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From knowledge to conservation: the hypogeum *trappeto* of Melpignano (LE, Apulia, Italy)

Giorgia Di Fusco[1], Ivan Ferrari[1], Francesco Giuri[1], Annalisa Malerba[2], Antonio Monte[1], Giovanni Quarta[1]

[1] National Research Council - Institute of Heritage Science, e-mail: giorgia.difusco@ispc.cnr.it; ivan.ferrari@cnr.it; francesco.giuri@cnr.it; antonio.monte@cnr.it; giovanni quarta@cnr.it
[2] Comune di Melpignano (LE), e-mail: annalisa.malerba@comune.melpignano.le.it

***Abstract* –The paper illustrates the first results of a study on an ancient production site of the industrial heritage of the Terra d'Otranto in South Italy: the *trappeto* of Melpignano in province of Lecce. It is an hypogeum oil mill for the production of oil for lighting. To understand the history of architectural transformations that involved the site over time a careful historical-archival research and a campaign of 3D architectural surveys using laser scanners and digital photogrammetry were carried out. Furthermore, a specific diagnostic survey, consisting in mapping of main alteration patterns, sampling and scientific analyses of materials and their alteration products was carried; all obtained data are useful for the following restoration and conservation project.**

I. INTRODUCTION

The extraction of oil from olives, in the ancient province of Terra d'Otranto (the current provinces of Lecce, Brindisi and Taranto), has always taken place in specific site that is named *trappeto* (from the Latin *trapetum*).

It is an hypogeum and semi-hypogeum (from the mid-eighteenth century) oil mill excavated in the rocky bank of local calcarenites called «pietra leccese», «tufo» or «carparo» [1,2,3]. These structures are from - 3.00 to -4.50 meters under the street level and their inner average height varies from 1.70 to 3.00 meters approximately. In the Salento area at the end of eighteenth century, a large number of hypogeum oil mills (about 2600) was present. This large widespread of underground oil mills was related to the easy excavability of the calcarenite rocks, and overall to the particularly stable environmental conditions (from 18° to 20° C in winter), suitable to favor the outflow of the oil during the operation pressing of the olives. [6].

The olive oil extraction was a process developing in different steps: in the first one, the olives were ground by a large cylindrical millstone, mounted in vertical position, rotating on another fixed horizontal stone wheel. In the second step, the olive paste obtained by grinding was spread on fiber discs, stacked on top of each other and placed into the mechanical press. Two types of presses were available: the "calabrese" type, characterized by two wood side screws, and the "genovese" one. This latter, already used in the regions of central-northern Italy, had a single central wooden screw and was spread in south Italy after 1768. After the pressing operation, the oil flowed from the collection well, put at the base of the press, to settling well.

The grinding olive system, as described above, was moved by animals (donkey, mule, ox, horse) while men operated on the *"strettoj"* (presses) [7]. The milling of the olives (crushing and squeezing) in the *trappeti* was a backbreaking and inhumane job; for this reason they were called in the specific Italian literature as *trappeti* "a sangue" (bloody) or even "a tiro" (pull).

These underground workplaces mainly characterize the historic centers of Salento and today constitute a conspicuous proto-industrial heritage: they can be included, by means of specific valorizations project aimed to promote of material culture of the past, within the assets of the cultural heritage of Italy.

In Puglia and in particular in the Terra d'Otranto area, between the 1600s and 1800s, the oil industry represented the main economic resource, more important than those of wine and milling production. The oil produced was defined *lampante* [4], because it was mainly used for lighting [5] and rarely for food by the rich owners. It was of very poor quality, very fat and "strong" as flavor, very appreciated features in various Countries of northern Europe to which it was exported. After, it was also much appreciated and sought by the French in the industry of soap making, namely by the Marseille soap factories, and by the English wool mills which used it to lubricate the machines for the spinning, combing and carding processes.

II. THE HYPOGEUM *TRAPPETO* OF MELPIGNANO: KNOWLEDGE OF THE PRODUCTION

In the municipality of Melpignano, there are six ancient *trappeti*, a rich *corpus* of industrial cultural heritage. One of most important and well preserved is located in via Roma. The hypogeum oil mill is accessed from the south-west by an "L"-shaped flight of stairs partly carved into the rock and partly built, on which is a lowered arch barrel vault with oblique shutters (Fig.1).

