

DANIELA PITTALUGA

FABIO FRATINI

(édité par/by)

**CONSERVATION ET MISE EN VALEUR
DU PATRIMOINE ARCHITECTURAL ET PAYSAGÉ
DES SITES CÔTIERS MÉDITERRANÉENS**

CONSERVATION AND PROMOTION OF ARCHITECTURAL AND
LANDSCAPE HERITAGE OF THE MEDITERRANEAN COASTAL SITES

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Medieval Sardinian castles. Transdisciplinary approach for the definition of typologies, masonries and materials

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Abstract. The present study stems from the awareness that researches on traditional masonry techniques in Sardinia, and particularly those aimed at dating historical architectures, are insufficient when compared to the studies on other Italian cultural areas started at the end of the 20th century. Over the last decade, the Chair of Restoration of the University of Cagliari has carried out a research project focused on the archaeometric investigation of traditional masonries (12th -19th centuries). This paper refers to the medieval Sardinian fortified systems (12th -15th centuries). The purpose is to define chrono-typological references, in order to date and preserve the so-called minor buildings, which are not philologically dated unlike the examined ones. The investigation protocol, specific for the local peculiarities and based on a transdisciplinary approach, started with the indirect analysis. A direct survey of the structures was further carried out through photographic, architectural and material assessments, with non-destructive diagnostic techniques. The creation of a Geo-Topographic Database and a WebGIS has been essential to archive and manage the collected information. The archival and archaeometric data have been cross-referenced, facilitating the definition of chronotypes. So, this method allowed to gain knowledge of local historical masonries and to identify important references in dating buildings. Architectures of ancient Sardinian villages often undergo improper interventions regardless their historical and cultural values. Consequently, dating becomes a tool to protect and preserve them. Also, this study offers a better understanding of the entire system, whose current fragmentation - as a result of the absence of conservation actions, abandonment, demolition, improper reuse and reconstructions - proves the need of identifying its values and critical issues, essential for a project aimed at the successful protection and enhancement of its components.

Keywords: medieval fortified system, archaeometry, masonry techniques, chronotypes, dating.

Introduction

The research is included in the studies on historical constructive techniques, that even if widely carried out in different national areas, dealt with the Sardinian context only recently. Therefore, for over a decade, the Chair of Restoration of the University of Cagliari has carried out a research on the masonry techniques employed in Sardinia between the 12th and the 19th century, in order to define chronotypes in order to date other historical architectures. Due to the absence of specific studies related to it, the investigation started with the analysis of the historical and architectural philologically dated heritage, consisting in religious, civil, residential, productive, military and defensive complexes.

The heterogeneity and the singularity of the Sardinian historical and architectural heritage, often abandoned and degraded, have led to define an investigating protocol, supported by specialised analyses for a deeper and wider knowledge of the heritage itself. The investigating protocol is based on a transdisciplinary approach, aimed to underline the dimensional technical-constructive, mensiochronological and material characteristics, as well as the physical-mechanical and energetic ones, necessary for the definition of the peculiarity, the structural behaviour and the performance levels of the investigated architectures. This allowed us to recognise chronological evidences as a function of type, formal and material variables able to define the chronological succession of masonry structures and the finishing of historical artefacts, arranged in homogeneous areas, thus facilitating the recognition and dating of the structures. This aspect has a fundamental importance. As it is well known, dating often implies expressing a historical and cultural value, very likely to be followed by protective actions. Therefore, the main aim of this research is to outline exploratory and operational guidelines supporting the interventions for the protection and the enhancement of the regional architectural heritage. This contribution, for synthesis sake, focuses on the results of applied research to medieval fortifications, investigated on the basis of a general operational protocol, but organised according to the peculiarities of any single case study¹.

¹ This study is forms part of the Basic Research project "Traditional building techniques: knowledge for conservation and enhancement", 2013 edition, lead scientist C. Giannattasio, financed by the Autonomous Region of Sardinia (L.R.7/2007 - Promotion of scientific research and technological innovation in

1. Transdisciplinary approach for the fortified heritage (CB, DRF, CG, SMG)

The study of the medieval fortified system has been carried out starting from the recognition of indirect sources through which the exploratory scenario could be reconstructed. This stage has allowed to identify 31 defensive structures representing the investigated contexts. Every case study has been further involved in a photographic, metric, geometric and material survey. Based on the first historical-architectural observations, studies in depth have been carried out on the constructive techniques and on the performance characteristics. As for the survey phase, traditional techniques have been integrated with innovative instruments and methods, such as *photomodelling* and *laserscanning 3D²*, analysing settings and results case after case, according to the specificity of the site. During a subsequent investigation campaign, masonries have been sampled aiming to the physical-mechanical and thermo-hygrometric characterisation of the materials and to understand the related constructive systems³.

