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THE CONSTRUCTION OF THE TRANSHUMANCE TERRITORY OF THE GERÊS-XURÉS: VERNACULAR HERITAGE IDENTIFICATION, ANALYSIS AND CHARACTERIZATION

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KEYWORDS: Vernacular heritage; architecture; corbelled domes; granite; laser scanning.

ABSTRACT

In order to ensure survival, the rural populations of the Gerês-Xurés mountain range transboundary region developed, over centuries, a very specific system of vertical transhumance. Focus on making the most out of their natural landscape harsh conditions, human intervention shaped the territory, and gave birth to the existent and very authentic vernacular heritage, that has in the corbelled dome building technologies one of its most characteristic identity features.

In the pursuit of fertile land, villages were scattered in small and compact settlements, built at lower altitude and occupied all year long. The surrounding mountain's slopes were turned into farming terraces, and the high-altitude plateaus were for livestock and farming, thru temporary settlements built in corbelled dome structures. These vital points were interconnect by a dense network of paths and masonry walls. Although the resemblance between most of the region permanent settlements, the temporary nuclei, due to each mountain particular features, show a large morphological and functional diversity, from complex structures, like the *"brandas"* or the *"brandas e inverneiras"* system, to very simple pasture areas, like the *"currais"*. Understanding the high potential of this endanger vernacular heritage is a key point for its preservation, as well as its recognition by the scientific community and society in general. A previous study aimed at the *"brandas"* morphological and constructive characterization was presented at the Rehabend 2016. This follow-up study is focus on, in a first level, the identification and characterization of the general system main features, and, in a second level, the evaluation of this vernacular heritage main preservation threats. The research, based on case studies analysed thru fieldwork surveys, geometrical and constructive, and literature support, allowed to identify the main morphological and typological features related to the heritage elements that take part in this occupation system, and are discussed in this paper.

1. INTRODUCTION

Corbelled dome heritage can be defined as one of the most intuitive types of construction found among both monumental and vernacular heritage. As shown in Figure 1, examples can be found all over Europe, and in particular around the Mediterranean, built in different materials and different corbelling systems. Examples go from honeycomb houses, built in adobe (Syria), to complex stone blocks masonry remote monasteries (British islands), to the elaborated double shell stone masonry *"trullo"* houses (Puglia, Italy) [2]. Being mainly related to agrarian life style, due to the past decades drastic changes to the traditional way of life, most of the existent vernacular corbelled dome heritage in Southern Europe is without use and in a advanced stage of abandonment. Although having high authenticity and being a fundamental part of rural cultural identity, the loss of knowledge and recognition concerning these vernacular forms of heritage placed them in an endangered position.

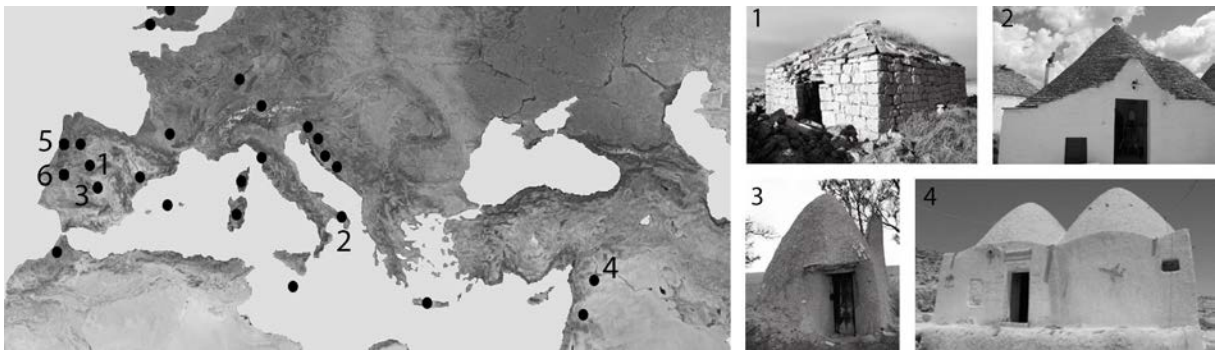

Figure 1 - Examples of vernacular corbelled dome heritage around the Mediterranean and British Islands (after Jovanec [2]): (1) and (3) *"chozos de viñas"*, Spain; (2) *"trullo"*, Italy; (4) *"earth dome dwellings"*, Syria; (5) - *"abrigos"* or *"cortelhos"* and (6) *"safurdas"* or *"fornos"*, Portugal. (for individual images credits see [1]).

