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DIGITAL RESCUE OF AN ARCHAEOLOGICAL SITE AT RISK: THE PREHISTORIC VILLAGE OF PORTELLA (SICILY)

1. Introduction

Traditionally, Italian archaeological heritage has been considered the basis of the identity of the entire population of the Peninsula. Not only is this due to its intrinsic historical value, but also to its use as an instrument to raise the sense of belonging to a national community (Bencivenni, Dalla Negra, Grifoni 1987, 189-270; Troilo 2005, 74; Papi 2008, 185-186; Barbanera 2015, 52-56). These historical considerations on the intrinsic and attributed value of archaeological remains induce further reflections on their fate. In general, cultural heritage is surveyed to be studied, analysed and documented. That notwithstanding, it is often and increasingly destined to an inexorable process of deterioration caused by both anthropogenic and natural factors (Brandi 1977). Although the debate on the methods and purposes of the conservation of cultural heritage is still ongoing, one of its most recent acquisitions is the concept of planned maintenance (Laino, Massari, Pesaresi 2014; Osanna, Rinaldi 2018; Osanna, Rinaldi 2020).

The present contribution, however, aims to complement this concept with that of 'digital rescue'. Specifically, for the sites where it is impossible to carry out conservation projects due to factors such as geomorphological impediments, it is necessary to initiate procedures that limit destructive processes. These include, precisely, the aforementioned activities of 'digital rescue'. For this latter reason, the writer wants to propose a standard, expeditious and low-cost procedure to systematically and three-dimensionally survey those archaeological surfaces destined for inevitable deterioration. This process will be described in detail through a case study. A fundamental step in these projects is the experimentation with technologies that have increasingly become part of an archaeologist's daily routine. Such tools, however, must not have mere research as their purpose but must pursue the aim of archaeology, consisting of historical reconstruction and the need to hand down the remnants of the past to posterity.

2. The archaeological area of Portella

The prehistoric village of Portella is located in the eastern part of Salina, one of the seven Aeolian islands, located off the northern coast of Sicily (Fig. 1). The island, made up of six different volcanos – M. Rivi, Pizzo Capo, Pizzo Corvo, M. Fossa delle Felci, M. dei Porri e Pollara (Iacobucci *et al.* 1977; Keller 1980) – is dominated by the highest two – M. Fossa delle Felci and

Fig. 1 – Salina Island. Satellite photo (Google Earth).

M. dei Porri – which, according to some scholars, in antiquity gave the island the name of Didyme from the Greek word that means 'twins' (Bernabò Brea, Cavalier 1995, 18). The island is characterized by very steep slopes and soil that constantly slips from the upper part. The rains, over the centuries, have created deep valleys separated by ridges. The prehistoric area of Portella, ca. 240 m long, occupies one of these ridges, starting from Monte Fossa delle Felci and ending in a high cliff of 50 m.

The prehistoric village was occupied during the Middle Bronze period by people of the so-called Milazzese culture, closely related to the Thapsos culture in Sicily. In the second half of the 1950s, the village was accidentally discovered by workers who were building a road connecting the eastern part of the island to the northern one. The village is one of the most important Bronze Age sites in the archipelago, comparable to Capo Milazzese in Panarea (Bernabò Brea, Cavalier 1968, 50-163, 208-214), Capo Graziano in Filicudi (Bernabò Brea, Cavalier 1991, 191, 207-209, 214-215) and the castle area in Lipari (Bernabò Brea, Cavalier 1980, 546, 705). These villages have a lot of similarities: firstly, all of them were built in naturally defended areas, e.g., ridges or hills from where it was possible to see the sea; secondly, all these villages were destroyed in large fires during the first part of the 13th century B.C., according to Diodorus (Diod. V., 7-9), caused by people who came from Campania (Cavalier 1957, 10, 1986; Bernabò Brea, Cavalier 1991, 215). The Portella site is perfectly preserved, possibly because the area