Looking at the structure, along the staircase you can see four tanks for the olives (*sciave*), excavated in the rocky bank, where they were left waiting to be ground under the millstone. Going down the stairway, one enters the large room devoted to the processing/crushing of the olives, located at -4.85 m from the external street level: the entire *trappeto*, in fact, is excavated inside a calcarenitic rocky bank of “pietra leccese”. In the middle there is a basin (*conca* or *bacino*) on which is positioned the fixed stone (horilzontal of cylindrical-shaped), on which was placed the imposing millstone (vertical of cylindrical-shaped) moved by animal strength, rotating on the fixed stone. Two millstones of different sizes originally rotated above the *conca*, were recognized: the bigger one is 1.84 m in diameter and 0,59 m thick and the smaller one is 1.25 m and 0,40 m respectively, attributable to two distinct phases of use. (Fig. 2). To the north of the basin is the stable with the mangers, while to the east is the sector for pressing the olive paste for extracting oil: here three two-screw presses of the “calabrese” type were placed. In this latter space developing on the north-south axis, the support bases of the presses with the respective positioning planes of the *fiscoli* are visible together the corresponding settling wells (Fig. 3). The *fiscoli* are circular-shaped filtering containers made from ropes into which the olive paste was inserted before pressing.

Fig. 1. Hypogeum oil mill of Melpignano: access stairway.

Fig. 2. Hypogeum oil mill of Melpignano: millstones of different sizes.

Only around the end of the XVIII century on the east side, a one-screw press of the “genovese” type was added to the production cycle, to speed up the process of the paste pressing and oil extraction.

Behind each press, a niche (*nozzaio*) where the exhausted pasta was deposited after pressing, is recognizable (Fig. 4 A+B).

Fig. 3. Hypogeum oil mill of Melpignano: internal view.

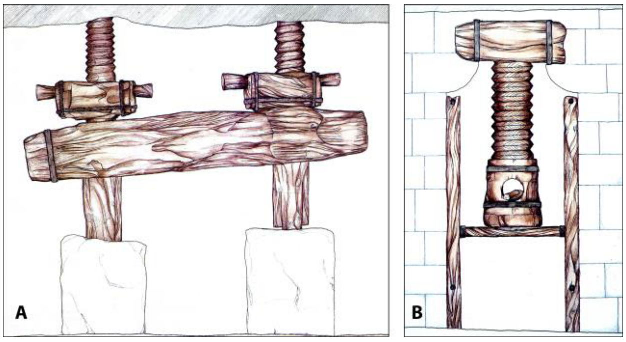

Fig. 4. Type of oil press: A) “calabrese”; B) “genovese“.

During the pressing, the oil and vegetation water, flowed into the settling well located at the base of press. Here, due to the different density (oil is lighter than water), the oil rose to the top and manually separated from the vegetation water which flowed in a large tank, located nearby the settling wells. After the separation from the vegetation water, the oil was deposited in four stone monolithic rectangular tanks, placed in a room in to the southern area of the hypogeum. Finally, a large cistern for storing rainwater is present in the southern part of the hypogeum.

Given the size of the *trappeto*, it is probable that 4/5 workers (*trappitari*) were useful to complete the oil production cycle. (AM, AM)

III. FROM THE 3D SURVEY TO THE TECHNICAL-CONSTRUCTIVE STUDY

An important step for the restoration project of the hypogeum oil mill of Melpignano concerns the graphic documentation, difficult to make according to traditional techniques such as geometric relief.

In the case of Melpignano hypogeum, a metric survey campaign, based on the combined use of the laser scanner and digital photogrammetry techniques, in order to obtain models with a different level of detail in the same 3D space, was carried out [10,11,12].

A total of 47 scans, using the Leica P20 ScanStation with two different presets on a dome with a 10 m radius were done. The first, aimed at the survey of the external surrounding spaces of the *trappeto* (6.3 mm spacing, quality 3 and time 06:46) and the second one, with a higher resolution, for acquiring of the underground environments (3.1 mm spacing, quality 3 and time 13:30). Subsequently, manual matching was carried out in Leica Cyclone software (v 8.1.1); the final point cloud (660 million points) was exported in .pts format (10 Gb) and imported after a 50% decimation in Geomagic (Studio 2003): here it was processed for the calculation of the polygonal mesh (18 million of polygons) then saved in .obj format.