To answer/react to this context, and understanding the full potential of this type of heritage (cultural - economical - touristic), a research was set in motion, in order to rescue the Iberian Northwest vernacular corbelled dome heritage from its announced destruction fate. Understanding it as part of a complex cultural, social, ethnographic and historic identity, the research plan was set to allow a full architectural and constructive characterization of the corbelling phenomenon of the Gerês-Xurés Transboundary Biosphere Reserve. A multi-skill research group was set together, combining different research expertise with local partners with intimal knowledge about the territory: *i)* University of Minho (ISISE) - Civil Engineering (coord.); *ii)* Vigo University (AG) Applied Geotechnologies; *iii)* University of Porto (FAUP-CEAU) - Architecture; *iv)* with the support of Arcos de Valdevez Municipality. The research is been carried out in four stages, with the following objectives: *i)* literature and fieldwork surveys, to achieve a global knowledge concerning the heritage context [1,3]; *ii)* a morphological, typological and accurate constructive characterization, based in case studies, thru a geometrical analysis and damage assessment, including the physical and mechanical characterization of vernacular construction materials [1,4,5]; *iii)* an overall safety analysis based in numerical models; *iv)* the development of specific preservation guidelines, based in international good practices, adapted to this particular vernacular heritage.

2. THE NORTHWESTERN MOUNTAIN RANGE TERRITORY CONSTRUCTION

The study area, located in the Gerês-Xurés Transboundary Biosphere Reserve, can be defined as a territory of harsh mountain range, with a natural geography of deep and narrow valleys, that due to the proximity to the Atlantic Ocean, has a climate of abundant rains, with severe winters and moderate summers [6]. Shared between Portugal and Galicia, as shown in Figure 2, the territory is divided on the Portuguese side in three main mountain ranges: *i)* Peneda/Soajo (1416 m); *ii)* Amarela (1362 m); and *iii)* Gerês (1545 m). In order to survive, local populations humanized the mountain range territory, turning it in very specific habitats, adapted to each mountain range particular features. Local communities that endure in this territory share a particular mountain range agro-pastoral common

identity based in a highly hierarchized rural social structure, organized around private and public property and the common management of all aspects of the yearlong agrarian cycle and of the very authentic local vertical transhumance system.

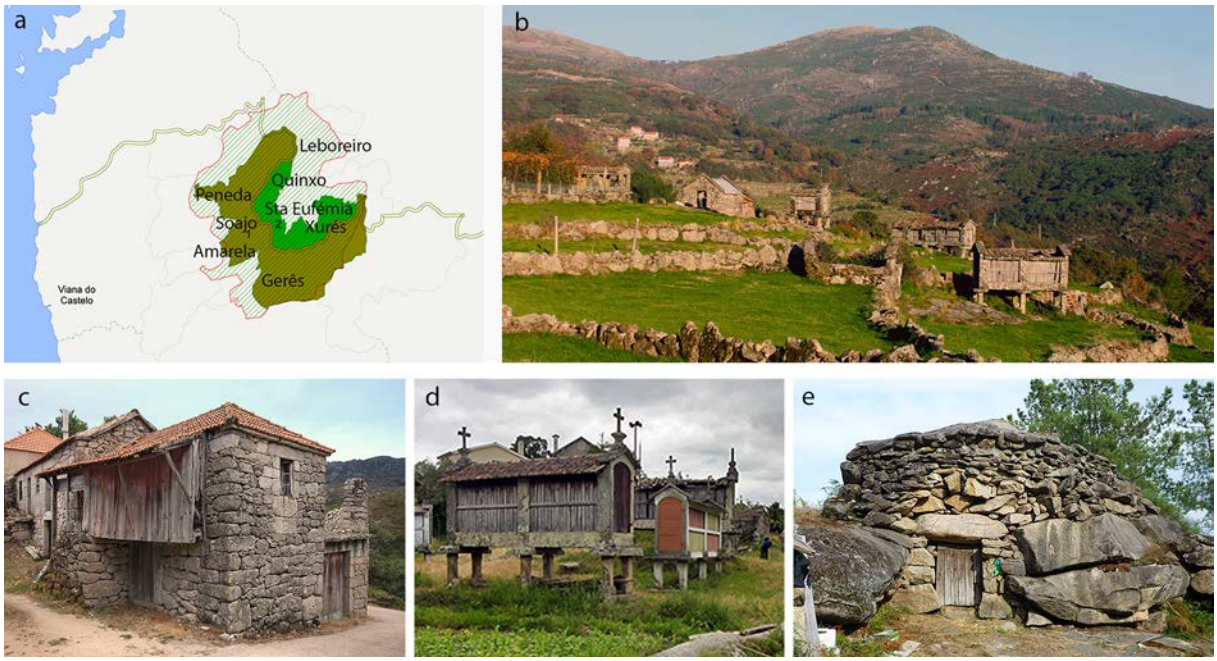

Figure 2 - a - survey area. Territory humanization: b – farming terraces; c – houses; d – granaries; e – shelters.