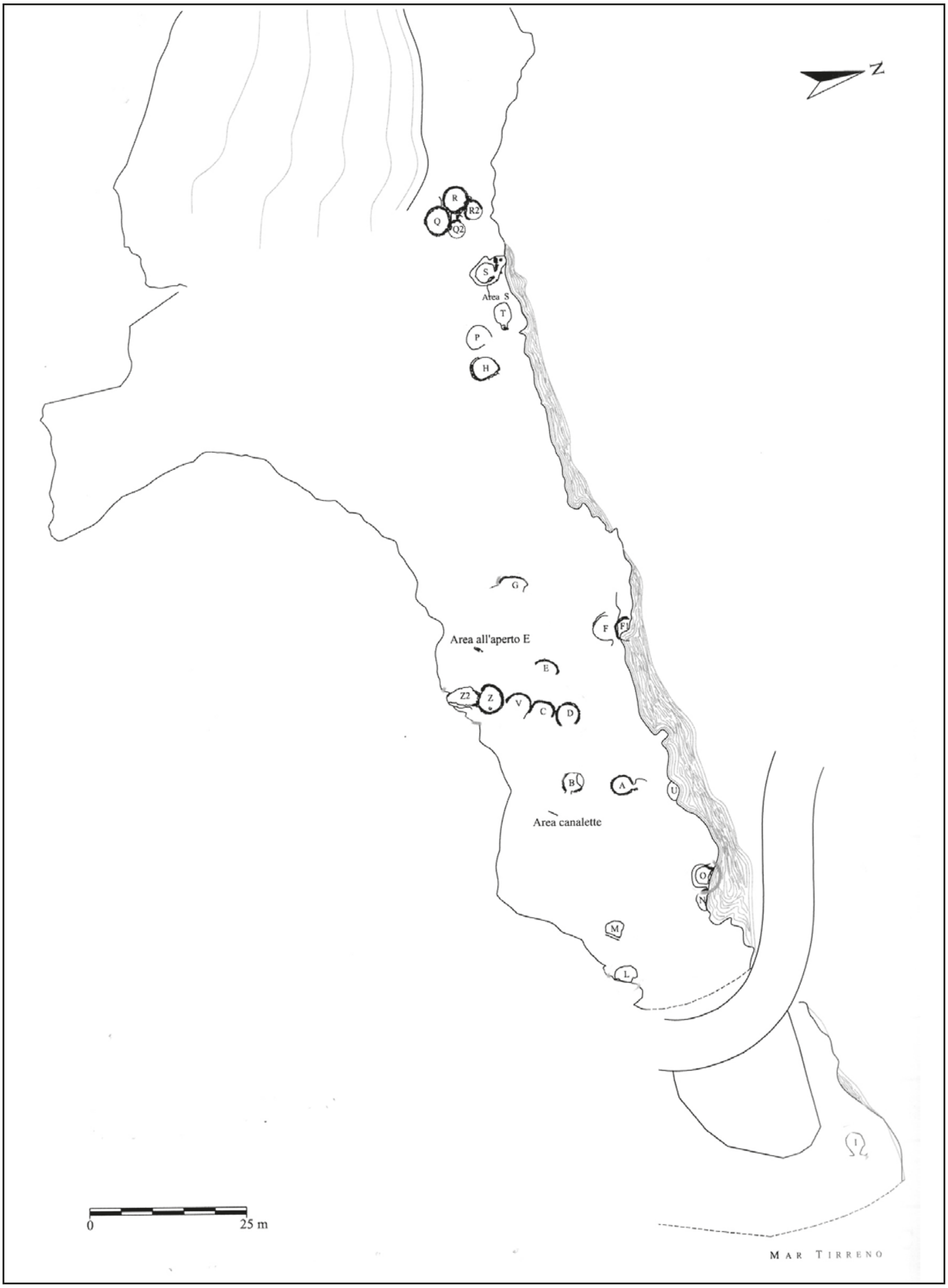

Fig. 2 – Schematic plan of the village (from Martinelli 2010).

Fig. 3 – Orthophoto of the village area.

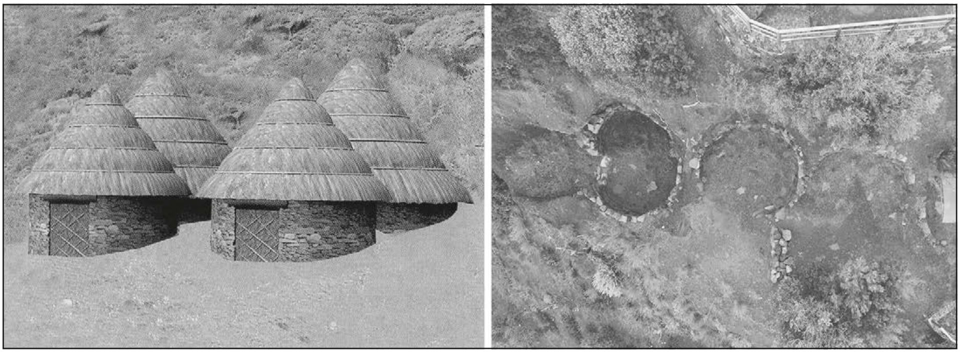

Fig. 4 – 3D reconstruction of the huts (from Martinelli 2010) and aerial photo of Z-V-C-D huts.

remained unoccupied until the 1980s and was exclusively used for the cultivation of olives. Furthermore, it was rapidly covered by landslides consisting of volcanic rocks from the higher area. These phenomena helped to preserve the Bronze Age huts and their contents.

Ten circular huts were excavated by L. Bernabò Brea and M. Cavalier in 1955 (Bernabò Brea 1955; Cavalier 1957; Bernabò Brea, Cavalier 1968, 144-180), but at the end of the campaign they were covered again to prevent their damage. In 1998, the Regione Sicilia bought the area with a POM project, and one year later another excavation (Martinelli 2001, 2005) started and continued in 2006 (Martinelli 2010). Inside these excavations, 25 circular or ellipsoidal huts with a diameter of 3-4 m were found (Figs. 2-3). These had different functions: some of them were habitations, while others were workshops. The walls were partly cut in the rock and partially constructed with two distinct types of stones: a volcanic stone with sharp edges, and one with a smooth surface, polished by the sea (Martinelli 2010, 254). The whole village was organized in small terraces, roughly the size of a hut. The huts did not necessarily occupy one level: a single building could be built on different levels, sometimes sharing walls with other dwellings (Fig. 4).

Among other features, the typology of the huts aided the defensibility of the village: their roof made up of broom could be easily mistaken with natural vegetation and the fact that they were carved in the rocks constituted an additional defense. The conic roof had to be supported by beams embedded in the walls or resting on the perimeter of the huts (Martinelli 2010). The floor consisted of beaten earth, probably to avoid humidity. The 25 huts are not single residential units: the pottery in the destruction layer helps us to understand that each dwelling had different functions. They were used as houses, workspaces, warehouses, or common areas (Martinelli 2010, 254). In the same area, some waterpipes of 30-40 cm wide to collect rainwater

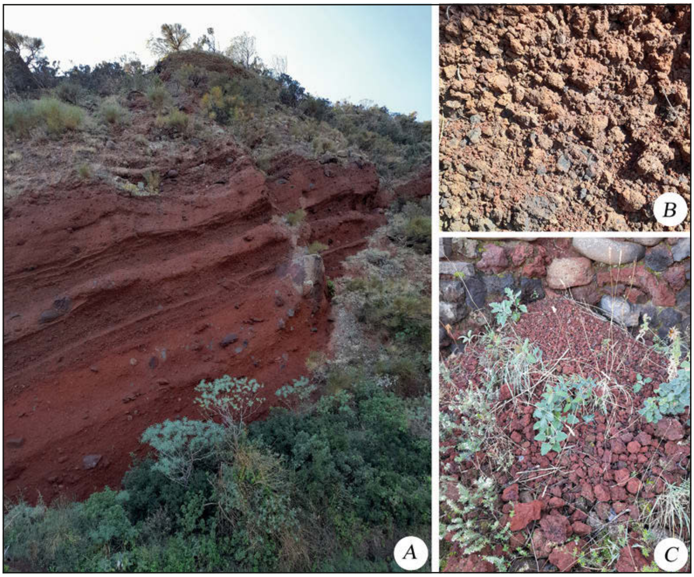

Fig. 5 – Petrography of the area: A) ridge; B) lapilli; C) eroded rocks.

were also brought to light, as were some walls that may have been used for common works (Martinelli 2010, 116-122).

