Sicilian Landscape and A-structural Architecture from Survey to Virtual Reconstruction: the Case of Calaforno Hypogeum

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Abstract The present paper is focused on a unique a-structural complex of the hypogeum of Calaforno and the surrounding landscape. The recent "rediscovery" of this hypogeum, thanks to many excavations and survey activities led by the University of Catania and the Superintendence BB.CC.AA. of Ragusa, allows a new reading of the monument and of its surrounding landscape. Starting from the prehistoric and protohistoric periods, a central idea utilized in the planning of the land use is evident at this site, which led us to read the hypogeism phenomenon as a peculiar marker of this area. The new studies of the hypogeum allow a rereading of its long history and its several usage phases, particularly in the light of its relationship with the neighboring landscape, features which underwent continuous transformation over the centuries. The characteristics of this type of architecture and the necessity of a more efficient communication in archaeology have led to the choice of a new approach of survey and analysis of this monument. The documentation and communication goals have been stressed in order to obtain a product by the laser scanning documentation able to read chronological articulations of the architecture; to document the actual condition and the possible degradation of the monument; to identify special architectural features and traces which are difficult to observe with the traditional survey activities; to make the monument visible also remotely; etc. The goal has been not only to obtain new and more accurate scientific results, but also to enable the site, labelled until today as "minor", to make an impact on the study of the landscape in a more meaningful and exhaustive way.

1 Introduction

One of the topics further analyzed in the "Modelling Archaeological Landscapes Workshops" has been the relationship between the archaeological landscape and the so-called "minor" cultural heritage, trying to focus on this kind of archaeological evidence from different perspectives. The role which such "minor" places played in ancient times, probably

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being endowed with greater importance than they are today and, in some cases, serving as expression of an economic or political power, or both, has been taken into account in addition to their current scientific, social and economic role. To understand the real value of a "minor" archaeological site is essential in order to read it as a component of the entire archaeological landscape. In general, apart from the physical sphere and role of landscape in human subsistence and experience, the notion of landscape involves various social and symbolic elements.[1] It was argued that "the relationship between a society and its environment is a product of both human consciousness and material reality. The study of social and cultural landscapes considers the way people engage with their surroundings in terms of their own individual experience".[2] The social archaeology of landscape considers therefore the landscape as a product of human interaction with the environment.[3]

In light of these statements, the "minor" sites are tightly connected with the landscape in terms of mutual interaction with the environment. They are part of the so-called "not outstanding" cultural landscapes and can be considered expressions and symbols of the "land use", maybe much more than the major archaeological sites. Less known places are usually scattered mainly in the inner areas as rural landscapes or inlands; such locations are not necessarily a downside but rather a real advantage for preserving traces of common roots and differences of identities.[4]

These types of evidence are also closely related to the concept of the diffused heritage and its perception.[5] The true challenge is represented by areas with a high density of cultural heritage and a rich stratification both on an urban and extra-urban level. Such complex realities should be evaluated based on a balance between the monumental sites, great attractors of considerable impact, and several minor realities. In the last ten years, the attention to the notion of diffused cultural heritage has grown considerably but the difficulty to guarantee its conservation and to propose its sustainable usage have become apparent too. In fact, even the major and more attractive sites have to face a considerable managerial complexity, just as the smaller sites and monuments which have further problems of their own, e.g. challenges associated with the absence of an appropriate connective network.

A possible solution could be the creation of "diffused museums" in which "minor" sites can be transformed from simple points of scientific interest scattered in the landscape to centres of education and tourist attraction. Following this course of action, it is possible to create a system based on shared cultural values and dissemination of information on a supralocal scale. Another important aspect is the active participation of local communities, which can play a significant role in encouraging independent management and creation of

1 Knapp 2013, 37.
2 Knapp 1999, 106.
3 Ashmore 2004, 259.
4 Salerno 2017, 513.
5 Giberti 2012, 161.

networks in order to promote social cohesion and integration, regeneration of abandoned areas, and creation of new jobs, thus generating shared understanding and a new sense of community.[6] Local identity is not a simply a passive projection but a dynamic negotiation: it is mediated by important processes, such as tourism and the archaeological apparatus. Local identities are therefore public and performative; they are linked to the habitus of daily lives and are mediated by archaeology and global processes related to tourism.[7]

Moreover, a fruitful implementation of digital technologies for enhancing the knowledge of the land and the significance of the land itself[8] fits well within the debate about the so-called "not outstanding" cultural landscapes. This digital aspect has been emphasized in one communication of the European Commission entitled "Towards an integrated approach to Cultural Heritage for Europe", especially in the paragraph that discusses opportunities to make cultural heritage widely available in the digital era. This report highlights the value of digital tools: digitisation of heritage contributes to the European Agenda for Culture, by improving public access to different forms of cultural and linguistic expressions. Digitising cultural heritage, making it accessible online, and supporting its economic exploitation are also activities at the heart of the Digital Agenda for Europe. Digitisation multiplies opportunities to access heritage and engage audiences; while digital tools such as 3D scanning can facilitate the preservation and restoration of physical cultural assets."[9] The use of technology also involves aspects related to the documentation and communication, such as the obtainment of effective digital tools which assist in the creation of a narrative and stimulate active participation of the public.[10]

2 The archaeological landscape of Giarratana

The dichotomy between what is considered today "minor" and what was or was not "minor" in the past is evident in the case of Giarratana landscape.[11] It seems to be emblematic for its geographically peripheral position, far from the main communication routes of South-Eastern Sicily, but from the archaeological point of view the area represents a meeting point

6 Salerno 2017, 513–14.
7 Hamilakis 2006, 159.
8 Salerno 2017, 511.
9 European Commission: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels 22. 7. 2014.
10 Volpe and De Felice 2014, 405.
11 See K.A.S.A. (Koiné Archeologica, Sapiente Antichità) developed between 2006 and 2008 by the University of Catania, University of Malta, and Officina di Studi Medievali di Palermo. In the Hyblaean area, 100 minor sites have been counted as characterized by visibility but today are no longer accessible.

in the road network, both in ancient and medieval times. The most recent historical events have transformed this centrality into marginality: the peculiarity of an area that remains physically central but functionally marginal is a typical element for Sicilian inland that has no outlets to the sea.