To make the most of geography and the scarce available fertile soil, a vertical organized human occupation was developed, see Figure 3 and Figure 4 (labels A,B and C), based in: *i)* concentrated settlements (A), where communities formed organized parishes, based at a rural catholic church, either in a larger single or several small individual settlements, spread around a specific mountain range territory, placed near a water source, nearby fertile soil and with sun exposure; *ii)* farmland by using fertile land at the bottom of the valleys or by the transformation of the mountain slope (B), around the settlement or nearby, in to farming terraces; *iii)* the use, during warmer months, of the mountain range plateaus for livestock and/or farming (if natural conditions allowed it) (C1 to 4 of Figure 6); *iv)* a very dense and vast network of dry stack small size farm walls (average 1 m of height) to help manage and guide livestock and to set property and territory boundaries; *v)* a vast spider web style mountain range network of earth or granite paved roads, allowing mobility all around the mountain. The use of the corbelled dome vernacular technologies comes as part of the local vertical transhumance strategies, being an authentic expression of inventiveness of resources management in the survival effort facing a very demanding natural environment [7].

Figure 3 - Examples of the territory occupation of the Padrão settlement area: A - the settlement; B - the surrounding farming terraces; C - the mountain range plateau temporary settlement of Alhal.

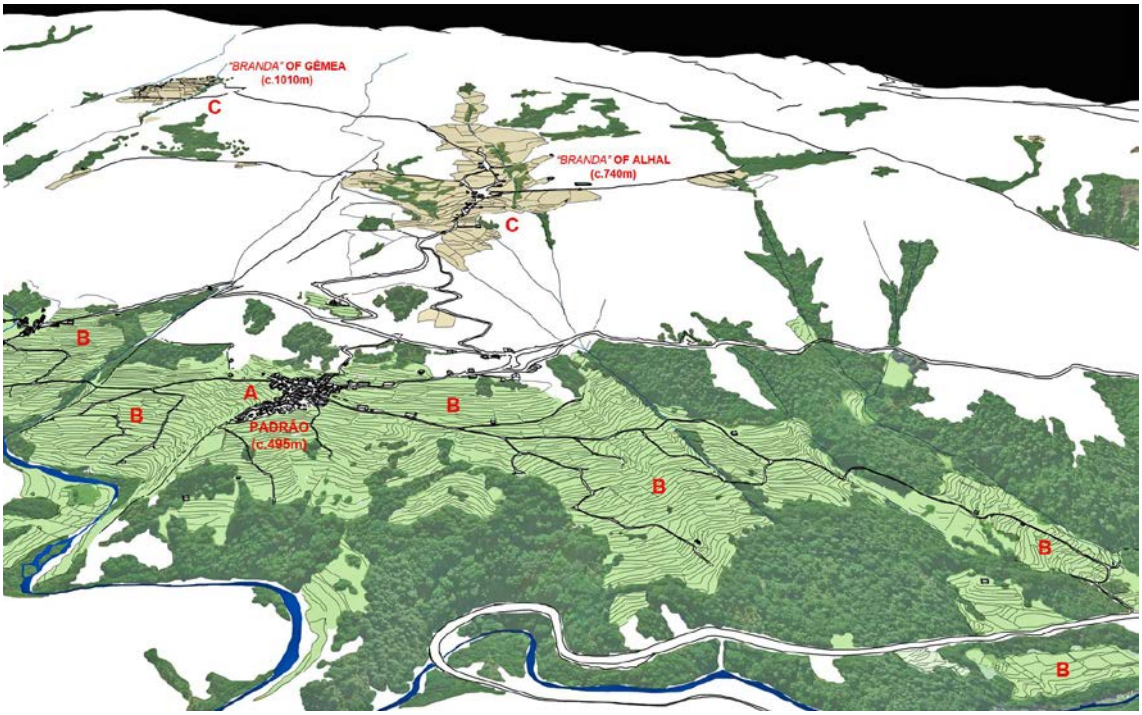

Figure 4 - Scheme of the territory occupation of the Padrão settlement (see Figure 3 for labels A, B and C).

Concerning the use of corbelled dome technique in individual buildings, three main typologies were identified during the fieldwork surveys [1]: *i)* the single-storey shelter; *ii)* the two-storey shelter; and *iii)* the gable roof *"branda"* house of one or two-storey. As shown in Figure 5, these buildings were either observed individually or combined and part of groups of buildings [1].