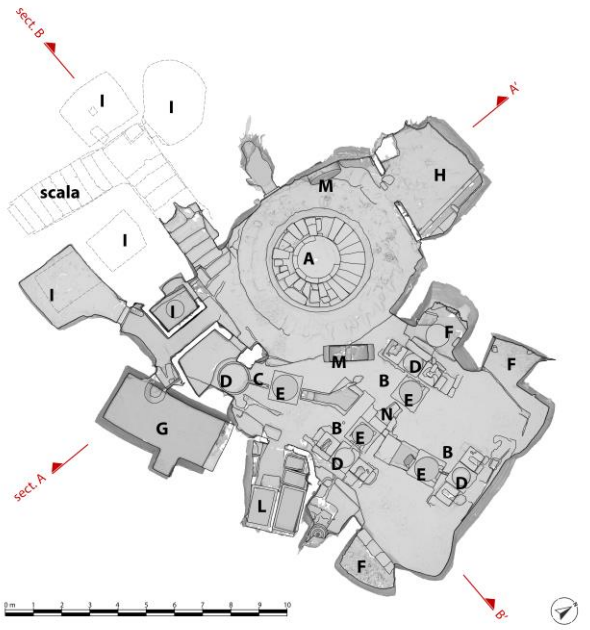

Fig. 5. Hypogeum oil mill of Melpignano. Plan from 3D laser scanner survey: A) conca; B) "calabrese" oil press; C) "genovese" oil press; D) support planes for "fiscoli"; E) settling well; F) "nozzaio"; G) water tank; H) stall; I)"sciave"; L) Oil tank; M) millstone; N) vegetation water tank.

The 3D photogrammetric survey of the hypogeum was carried out with a Sony Apha 7R III camera with a Canon 24 mm lens but, given the low luminosity of the environment, it was necessary to use a tripod to lower the shutter speed using LED spotlights for a diffused lighting with few shadows. 915 photos were acquired and then processed in Agisoft Metashape Pro®: the final model, scaled and oriented, has 24 million polygons and 6 4096x4096 px textures. Both digital models have been imported and superimposed in a digital environment for the creation of the graphic documentation, the volumetric calculation of the removed rock material -which stands at around 550 m^3-, and the definition of the construction phases. (Fig. 5-6). The close-up visual analysis of the internal surfaces, combined with the overall view of the 3D digital duplicates, led us to understand how the *trappeto* was born by reusing a large bell-shaped cistern that is probably no longer functional.

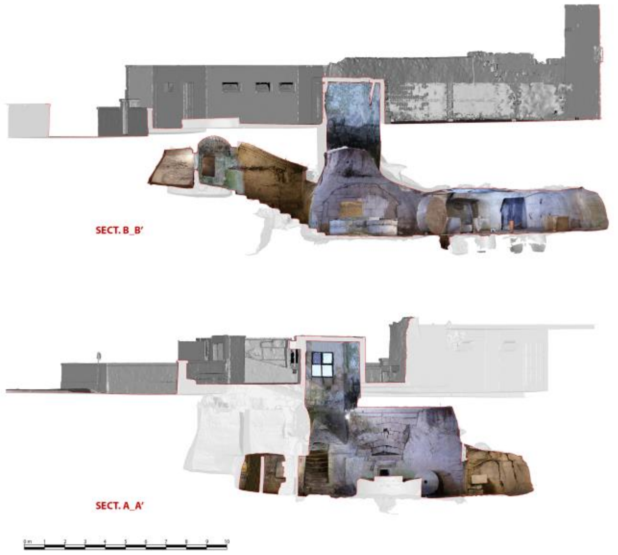

Fig. 6. Hypogeum oil mill of Melpignano: sections plan from 3D model.

The circular masonry base on which the millstone rotated was placed at the base of the original cistern, while the vertical pivot that served as the axis of rotation was inserted at the top in a large segmental arch, later demolished, as it possible to deduce by the first lateral blocks, still visible on both sides. The 3D simulation carried out in the Maxon C4D R21 environment, with hand-made modeling techniques, and the support of the V-Ray 5 render engine [13,14,15], has allowed us to understand how this first arrangement allowed an adequate space only for the smallest millstone existing in the crusher. Indeed, the reconstruction of the lower profile of the arch returns a height of about 2 m from the basement, sufficient to guarantee the rotation of a millstone of 1.25 m in diameter (Fig. 7).

Interesting is the technical-constructive solution adopted for the lowered barrel vault located on top of the old water tank, perhaps due to the collapse of the dome itself and part of the west wall. Unlike the eastern front, where the rocky bank is intact and suitable for offering a solid support base for the vault, the western one actually has a showy "V"-shaped gap, under which there is an opening into a storage compartment, surmounted by a lithic architrave. Above the architrave are five discharge arches, progressively jutting out and of increasing width. They give support to the west side of the vault, conveying its thrust on the rocky sides of the large gap, safeguarding the integrity of the architrave and of the underlying room.

