Non-destructive diagnosis of a hypogean mill

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Abstract. The oil production in the "Terra d'Otranto" (the current provinces of Lecce, Brindisi, and Taranto) has accounted for about four centuries, the primary economic resource in the area. It happened in "places" known as the presses that have a constructive peculiarity, as they derived entirely within the bedrock calcarenite like "Lecce stone", "carparo". They were prevalent on the territory of the three provinces and are present both in urban centres and in the farms. These places, vivid and direct testimony of the rural civilization, are now at the centre of extensive restoration and enhancement work. Given the cultural heritage industry in all respects, the "oil mills" are inserted into the channels of the national roads Olive Oil, and Olive Oil Roads named n° six and n° seven (Adriatic and Ionian Antica Terra d'Otranto). The best solution is conservative reuse, even for the underground presses, as with all industrial archaeological heritage. In this case, new functions mean recovering the fine in its historical identity as a cultural centre to activate it as a place or insert it into a circuit in which the museum is faithfully reconstructed the ancient "art" of unique production processes. Here, we present the work carried out to recover, conserve and enhance the underground oil mill located in the centre of Maglie (LE). Right from the initial design stage, there was a close relationship between designers, researchers-CNR for diagnostics and the responsibility of the City of Maglie. After a detailed knowledge of historical material and construction of the hypogeal phenomenon, both a laser scanner and the non-invasive diagnosis by geophysical surveys were performed.

1. Introduction

In the Apulia region and particularly in Terra d'Otranto (the provinces of Lecce, Brindisi and Taranto), oil production occurred in areas known as trappeti; only with the advent of mechanical force, consisting of a locomotive "steam", the modern mills were built. These "workplaces" in different regions of southern Italy have characterized the urban nuclei, and today I constitute a large fortune proto-industrial and industrial. These places can be counted, through a work targeted capitalization (worthy of conservation, reuse, and restoration of local development processes), among the assets of our nation's cultural heritage. The oil industry accounted for Puglia's primary economic resource; In fact, the food industry was considered as the carrier industry than wine and milling. The oil, from the modern to the end of the nineteenth century, was produced in manufacturing facilities trappeti known as "blood" or "oil mills" or "oil-presses." For many centuries, the force used to operate the mill (or slaughterhouses) of mills and presses was left to the human power "off the cuff" and that animal (hence "blood"); there were few trappeti operated with mechanical force [1, 2]. The *trappeti* in Salento are located in the subsoil (Fig.1) in the bedrock of calcareous stone, tufo or carparo; there are few semi- hypogean; they are below the road level and reach a share of trampling feet that ranges from about 3 to about 4.5 m; their average height is variable within 1.70 m in about 3m. The fact that they were built in the subsoil was to optimize the storage of the product: the internal environment has a warm and constant temperature (ranging between 18 ° and 20 ° C), to facilitate the flow of oil when the mass of mush of crushed olives was subjected to pressing and separation of the oil from the vegetable water (bilge) that was deposited in the wells of settling.

Given the cultural heritage industry, this last decade has initiated a comprehensive process of capitalization. Therefore, the growing interest in the recovery of both memory and identity of a community has led to a substantial territorial reality of projects and interventions aimed at re-functioning, development and fruition of several

abandoned structures. Thus, the underground presses have become part of the national circuits of the Roads of olive oil. In Salento, Roads No. 6 and No. 7 are "the Adriatic and Ionian Ancient Terra d'Otranto".