The abundant archaeological evidence attests to the high interest in this area, especially in the Prehistoric period, when it was characterized by the high concentration of hypogeal structures, rock-cut tombs, and other complex structures. A brief overview of the prehistoric landscape allows us to highlight the most interesting sites of that period (Fig. 1). The

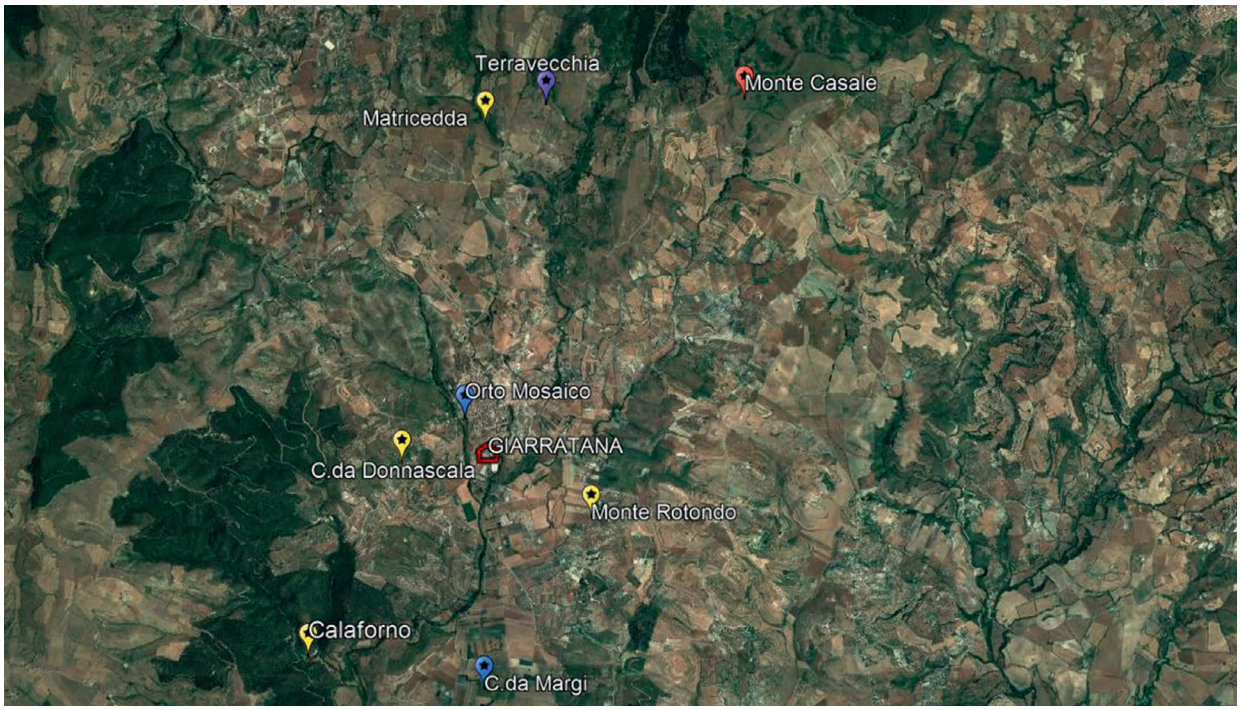

Fig. 1 The landscape of Giarratana: main archaeological evidences (Google Earth).

first site of importance is Calaforno, characterized by the presence of a Neolithic settlement and a grave tomb belonging to the *Stentinello* facies;[12] a multicellular hypogeum with a long history starting in the Copper Age; traces of a settlement dating to the *Malpasso* facies; and tombs belonging to the Late Bronze Age and the *Pantalica-Cassibile* facies.[13] Other sites that are characterized by the presence of hypogeic structures are: Donnacarmina,[14] Matricedda,

12 Cafici 1930–31; Guzzardi 1978.
13 Guzzardi 1978, 1980.
14 Dell'Agli 1886.

with a multicellular hypogeum on two floors dated to the Middle Bronze Age,[15] and Monte Rotondo, with a complex cave[16] and cemeteries dated to the *Castelluccio* facies. Two other significant areas are located in C. da Donnascala, where a rock-cut cemetery[17] and a repository of bronze objects[18] dated to *Finocchito* facies (Iron Age) have been identified, and in Monte Casale, with the presence of huts dated to the *Castelluccio* facies.[19]

The area of Giarratana preserved its central role also in the following periods. This continuity is proved in C. da Donnascala with the presence of a Greco-Roman funerary area[20] and in Monte Casale with the remains that span a period from Prehistory to the Greek times (a necropolis with chamber and shaft graves[21] and a settlement identified as the ancient *Casmene*[22]). A Roman villa decorated with mosaics of the Late Imperial period has been identified in the site called Orto Mosaico;[23] while in C. da Margi the site of Cozzo Anticaglie (or Cozzo dell'Anticaglia) was occupied from the Roman to the Medieval period by dwellings[24] and a cemetery.[25] All this archaeological evidence attest to the continuous occupation of the area from Prehistory to the Medieval period and later, until the late Renaissance period.[26]

A common thread in this landscape is the presence of the so-called "a-structural" architecture. This term is usually used to identify the architecture "in negative," a specific kind of technique utilized for building inside of the bedrock by removing it, both under and above ground. The term does not have a negative connotation and it is not a synonymous with "non-monumental" or "less important." On the contrary, the rock-cut architecture is characteristic of several time periods and locations, especially those linked with certain geological features. Historically, it has been adopted to construct various kinds of structures with different functions, both for domestic and funerary purposes. This type of architecture is closely connected with the geomorphology of the area: the Hyblean Plateau is a geological platform consisting of carbonate formations, and the area of Ragusa is characterized by the so-called gorges, locally known as *Cave*.

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15 Militello 2014.
16 Bruno 2003; Guzzardi 2004, 2008a; Militello 2014.
17 Dell'Agli 1886; Orsi 1898a; 1898b; 1900.
18 Orsi 1900; Bernabò Brea 1964–65; Bietti Sestieri 1980–81; Crispino 2014.
19 Orsi 1928.
20 Guzzardi 1980; Bejor 1986.
21 Orsi 1912.
22 Orsi 1933; Pace 1935; Di Vita 1956; 1961a; 1961b; Rizza 1957; Voza 1973, 1976–77, 1999, 139–43.
23 Di Stefano 1993–94; 1997; 1997–98; 2001; 2005; 2014b; Di Stefano and Ventura 2011.
24 Solarino 1885; Dell'Agli 1886; Pace 1919; 1926, 130–133; Bejor 1986; Di Stefano 1993–94; 2014a; Di Stefano and Ventura 2011.
25 Dell'Agli 1886; Pace 1919.
26 The Late Renaissance settlement of Giarratana, called Terravecchia, was destroyed and abandoned after the earthquake of 1693. Starting from 2004, it has been excavated by a team of the French University J. Verne, see Militello and Marino 2001; Di Stefano and Fiorilla 2014.

