A 3D approach to the archaeological study of the built remains at the Santa Cristina well sanctuary, Sardinia, Italy

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A R T I C L E  I N F O

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A B S T R A C T

The paper presents the 3D investigation of the architectonic remains at the well complex of the archaeological site of Santa Cristina, located near the town of Paulilatino, in the province of Oristano, the Sardinian Island, Italy. The visible today remains integrate original fragments of the initial structure, built sometime 3000 years ago, and modern reconstruction conducted almost half a century ago. Despite the fact that the site has been excavated and its remains investigated for more than 50 years, no publications detailing the archaeological finds are available. The research presented here focuses on the contribution of 3D documentation and subsequent analysis of the well complex for understanding social aspects related to and reflected by the architectural remains.

1. Introduction

1.1. History of research

The archaeological site of Santa Cristina, Sardinia, Italy, famous for its so-called sacred well complex, has a long history of research. It is first mentioned by Alberto della Marmora, who describes it as an “ancient temple” (della Marmora, 1826, 1860; Spano and Marmora, 1874). Some years later, the Casalis dictionary (Casalis, 1846), states under the term Pauli Latio “...a singular funnel shaped construction, accessible through the hole and the cone shaped stairs, made of well refined stones, that also make up the wall around the staircase, which looks like a tilted funnel... the Well Temple ...”. The first systematic drawing of the site, including a plan, a side section and a prospective view, is drawn by Vincenzo Crespi, on behalf of Giovanni Spano, a representative of the Catholic Church (Spano, 1857, 1867). He describes a “cyclopean” work: “... built with big volcanic black stones, from a local cave... The access is through an underground passage, with a perpendicular vaulted roof made with overlapping stones that create overlying layers. From top to bottom it is over 4 m high... a total of 10 layers narrowing towards the top to form a shape of a cone cut short and the mouth of an ordinary well...”. He proposed to see it as a prison. Towards the end of the 19th century, Father Peter Paul Mackey immortalizes the situation of the site during his visit there by two photographs, now archived at the British School in Rome (Olivo, 2000). One may note that the passage to the underground space is obstructed by accumulation of debris and collapsed stones, while the surface is covered by vegetation. Finally, a decade later, Duncan Mackenzie visits the site and draws a schematic plan (Mackenzie, 1913).

Meanwhile, mainly through investigations at other archaeological site and historical parallelism, the notion that such structures are related to water cult (Petazzoni, 1912) begins to take shape (Taramelli, 1977). However, apart from a guide book giving general description of the site for its visitors (Moravetti, 2003), there are no other publications of the site systematically describing its finding and related stratigraphy, nor a detail of restoration works performed at the site. Finally, attempts to relate the well complex to astronomical observations are summarized by Lebeuf (2008). A one-week detailed 3D documentation campaign in 2013 yielded the publication for the first time of accurate and detailed plans of its architectonic remains (Atzeni, 2013) and a proposed hypothetical virtual reconstruction of the entire structure (Vico et al., In press).

The well-complex, as seen today by its visitors, includes a large oval enclosure, restored to a possibly arbitrary height of more or less one meter, an inner, keyhole shaped structure restored to a similar height (including a “bench-like” row of stones along the inner perimeter of the keyhole loop) and the well itself, consisting of the famous monumental stairs, its supporting side walls, the partial covering of the stairs (shaped as reversed stairs), and a conic shaped tholos, with the larger base at the bottom, usually full with perennial water (Fig. 1).
opening of the external enclosure, of the keyhole structure, the monumental stairs and the tholos are more or less aligned along the same longitudinal axis (see below).

As of today, the chronological assignment of the well-complex is still under debate, as the overall archaeological chronology of the island Moravetti (2003) suggests an 11th century BC installation, while Atzeni under debate, as the overall archaeological chronology of the island Moravetti (2003) suggests an 11th century BC installation, while Atzeni and Sebis (2012) suggest the 12th – 8th centuries BC. The practically inexistent archaeological material published and the scarcity of absolute chronological dating at similar sites elsewhere in Sardinia, make and chronological statement hazardous. Moreover, our focus in this article is the detail of the contribution of a 3D documentation at archaeological sites, with a focus on a 3D methodology that covers data acquisition, processing, analyzing and publication.