Structures and open spaces were built along the northern and southern slopes of the ridge after an intensive shaping of the natural rock. Possible internal pathways must have developed on the sides of the huts through small ramps. Because of the steep slope of the ridge, the passage was likely facilitated by the presence of perishable elements such as ropes or wooden ladders. Interesting structural elements were found within the 25 structures discovered at Portella: they can be distinguished into architectural and furniture elements. The former represents the structural parts of the dwellings found, like thresholds, jambs and stairs, while the latter has a purely functional purpose for greater exploitation of the available space. This category includes hearths, closets, shelves, and *pithoi* supports. The latter were fundamental to the village: excavations have brought to light 32 of them, referable to two types and distributed both inside and outside the huts. Except for eight structures, a *pithos* was always present. This presence could be justified by the inhabitants' water supply in an area with scarce water resources. Based on the size of the huts, the open spaces and the distinct functions of the structures identified, it was possible to estimate that the village had been inhabited by about five or six households. Therefore, it was calculated that the population of the village was around 100 inhabitants (Martinelli 2010, 212).

3. Research, methods and results

The conditions of the archaeological deposit are excellent due to the constant slipping of material from the highest part of the ridge in which the site lies. This has determined the preservation of the walls and of a considerable number of artifacts inside the huts. That notwithstanding, the erosive activity negatively affects the remains (Bernabò Brea, Cavalier 1968, 163): the lateral erosion of the ridge, due to the water flow, is destroying part of the village (Fig. 5). The team that worked on the last excavation campaign recently hypothesized that around fifty percent of the protohistoric village had already been lost at the time of discovery (Martinelli 2010, 206, 254). These problems need programmatic studies and continuous monitoring of the site. For these purposes, modern photogrammetry with the use of drones is important for interpreting the material evidence and creating plans, sections, orthophotos, DEMs and 3D models. These instruments are extremely important for the monitoring, safety, restoration and enhancement of the archaeological site.

In the next sections we will present the activities and the methodology used for Portella and the making of a virtual tour that could allow the digital conservation of the buildings and an increased accessibility.

3.1 *Aerial recording and data processing*

In the last decade, drones or UAVs (Unmanned Aerial Vehicles) have become a precious instrument in the study of cultural heritage (Pecci 2021)[1]. In the archaeological field, aerial photos taken by UAVs allow archaeologists to highlight the presence, shape and dimensions of ancient remains otherwise invisible or impossible to reach. Currently, digital detection techniques are the best tool to document the archaeological evidence, in terms of accuracy, precision and detail of the data obtained. The experimentation and use of 3D digital acquisition techniques in archaeological fieldwork have now become an established practice, as confirmed by the widespread use of systems based on active sensors (range-based methods), such as laser scanners and total stations, whose methodology of acquisition and data processing is well known and standardized (Böhler, Marbs 2004).

In recent years, systems based on passive sensors (image-based methods), such as digital photogrammetry and computer vision algorithms, have become progressively optimized and are nowadays widely used in archaeology. Photogrammetry (Thompson, Gruner 1980; Mikhail, Bethel, McGlone 2001; Parisi 2012; Angelini, Gabrielli 2013, 389) and Remote Sensing (Colomina,

[1] The spread of these instruments is witnessed by the multiplication of scientific research and articles in which drones play a key role. In Italy, it is worth mentioning how these drones have achieved a prominent role in technical-scientific journals such as «Archeologia e Calcolatori» or even «Archeologia Aerea».

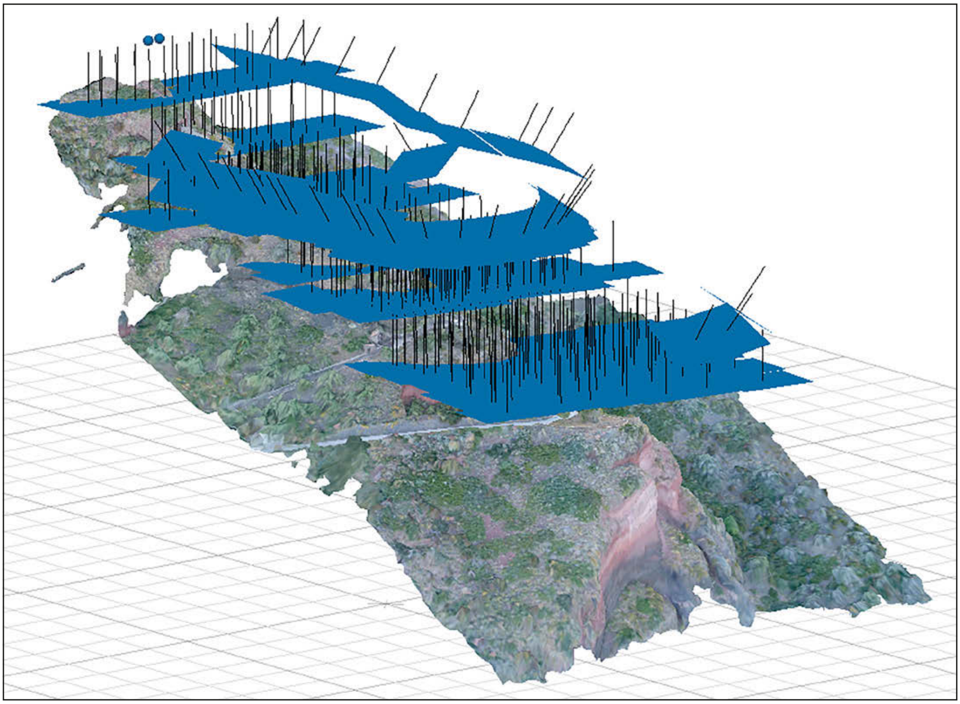

Fig. 6 – Aerial photos distribution on the ridge (Agisoft Metashape).