In the landscape of Giarratana the "a-structural" architecture has a more specific intended use: the hypogeum architecture seems to be a sort of central idea in the "land use." Starting from the prehistoric and protohistoric periods, the hypogeism phenomenon seems to be a peculiar marker of this area. Furthermore, the presence in this rather small area of a great number of these structures (Calaforno, Donnacarmina, Matricedda, and Monte Rotondo) is even more unique, when compared with other Sicilian sites, where such a remarkable concentration of this kind of architecture is completely absent.

3 The hypogeum of Calaforno: researches and architectural features

The hypogeum of Calaforno is located in the south-eastern Sicily, in the province of Ragusa, on the boundary between the cities of Giarratana and Monterosso (c. da Manna), current within the Forest Park of Calaforno, an equipped area useful for the preservation of the landscape as well as its flora and fauna. This area was already known from the archaeological point of view at the end of the 1800s, thanks to the survey of Ippolito Cafici,[27] and was included among the *"meraviglie"* of Giarratana by Antonino Dell'Agli.[28] In the 1970s, Lorenzo Guzzardi[29] started a systematic land survey of the area, identifying two cemeteries and the monumental hypogeum (Fig. 2). The discovery was followed by several publications. Notwithstanding the peculiar characteristics that may make it one of the most important prehistoric monuments of Sicily,[30] the hypogeum has been considered a "minor" site until 2013, when analytical research of this site has began. This trend was caused by the lack of documentation about the entire landscape and a low level of scientific interest that cannot be justified, considering the peculiarity of Calaforno hypogeum. Added to this, is the exclusion of the site from the main tourist itineraries, which also has contributed to the lack of valorisation policies. Hence, it is legitimate to speak of a "rediscovery" of the hypogeum, which occurred in the last years, thanks to the work led by the University of Catania under the supervision of Prof. Pietro Militello and the Superintendence BB.CC.AA. of Ragusa. Many excavations and survey activities have been carried out in order to allow a new reading of the monument and its surrounding landscape: the University of Catania worked inside the hypogeum from 2013 to 2018, while the Superintendence has led since 2016 excavations outside, near the main entrance of the monument. This renewed interest in the hypogaeum has been brought about not only through a series of investigations, but also in the light of a reinterpretation of the entire landscape, particularly after the discovery in 2014

27 Cafici 1878; 1926; 1930–31; Pace 2010.
28 Dell'Agli 1886.
29 Guzzardi 1975; 1978; 1980; 1984; 1996; 2004.
30 See Bernabò Brea 1976–77; Pelagatti 1976–77; Di Stefano 1984; Tusa 1992.

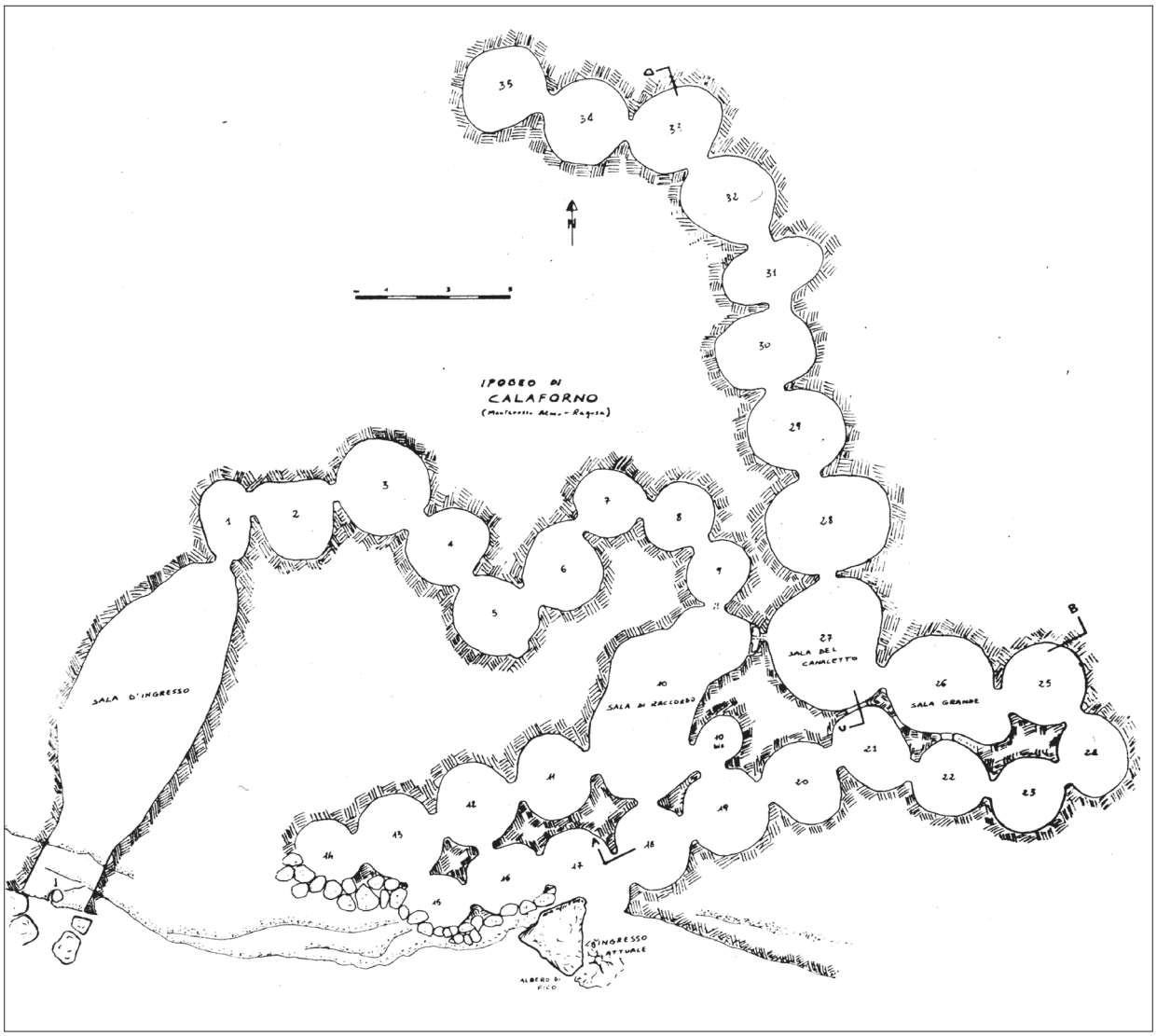

Fig. 2 Calaforno Hypogeum: the first plan (Guzzardi 1980).

of the two-story hypogeum in c. da Matricedda.[31] The new investigation[32] has been undertaken in order to reconstruct the chronology of the construction through the architectural analysis of the monument and the phases of its use, aiming at a clarification of its functional

31 The hypogeum, unknown in scientific literature, has been discovered by Prof. Militello, thanks to a report from a local inhabitant.