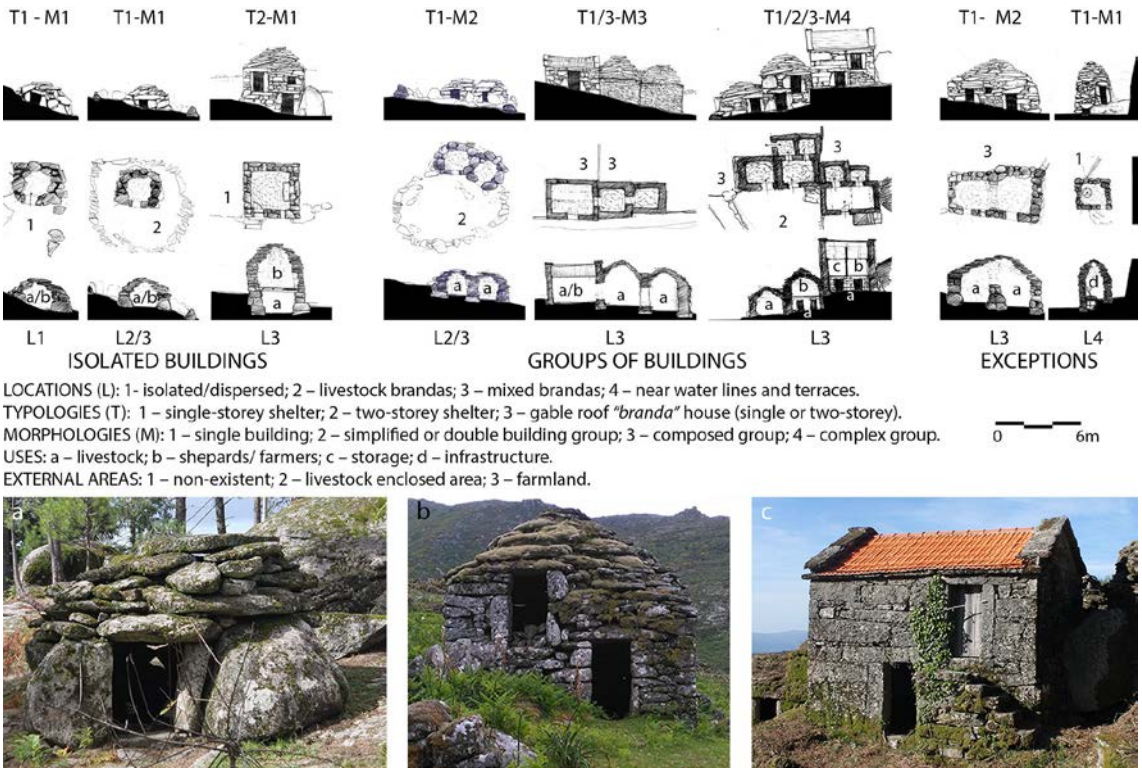

Figure 5 - Schematic examples of corbelled domes buildings morphological and typological main features, based in the *"brandas"* de Padrão study cases [1]. Examples of: a - single-storey shelter (*"branda"* of Travanca); b - two-storey shelter (*"branda"* of Rio Côvo); c - two-storey *"branda"* house (*"branda"* of Gêmea).

Depending on the mountain range and its specific natural conditions, different types of temporary settlements can be found, and a schematic representation is shown in Figure 6.