Molina 2014; Campana 2017) make possible the use of the Structure from Motion (Szeliski 2010; Clini *et al.* 2016) technique, helpful to generate territorial 3D models (Nex, Remondino 2014) and 3D documentation for archaeological excavations (Sfacteria 2016; Ceraudo, Guacci, Merico 2017).

To document the state of the prehistoric site of Portella (3600 m²) the work was divided into different phases, the first in the field and the second in the software environment. For the first phase, we decided to undertake a UAV survey to further preliminary steps. The first and most important one is the flight planning. In general, the operator creates a flight configuration using a dedicated application, in which it is possible to set variables like the speed of the drone, the flight altitude, the angle of sight of the camera and the shooting mode. It is necessary to perform a pre-flight to check for the correctness of the plan designed. Once all the parameters are verified, it is possible to begin the survey. During the flight, the UAVs proceeds automatically following the loaded settings but the operator in any case has to remain in the vicinity to deal with unexpected events, which can be related to various factors (wind, vegetation, presence of infrastructure, loss of satellite signal, etc.).

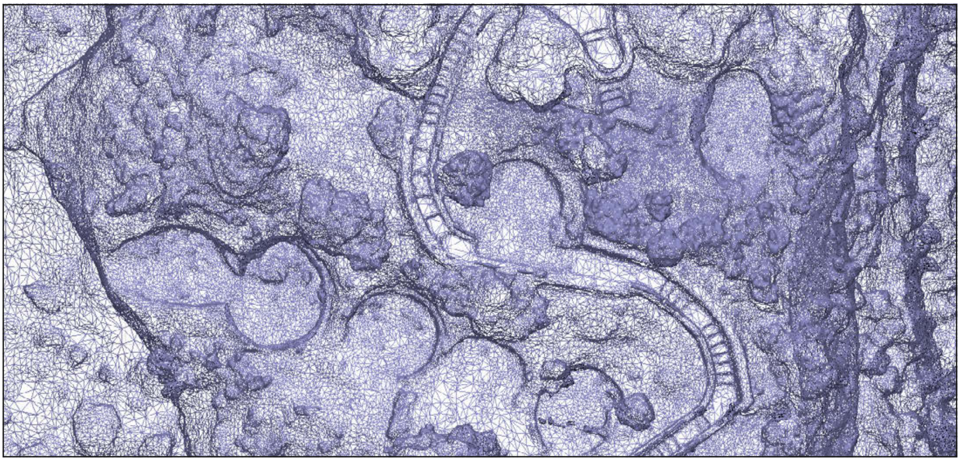

Fig. 7 – Mesh reconstruction in wireframe mode (Agisoft Metashape).

It is advisable to fly under optimal conditions of wind and light-shadow, and it is essential that the area to be surveyed is mostly clear of tall grass that could obscure the archaeological remains. For this project a DJI Phantom 4 Pro drone[2] was used, its trajectory following parallel lines from N to S. We took 420 zenithal and oblique photos at a variable height of 5-20 m from the ground, sloping from E to W. To obtain a total coverage of the area, all the photos have an overlap range from 50 to 70% (Fig. 6). In the second phase of the work, the photos were processed in Agisoft Metashape software. Normally, the workflow involves the following steps: camera calibration, images acquisition and pre-processing, tie points extraction, images orientation, point cloud generation, generation of the mesh, and texturing (Remondino, El-Hakim 2006; Barazzetti, Remondino, Scaioni 2010; Russo, Remondino 2012). At the stage of image orientation, the algorithm detects up to 40,000 tie points per photo, leading to the creation of a sparse point cloud. Once the point cloud is turned from sparse into dense, we can create the geometric structured model (mesh), of which it is possible to set some parameters, such as the quality of the model and the total number of triangles.

The last operation involves the generation of photorealistic texture, which allows projecting onto the shaded surface a blend of the images taken to create the 3D object. The resulting model must be scaled and oriented, by setting a known distance or entering known coordinates both absolute and

[2] Quadricopter weighing 1388 g, with 4 brushless motors equipped with compass, altimeter, GPS, and a range of approximately 20 minutes. Equipped with a camera, mounted on a 3-axis gimbal stabiliser, 20 Megapixel, 8.8 mm/24 mm lens, f/2.8-f/11 and autofocus.

