system.

The integration of the different 3D survey technologies allowed us to obtain a complete and precise model. Based on this model, the stratigraphic analysis of the walls and the virtual reconstruction of the monastery have been done [3].

The 3D survey, the analysis and the reconstruction of the church and its monastery has being realised using: archaeological and geophysical (GPR technique) surveys carried out in 2014, and in 2014 and 2016, respectively; surveys carried out by TLS e photogrammetry; comparison with other monastic structures, such as the abbey of the SS. Trinità di Saccargia (Codrongianos-SS), about 3 km from Salvennor [4].

During the 3D survey, carried out inside and outside the church, a preliminary direct analysis of the walls was conducted. This has allowed to us to obtain an immediate definition of the stratigraphic units of the walls on the 3D models, after the cleaning of the point cloud [5].

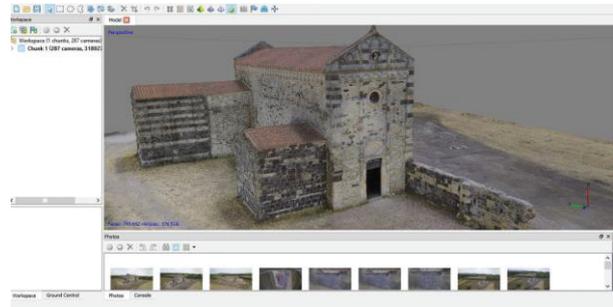


Fig. 5. San Michele di Salvennor church: 3D reconstruction.

After the decrease of the mesh, the pattern obtained was of such high precision (below the order of the centimeter and millimeter for the photogrammetric survey and for the laser scanner survey, respectively) that it greatly facilitated the interpretation of the walls and their stratigraphic units [6].

As mentioned above, the analysis, in progress, of the architectural complex is based on the two different 3D techniques; in fact they permit to obtain a measurable and high resolution pattern.

In order to reconstruct as the monastery was in Medieval, the analysis of the radar anomalies and the comparison between these and the archaeological evidence have been very important.

The 3D survey was obtained by 20 different scans, respectively 13 carried out outside and inside 7 the church. Then bi-dimensional sections at a pre-established height (or at different heights) and at a precise distance have been obtained, after the survey was sectioned along the X, Y and Z axis. This output permitted to realized surveys useful to the reconstruction of the building phases of the church and to the plans of excavation.

These bi-dimensional cuts allow us to get an useful comments not only from other archaeologists, but also with architects and engineers for possible conservative works.

About the 3D survey it is worthy to note that the use of the different methodologies of acquisition has been directed to obtain different results. The laser scanner is used for the study of the wall stratigraphies because it permits to obtain precise and measurable results; in fact it deals with a complete technique that, by a great amount of points acquired (about 8 GB of not processed data), allow to us to obtain the monument in a very appreciable scale (1:1).

The photogrammetric survey, both aerial (UAV system) and from the ground, was carried out to: to 'fill the cones of shadow' due to the laser scanner survey (as the roof of the church); to obtain a



Fig. 6. Church and abbey of the SS. Trinità di Saccargia (Codrongianos-SS; photo taken by G. Saturno).

precise and complete 3D model of photorealistic texture. This model is measurable like the previous (though with a different level of precision), but it permits a lower use of hardware resources (about 1/10 respect to that realized by laser scanner).

The monastic complex of Salvennor has been reconstructed on the basis of this second model and of the comparison with the nearby abbey of the SS. Trinità di Saccargia.

Furthermore we are interpolating these data with the GPR the surveys, that highlighted some anomalies related to the bell tower and the cloister with a very high level of precision (about 40 cm of gap) and a square structure in front of the façade.

According to the aim of promoting the Salvennor area, we intend to use part of the acquired data as multimedia products and mobile and gamification technologies.

This work in progress illustrates how the application of two different 3D techniques can create a measurable and high-resolution pattern. At the same time, the reconstruction of the monastic complex will be based on the GPR surveys obtained at different levels (see above sub section A).

The use of these technologies can vastly enhance the possibilities of the archaeological interpretation of buildings and horizontal and vertical stratigraphy.

Furthermore, the study and the sharing of the results are closely connected with a more open perspective of research (production and management of open data) and tourist-cultural promotion [7].

IV. FINAL OBSERVATIONS (E.G.)

The preliminary data illustrated above indicate that the combined and integrated use of different sources is a suitable method for the study of the territory of Salvennor. In the case of church of San Michele, this multidisciplinary approach gave back archaeological data both for the walls and the architectures and for

reconstructing the plan of the abbey.

But the technologies are very important for the landscape analysis too, as already observed in the case of the Medieval site of Sardinia, the Burgos castle [8].

For the archaeological research in the Salvennor valley, deeply signed by recent transformations, these techniques can be very useful to detect evidence or traces not recognizable by archaeological methods.

The Salvennor project aims to give back cultural and historical coherence to the landscape of the Salvennor valley, today fragmented by works with a strong environmental impact.

In this perspective the multidisciplinary approach plays an important role in pursuing these aims: increase the knowledge of this territory; to reconstruct the changes occurred during the time and the population trends.

The Salvennor Project, that involve students of archaeology, can be a good training ground for them for the aspects already mentioned: the analysis of a modified territory and the comparison with other specialists (geologists, architects) and different perspectives.

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