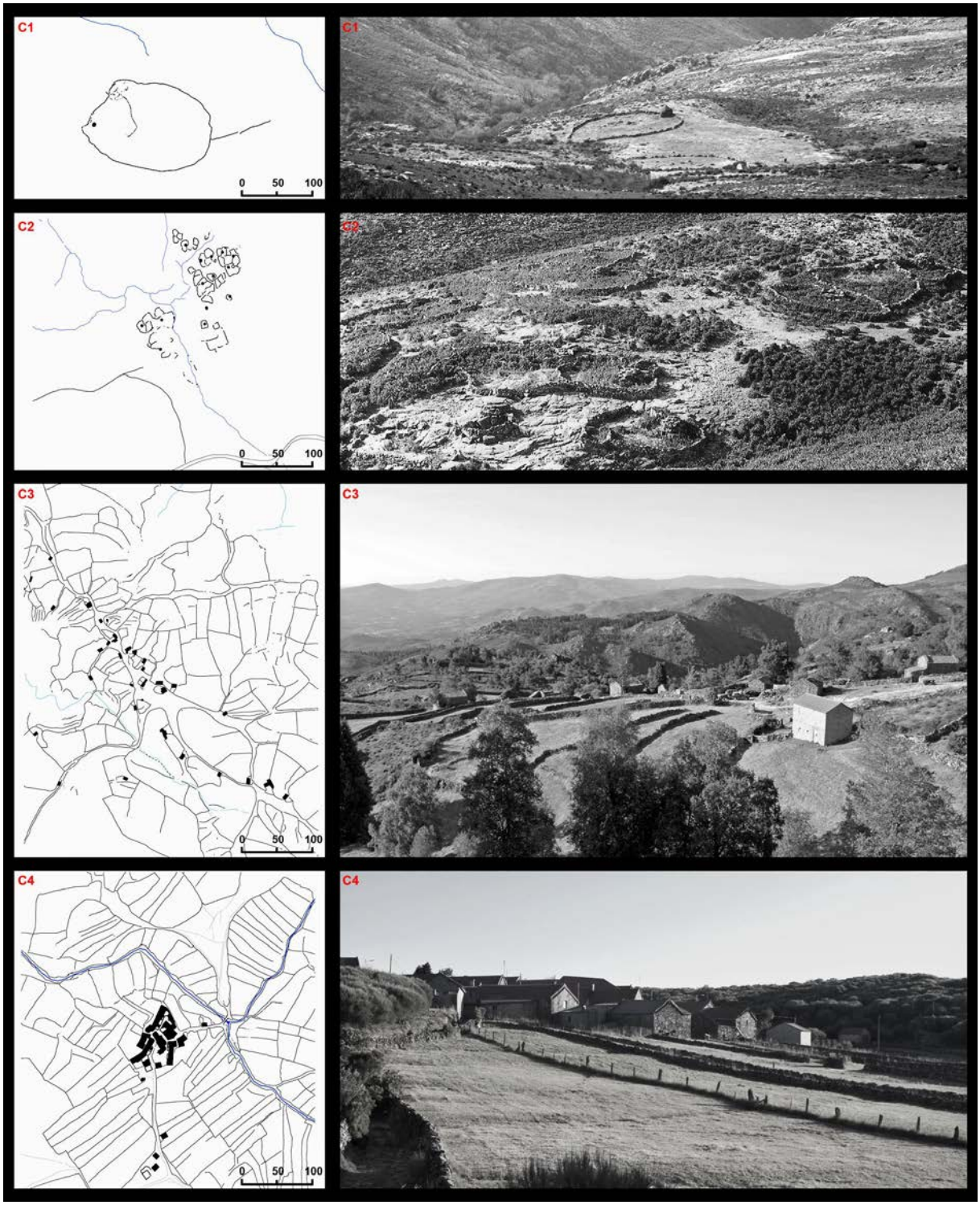

Figure 6 - Examples of the different types of temporary mountain range plateau settlements: C1 - *"currais"* (Ermida, Amarela mountain range); C2 - *"branda de Gado"* (*"branda"* of Arieiro and *"branda"* of Burzavô, Peneda mountain range); C3 - *"branda de cultivo"* (*"branda"* of Alhal, Peneda mountain range); C4 - *"branda"* of Portos (*"brandas/inverneiras"* of the Peneda/Leboreiro mountain range system).

As shown in Figure 6 (labels C1 to 4) four main typologies of temporary mountain range plateaus settlements identified: *i)* communitarian livestock settlements for pasture (C1), or *"currais"* , formed by a single large corral with a one-storey shelter; *ii)* livestock settlements for pasture (C2), or *"branda de gado"*, formed by several nuclei of corral and a one-storey shelter; *iii)* mixed pasture and farming settlements (C3), or *"branda de cultivo"*, organized in walled farmland areas with groups of one and two-storey shelters or/and *"branda"* houses, anchored to a paved road network; and *iv)* prolonged stay pasture and farming settlements (C4), or *"brandas e inverneiras"*, being the *"branda"* used in warmer months and the *"inverneira"* being the base settlement used for a shorter period of time during winter, resembling a lower altitude settlement, with a simplified urban organization and nuclei of walled farmland and *"branda"* houses, used as dwellings during the warmer season.

3. CORBELLED DOME CONSTRUCTIVE CHARACTERIZATION

The initially visual identification survey, that allowed a global view concerning morphologies and typologies, was later followed by and accurate laser-scanner [8] survey on study cases of *"branda"* of Gêmea [1]. Some results are shown in Figure 7.

