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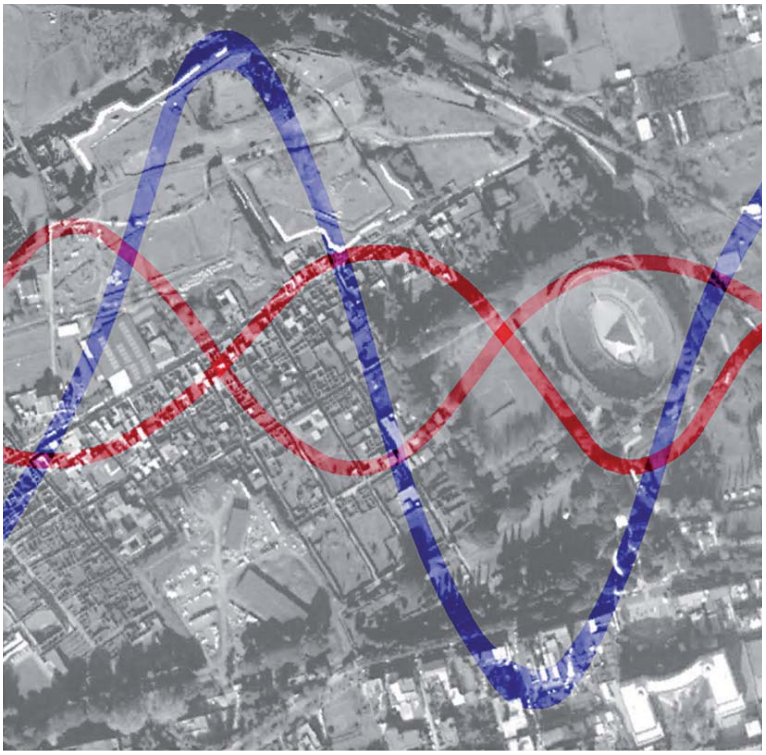
XVII INTERNATIONAL FORUM

Le Vie dei Mercanti



WORLD HERITAGE and LEGACY

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Preface

The XVII Forum "World Heritage and Legacy" addresses the issue of the handed down in the sense of transmission over time of generation, at the state of knowledge, the material and immaterial heritage that comes from the past. A generational commitment to operate, in the cyclical temporal process, in order to preserve and protect the cultural heritage; a duty of the present generations to deliver to the future generations the legacy of the past at least in the same conditions in which it is received.

A commitment that takes on an even more meaningful significance in a historical moment that is crossed by destructive and iconoclastic wars and by great migration phenomena involving abandonment of territories undermining the identities of places, traditions, material and immaterial culture, which characterize the Cultural Landscapes. A re-appropriation by humanity of the value of a biological continuity that is traceable in its genetic complexity as a custodian and bearer of the memory of the past and, at the same time, belonging to those who live in the future by living the present. Moreover, "to the state of knowledge" should not be interpreted as a limitation but as an exhortation not to live on the position income and above all to remind men that they were not "made to live like brutes but to follow virtues and knowledge".

Knowledge therefore contains an evolutionary value in the history of progress. Where knowledge is substituted by acts or policies conducted by brutal and unreasonable actions against Humanity and its Patrimony, a fracture on historical continuity is created, which produces a negative value due to the great expenditure of economic resources and loss of human values . Therefore, in the awareness that the value produced by the past generations, which have given us and above all entrusted as heritage to be transmitted to the future is not commensurable to the value of time to re-establish and restore continuity to the regenerative space of the common good, it is impossible to activate more and more moments of reflection and I would say to monitor the behavior of supranational cultural policies.

This in the spirit of inducing to avoid the disastrous temporal intervals that involve serious losses of the human heritage, which break the glue that binds the generations. Architecture, Cities, Infrastructures and Landscape not only represent the form of time but all the disciplines that have contributed to and contribute to their characterization. The form of time is the body of a cultural program of society and the modification project makes use of the knowledge at the date. Economics, mathematics, physics, in one the sciences are always traceable in the construction of man's works, from the simple artifact to monumental architectures, to cities, to large infrastructures. In fact, with

the previous sixteen editions of the International Forum "Le Vie dei Mercanti" an interdisciplinary community has been created of about 6000 scholars and researchers, coming from over 50 Countries of the World. These have presented realized projects, theoretical research, good practices, technological innovations, which are recognized in the principles and actions to be carried out so that the Planet with its species can always adapt itself to the needs of humanity in a sustainable reciprocal relationship for the salvation of the same Planet. And if Beauty will save the world, the principles and actions shared in these sixteen previous years will find with the seventeenth Forum a moment of evaluation of the state of art so that they can increasingly reach, interest and belong to as many people as possible such as Governments, Institutions, Universities, and Enterprises.