More precisely, the material characterisation has been conducted with a mineral-petrographic approach through *in situ* investigations and archaeometric analyses, aiming to gain a systematic census of natural and artificial stone materials. This exploratory phase has been divided into two parts: the first one related to the macroscopic analysis of the stone

Sardinia). In particular, it is the synthesis of two PhD researches carried out by Valentina Pintus (PhD in Technologies for the conservation of Architectural and Environmental Heritage - 28th cycle) and Maria Serena Pirisino (PhD in Civil Engineering and Architecture - 29th cycle) at the University of Cagliari. Specifically, V. Pintus analyzed the masonry chrono-typologies of the fortified architectures of South Sardinia and M.S. Pirisino studied those referred to North Sardinia, this last one carried out with the support of a scholarship financed with the resources allocated by INPS - Management of Public Employees, as part of the initiatives of *Homo Sapiens Sapiens*.

² Surveys have been processed with the support of the Mediterranean Laboratory for the Knowledge and Development of Historical-Traditional Materials and Architecture, Unit Survey, Restitution and Modelling (LabMAST-URRM), University of Cagliari, Scientific Manager A.M. Cazzani, Administrative Manager S. De Montis, Operating Manager V. Pintus.

³ These surveys have been carried out with the support of the Engineering Architectural Centre laboratories (Polilab) connected to the University of Cagliari, in cooperation with the National Council of Researches (CNR).

materials, and the second one consisting in the lab analysis⁴. Some assessments have been carried out on the residual resistance of the loading capacity increment, gained through improvements. Similarly, the knowledge of thermic and hygrometric performances has proved fundamental to improve and adapt historical buildings to the current requirements of energetic performance. The information gained in the three exploratory phases have been archived on an IT relational support, through the use of reproduction, archiving and divulgation technologies. The collected data are implementing a WebGIS, still under experimentation and development. These data have been analysed, systematised and compared through specific scientific data sheets and graphical theme tables, which have led to identify the discretisation and extrapolation parameters of effective chrono-typological models. Further in-depth studies on the identified chronotypes, have been arranged through BIM applications, by which a three-dimensional parametric library is being realised, to support sustainable conservation and restoration of historical architectures. The transdisciplinary approach has therefore allowed building exploratory and operational tools, defining materials and technology according to the principles of compatibility and reversibility, as well as new guidelines supporting the conservation and protection of the historical architectural heritage and, in particular, of common buildings⁵.

2. Historical background (VP)

The birth and the evolution of medieval Sardinian defensive systems have been strongly influenced by the complex historical events characterising Sardinia in the long span between the 11th and the 15th centuries. In this period the island was actually divided into four kingdoms, called *Giudicati*, those of Cagliari, Torres (or Logudoro), Arborea and Gallura, and different powers alternated on the territory: first of all, the kings, then the maritime republics of Pisa and Genova - with the Donoratico, Massa, Visconti, Malaspina and Doria families - and finally the Crown of Aragon.

In this context, defensive structures were realised and transformed both for the control of the territory and for the success and consolidation of the different

⁴ Analyses have been carried out at the LabMast (Historical Materials Lab) and the DICAAR lab.

⁵ In this sense, efficacy is recognised to the synergy with the local productive structure represented, in this research context, by the Buccellato s.r.l. company.

powers established in the island. At the end of the 13th century, with the infeudation of the *Regnum Sardiniae et Corsica* to James II of Aragon, castles became the object of a dispute among the different authorities fighting to unify Sardinia under a single kingdom. Starting from the 15th century, with the final conquest of the island by the Crown of Aragon, the political reorganisation led to a transformation of the defensive system. As a matter of fact, many sites lost their defensive function being destroyed and/or abandoned while other structures were built *ex-novo*. In particular, the Aragonese-Catalan government enhanced strongholds close to villages and cities, and, in the second half of the 16th century, started building towers to protect the coast.