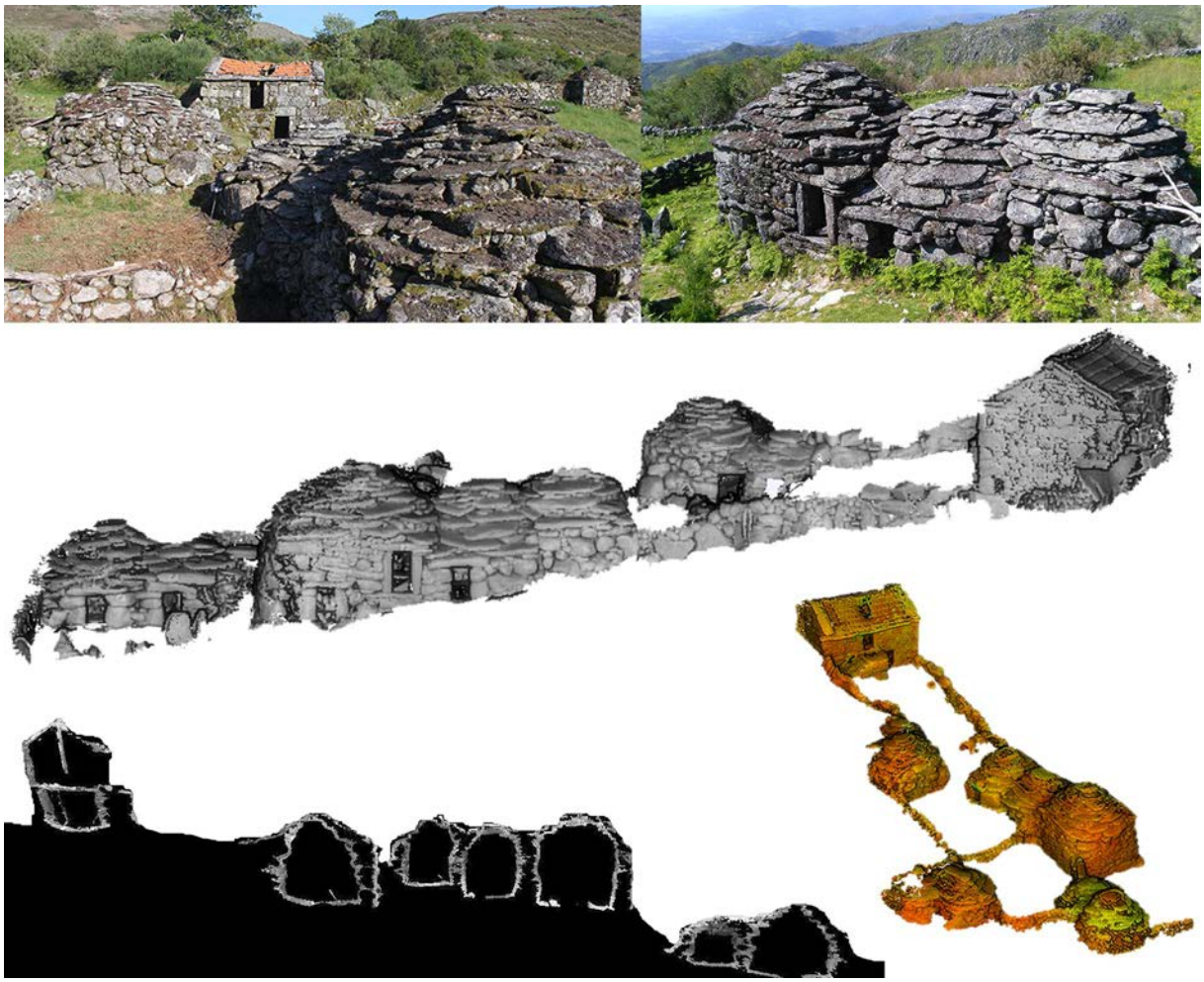

Figure 7 - Images of the study case Group A of *"branda"* of Gêmea (above). Examples of the 3D images obtained from the 3D point clouds using *CloudCompare®* and *RiscanPro®* (cross-section) [1,4].

Concerning these buildings structural organization, they can be divided in two overlapping structural elements, the masonry load-bearing walls and, over them, the structural single-shell corbelled dome roof. Both elements were built in ordinary dry stack stone masonry, resulting in a building of cone shape appearance, of very harsh and primitive aspect, with masonry reinforcements at corners and openings

(mainly doors). Two-floors structures shown upper-floor timber pavements. These were massive buildings, with 50% of the gross area used by masonry walls showing very low slender walls (average ratio over 1:1.5) and a large percentage of visible voids.

Although seeming buildings of vertical proportion, due to the corbelled dome cone shape, the laser scanner survey showed that in fact, these are horizontal proportion buildings. Comparison between buildings vertical and larger horizontal axis shows a ration of 1:1, being at the walls level of 1:2, and at the domes level from 1:2 to 1:3. Base plan geometric analysis, see Figure 8, a predominant quadrangular proportion, with a dominating axis either, perpendicular or transverse to entrance.