This is to create and disseminate a new Humanism that acts as a generational glue through a review of the inheritance concept, or of an ongoing heritage formed by resources intended as lot, which, declined as an income statement, create solidarity, peace, trust, work with art and quality of life.

For these reasons and for the history of the Forum, I am sure that the scientific community will establish a debate in Naples and Capri on 6th, 7th and 8th of June which will bring further richness to the discussion among researchers who have faced the protection and safeguard of heritage handed down to us and the researchers who through their works will be the bearers of the future legacy.

Carmine Gambardella

President and Founder of the Forum

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The *dammuso*: constructive characters of the traditional stone buildings of the isle of Pantelleria (Sicily)

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Abstract
Pantelleria, a volcanic island between Tunisia and Sicily, is characterized by a highly windy territory constantly hit by the sun. This harsh environment forced the inhabitants to build in an extremely effective way against the natural elements. This paper investigates constructive technologies, local materials, and phases of construction of the traditional rural houses, the *dammuso*, a Sicilian word meaning “vaulted-building”. It is a traditional passive cooling building characterized by a cubical shape covered by a vaulted-roof. This typology can be found almost everywhere in the isle, both old and pretty new, as the only one permitted. The minimum configuration unit is a cube made of bearing walls and an extrados-shaped vault; a more articulate disposition is realized juxtaposing three-dimensional cells. The different types of stones generate various typologies of masonry; the stone vault - finished by a white lime mortar making an inner comfortable micro-climate – is traditionally constructed by means of a wooden centering light structure; systems of rainwater disposal and internal/external finishing are also investigated. Ultimately, the *dammuso*, as a typical Mediterranean typology of vernacular house, is particularly interesting as it represents a simple passive cooling system whose principles are still reproduced in a contemporary way in modern buildings intended for a valid and functional energetic control along with making a perfect harmony between natural and built environment.

Keywords: Verrnacular architecture, constructive technology, vault, stone, passive cooling.

1. Introduction
Pantelleria is a volcanic island located about 70 km far from Tunisia and 100 km from Sicily and is a highly windy territory constantly hit by the sun. The climate is temperate, maritime Mediterranean, with a yearly average temperature of 18°C, with excursions of even 14°C. Hot summers, high drought and dominant winds - Sirocco (south-east) and Mistral (north-west) - that can easily reach a velocity of 55 km/h. Nevertheless, this island has been inhabited since the IX century by the Phoenicians who made it a strategic territory for trading in the centre of the Mediterranean sea. Due to the harsh living conditions, the inhabitants developed a constructive typology extremely effective that, still today, represents a typical Mediterranean passive cooling architecture: the *dammuso*. That is a Sicilian word meaning “vaulted-building”. Indeed, the constructive dominant element is the dark igneous stone historically used to build such a rural houses that are characterized by a cubical shape covered by a white (mortar) vaulted-roof. Buildings of that type can be find almost in every part of the island, both old and pretty new. Indeed, Pantelleria is one of those “happy territories” where cultural heritage is finely preserved to the point of prescribing such a constructive typology by a territorial plan.
A *dammuso* represented a daily shelter for peasants, who had to work all day long quite far from their proper house. At the same time, it was a warehouse for rural tools and goods. They are generally located in the centre of a land tenure (figure 1, A) or on a rocky side, even built-in it (figure 1, B). It is very rare finding in the Mediterranean environment such a perfect harmony between the natural and built environment.