32 Exavations in 2013 involved the rooms nos 17, 26, and 19, and in 2017 the main entrance, rooms nos 1, 13, 24, 30, 34, and 35.

aspects. The final report of the investigation results is forthcoming.[33] In this context, it suffices to refer to the information related to the survey activity.

Calaforno is a perfect example of an "a-structural" complex: the hypogeum consists of 36 rooms forming an irregular serpentine route c. 100 m long. Originally, the entrance was a natural cave (c. 12 × 4 m) that might have been used for the extraction of flint. The wide vestibule was provided with a monumental entrance built out of large blocks and a complex dromos structure, now being excavated by the Superintendence.[34] After a period of time, this original access was hidden by a stone collapse, therefore, a second entrance was opened later on SE. The rooms, 35 in total, were built into the limestone rock. They have concave floors and walls slightly curved towards the ceiling, which is perfectly flat (Fig. 3).

Fig. 3 Calaforno Hypogeum, room ceiling and wall shape (photo by the author).

Their dimensions are variable, with a diameter ranging from 1.5 to 3 m, and a height between 1.6 and 1.8 m, except for three connecting rooms (nos 10, 27, and 26) that are wider and slightly higher.

From the architectural point of view, there are two different planimetric sections with different design concepts that suggest the realization of the entire complex over a rather

33 See Militello and Di Stefano 2015; Militello, Sammito and Scerra 2018; Militello forthcoming.
34 See Militello, Sammito, and Scerra 2018.

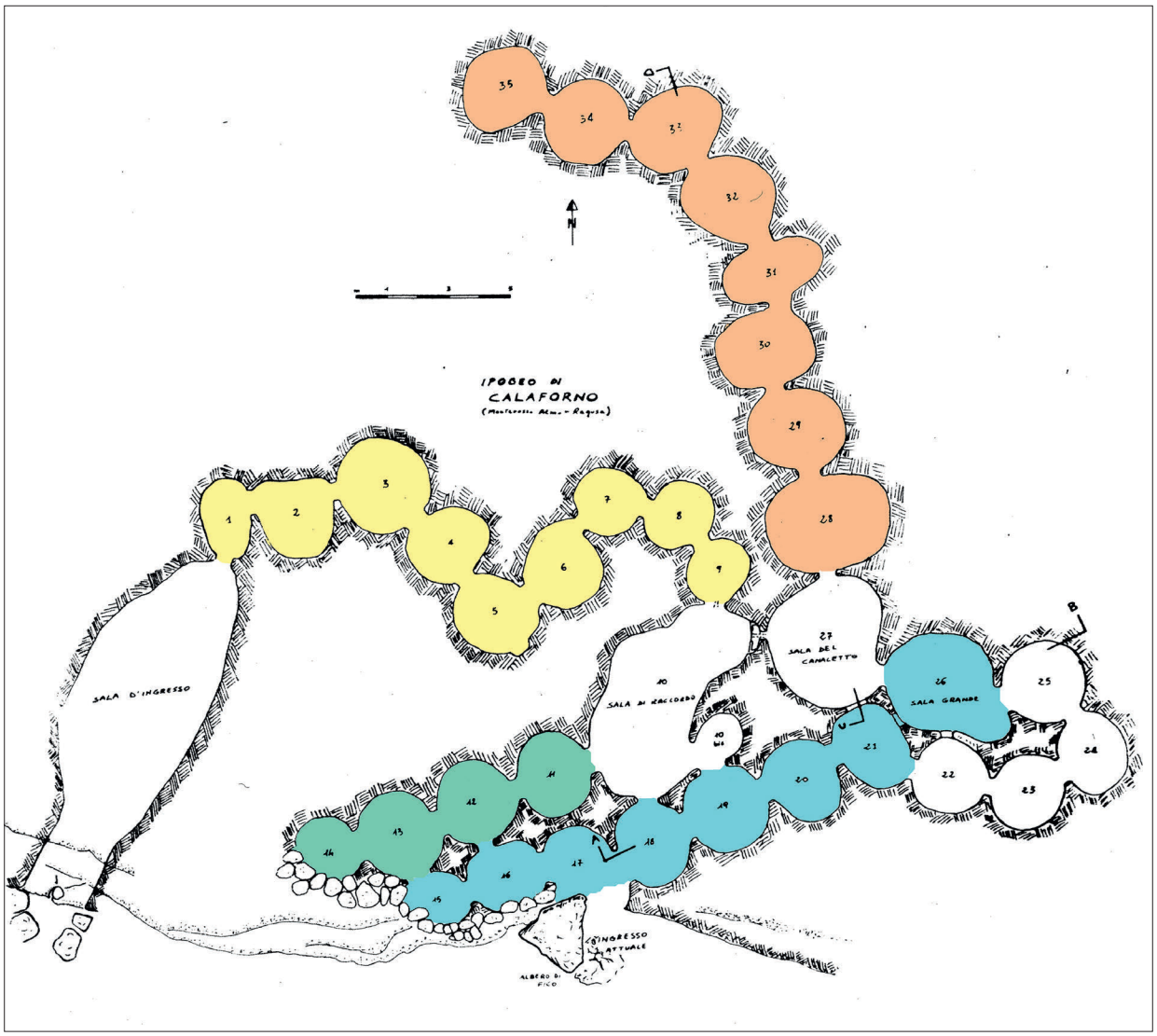

Fig. 4 Calaforno Hypogeum, the different architectural sections: rooms nos 1–9 in yellow; nos 11–14 in green; nos 15–26 in light blue; nos 21–31 in orange (Guzzardi 1980, modified by the author).

long period of time (Fig. 4). The first section was the earliest to be excavated as the nearest to the main entrance (ca. 2700 BCE). It consists of smaller and low rooms (nos 1–9), organized in a serpentine shape. They lead to the first large connecting room (no. 10). The second section includes larger and higher rooms (nos 11–31), connected by rooms arranged in a ring shape (nos 22–5). The construction of the second section implies a more advanced technological level, retaining a main alignment and avoiding interference between different groups. Therefore, is is likely that it resembles a later addition (ca. 2500–2200 BCE).