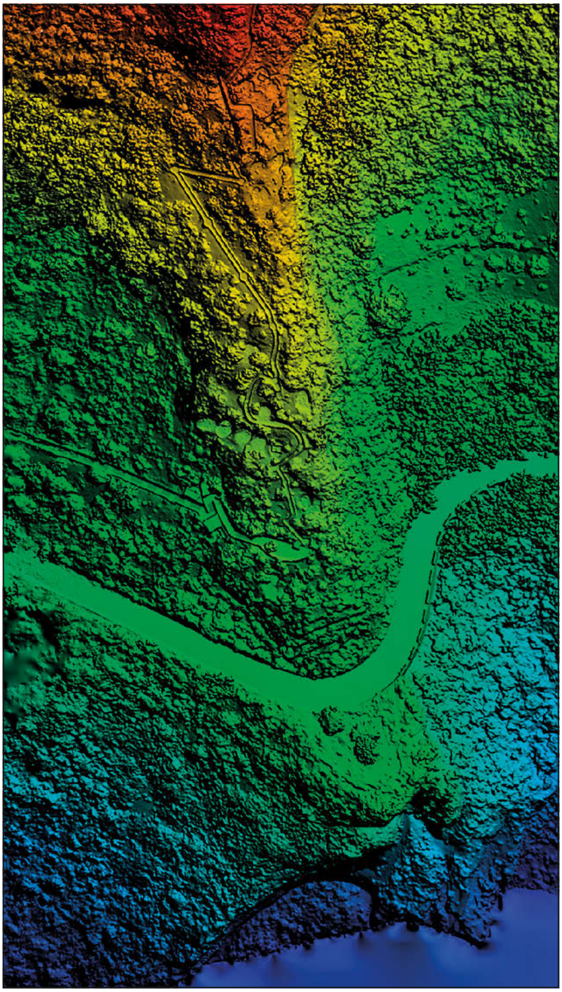

Fig. 8 – DEM of the village area.

relative, using ground control points (GCPs) appropriately distributed on the survey area and measured with a total station or a GNSS. In our case it was possible to create a dense cloud of 359,567 points, a mesh of 2,652,048 faces (Fig. 7) and a 3D model, for which 5:20, 3:10 and 3:40 hours of processing in the software environment were respectively required. The project, scaled with metric references on the ground, was georeferenced for greater precision, thanks to some GPS points deriving from a previous topographical survey conducted during the archaeological mission of 2008-2009.

Fig. 9 – Northern face of the ridge. Wind erosion has created a hole.

3.2 *Results*

Two important outputs extrapolated from the 3D model were an orthophoto (9.63 mm/pixel) (Fig. 3) and a DEM (Fig. 8) (1.93 cm/pixel) (Zoni 2017, 219-221). The overlap between the new orthophoto and the previous topographical documentation confirms that we have lost part of the surface on the northern and southern sides of the ridge, especially nearby the huts O, Z2 and F1. The flow of water and the wind are eroding the northern part of the ridge: that is why we see an accumulation of stones (red lapilli) at the end of the slope, under the place where hut O is located. The natural activities also affect an area where a very worrying grotto is sited (Fig. 9). This could potentially lead to the partial collapse of the prehistoric village, especially in the area where huts F and F1 are located. The orthophoto shows another problem, too: plants and shrubs are growing within the archaeological evidence, impeding a complete view of the village and contributing to run-off risk. Hut U is particularly affected by these problems: this dwelling is no longer visible and is partly lost. It should be noted as well that the presence of shrubs also negatively affects the realization of DTM based on aereophotogrammetry. For this problem there is, at the moment, no other solution than taking constant care of the site and its spontaneous vegetation, which can encourage the construction of more accurate and precise models.

The possibility to carefully record the development of the erosive activity, once a year or more frequently, is obviously followed by the opportunity to understand this process, in terms of measurements, distances and timing of the erosion (Taccola, Olivito 2019). The orthophoto can have a second function, consisting of creating a new survey of the area. Compared with the previous product made through traditional techniques, such as a manual survey on points taken with the total station, the survey through UAVs will certainly present a greater degree of detail and accuracy.

3.3 *A virtual tour for the site*

In the last years, virtual reality became one of the most useful techniques to enhance and enjoy cultural heritage, especially in relation to archaeological sites with accessibility issues (Arnold *et al.* 2001; Barbieri *et al.* 2017; Pecci 2018, 1678-1679). There are several reasons for creating a virtual tour: the first one is the opportunity to expand the audience by offering a visit to an archaeological site to all those people unable to go there in person for various reasons. Among them, we also find the need to connect cultural sites with an audience that needs new forms of communication. For digital natives, experiencing a combination of education and entertainment is indeed significant and could be pursued by exploiting immersive technologies and educational gaming (Scatà, Bertolini, Hohenstein 2021, 40). Virtual reality also allows us to live different experiences, e.g., reconstructing a specific place in 3D. Finally, the focus of our contribution, that is the creation of Virtual Tours (and attached 3D reconstructions), can also be considered an effective resource to preserve and communicate fragile, damaged or endangered historical sites and monuments (Grün *et al.* 2004; Fernàndez-Palacios *et al.* 2017; Mah *et al.* 2018). A fitting example in this regard may be considered the *Rebuilt Palmyra?* exhibition held in Constance in 2017, in which together with some 3D prints, virtual reality led the visitor to the city of Palmyra before its destruction (Skowronsky *et al.* 2018).

For the village of Portella a virtual tour was made with two different functions: firstly, to take a picture of the state of preservation of the monument and secondly, to ensure greater fruition. The archaeological site is located on a high ridge and the visit is possible only by means of long stairways. This made the place hardly accessible to people with physical disabilities or reduced mobility, such as the elderly. The virtual navigation could make it possible to move on the ridge and to explore the huts or the whole village with the help of a special menu provided with a navigation bar and arrow to move in different directions. The virtual tour was built up in two phases: the first was carried out in the field and consisted of shooting 360° photos with the Insta360 One X2 camera[3].

A compatible smartphone (Samsung A21s) was used in conjunction with this camera, which allows users to preview the shot, change settings (such as quality, resolution, ISO, white balance, exposure, etc.), select the shooting mode, view and transfer content on the camera or device via the Insta360

[3] Aperture F2.0. Equivalent to 35 mm focal length 7.2 mm. Photo Resolution 360°: 6080×3040 (2:1) Pan: 4320×1440 (3:1).

Fig. 10 – 360° photo taken with Insta360 One X2.

Fig. 11 – Virtual tour. Information provided by the panels and arrow keys (Marzipano Tool).

Studio app. The Insta360 One X, consisting of two 180-degree lenses, generates two fisheye images of the surroundings; the smartphone, via the app, also takes care of stitching the photographs and videos generated by the camera.