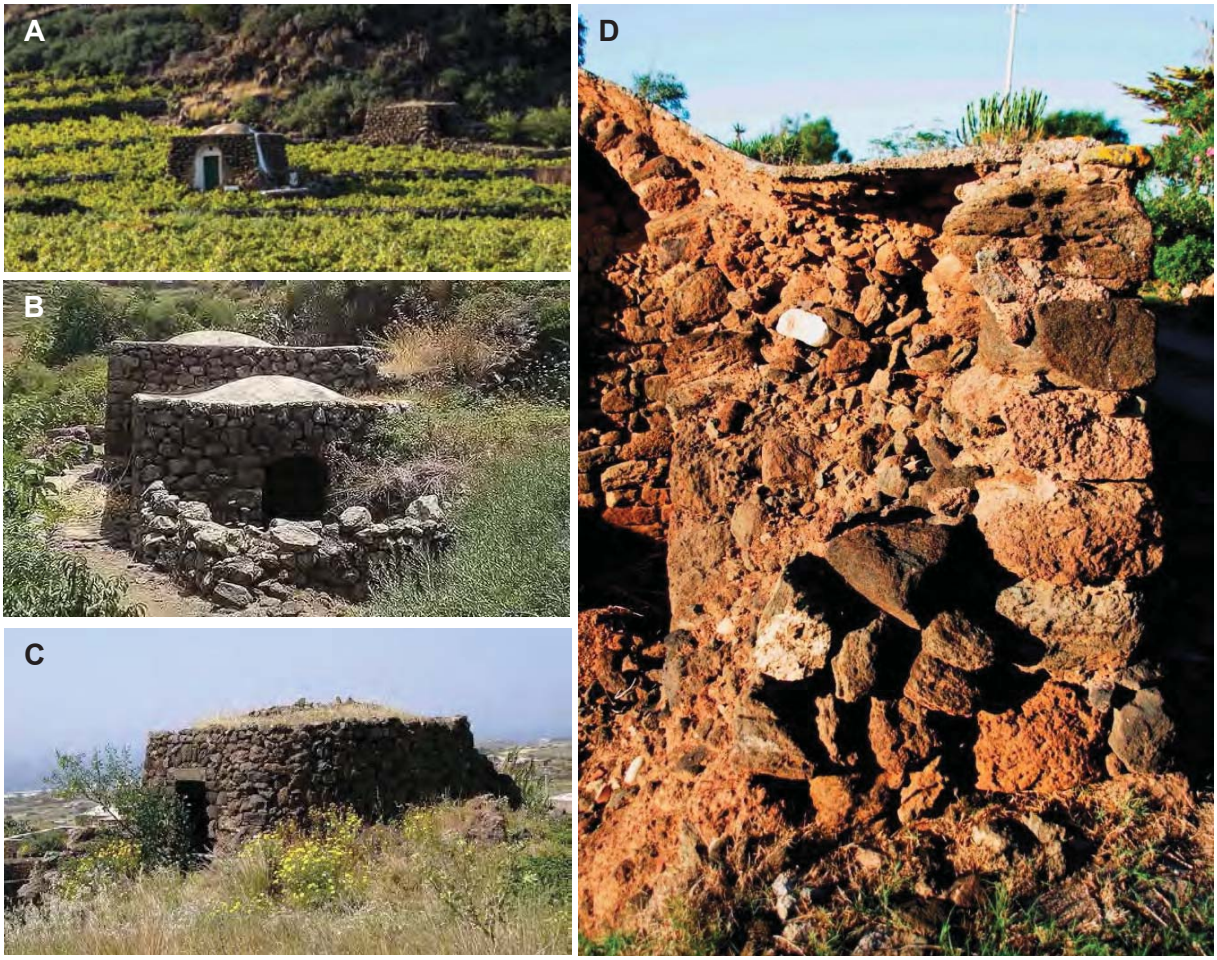

Fig. 1: A: *dammuso* in the middle of a vineyard; B: a built-in rock *dammuso*; C: a *dammuso* with the grass covering; D: masonry section of a collapsed old *dammuso*. Worth to notice the absence of cross-connections among the two walls.

2. Historical evolution of the constructive technologies

Historically speaking, the *dammuso* represents a spontaneous architecture whose constructive features are extremely simple. It is generally composed by a single room with a quadrangular or rectangular plan, extruded into a cubical building and covered by a white vaulted-roof, equipped by a few openings that are built by an arch or a lintel set on jambs; often there is an underground cistern used to collect and store rain waters, quite rare and precious.