From the technological point of view, the construction of these rooms was also facilitated by the geomorphologic features, such as the sub-horizontal layers with an alternation of calcarenites and marl, the soft sandy layers which are easily removable. The rooms were dug into these soft layers, while the harder rock layer was utilized to form their flat ceiling. There are different passages between the rooms: some of these reach the ceiling and others are smaller and had to be closed by door slabs (some of them still remain in the rooms), yet it is difficult to reconstruct their original shape. In fact, some of them were clearly reworked or enlarged at a later time. There are also two small windows (between the rooms nos 10, 19; and nos 26, 27) and some pseudo-niches, possibly also added in later periods (Fig. 5).

Fig. 5 Calaforno Hypogeum, architectural features: passages, door slab, windows and niches (photo by the author).

The function and chronology of the hypogeum will be discussed in the forthcoming final publication.[35] To provide a brief summary, its chronology begins from the Late Copper Age (*Malpasso* facies, c. 2700 BCE), when it was constructed, to c. 1000 AD, when it was abandoned due to an earthquake. In this long period, it acquired multiple uses which alternated

35 Militello forthcoming. See also: Militello and Di Stefano 2015; Militello, Sammito and Scerra 2018.

with periods of abandonment. During the Early Bronze Age (*Castelluccio* and *Thapsos* facies), it was used as a burial area. Between the Iron Age (*Pantalica South* facies) and the beginning of the Greek colonization, the hypogeum likely served a ritual function, while during the Greek period it was perhaps no longer accessible. However, recent excavations identified a sanctuarial area in front of the main entrance. From the Late Roman-Early Christian Period, it was partially reactivated as a cemetery. Finally, during the Medieval Period, some of the rooms were used for food storage or as a refuge for animals.

The hypogeum of Calaforno has such unique architectural features that no suitable comparanda can be found in other regions of Sicily, i.e. outside the landscape of Giarratana itself, where the hypogeism is deeply rooted, as it is demonstrated first of all by the hypogeum of Matricedda.[36] Other Sicilian "a-structural" monuments, yet with different functions, are the mines of Monte Tabuto,[37] the polylobate structure of c. da Margione,[38] and some smaller hypogea, such as Torre Mazzarronello,[39] and Malpasso.[40] Analogies can be found only with other hypogeic structures in the Mediterranean, such as the *domus de janas* in Sardinia, the graves of Xjemxia, or the hypogeum of Hal Saflieni in Malta.[41]

4 The technological approach: survey problems in "a-structural" architecture

The technological approach to this archaeological context applies both on the territorial scale and the scale of the monument itself. The creation of a topographical aid with some georeferenced points on the ground, fixed by means of the GPS, was the first step. These were used as reference points for all the survey activities conducted through total station, drone, and laser scanner.

The investigation of the area surrounding the hypogeum was carried out by means of a drone flyover, which allowed us to obtain a larger orthophoto of the area and an image of the hypogeum's immediate surroundings, as well as a Digital Elevation Model (DEM) of the entire area (Fig. 6)[42]. In regards to the monument, the technological approach is focused on solving the problems associated with its architectonical features. In general, a survey of a site with the rock-cut or "a-structural" architecture presents several challenges that do not

36 Militello 2014; Figuera, Gianchino and Żebrowska 2014.
37 Orsi 1898c.
38 Bruno 2002.
39 Guzzardi 1984, 1996.
40 Bernabò Brea 1958, 80–81; Albanese 1988–89; Tusa 1992, 250–52.
41 Evans 1971; Guzzardi 1980; Procelli 1981; Bernabò Brea 1976–77; Giannitrapani 1997; Cazzella 2000; Guzzardi 2008a; 2008b.
42 This work was carried out by Prof. G. De Guidi, Department of Biological, Geological and Enviromental Science, University of Catania.

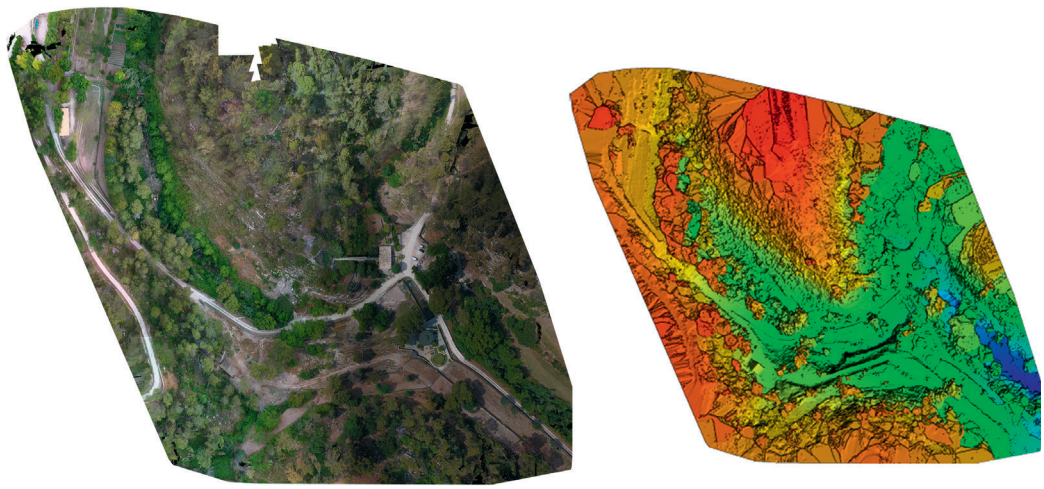

Fig. 6 Orthophoto and DEM of the hypogeum area (University of Catania).

permit a standard approach due to the lack of relevant points of discontinuity and, consequently, difficulties in identification of the section planes to be choosen, which are essential for understanding the monument. Moreover, there are usually practical problems, caused by the narrowness of spaces and the lack of light. The hypogeum of Calaforno has all these features and architectonical peculiarities. The difficulties are linked mainly to the small size of the rooms, their serpentine route, the lack of light, and the presence of rising water in some of the rooms.

5 Laser scanning: scientific purposes

In the case of Calaforno, a 3D surveying with laser scanning was carried out, providing a solution to the aforementioned problems and allowing us to collect a lot of useful archaeological information. The laser scanner is not impeded by the absence of natural light and can be used even in narrow spaces (Fig. 7). The basic aim of the laser scanning of the hypogeum was to obtain a new complete survey of the monument and to verify previously acquired data. It is a fundamental method for resolving a series of scientific problems and provides an effective way to: (1) check the accuracy of the old survey data (Guzzardi 1980); (2) identify chronological articulations in order to verify the presence or absence of continuity in the excavated area;[43] (3) check the alignment of room clusters; (4) document the

43 The long occupation of the site involved various changes from the architectural standpoint, which complicated even more the reading of the monument.