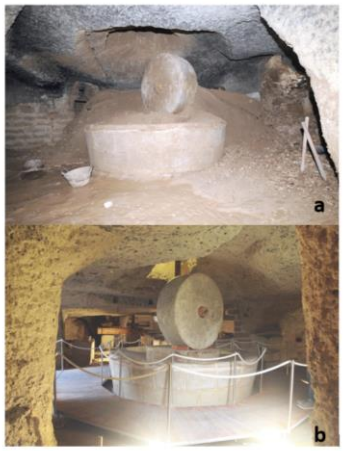

Figure 1. The hypogean mill: a) before; b) after the restoration

2. The Laser Scanner Survey

The digitization of the site was carried out by using a laser scanner Leica Scan Station P20. To create an accurate photographic helpful database for the return of the material, at each station 3D Laser Scanner was shooting a 360° orbital image through professional equipment calibrated in the laboratory to be the same mathematical model derived from laser survey 3D scanners and photographic images orbital. The orbital picture is called the "equirectangular" and is viewable in an immersive way through specific software. The SLR camera Canon EOS 5D Mark II was used. To reconstruct in a single reference system, scans were adopted the mixed method, and target semiautomatic geo-morphological clouds were calculated. To scan the entire area have occurred n ° 6 stations 3D laser scanner internal-external and No. 24, with an average of points earned by about 12 million per scan, for a total of registered points equal to 362 million. (Fig. 2) We then proceeded to the preparation of the elaborate two-dimensional relief. The data points were then entered and processed in each environment to refund plants and the two-dimensional section. The cutting planes of the point cloud for the return of the plants were hired about five feet from the walking environments. We then recalled the three underground plants outside the square's layout of distinguishing layers dedicated elements sectioned projected elevations and elements in the projection from above and detectable lesions. A similar process was for the return of the vertical sections. For a smoother and more immediate reading of the papers, it was also considered desirable to distinguish different layers and colours of the projected elements more or less distant from the plane of section. The survey carried out with the laser scanner was used to obtain information on the significant geometrical crack pattern of the interior of the hypogeum; In fact, the data acquired were highly accurate and represented the object's topology in three dimensions.

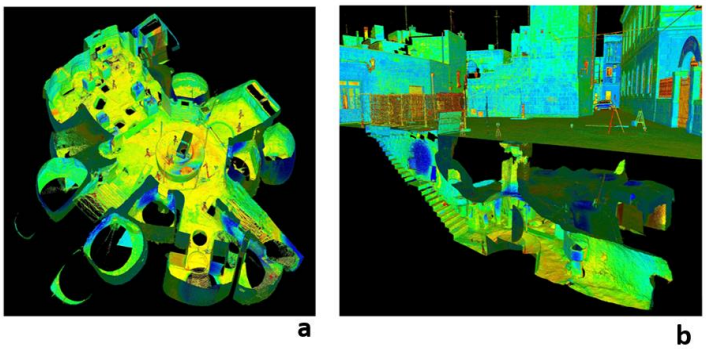

Figure 2. Perspective images of the point cloud sectioned with horizontal (a) and vertical (b) plane

3. Geophysical Survey

A ground-penetrating radar (GPR) survey was undertaken to characterize the subsoil and to found other cavities. The georadar SIR-3000 with the 270MHz antenna was used. A rectangular grid with parallel and perpendicular profiles spaced 0.5m was performed.

The quality of the raw data did not require advanced processing techniques. However, appropriate processing has been performed for a more straightforward interpretation using the REFLEXW software [3]. The following data processing has been completed:

(i) amplitude normalization, consisting of the declipping of saturated (and thus clipped) traces using a polynomial interpolation procedure [3];

(ii) background removal, whereby the filter is a simple arithmetic process that sums all the amplitudes of reflections that were recorded at the same time along with a profile and divided by the number of traces added to the resulting composite digital wave, which is an average of all background noise, is then subtracted from the data set;

(iii) Kirchhoff two-dimensional velocity migration [4], a time migration of a two-dimensional profile based on a two-dimensional velocity distribution, is performed. The goal of the migration is to trace back the reflection and diffraction energy to their 'source'. The Kirchhoff twodimensional velocity migration is done in the x–t range. This means that a weighted summation for each profile point over a calculated hyperbola of pre-set bandwidth is performed. The bandwidth implies the number of traces (parameter summation width) over which resume takes place. A processed GPR profile is shown in Fig. 3.