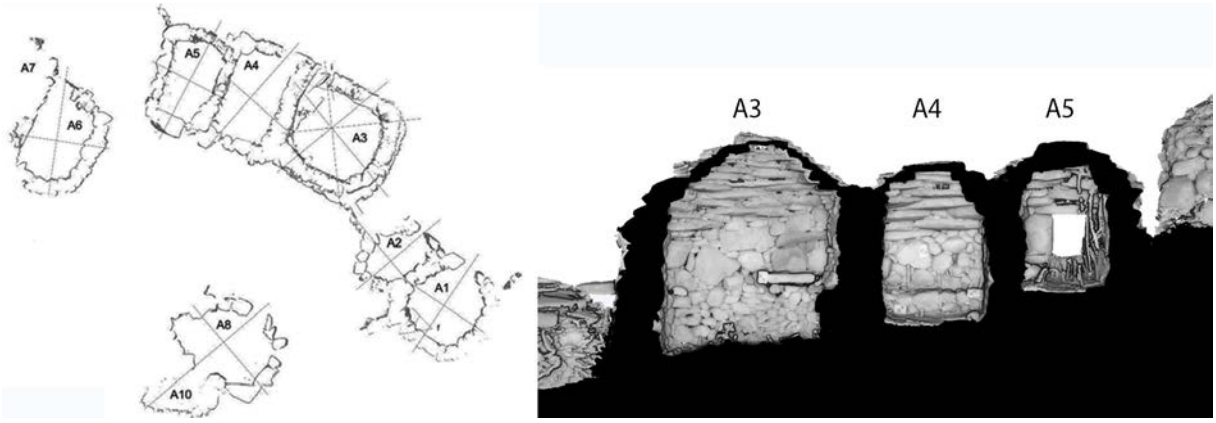

Figure 8 - Base plan (using *RiscanPro*®) and longitudinal cross-section (using *CloudCompare*®) [1,4].

Concerning the local buildings tradition, at lower altitudes it is similar to the entire Portuguese Northwest region, based in structural load-bearing stone masonry walls (dry stack masonry), with ashlar reinforcements in corners and openings, and timber frame pavements and roofs.

The corbelled domes were built by overlapping plate shape stones, laid out jutting towards the centre, supported in an average of 2/3 of its horizontal section over at least two larger underneath masonry units, and leaving its central portion working as cantilever (see Figure 9). Wedges were used by the inside of the dome, to give the stone blocks a slope outside to drain rain water, and by the exterior, to fill larger holes. Vertical load is passed thru the very irregular stone blocks interface and thru the wedges to the walls, and the structure is stabilized by friction between the stone blocks interface [1].

Figure 9 - a and b - external and internal views of a corbelled dome built with large-size plate shape granite units; c - internal view of a corbelled dome built with irregular plate shape granite units [1]. (*"branda"* of Gêmea).

4. RISKS AND THREATS

During the fieldwork survey, an accurate damage identification was performed and allowed to concluded that three different levels of damage and associated risk can be found. The collapse of the walls and of the domes, shown in Figure 10a, present the higher level of risk to this building's structural security [4].

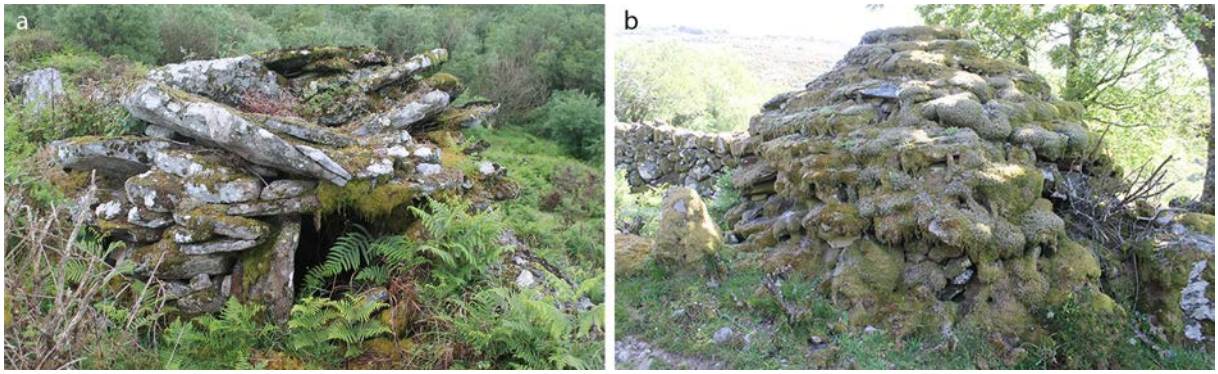

Figure 10 - Damage in corbelled dome structures: a - corbelled dome collapse (*"branda"* of Braçal); b - severe biological colonization due to lack of maintenance (*"branda"* of Gêmea) [4].