Fig. 7 The laser scanner activity into the hypogeum (photo by the author).

actual state of preservation of the complex in detail, by monitoring the ongoing changes; (5) identify special architectural elements, often missed by traditional surveys; (6) discern traces of working that have been ignored until now. Lastly, the laser scanning provides an opportunity to create a virtual tour of the monument, featuring an immersive visualization. The great potential of this technology is especially evident in a case such as this, due to the challenging aspects of the hypogeum's accessibility.

6 Laser scanning: technical advantages, processing, and post-processing

The laser scanning work was performed by the Garro Technical Office[44] in two processing sessions which took place in 2017 and 2018. The use of this simple and fast documentation technique allows us to obtain a 3D model of the monument, a detailed and accurate reproduction without optical distortions, one which is searchable and editable. The laser strikes

44 I would like to thank Antonio and Salvatore Garro for the collaboration in the fieldwork, which was conducted under hard conditions, and the post-processing stages.

objects in several points, located very close to each other, recording each specific position in space as well as various additional data, such as the reflectivity and the colour provided by the integrated camera. As a result, it guarantees high accuracy and security of data collection and storage as well as completeness of the gathered information.

The laser scanner used in the hypogeum belongs to the last generation, Leica P30, and has specific features which are particularly useful in an archaeological context. Thanks to its technical characteristics, field operations are made easier: its small size facilitates movement in narrow spaces; the integrated, small, and lightweight batteries make manuvering and positioning easy and guarantee a documentation process without interruptions; finally, its Wi-Fi capabilitiy allows remote control of the scanning process, thus improving its mobility. The scanner's capacity to function without the use of targets significantly aided field operations, especially in the context of small rooms, narrow passages, frequent changes of direction, and the total lack of natural light. Furthermore, the integrated camera with high resolution and colour rendering enables obtainment of high-quality images, accurate colours, and thus a point cloud with a realistic visualization.

All these features are essential in such a complex context, which requires survey procedures with a multipoint station. The atypical nature of the monument demands a complex and lengthy traditional survey process and management of a large number of measurements and other data.

The speed, accuracy, and quality of the results exceeded our expectations, notwithstanding the fact that the processing was not free from practical problems. The first challenge was posed by the physically restricted spaces. A further obstacle was the lack of illumination, which was solved by the use of spotlights. However, the main and unforeseen problem was caused by the presence of rising water in a group of rooms, which did not allow us to properly scan two of them, due to the reflectivity of the water surface.

The post-processing was conducted by utilizing the software Leica Cyclone 9.2. Already in this phase, numerous valuable observations were made, relating to the connection between the monument and the surrounding landscape, which enabled a better understanding of the morphology of the rock, its relation to the slopes, various geo-lithological characteristics, etc. The laser scanning has also allowed to join the survey of the hypogaeum to the survey of the surrounding terrain through the ground georeferenced points of the topographical survey.

For obtaining a complete survey of the hypogeum, it was necessary to perform several scanning sessions, one for each room. As a result, many point clouds were created, which resembled data sets useful for extraction of a wealth of information. The first step of the post-processing has been the unification of the point clouds, both external and interior, in order to acquire a complete model.

The 3D view made possible to obtain a general section, providing us with some interesting data, such as the true inclination of the floor of the hypogeum compared to the ground

axis (Fig. 8). Furter, it provided many technical outputs, such as a 3D view of the hypogeum with the roofs of the rooms in transparency, and a view with natural and original colours, based on the reflectivity of the materials detected by the instrument (Fig. 9).[45]

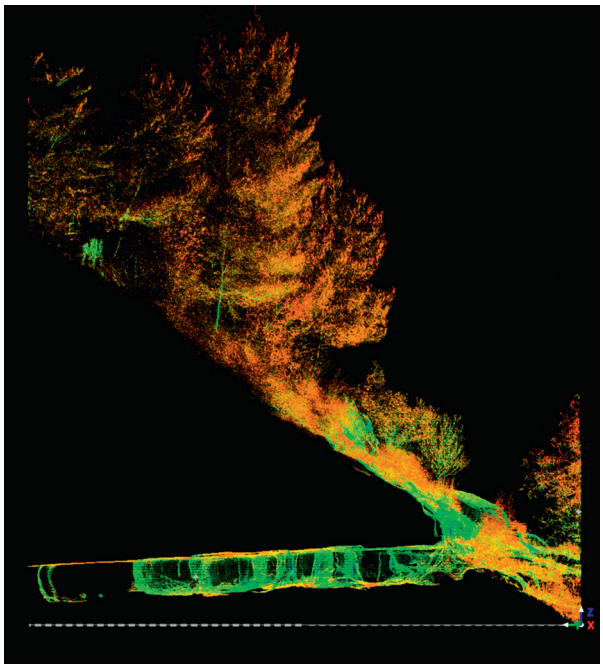

Fig. 8 3D view: general section of the hypogeum compared to the horizontal axis of the ground (post-processing by Garro).

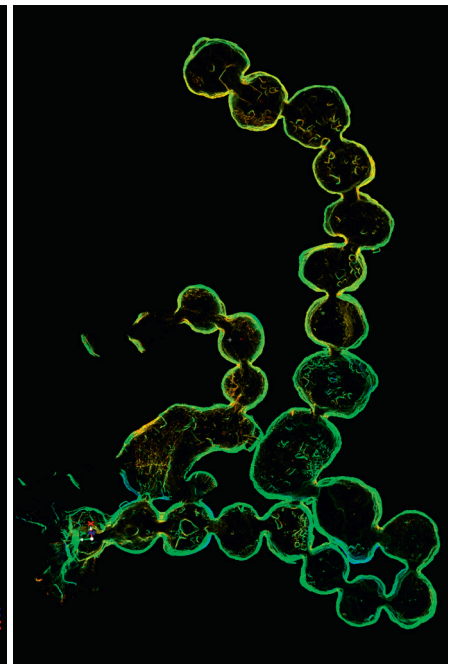

Fig. 9 3D view of the hypogeum based on the reflectivity of the materials detected by the instrument (post-processing by Garro).

Finally, this documentation method enabled us to acquire detailed plans and sections of the rooms with the preferred point section; to obtain information about the colours, shapes, and dimensions of all the elements inside the rooms at the time of the survey; and to highlight details or perform direct measurements (Figs. 10, 11). In the post-processing phase, we produced outputs in macro and micro scales and were able to choose the preferred view and visualization as well as to add further information, graphical elements, and hypothetical reconstructions, etc.

45 Each material responds in a different way to the laser, so the output is characterized by different colouring of the points detected, which makes immediately distinguishable the different types of materials.