2. 3D field documentation and data processing

While the archaeological complex of Santa Cristina consists of several structures (Moravetti, 2003), the detailed 3D documentation campaign (Hermon et al., 2012, 2013) focused on the well complex solely. Its aim was to obtain three types of data: geo-location in the Cartesian space of the well remains, detailed geometric data of its architectural remains along with their colour texture. The instrumentation included a laser scanner (Surphaser 25HSX), a Leica total station and a Nikon d3x digital camera. The 3D captured area (Reilly, 1992) is ca. 28 m long and 14 m wide (almost 400 sqm.); the stairs and related tholos descend to a depth of ca. 6.5 m. Overall, given the complexity of the structure and its geometric irregularities, fifty scan episodes were needed to cover the entire subject area from all angles, concluded within two days of fieldwork. The scanner was set to medium resolution, which, according to previous metrological testing, operates with a registration density of points of less than 5 mm. Sixty-five targets were positioned in strategic positions along the structure; their location was registered with the total station, in order to facilitate the integration of all scans within a single file. Data was processed using a combination of software: instruments software, open-source (Meshlab) for obtaining a meshed 3D model and commercial (JRC) for further measurements and extraction of cross-sections and profiles. The data post-processing stage (cleaning, aligning, mesh creation, etc.) was completed within a week. While it is recognized that such process requires several data transformations and conversions between file formats, and instruments registration margins of error may influence on the overall accuracy of geometry restitution, we are confident that such errors may occur within acceptable limits of less than a few mm, and therefore we assume that the 3D model obtained (Fig. 2), is a reliable base upon which we can build our inferences (Hermon, 2012). The 3D model obtained includes all architectonic components, both above and under ground and therefore was instrumental in assessing the relationships between the various components of the structure, their spatial relationship, accessibility and human mobility along them. Moreover, the ability to move inside the 3D model and view various components from different viewpoints helped in assessing the possible use and function of the structure. Finally, the analysis of the surface roughness of various stones helped indicating which ones are belong to the original structure and which one were added in the sixties during the restoration and physical reconstruction of the site.

3. Analysis of the architectural remains

The 3D analysis followed three investigation axes: geometry / symmetry, statics / weight and space / accessibility, converging into two main research questions: what was the nature of the cultural / social actions that dictated the shape of the well structure and how these are reflected in the architectural remains? The main assumption is that such activities cannot be related to the profane sphere of human activities, given the architectural characteristics of the well complex, different from those of typical domestic architecture of the period (Manunza et al., 2014). The working hypothesis is that the site was built by a local community, using locally available raw material processed according to standardized rules and the final shape of the structure depicts canonical traditions dictated by the type and nature of the ritual performed there.

3.1. Raw materials – collection and processing

The raw material used for the construction of the well complex (above-ground and below-ground components) is the locally available basalt, notable in the area as exposed bedrock. Even though the localities of stones collection / extraction and their subsequent cutting / hewing are uncertain, we may assume (based on the overall geology of the area) that the former was in the immediate vicinity of the site, within a hypothetical circular area with a maximum diameter of 1 km, while the later could have been located at the construction locality of the well structure, within a temporary workshop whose traces got lost in time (or are still to be reported by the archaeologists who excavated at the site the past). Most of the construction material (Fig. 1) consists of large rounded boulders of ca. 20 kg each (considering 2.89 kg/m³ and the average stone dimensions of 0.75 × 0.3 × 0.3 m). Some larger stones were finely cut and carefully shaped in pre-planned forms in order to build the underground components: stairs, sidewalls, false stairs, water basin and tholos. Thus, a clear dichotomy between aboveground and belowground construction style is evident: un-modified, rounded boulders for the aboveground components and finely cut and smoothed parallelepiped ashlav masonry for the underground components.

While the outside enclosure wall and the keyhole structure were reconstructed to a height of ca. one meter, there is neither archaeological evidence nor comparative material at other similar sites to support such a decision (cf. Webster, 2014). The attempt to virtually reconstruct the original height and shape of these components must consider statics analysis, based on (the scarce) archaeological evidences discernible today and considerations on the social function and nature of activities performed at the site during its original use. For the sake of simplification, and based on the fact that the enclosure has no foundations, we may assume here (but see below), that the outside enclosure walls originally raised to any height between what is observed today and up to a height of ca. two meters, and the keyhole structure was roofed with a pseudo-vault (Vico et al., In press), ca. ten meters high (needed for reaching an equilibrium of the wall), the entire structure being built with the same raw material as the surviving walls.

3.2. The ashlav masonry

The ashlav masonry consists of rectangular basalt blocks with
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