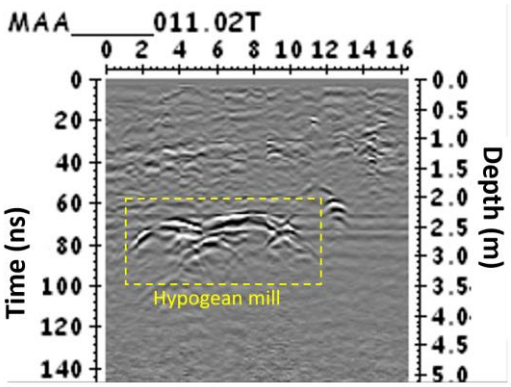

Figure 3. The processed GPR profile

A close examination of the data showed the presence of numerous reflection hyperbolae from a point source. This allows us to estimate the EM wave velocity propagation [5, 6] of 0.07 m/ns in the surveyed area. A general characteristic of the surveyed area shows a good penetration of the electromagnetic energy (120 ns corresponding to a depth of about 4.20 m if the mean velocity value of 0.07 m/ns is used). This is a result of the physical characteristics of the shallow subsurface, which is characterized by material that is slightly dissipating to electromagnetic energy. In all the radar sections, a reflection event is identifiable at the time ranging from about 20 ns to about 100 ns (from 0.7 m to 3.2 m in depth). It has a hyperbolic shape that could be related to hypogean cavities. The arrangement of the profiles in a grid has allowed us to correlate, spatially, the important reflections within two-dimensional reflection profiles (standard radar sections). A way to obtain visually useful maps for understanding the plan distribution of reflection amplitudes within specific time intervals is to create horizontal time slices.
Time slices examine only reflection amplitude changes (or energy changes if the square value is used instead of the absolute value) within specific time intervals and thus within consecutive soil layers of nearly constant thickness. Each time slice is, therefore, roughly comparable to a standard archaeological excavation level [6]. Areas of low reflection amplitude (or energy) indicate uniform matrix materials or relatively homogeneous soils. The high amplitude denotes zones of high electrical subsurface properties contrast, such as buried archaeological features, voids or significant stratigraphical changes.
In the present work, the time slice technique has been used to display the energy variations within the 1.3m-1.75m in depth, where most anomalies (of hyperbolic shape) were observed in all acquired radar sections (Fig. 4).

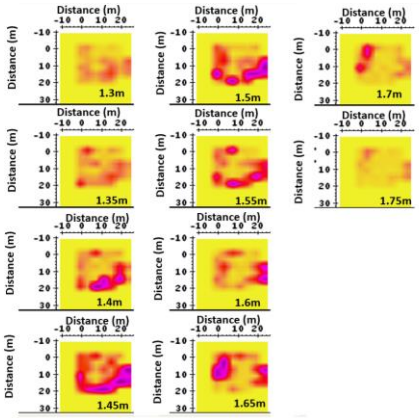

Figure 4. The time slices
One high-amplitude anomaly (red colour in Fig. 4) is visible. The irregular shape and the size of the high-amplitude anomaly suggest that it is related to hypogean cavities.

An analysis related to the fracture degree of the rock that is the roof of the hypogean structure was performed. Fractures can be identified from the analysis of radar profiles. The fractures are characterized by the presence of small discontinuities, representing karstic voids or recrystallized zones. Therefore, the zones with high back-scattered EM energy can be related to more To perform the fracture degree analysis, a further step on GPR data processing was completed, the traces envelope. Results are shown in Fig. 5.