The evolution of the constructive technologies follows the developments of the historical events that affected the Mediterranean territories. The Romans occupied Pantelleria around the III century b.C. and brought prosperity in both construction (public buildings, ports, villages, etc.) and agriculture. With the end of the Roman Empire and the commercial trading, along with the pirates' incessant devastations, the inhabitants were forced to practice agriculture only. Hence, the necessity to have an adequate shelter from winter rains and summer heat on the field. So the first dammusi took birth as real and simple "containers" used to shelter people, tools, and goods. They were usually composed by a single room without window/door frames or inner/external finishing, and a packed dirt floor.

The shortage of construction materials, the impossibility of trading with land, and the extreme poverty of the population, made the inhabitants use the few available natural resources, first of all the volcanic stone [1]. That was extracted directly from the construction site field, and used after a simple rough-cut. Masonry were generally made of two parallel walls, separated to create an inner void that used to be filled with small rubble stone and a mixture of soil and water (figure 1, D) [2]. It is evident the obvious origin of such a technology from the Roman rubble masonry, the *opus caementicium* [3]. The typological roof was a barrel vault made of volcanic stone that granted a rapid and easy execution. The final cover was generally made of a pressed layer of wet soil that filled in the voids between the stones. Finally, a grass blanket was let grow on it (figure 1, C) to further reduce the voids with the roots, improve the thermal insulation of the roof, and limit the water infiltration [4-5].

From the VI century with the Byzantine domain, the old *opus caementicium*-like masonry was substituted by a novel technology that foresaw the employment of squared volcanic stone ashlars,

with an approximate dimensions of 25x38x80 cm, and lime mortar to set the courses. The final work resulted a sort of *opus pseudoisodomum*, a stone masonry where the rows of the courses run unequally, referring to the height and length of the blocks [6]. Indeed, with a greater political and economic stability, trading started again and the lime began to be imported into the island, giving a strong improvement to construction. This pseudo-isodomic masonry let a reduction of thickness possible, from 1-2 m to 40-80 cm, granting a higher stability (the two rubble stone walls were not connected), and a faster and easier execution [4]. In roofing, two important innovations were introduced: a) different configurations at the two sides - with a barrel vault at the intrados and a more regular profile at the extrados - and b) the substitution of the dough of soil and water with a proper lime mortar mixed with volcanic sand to feature a pozzolanic activity.
Such an innovations remained the basis of the constructive practice in the Isle of Pantelleria and still today they are largely exploited, even though highly limited, in new constructions.

3. Architectural composition and constructive features

A traditional *dammuso*, as discussed, is a single-room cubic structure made of volcanic stone masonry and covered by a vaulted roof. As a common architectural/constructive typology of Pantelleria, the *dammuso* could envisage the union of many units to generate larger buildings used as permanent houses. They were usually composed by three spaces (figure 4-5): a) a main hall used for daily activities, in communication with the exterior, b) a rectangular bedroom, accessible from the hall through an arched opening and delimited by three walls without any other opening, and c) a little room, used for secondary activities or as bedroom. The kitchen was usually located outside and was equipped with a wood-oven that, only recently, was located into the house. Inner walls often show some notches, that created a sort of built-in wardrobe, usually located in the centre of the wall and far from the corners where the vault's weight is applied.
A proper foundation was not usually required thanks to the high wall's thickness and the excellent properties of resistance of the rocky terrain. The masonry usually began in an excavation, 20-50 cm deep, that followed the building's perimeter, and the base of the wall coincided with the dig depth, if further enlargements were not needed. Therefore, the foundation corresponded to the lowest part of the wall and was an integral part of it.
In the case of the oldest or poorest systems, the masonry was made of rough-cut stones set in a soil mortar. Thickness ranged from 80 cm to 2 m, depending on technology and available construction material. The construction usually began with setting large stones at the corner of the future building perimeter. The other stones were placed following a rope, stretched between the corners, that acted as a guide [5]. The smooth surface was located in-sight to the exterior of the wall. It was very important that ashlars' surfaces corresponded perfectly one to each other in order to ensure a good wall's stability. Such a procedure is still used nowadays in the contemporary *dammuso* construction. While the two parallel walls has been erecting, the inner void was filled with rubble stone and a mixture of soil and water as binder that had to be pressed very well in order to generate a resistant layer able, along with the external walls, to support and transmit the vault's vertical loads to the foundation. Furthermore, it acted as a thermal insulation, to maintain constant the inner environment. Sometimes, to balance the tilting moment of the vault's horizontal loads, an additional layer of stones was arranged around the wall (figure 3). It was a sort of hooping to counter-push the loads, essential in the case of an earthquake [4].