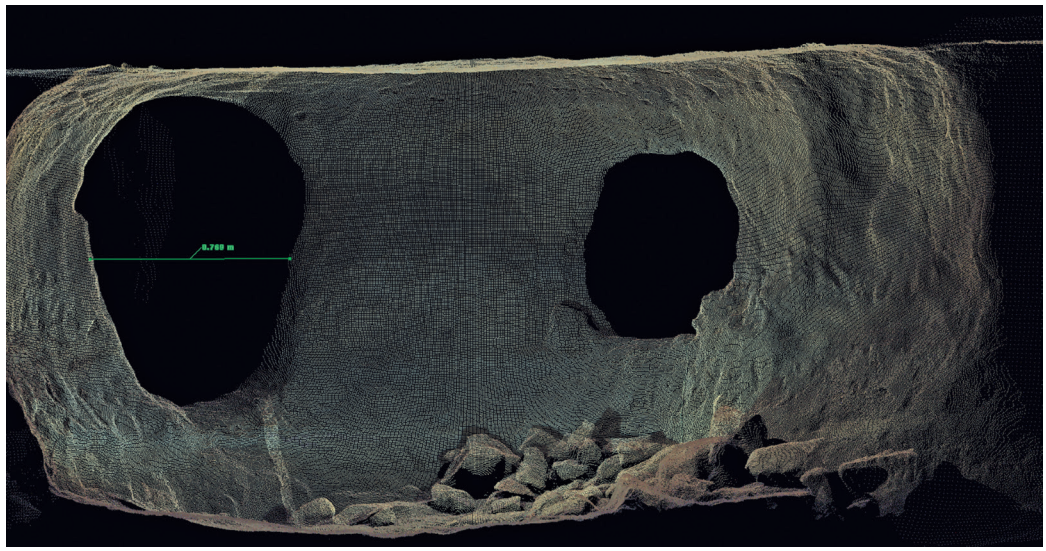

Fig. 10 3D view of the hypogeum and possibility to perform direct measurements (post-processing by Garro).

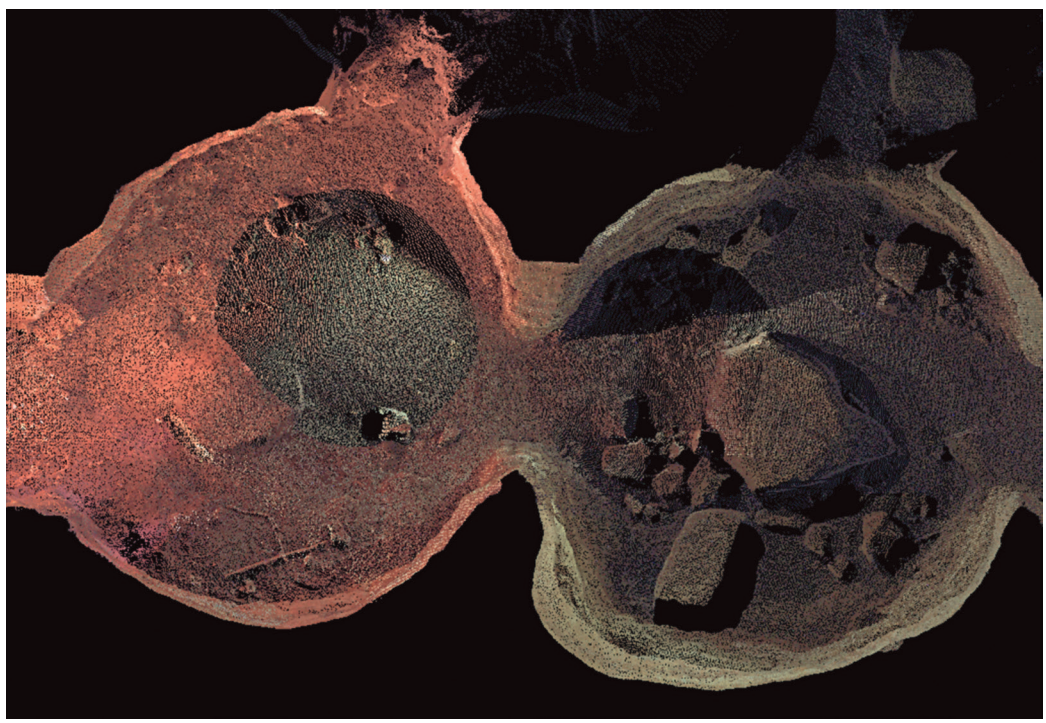

Fig. 11 Rooms nos 18–19 with all the elements present inside the rooms at the time of the survey (post-processing by Garro).

7 Conclusions

The digital solutions utilized in the hypogeum of Calaforno have helped us to achieve both the documentation and communication goals. The laser scanning has been conducted in order to obtain results that record the monument's chronological and architectural variability, to identify special architectural features and traces, and to document the present state of preservation of the hypogeum. All these aims have been achieved following the highest standards of scientific quality. Several valuable scientific results have been obtained. The primary purpose was a review and inspection of the old survey. After its comparison with the results of the new survey retrieved by laser scanning, a number of errors have been revealed. A few of them were associated with the dimensions of individual rooms, while almost all were related to the orientation of the room cluster. The alignment of some rooms has been confirmed, particularly of those forming a part of the second main section of the hypogeum, where the largest and highest rooms are located. These seem perfectly organized in three axial groups (rooms nos 11–14, nos 15–26, and nos 21–31), providing further confirmation to the hypothesis of different construction phases of the monument (Fig. 12).