The stitching procedure via the app is a very simple process: once the photograph is captured, the user can access the gallery, select the images contained in the camera and start the saving process on the smartphone. In the end, the result will be an equirectangular photo. The second phase was the creation of a tour with Marzipano Tool, a web service free of charge (https://www.marzipano.net/tool). The first process has provided thirty-three spherical photos starting from the entrance of the site, continuing up the terraces, and arriving at every single hut. All the pictures were taken during sunset hours, helping us to have a good range of colours and no overexposed photos (Fig. 10). In software environments, the spherical photos were processed to remove hypothetical errors of stitching or unwanted elements.

The new visit itinerary to follow has been ideally programmed with Marzipano Tool. Each space/area generated from the images uses spherical projection, which creates a virtual environment that can be viewed through specific interactions, such as Drag to (rotating the view by dragging), or Move to (performing a continuous rotation toward the chosen direction and the rotation ends when the interaction is stopped).

For navigation between environments, the 360° tour uses hotspots. It is possible to move inside the scene with the same arrows provided to change the view (Fig. 11). In the case of hotspots used for navigation, the corresponding area to be reached will be associated in the parameters of the action. The result of the connection between the various environments via hotspots is the creation of a map in the workspace, showing all the connections between the various environments. For each hut or archaeological evidence, it is possible to activate specific hotspots with different digital contents (texts, photos and videos) that have a dual function: to prevent the digital visitor from missing some real details, and to enrich the educational and cultural offer.

The file, consisting of a group of JavaScript, CSS and HTML codes, could be improved with the help of programmers: it could be possible to change the layout or to have more details. The work, conducted with the approval of the Archaeological Museum Luigi Bernabò Brea at Lipari, could be shared with the public through the website of the Museum or loaded on hardware (e.g., a screen) in the rooms of the Museum, in which the main materials from the archaeological site are on display.

4. Conclusions

The archaeological site of Portella, situated in S. Marina Salina (ME), could be considered one of the most endangered monuments in Italy. Natural phenomena, misguided political choices, and the lack of maintenance (just once a year before summer) have damaged the archaeological site. One of the aims of this paper was to show how a periodic monitoring with drones could be the base of a maintenance plan. One similar process was carried out on the Punta Stilo sanctuary at Caulonia (RC) between 2012 and 2014. Part of the archaeological surface is now lost because of a storm surge (Taccola, Olivito 2019, 100-102, figs. 9-10). Although this event was more violent than the slow erosion of the archaeological surface in Portella, in the long run, the results of this process may be comparable with what we saw in Punta Stilo, especially for the portion of the site endangered by the action of the wind (Fig. 10). More specifically, a yearly elaboration of orthophotomosaics would make it possible to understand the conditions of the village, to calculate its vulnerability and to comprehend the potential risk of erosion and landslides. This work could also help the local institutions to compile an adequate program for making the slopes safe.

The potentialities of the virtual tour respond to different purposes. Firstly, the tour will also permit digital openings of the site to new users; thanks to this, problems of accessibility, such as the considerable altimetric difference between the entrance and the upper part of the village, would be easily overcome. Secondly, it can ensure the digital preservation of the site. Even in the worst possible scenario, the destruction of the site, archaeological evidence could still be enjoyed with digital devices (PC, smartphones, and tablets) or with 3D viewers for an immersive experience. Consequently, in the event of serious endangering, this digital preservation is surely a remarkable opportunity to make the site accessible for a longer period. That notwithstanding, we should be aware that we are not yet capable of producing digital data that last forever: for this reason, while IT research goes on to make data supports more and more durable, we propose in this article a periodical monitoring[4]. By producing new datasets in a determined time, we can avoid their irreparable loss or damage. Even though this type of intervention is periodical, it is extremely low cost and not at all time-consuming, as the elaboration time for the process shows (see above, § 3.1).

Finally, we should consider whether to apply this procedure to other Italian sites (or cases) with various preservation and fruition problems. For example, another possible application of these processes can involve the possibility to make virtually accessible those structures which are under restoration. Moreover, when mass tourism or the lack of adequate security conditions for people and archaeological remnants become a problem for the preservation of archaeological evidence, we should consider if a possible solution to these problems could be avoiding a 'physical' fruition of the sites (or parts of them) in favor of a virtual one (just to mention the most resounding case, Osanna 2020, 351-384). This should not be interpreted as a restriction but as a possible safeguarding instrument to be applied in extreme circumstances.

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[4] Nowadays, this instance is becoming more urgent in various scientific fields: just to give an idea about how significant these issues are, I refer to the commitment of the University of Helsinki to preserve the datasets of its researchers (https://www.helsinki.fi/en/helsinki-university-library/library-researchers/helda-digital-repository).

REFERENCES

Angelini A., Gabrielli R. 2013, *Laser scanning e photo scanning. Tecniche di rilevamento per la documentazione 3D di beni architettonici ed archeologici*, «Archeologia e Calcolatori», 24, 379-394 (http://www.archcalc.cnr.it/indice/PDF24/21_Angelini_Gabrielli.pdf).

Arnold D., Chalmers A., Fellner D. (eds.) 2001, *VAST '01: Proceedings of the 2001 Conference on Virtual Reality, Archeology, and Cultural Heritage (Glyfada 2001)*, New York, ACM Press.

Barazzetti L., Remondino F., Scaioni M. 2010, *Automation in 3D reconstruction: Results on different kinds of close range blocks*, «International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences», 38, 5, 55-61.

Barbanera M. 2015, *Storia dell'archeologia classica in Italia: dal 1764 ai giorni nostri*, Roma, Laterza.

Barbieri L., Bruno F., Muzzupappa M. 2017, *Virtual museum system evaluation through user studies*, «Journal of Cultural Heritage», 26, 101-108 (https://doi.org/10.1016/j.culher.2017.02.005).

Bencivenni M., Dalla Negra R., Grifoni P. 1987, *Monumenti e Istituzioni*, 1, Firenze, Alinea.