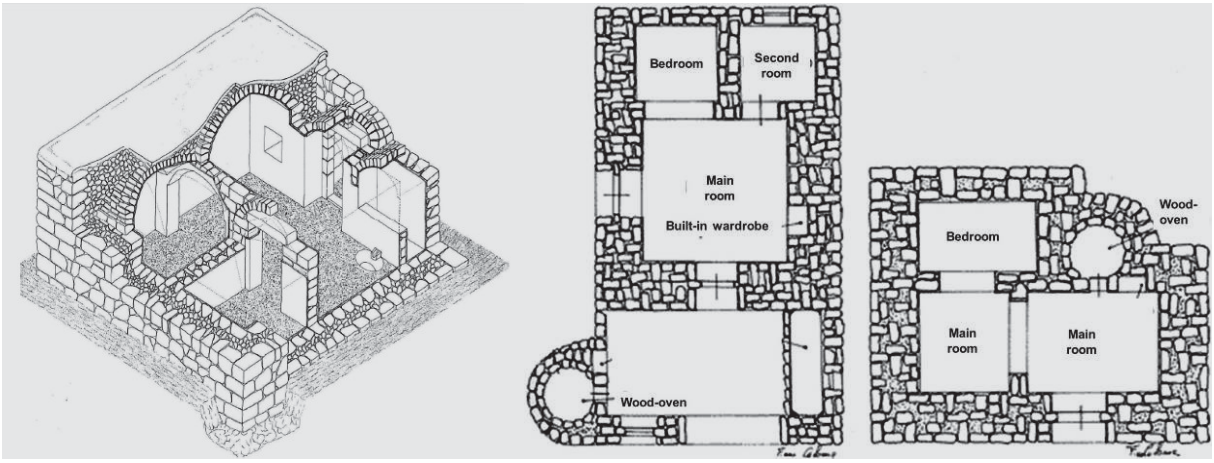

Fig. 2: Section (left) and plans (right) of a typical *dammuso*-house.

Fig. 3: Counter-pushing layer of stones built to balance the vault's tilting moment.

Fig. 6: The oldest typological system of roofing is the real barrel stone vault.

Fig. 4: Particular of the ashlars of a corner.

Fig. 7: Typical finishing made of lime mortar.

Fig. 5: Combined system arch-architrave.

Fig. 8: Meteoric water disposal system.

In the case of modern masonry, squared ashlars of about 25x38x80 cm were used to build the walls. Ashlars were arranged in pseudo-isodomic courses, with staggered vertical joints, set in pozzolanic lime mortar. The final wall thickness resulted about 40-50 cm. A particular care was always paid on the corner realization as they acted as connection between the two walls along being the most stressed part under the pressure of vault's loads, vertical and horizontal. Corners were usually built of large, squared and solid stones set with staggered vertical joints (figure 4).

Openings were realized by means of arches or architraves. In the largest dammusi, where the vaults' loads reached very high values, a combined system of a blind arch standing on the architrave was used. If the infill was removed, than a lunette acted as an air and light intake from outside (figure 5).

The typological system of roofing is the real stone vault, barrel or cloister, whose construction will be discussed in section 5. The oldest buildings usually showed a barrel vault where the curvature at the extrados was the minimum to guarantee an adequate rain water's disposal (figure 6). On the contrary, the arrival of lime let extrados and intrados be shaped differently. More particularly, a squared-plan *dammuso* was usually covered by a cloister vault, less pushing than the barrel one, with different apparent geometrical configurations.