In a third phase, the smaller millstone wheel was replaced with a larger one of 1.84 m in diameter: a modification that led to the demolition of the arch, too low for the new wheel, and the installation of a large wooden beam at a higher level.

It cannot be excluded that the enhancement of the milling activity could coincide with the technological modernization of the olive pressing system, datable to the second half of the XVIII century, which took place with the addition of the "genovese" press, much more performing both under the quantitative and qualitative aspect. (IF, FG)

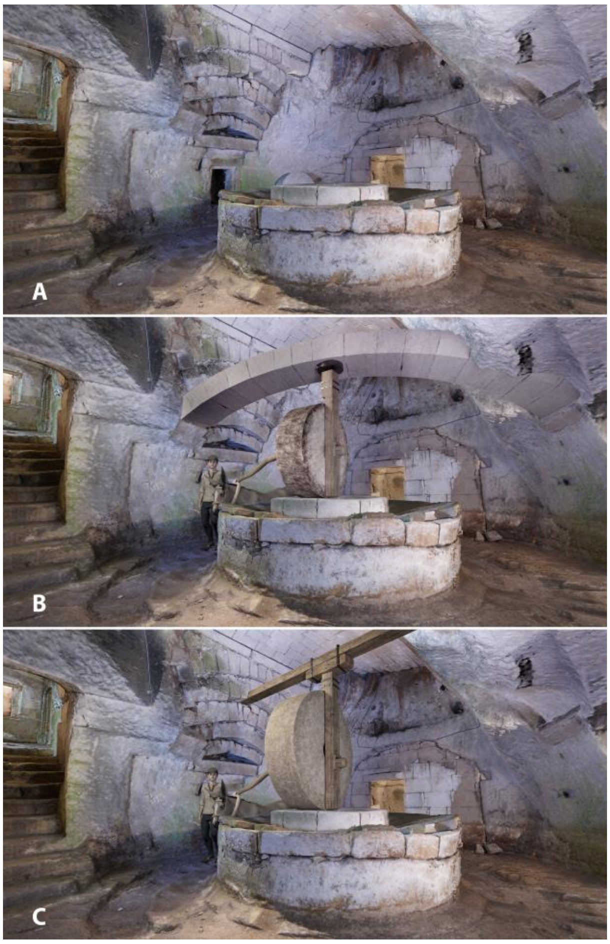

Fig. 7. Hypogeum oil mill of Melpignano: A) current view; B) 3D reconstruction of the first arrangement with the smaller millstone; C) 3D reconstruction of the second arrangement with the bigger millstone.

IV. DIAGNOSTIC

In order to obtain information about the materials constituting the main artefacts of the hypogeum oil mill and their conservation state, a relief of main deterioration patterns was executed. This important step of the restoration project was need with the aim to investigate which deterioration processes are in progress within the hypogeum and to design the right interventions of rehabilitation of the whole hypogeum system. The hypogeum was excavated within a rock bank constituted by a soft calcarenite, namely Pietra Leccese, outcropping in the area and largely employed as construction and decorative material in the built cultural heritage. Remains of *cocciopesto* plaster is present on a part of the vault, in correspondence of the millstone, which testifies a previous use of the hypogeum as water tank. For mapping the main deterioration patterns, interesting the surfaces of hypogeum oil mill, a specific lexicon (UNI 11182, 2006) was used. A frame of this mapping is shows in Figure 8.

Sample number	Sample description	OM	SEM-EDS	DRX	IC
MELP 1	Rotating grinding-stone (vertical stone) of the oil mill	X	X	X	-
MELP 2	Fixed-stone (horizontal stone) of the oil mill	X	X	X	-
MELP 3	Stone from the rocky bank	X	-	-	-
MELP 4	Cocciopesto mortar from the vault	X	-	-	-
MELP 5	Red earth-based mortar from the joint between the ashlars of masonry	X	-	X	-
MELP 6	Powder from efflorescence	-	-	X	X

Tab.1. Type and provenance of the samples and analyses performed.

As it is possible to note, efflorescence are mainly present on the lower parts of wall and biological patina on the surfaces exposed to the sun light. Lack of binding mortar in between the ashlars on the masonry is also present. In addition, fissures of variable thickness, sometime filled of red earth (not visible in Figure …), involving the rocky mass, are also present. Some stability problems have been detected in correspondence with the access stairway to the hypogeum, where some ashlars of the vault show fractures and/or disconnections between them.