Bernabò Brea L. 1955, *Salina (Dydime)*, «Rivista di Scienze Preistoriche», 10.

Bernabò Brea L., Cavalier M. 1968, *Meligunìs Lipára III. Stazioni preistoriche delle isole Panarea, Salina e Stromboli*, Palermo, S.F. Flaccovio.

Bernabò Brea L., Cavalier M. 1980, *Meligunìs Lipára IV. L'Acropoli di Lipari nella Preistoria*, Palermo, S.F. Flaccovio.

Bernabò Brea L., Cavalier M. 1991, *Meligunìs Lipára VI. Filicudi. Insediamenti dell'età del Bronzo*, Palermo, Accademia di Scienze, Lettere e Arti.

Bernabò Brea L., Cavalier M. 1995, *Meligunìs Lipára VIII. Salina: ricerche archeologiche (1989-1993)*, Palermo, Accademia di Scienze, Lettere e Arti.

Böhler W., Marbs A. 2004, *3D scanning and photogrammetry for heritage recording: A comparison*, in *Geoinformatics 2004. Geospatial Information Research: Bridging the Pacific and Atlantic. Proceedings of 12th International Conference on Geoinformatics (Gävle 2004)*, Gävle, Gävle University Press, 291-298.

Brandi C. 1977, *Teoria del restauro*, Torino, Einaudi.

Campana S. 2017, *Drones in Archaeology. State-of-the-art and future perspectives*, «Archaeological Prospection», 24, 5 (https://doi.org//10.1002/arp.1569).

Cavalier M. 1957, *Salina. A prehistoric village in the Aeolian Islands*, «Antiquity», 31, 9-14.

Cavalier M. 1986, *Salina nella preistoria e nell'età greca e romana*, in L.S. Herzog Von Absburg, *Die Liparischen Inseln, II. Salina* (Riproduzione litografica dell'originale con trad. a cura di P. Paino), Lipari, Edinixe, 77-81.

Cavallaro C., Maccarone E. 1982, *Isole Eolie*, Genova, Sagep Editore.

Ceraudo G., Guacci P., Merico A. 2017, *The use of UAV technology in topographical research: Some case studies from Central and Southern Italy*, «SCIRES-IT-SCIentific RESearch and Information Technology», 7, 1, 29-38.

Clini P., Frapiccini N., Mengoni M., Nespeca R., Ruggeri L. 2016, *SfM technique and focus stacking for digital documentation of archaeological artifacts*, «ISPRS Archives», 41-B5, 229-236.

Colomina I., Molina P. 2014, *Unmanned aerial systems for photogrammetry and remote sensing: A review*, «ISPRS. Journal of Photogrammetry and Remote Sensing», 92, 79-97.

Fernàndez-Palacios B.J., Morabito D., Remondino F. 2017, *Access to complex reality-based 3D models using virtual reality solutions*, «Journal of Cultural Heritage», 23, 40-48 (https://doi.org/10.1016/j.culher.2016.09.003).

Fiorentino G. 2005, *Analisi archeobotanica*, in Martinelli 2005, 263-278.

Fiorentino G., Colaianni G., Grasso A.M., Stellati A. 2010, *Analisi archeobotanica*, in Martinelli 2010, 235-241.

Grün A., Remondino F., Zhang L. 2004, *Photogrammetric reconstruction of the Great Buddha of Bamiyan, Afghanistan*, «The Photogrammetric Record», 19, 107, 177-199 (https://doi.org/10.1111/j.0031-868X.2004.00278.x).

Iacobucci F., Incoronato A., Rapolla A., Scarascia S. 1977, *Basament structural trends in the volcanic islands of Vulcano, Lipari and Salina (Eolian Islands, Southern Tyrrhenian Sea) computed by aereo-magnetic and gravimetric data*, «Bollettino di Geofisica Teorica e Applicata», 20, 49-61.

Keller J. 1980, *The island of Salina*, «Rendiconti della Società Italiana di Mineralogia e Petrologia», 36, 489-524.

Laino A., Massari A., Pesaresi P. 2014, *La manutenzione programmata ad Ercolano. Obiettivi e complessità di una macchina di cura continua e sostenibile*, in *Quale sostenibilità per il restauro? Estratti del 30° Convegno di Studi Scienza e beni culturali (Bressanone 2014)*, Venezia Marghera, Edizioni Arcadia Ricerche, 505-515.

Mah O.B.P., Yan Y., Tan J.S.Y., Tan Y.X., Tay G.Q.Y., Chiam D.J., Wang Y.C., Dean K., Feng C.C. 2018, *Generating a virtual tour for the preservation of the (in)tangible cultural heritage of Tampines Chinese Temple in Singapore*, «Journal of Cultural Heritage», 39, 202-211 (https://doi.org/10.1016/j.culher.2019.04.004).

Martinelli M.C. 2001, *Portella (Santa Marina Salina, Isole Eolie, prov. Messina)*, «Rivista di Scienze Preistoriche», Notiziario, 51, 527-528.

Martinelli M.C. (ed.) 2005, *Il villaggio dell'età del Bronzo medio di Portella a Salina nelle isole Eolie,* Firenze, Istituto Italiano di Preistoria e Protostoria.

Martinelli M.C. (ed.) 2010, *Archeologia delle isole Eolie. Il villaggio dell'età del Bronzo medio di Portella a Salina. Ricerche 2006 e 2008*, Milano, Rebus.

Martinelli M.C., Fiorentino G. 2008, *The fires of Aeolian villages at the end of the Middle Bronze Age: The case of Portella site in the Salina Island (ME - Italy)*, in G. Fiorentino, D. Magri (eds.), *Charcoal from the Past. Cultural and Paleoenvironmental Implications, Proceedings of the third International Meeting of Antracology (Cavallino, Lecce, 2004)*, BAR International Series 1807, Oxford, Archaeopress, 177-181.