The most evident – and famous - character of the *dammuso* of Pantelleria is the white coating of the roofing (figure 7). Lime was imported directly from Sicily and underwent the traditional hydration process that foresaw the complete immersion of the paste in water in some dedicated pits dig in the ground. After a certain length of time, and a subsequent drying, slaked lime was admixed with some volcanic tuff sand in order to achieve the desired hydraulic properties. Subsequently, it was laid on the flooring and punched with a wooden hammer or, sometimes with a flat stone, in order to eliminate the surplus of water from the slurry. Furthermore, such a procedure also reduced the final porosity of the hardened mortar, making it more resistant, durable, and waterproof. Finally, the external surface was protected by two or three layers of limewash, that is to say some slaked lime highly diluted in water.
The coating was shaped in order to collect as much as possible of the falling rain water, a precious resource in such an arid environment. Hence, the roof's edges were shaped as to generate the canals useful to drive water to a precise point of plumbing (figure 8). The drainpipe was simply a dig in the wall, whose surfaces were covered by the same hydraulic mortar used in the roof. In other cases, a sort of ramp is formed (figure 9). Water was usually driven and collected in subterranean tanks.

Fig. 9: White superficial lime coating and different disposal systems.
Top and centre: a hole in the edge is used to collect water in a wall dig; bottom: a ramp.

Fig. 10: Traditional external finishing: left – bare masonry stone; right – natural hydraulic lime plaster.

4. The traditional finishing of a *dammuso*

In the architectural technology of the *dammuso*, the external finishing is something quite modern as their vernacular vocation did not require any superfluous expenses. A proper flooring was almost absent, and a simple layer of rammed earth was generally arranged. In the most refined solutions, a stone paving was built using local stones cut in slab shape. They were directly located on the ground without any setting layer or on a soils mortar stratum. The lime arrival brought interesting innovations also in this field. Lime mortar has been used, beyond the roofing's finishing, also to pave inner and external spaces. The *dammuso*-house was furnished by a proper paving of red mud bricks. From the XX century glazed tiles started to be used according to the new vogue and technology. For financial instances, glazed tiles were often used in the main hall only, leaving poorer (and cheaper) materials for the other secondary rooms.

Plaster was initially absent and the stone masonry was left in-sight, both in the inner or external parts of the building (figure 10 left). With the arrival of lime, the inner walls' surfaces were covered by a first layer of soil-mortar to regularise the surface followed by a finishing layer of aerial lime mortar. Subsequently, many limewash layers were applied to white the surfaces. Traditionally, external walls were pink-like coloured, while doors and windows were usually framed by a white cornice (figure 10 right). Sometimes, the opposite configuration is reported. The external plaster was made of a natural lime mortar admixed with volcanic tuff sand, as the roofing's one, in order to acquire the desired hydraulicity.

5. The traditional vault construction

The construction of the real stone vault was a particularly intense work (figure 11). Indeed, the nature and the geometrically corrected pieces of stone were carefully selected across the lands. After that all the wedges had been selected, the vault construction could began.

Fig. 11: Real section of a collapsed vault. Stone shaped as voussoir is used to build the inner shell; a layer of soil mortar is spread and abutments are made of sand, soil and little stones. A finishing layer of mortar define the external shell..