Concerning the corbelled domes, three possible outcomes were identified: *i)* a simple collapse of isolated stone blocks, with reduce damage to the remaining structure, allowing it to be repaired; *ii)* corbelled dome full collapse, generally inwards, causing low level of damage to the walls, thus allowing the corbelled dome reconstruction; *iii)* full collapse of the corbelled and the masonry walls, generally outwards, leaving the building unrecoverable. Due to the structural system type, a load-bearing wall significant collapse ultimately leads to the corbelled dome full collapse, representing the higher level of risk for the buildings safety. Regarding biological colonization, see Figure 10b, small and medium size species colonization is overwhelming, although not posing an immediate risk. Large size species, like bushes and trees, pose a serious risk: *i)* by destroying farm walls (out-of-plane loads) and making roads unusable; *ii)* penetrating roots disaggregate buildings and corbelled domes masonry structures, leading to their collapse; *iii)* by making structures to disappear in the landscape, thus, from collective memory.

The observed human caused damage is related to: *i)* severe lack of maintenance; *ii)* inappropriate interventions and uses; *iii)* losses of authenticity and identity of mountain range settlements due to uncontrolled real estate and touristic pressure; *iv)* lack of recognition of local vernacular heritage cultural value.

5. CORBELLED DOME PRESERVATION AND REHABILITATION METHODOLOGIE

The success of any attempt of preserving and rehabilitating of the fragile and endangered vernacular corbelled dome of the Gerês-Xurés region depends on understanding the problem for its multi dynamics and perspectives, requiring a methodology able to operate with this heritage constructive, social and economic but also historical, ethnographic and emotional diversity. Based on the developed research and in the international good practices [9,10], a proper action plan should attend to: *i)* the vernacular heritage identification and full knowledge, aiming at its management and monitoring; *ii)* a suitable legal framework able to integrate needs and mitigate risks and threats; and iii) the technical challenges concerning vernacular heritage preservation and reuse. Concerning the first topic, a necessary vernacular heritage management and monitoring depends on knowing the heritage at hand. During the research, it became clear the very scarce available information concerning corbelled dome dispersion in the territory, with very deficient mapping of existent buildings and no information concerning state of preservation and cases of abandonment and. Thus, a full inventory is seen as a necessary first step, capable of reaching the entire region of the vertical transhumance phenomenon. Adequate management and monitoring strategies would pass by: *i)* identifying ownership and action areas of the different territory management authorities; *ii)* defining preservation intervention priorities and levels; *iii)* establishing areas of high sensitivity destined only for preservation interventions and areas destined to reuse; *iv)* the involvement of local communities in this process. Concerning the second topic, a state of absence of adequate legal frameworks concerning vernacular heritage was recognized. Lack of knowledge concerning the high cultural, economic and touristic potential of the landscape and its vernacular heritage seems to be the main reason to the absence of protection measures in the existent territory management plans. For an effective protection of the region's corbelled dome heritage and its

natural context, the legal frameworks should adopt: *i)* the identification of specific protection areas and rules concerning conservation in the endangered vernacular heritage; *ii)* the adaptation of the technical standards to interact and preserve local building tradition; *iii)* the establishment of control mechanisms over the type of intervention allowed in these heritage buildings focused in authenticity and identity criterions. Concerning the technical challenges related to the preservation and reuse of vernacular corbelled dome heritage, attending to its overwhelming diversity (morphological, typological and constructive), further research is needed to embrace its full knowledge, and to determine the adequate techniques to apply concerning achieving structural safety in structures at risk, but also to allow technicians and builder to intervene and reuse this specific type of heritage without threatening its high cultural value.

6. CONCLUSIONS

In this paper, a follow up to the ongoing research (with a previous paper in Rehabend 2016) concerning the vernacular corbelled dome heritage of the Gerês-Xurés region is presented. The full territory phenomenon was addressed and explained, mainly its vertical organization and the different types of mountain range temporary plateaus. The vernacular corbelled dome basic architectural and constructive features were also presented based in study cases, as well as new 3D images produced from the initial laser-scanner survey, as proof of the technique's potential when used on study cases of high geometric irregularity. The conclusions of the risk and threats analysis were also addressed, being the collapse of corbelled domes, the biological colonization and human actions (lack of maintenance and poor and harmful interventions) the main causes of damage and threats to the presented endangered heritage. A first methodological approach to preservation and rehabilitation guidelines specific for vernacular corbelled dome heritage were also discussed. The ongoing research concluded, in this phase, that three main lines of action are in order: *i)* the promotion of full knowledge of this specific and sensitive heritage (inventory, constructive characterization and conservation assessment, management and monitoring); *ii)* a suitable legal framework adapted to its particular characteristics; and *iii)* the need for further research aiming at the technical and constructive challenges that corbelled dome heritage faces nowadays. As a final remark, we must point out that, for the success of any preservation and rehabilitation strategy, it is required the involvement in the process of the local communities, the different territory management authorities and the promoters. Thru an inclusive and flexible, yet scientific methodology, based in the best international preservation good practices, it is possible an effective effort of building knowledge and technical information sharing, to promote and preserve in the best way the endangered cultural value of the vernacular corbelled dome heritage for future generations.

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