The macroscopic survey of the degradation patterns was followed by a diagnostic campaign aimed at both the characterization of the materials constituting the various parts of the hypogeum and their alteration products. Micro-samples taken from the two millstones, fragments of mortar of various types (cocciopesto and red earth-based mortar) and powders coming from saline efflorescence have been undergone to the following analyses: Optical

Microscopy (OM), Scanning Electron Microscopy (SEM) and EDS microanalysis, X Ray Diffractometry (DRX) and Ion Chromatography (IC).

The equipment used for the analyses are the following: NIKON Mod. Eclipse LV 100 for OM observations; SEM Zeiss mod. EVO 15, linked to a microanalysis EDS system OXFORD Mod. Ultramax 40; Diffractometer Philips Mod. PW 1729 with goniometer PW 1820; Ion Chromatometer Dionex mod. DX 500.

Fig. 8. Hypogeum oil mill of Melpignano: surface degradation mapping.

The results of the performed analyses indicate that the the rotating grinding stones and fixed (horizontal stone) are made of carbonatic compact stones made respectively of Dolomite and Calcite respectively (Fig. 9). The dolomitic one is a crystalline rock (Dunham, 1962) made exclusively of dolomite crystals, while the calcitic one is composed of peloids kept together by micrite and/or sparite. This latter stone can be classified as wackestone-packstone (Dunham, 1962). This different composition could be due to the intentionally employ of dolomitic rocks (harder than calcite one) for grinding purposes as just found in the millstones of Vernole and Martano [2].

The rocky bank is a stone composed almost exclusively of Foraminera immersed in a fine micrite. Some quartz grains and glauconitic masses (inside the Foraminifera cameras) are also present. It can be classified as wakestone/packstone (Dunham, 1962). Above petrographic point of view, it belongs to Pietra Leccese formation of Miocene age, largely outcropping in the Melpignano area.

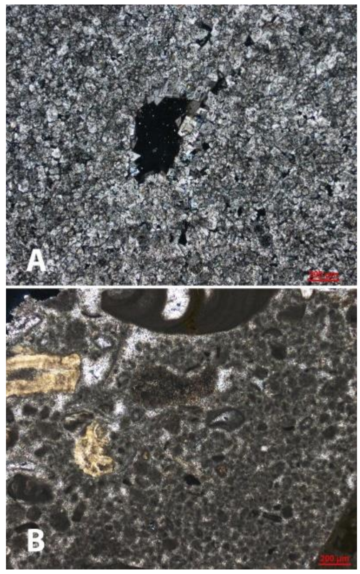

Fig. 9. Thin section, Nicols +: A - Grinding millstone-dolomitic crystals are well visible; B Fixed millstone made of peloids kept together by micrite and/or sparite.

The mortar taken from the vault displays a carbonatic binder and an aggregate made mainly of cocciopesto coming from the crushing of ceramic materials such as bricks or tiles. Some grains of carbonate rocks and quartz are also present. The size of aggregate varies from tens of micron up to 6-7 millimeters. The binder/aggregate ratio is about 1:2,5/3. This kind of mortar has hydraulic characteristics so that its use in this context suggests that the hypogeum, in a previous period, could have been used as a water storage.

The red-earth based mortar is composed almost exclusively of red earth mixed to a scarce lime. The red earth is made of oxide and hydroxide of iron, clay minerals, quartz and low amount of calcite. Its employment as joint mortar was common in the building practice of the past. The results of the efflorescence analysis, obtained by IC, show a high content of Sulfate and low amount of Nitrates e Chlorine, between the anions, while for the cations display a high amount of Calcium and low content of Magnesium and Sodium. The XRD analyses confirmed the presence of Gypsum and traces of Mirabilite. (GDF,GQ)

V. CONCLUSIONS

In this case study, the use of integrated methodologies concerning the historical information of ancient practices of olive oil production, the use of advanced metric survey methodologies and of a diagnostic campaign, allow to the reconstruction of historical evolution of the site and its reuse over time, useful for the restoration and valorization project. In detail, the metric survey and diagnostic campaign allowed to identify the main phases involving the site. The first one is related to its use as water storage, testified by the presence remains of hydraulic cocciopesto mortar, employed as renderer of cisterns. The metric survey also allowed to claiming that the original arch present above the *conca* was removed due to the need to substitute the smaller original millstone with a bigger one, when at second half of the eighteenth century, larger production of oil was required.

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