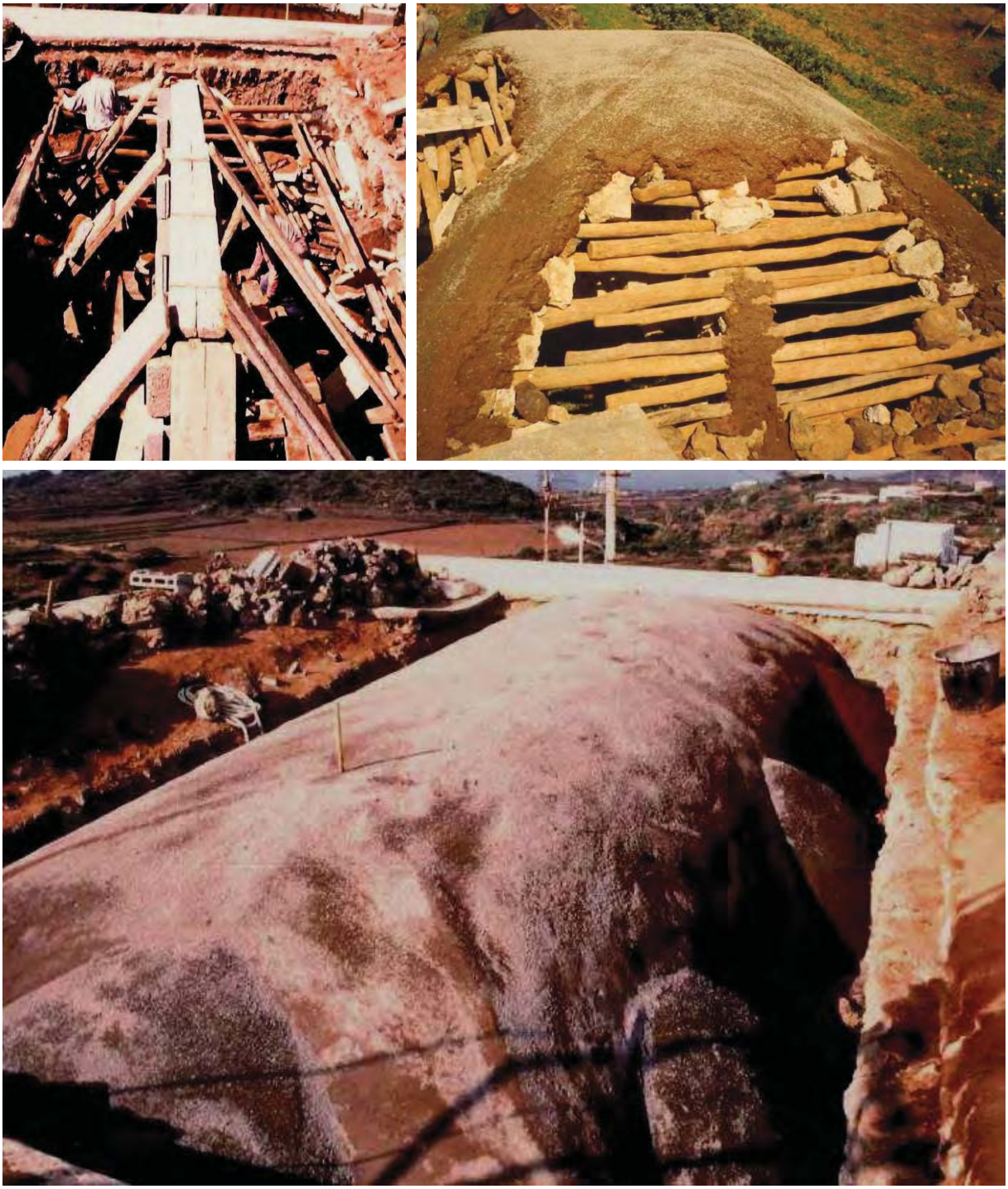

Fig. 12: Top left: Placing of the provisional wooden structure. Top right: Once the centering is placed and consolidated, stone are arranged on it, starting from the diagonal (in the case of a XX vault) or from the base (in the case of a barrel vault). Subsequently, the voids between the stones are filled with little pieces of stone and mortar. Bottom: Once the structure of the vault is completed, the external part is covered with a lime mortar layer to create the final shell that will be, lately, plastered by the white natural hydraulic lime mortar.

To build a real stone vault, the first work was setting the impost by a line of squared stones on the walls' top. Then, a wooden centering was built using orthogonal beams framed into specific holes at the erecting vault base. Centering stability was granted by a timber or stone pillar placed at the beams' intersection. Four sloping beams connected the top of the pillar with the parietal walls. Lastly, to complete the provisional structure a set of beams was located crosswords on each side (figure 12, top left). Once the centering has been completed, then the voids were filled with stone and mortar (figure 12, top right). On the top of that, a thin layer of dried sand and a final layer on soils and water – in the oldest examples – or lime mortar – in the most recent – was then spread (figure 12, bottom).

Fig. 13: Cloister vaults equipped with lunettes used to open doors and windows into the walls (figure 13).

Fig. 14: Finishing of a stone vault by means of a natural hydraulic lime layer. Cracks were closed by means of fresh mortar.