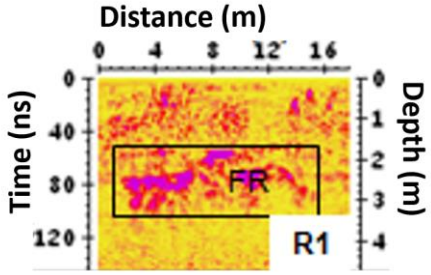

Figure 5. The enveloped radar sections: FR indicate the hypogean cavities

4. Analysis of conservation state

For the Analysis of the State of Conservation has been used the terminology of the Italian standard UNI 11182: Cultural Heritage. Materials, natural and artificial stone. Description of the form of alteration. Terms and definitions (UNI-Italian Organization for Standardization, Milan, April 2006). The analysis carried out directly in situ showed that the underground was in a state of extreme deterioration. Once through the access of the productive structure, a large accumulation of material covered the milling basin could be seen, which in turn resulted in part diruta with stone molar abandoned on one side. After careful observation of macroscopic "sight" (despite the difficulties encountered due to the presence of a large accumulation of earth, stones tell of various sizes and debris of various kinds) have defined the main forms of alteration that determine the state of degradation besetting the entire underground structure. On the whole decking of the hypogea, there were superficial deposits consist of the accumulation of foreign materials of different nature (earth and debris of various kinds, halos and alterations to sediment deposits earth and dust). Also, there were superficial deposits in the deposits of the olives (the sciave) in the wells of decanting, in tanks, in the barn and in other environments. While on stone surfaces (vertical and horizontal), on limestone blocks, the presses and the batteries were fouling by biological cycle wet type mosses and lichens. Unfortunately, as usual, have been lost all the original "ordnance mills" in the wood. The milling basin was devoid of the horizontal axis, vertical shaft, and the shaft that was tied on the back of a mule while, on the stone blocks to support the three presses were missing two screws of the type "Calabrese" and in its cradle lacked even the press "Genovese". Finally, the platforms that support the fiscoli were partially ruined. The square where the trappeto had the floor made of a compound of bituminous road surface, which appeared to be particularly compromised and degraded in some areas. the road surface appeared improper and inconsistent with the picturesque scenery of architectural scenes featuring the little "enclosed square." Therefore, the new pavement will highlight the geometry of urban space in chromatic harmony with the surrounding facades. For the re-functioning of the underground structure and the redevelopment of the entire architectural space that constitutes the "closed court", there have been numerous restoration projects that have ensured the preservation and regeneration of urban public space where meetings and exchanges were done in the past is public and private, due to the presence of the mill and numerous grain pits. Therefore it was removed (by hand) all the earth, and the resulting material (made up of blocks, stones, etc. ..) that hid environments of the hypogea, until you get to the floor original; was opened the gate where he had placed the original scale of access and fully recovered after removal (done

with a careful numbering of the segments according to their original position) and installation of the segments. Finally, the protective coating of the facing calcarenite with colourless breathable; the partial reconstruction of the milling basin with the construction of the horizontal beam, vertical shaft and shaft; the creation and positioning in their respective slots, a press with two screws of the type "Calabrese" and a press to a screw-type "Genovese" in oak; a wooden walkway that allows the card. While the above "closed court" has been removed all the old road surface; developed a new concrete screed and positioned paving (thickness 10 cm) of limestone "Apricena" of the type "bronze" picconata hand. E 'was made a new electrical system, both internal and external to the mill, aims to redevelop the urban space and enhance the historical, architectural and archaeo-industrial "square." Finally, a steel cover marks the entrance to the oil mill. During the work, there has been a lesion passing on the roof, consisting of calcareous bedrock; therefore, an intervention of consolidation was necessary through the impernea cover injected resin organo-mineral Master Roc 364 Flex and resettlement some lesions with Portland cement microfine MasterRoc MP 650. The restoration of the bedrock was performed, starting with a series of holes and the injection of the resin. The holes were made with a diameter of approximately 50 millimetres and a distance of 150 cm from each other, creating a mesh of 150 cm to 150 cm. In each hole was injected in a liquid two-component resin body mineral. This injection mode has allowed the resin to penetrate voids, cracks and micro-voids present in the calcareous substrate. The final number of injections, as designed, was 122 injections. The resin that has been injected is the "MASTER FLEX ROC MP 364" by BASF. To perform resettlement of some lesions present on the soffit of the roof of the hypogeum was done by injecting into them a microfine cement grout "MASTERROC MP 650" by BASF. To do this, with the aid of portable drills, a series of holes with a diameter of 32 mm, at a depth of 1.10 m distance of 50 cm, were performed. Before the injection of the slurry phase, it was decided to compensate the injury with eco malta obtained by mixing the aggregates deriving from the crushing of the rock on the ground. The slurry was prepared by following the manufacturer's specifications, and in particular, it is observed the 1: 1 ratio based on the weight, the mixing time of 2 minutes with a high-speed mixer, and the mixing constant for all the times of injection operations. Regarding the lesion wider, we proceeded to perform a second injection of grout, following the same procedures listed above and realizing the holes with a total distance of 25 cm.

5. Conclusions

The experience gained in this restoration project was very constructive and "interdisciplinary" because it has involved some professionals (architect, engineer, geologist, geophysicist, structural engineer, industrial archaeologist) with different specializations. Through a close relationship between them, they were allowed to return to the citizens and tourists a unique "document" of material culture and civilization of southern Italy.

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