Mikhail E.M., Bethel J.S., McGlone J.C. 2001, *Introduction to Modern Photogrammetry*, New York, Wiley&Sons.

Nex F., Remondino F. 2009, *UAV for 3D mapping applications: A review*, «Applied Geomatics», 6, 1-28.

Osanna M. 2020, *Pompei: il tempo ritrovato. Le nuove scoperte*, Milano, Rizzoli.

Osanna M., Rinaldi E. 2018, *La manutenzione programmata*, in M. Osanna, R. Picone (eds.), *Restaurando Pompei. Riflessioni a margine del Grande Progetto*, «Studi e Ricerche del Parco Archeologico di Pompei», 38, 135-156.

Osanna M., Rinaldi E. 2020, *Il sistema programmato di prevenzione e manutenzione di Pompei: dalla sperimentazione al metodo*, in A. Russo, I. Della Giovampaola (eds.), *Atti del Convegno Internazionale di Studi Monitoraggio e manutenzione nelle aree archeologiche. Cambiamenti climatici, dissesto idrogeologico, degrado chimico-ambientale (Roma 2019)*, Roma, L'Erma di Bretschneider, 35-43.

Papi F. 2008, *Cultura e tutela nell'Italia unita, 1865-1902*, Perugia, Tau.

Parisi L. 2012, *Fotogrammetria e/o fotomodellazione*, in A. Casale (ed.), *Geometria descrittiva e rappresentazione digitale. Memoria e innovazione*, Roma, Kappa, 55-62.

Pecci A. 2018, *La Realtà Virtuale (Virtual Reality) per la conservazione e la fruizione virtuale del patrimonio immateriale*, in V.D. Porcari (ed.), *La conservazione del patrimonio artistico, architettonico, archeologico e paesaggistico*, *Atti del XIV Congresso internazionale di riabilitazione del patrimonio (Matera 2018)*, Napoli, Luciano Editore, 1676-1685.

Pecci A. 2021, *Introduzione all'utilizzo dei droni in archeologia*, Roma, Arbor Sapientiae Editore.

Racheli G. 1998, *Eolie: natura, storia, arte e turismo*, Milano, Mursia.

Remondino F., El-Hakim S. 2006, *Image-based 3D modelling: A review*, «The Photogrammetric Record», 21, 115, 269-291.

Remondino F., Fraser C. 2006, *Digital camera calibration methods: Considerations and comparisons*, «International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences», 36, 5, 266-272.

Russo M., Remondino F. 2012, *Laser Scanning e fotogrammetria: strumenti e metodi di rilievo tridimensionali per l'archeologia*, in G.P. Brogiolo, D.E. Angelucci, A. Colecchia, F. Remondino (eds.), *Teoria e metodi della ricerca sul paesaggio d'altura*, Mantova, SAP, 141-170.

Scatà L., Bertolini M., Hohenstein U.T. 2021, *Virtual tour e fotogrammetria 3D applicati al Museo universitario di Paleontologia e Preistoria P. Leonardi*, in F. Barbagli, E. Cioppi, E. Falchetti, A.M. Miglietta, G. Pinna (eds.), *I musei scientifici italiani nel 2020*, Museologia Scientifica Memorie, 39-45 (https://www.anms.it/upload/rivistefiles/1754e70229c038cca5a0a07c2b24df1b.pdf).

Sfacteria M. 2016, *Fotomodellazione 3D e rilievo speditivo di scavo: l'esperienza del Philosophiana Project*, «Archeologia e Calcolatori», 27, 271-289 (https://doi.org/10.19282/AC.27.2016.14).

Skowronsky M., Wieland J., Borowski M., Fink D., Grösch el C., Klinkhammer D., Reiterer H. 2018, *Blended Museum: The interactive exhibition Rebuild Palmyra*, in S. Abdennadher, F. Alt (eds.), *MUM 2018, Proceedings of the 17th International Conference on Mobile and Ubiquitous Multimedia (Cairo 2018)*, New York, Association for Computing Machinery, 529-535 (https://doi.org/10.1145/3282894.3289746).

Szeliski R. 2010, *Computer Vision: Algorithms, Applications*, London, Springer.

Taccola E., Olivito R. 2019, *Il dato oltre l'immagine aerea: il rilievo 3D da APR per la documentazione, l'analisi e il monitoraggio in archeologia*, «Archeologia Aerea», 13, 96-104.

Thompson M., Gruner H. 1980, *Foundations of Photogrammetry, Manual of Photogrammetry*, Falls Church, Virginia, American Society of Photogrammetry.

Troilo S. 2005, *La patria e la memoria. Tutela e patrimonio culturale dell'Italia unita*, Milano, Mondadori Electa.

Zoni F. 2017, *L'uso della tecnologia DEM nella documentazione archeologica. Alcune applicazioni in casi di contesto stratigrafico e nello studio dell'edilizia storica*, «Archeologia e Calcolatori», 28, 1, 219-238 (https://doi.org/10.19282/AC.28.1.2017.13).

ABSTRACT

The prehistoric village of Portella (Salina, Eolian Islands, ME), occupied during the Middle Bronze period, was discovered by chance in the 1950s and excavated in three different phases, from the moment of discovery until 2008. The site is well preserved because, after partial destruction, it was rapidly covered by landslides of volcanic rock. That notwithstanding, the erosive activity had negative effects, too: the lateral erosion of the ridge is destroying part of the village; possibly a portion was already collapsed at the time of discovery. We can consider this erosion an unstoppable process that needs programmatic, continuous monitoring of the site. In the article, we will discuss how it is possible to make one 'screenshot' of the monument's status with the help of new technologies, specifically, photogrammetry through UAVs. To enhance fruition, a virtual tour of the site was also created. This allows people with physical disabilities or reduced mobility to access, though virtually, the site. In conclusion, other possible areas of application of this low-cost and expeditious methodology are suggested, in particular inaccessible or overcrowded sites.