The stone used to build the vault's surface might be squared, resembling a sort of voussoirs, or simply rounded. Parietal walls were raised to contain the abutment, made of small stones and soil, and to increase the jambs' weight and guarantee more stability. Larger spaces were covered by cloister vaults equipped with lunettes that transferred the loads to the corners of the building allowing to open doors and windows into the walls (figure 13). In this case, the intrados may show different configurations depending on the lunettes' number, dimension, and position. The centering system is analogous of what has already been described with the addition of the semicircular lunette [5]. When the structure was completed, and the centering taken down, the finishing was spread. It consisted on a layer of a mixture of soil, volcanic sand and water to waterproofing the structure and, in the most

recent cases, a final layer of lime mortar and volcanic tuff [7]. Possible cracking due to thermal expansion were closed with a new layer of mortar (figure 14).

6. The *dammuso*, a cultural heritage to be preserved and reproduced

The discussed architectural, constructive, and material studies are an unavoidable phase to acquire an intimate knowledge of the traditional architecture such as the *dammuso* one. That is extremely useful to preserve a cultural patrimony which strongly characterizes the Isle of Pantelleria. Not only the way traditional constructions are built but also the intimate relationship between built and natural environment still finds in Pantelleria a deep Mediterranean root.

In such a considerations, preservation and restoration of such a buildings configure themselves as proper actions of memory recovery intended for the conservation of the identity of a population and a vernacular culture. At the same time, they may be regarded as initiatives of promotion and valorisation of the territory according to an increasing, but sustainable, tourism. Indeed, Pantelleria is quite famous around the world not only for its amazing sea but also for the natural environment and the characteristics constructions, the *dammusi* themselves.

Nowadays, in the Isle of Pantelleria some strict urban plans are in force to preserve the local environment. The Territorial Landscape Plan provides prescriptive rules intended to conciliate in a balanced way the preservation of the environment and the economic development, factors of great importance for an island that is economically based on agriculture and tourism. This plan aims «to preserve the historical and cultural identity of the island; to protect the natural and the cultural landscape; to improve the territorial fruition through interventions compatible with the characters and the quality of the landscape, that represents unique resources capable of promoting a balanced and long-lasting economic development». In architectural ambit, the Territorial Landscape Plan defines the *dammuso* as the element that «characterizes the environment of Pantelleria with limited volumes, peculiar materials, constructive technologies and shapes, that are simple and recurring». Furthermore, such a Plan is highly advanced and responsible towards a sustainable building development. Indeed, it provides procedure not only to restore and preserve the existing architectures but also to build new constructions. Therefore, it is absolutely compelling with using local and traditional technologies and materials, at least in the aspect, shape and dimension. The structure can be realized of modern reinforced concrete and bricks but it must be externally coated by local volcanic stones - in the countryside - or plaster - in urban environment; roof must be realized using vaults, etc. (figure 15-16).

Fig. 15: Construction of a modern *dammuso* using contemporary constructive technologies. According to the Pantelleria Building Regulations, aspect, shape, and dimension of a traditional *dammuso* are respected. Moreover, the vault is realized by means of real stones.

Fig. 16: The exterior of a modern *dammuso*, built using contemporary constructive technologies, is then covered by natural islander stones to simulate the traditional aspect of the building typology.

Also the General Urban Plan consider a *dammuso* a «typology that defines the architectural features of the isle. Thus, such constructions must be preserved by restoring the existing ones, or building new, exploiting the local and traditional technologies and materials». Projects might be respectful of the native architectural and technological features that will enable the building valorisation at all scales.
This study is also aimed at defining a regional "code of practice" intended as a fundamental instrument to all the operators (architects, engineers, restorers, workforce, etc.). An indication of the suitable interventions of preservation and reuse. That is hailed from specific local studies and shows how traditional architecture represents a uniqueness. Such a code, however, might also compensate the territorial development with the safeguard of its historical environment. Therefore, the valorisation of architectural heritage, also intended as the image of a typological feature, has to pass through a choice of quality but with the compromise of contemporaneity.

7. Acknowledgements

This paper takes motion from the thesis by Eng. Lorenzo Giuseppe Silvia, "Caratteri costruttivi del dammuso di Pantelleria", for the Degree in Civil Engineering, University of Palermo, academic year 2012-2013; supervisor: Prof. Tiziana Campisi. Images are mostly taken from this thesis.

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