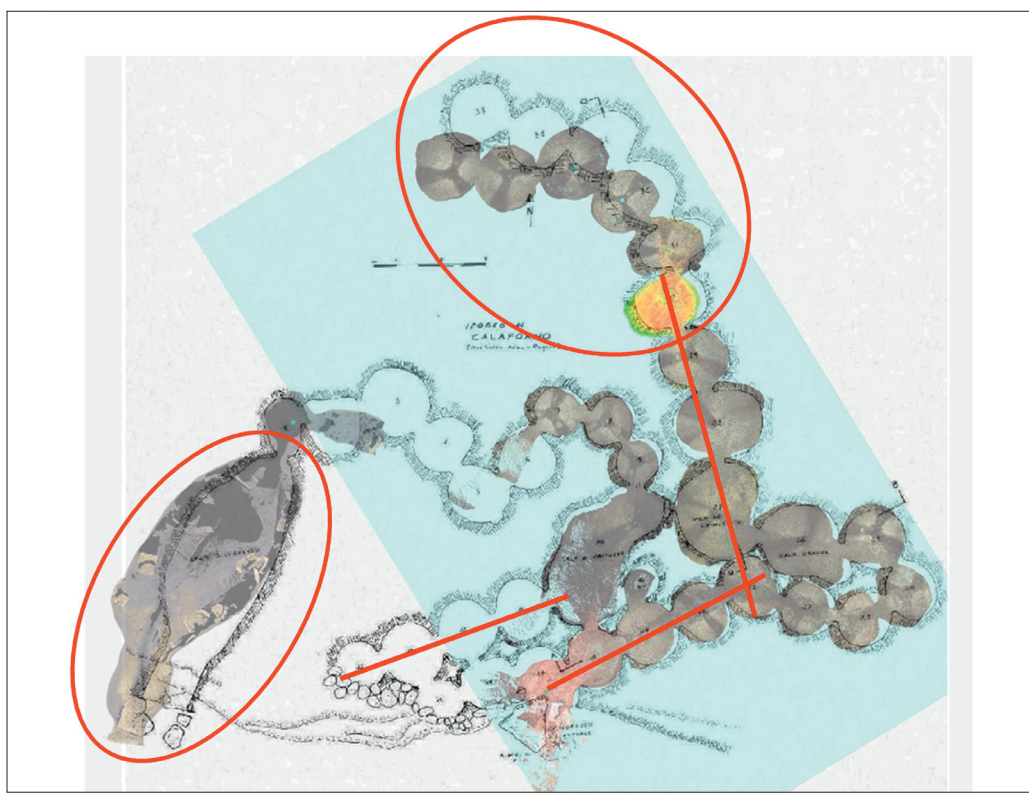

Fig. 12 The overlap of the old (in light blue) and the new survey: dimensional errors and three axial groups (rooms nos 11–4; nos 15–26; nos 21–31) (elaboration by the author).

Another useful outcome was the identification of many traces of working, undetected until now, especially on the ceiling and walls, which were left by the tools during the carving out of the rock for the rooms' construction (Fig. 13). For all the aforementioned reasons,

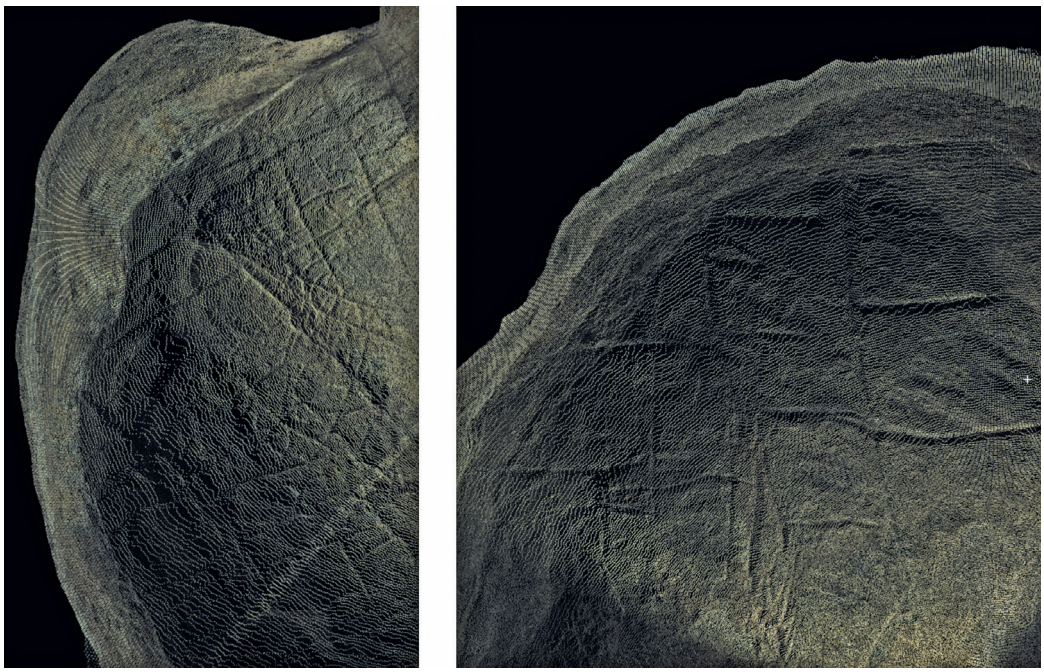

Fig. 13 The traces of work in the ceiling of rooms (post-processing by Garro).

it has been confirmed that laser scanning is an ideal solution to the problems inherent in archaeological surveys of a-structural complexes. Besides having an apparent scientific significance, the digital technologies utilized by the project also possess informative and communicative value. The communication aspect is of extraordinary importance for establishing a proper relationship between archaeology and society, and for safeguarding the cultural and landscape heritage.[46] Our goals have been not only to obtain updated and more accurate results, but also to open new opportunities for the site, which has been labelled as "minor" until this day, and to promote a deeper and more comprehensive approach to the landscape.

From this perspective, communication plays a key role. Thanks to the laser scanner technology, it was possible to create a digital tour that allows people to visit the monument virtually. The virtual navigation through the hypogeum with an immersive visualization

46 Volpe and De Felice 2014, 402.

technology makes the monument remotely visible in two different modalities: one that follows the actual sequence of the rooms and the other that offers a choice of individual rooms to be visited in order to obtain more targeted information. The potential of this technology is especially evident when applied to a monument with a limited physical accessibility, such as the hypogeum.

Another digital product of the project is a video produced with the help of a drone, which provides a valuable experience of immersion into the landscape surrounding the hypogeum. In this particular case, there has been a decline in communication with and education of the wider public and local communities, which led to the long-standing labelling of one of the most important sites in the Sicilian Prehistory as "minor" until now. After the first excavation of the site in 2013, this virtuose monument has become visible to the local communities living on this land. Within a short period of time, they realized with proud the significance of their own archaeological heritage and in 2014 they even organized a permanent exhibition in Giarratana entitled: "Giarratana ed il suo territorio. Storie dal passato".[47] The exhibition's aim is to engage the local communities and promote learning and the proud acknowledgment of their history and heritage by interacting with the exhibited archaeological finds found in the Giarratana landscape.[48]

In the case of Calaforno, which has been considered a "minor cultural landscape", the added value of the digital technology is evident; it made the new reading of the monument and its surrounding landscape possible. The digital technologies have proved themselves to be indispensable tools both for the acquisition of knowledge and for the dissemination of information on multiple levels, from the local to a supralocal scale.[49]

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47 Organizers: Superintendence BB.CC.AA. of Ragusa, Municipality of Giarratana in collaboration with the University of Catania.

48 Panvini 2014, 3.

49 Salerno 2017, 511.

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