3. The places (MSP)

The rich lithology of the island, resulting from a long and complex geological history, characterised architectures in different historical periods, determining not only the distribution of the investigated buildings, but also the choice of the construction materials. From a geological point of view, Sardinia consists in two main components: a Palaeozoic base and volcanic and sedimentary covering dating back to an age included between the late Palaeozoic and the Quaternary periods. The basement, of magmatic and metamorphic nature, emerges in a wide eastern belt extending from north to south and, at a lower level, in the southwest sector. It is made up of acid plutonic rocks-granites (granodiorites, monzogranites and leucogranites) and of metamorphic rocks (gneiss, micaschists, schists and meta sandstones). The western part of the island, starting from the upper Oligo-Miocene up to the lower Miocene, is involved in two volcanic cycles, the first calco-alkaline showing the emplacement of a powerful succession consisting in andesites, rhyodacites and rhyolites with a texture from aphanitic to porphyritic; the second alkaline, with the extrusion of basalts. Sedimentary rocks, of a different age are distributed on the whole island with sediments of a continental environment, mainly represented by alluvial pebbles and marine deposits: conglomerates, sandstones, organogenic limestones.

Furthermore, the different lithologies give the Sardinian territory rather diversified morphologies. As a matter of fact, irregular mountainous systems and inaccessible coasts are present in the granitic and metamorphic areas, alternated with regular and hilly morphologies in the central areas characterised by sedimentary rocks. Finally, in the western

part of the island, where highly different volcanic outcrops for composition and texture prevail, wide morphological variations can be observed.



MASONRY CHRONOTYPOLOGIES | 12th - 13th centuries

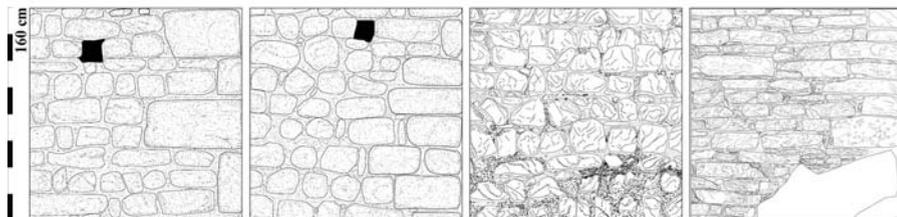


Fig.01: The image shows the mapping of the Sardinian fortified system (12th - 15th centuries), the fortified palace of Re Baldo (Luogosanto, Sassari), the fort-house of San Michele (Cagliari), the donjon of Ghilarza (Ghilarza, Oristano), the fortress of Del Goceano (Burgos, Sassari) and a synthesis of the chrono-types of masonries referred in the 12th-13th centuries, realised with ashlars, arranged according to sub-horizontal courses (survey and graphic elaboration by V. Pintus and M.S. Pirisino)

4. Fortified architectures (VP, MSP)

The medieval fortified system, object of this study, consists in about 105 sites, among which 59 localised in the northern sub-region and other 46 are positioned in the southern one, characterised by a fairly advanced state of damage or decay. They are uniformly distributed in the territories historically belonging to the *Giudicati* of Arborea, Cagliari and Torres, and along their respective borders. On the contrary, in the north eastern sector, historically coinciding with the *Giudicato* of Gallura, given the complex morphology of the territory, structures are mostly concentrated along the coast belt and next to important harbours.

4.1 Typologies (VP)

The survey has highlighted a rather complex and heterogeneous defensive panorama, resulting from the different historical-political events and from the several cultural influences occurred between the 12th and the 15th centuries. On the one hand, these features emerge from the structure models of the social-settlement context; on the other hand, they derive from the characteristics of the specific structures, especially with peculiar type models as well as formal and stylistic expressions. In particular, the study of defensive architectures allowed to identify two categories: walled systems and so-called castles. With reference to the latter, four sub-categories have been distinguished: the fortified palace (01), the fort-house (02), the donjon (03) and the fortress (04). As for fortresses, the observation of recurring formal, structural and morphologic characters have allowed defining four types, according to parameters related to the location, the planimetric configuration, the characterising elements and the prevailing function. Every type can be associated to a chronology and to the phases of *incastellamento* characterising the fortified Sardinian landscape. The type 04/01, related to the 12th century fortifications, shows wide sizes and is realised on an inaccessible relief, directly on the rocky outcrop. It has a strictly strategic-defensive function, emphasised by the lack of decorative elements. The defensive site usually consists in a main tower, around which service spaces are built, such as cisterns, storehouses, etc.

The type 04/02 consists in military-residential fortresses of the late 12th century. These fortresses are located on an inaccessible relief controlling the territory, and have reduced size, with a regular elongated shape,

along a NE/SW direction. Only the openings usually overlook the inner courtyard. Instead, the stronghold is characterised by a high-fortified tower and protected by a wall located at a lower level. A refined fortress, dated to the first half of the 13th century, represents the type 04/03. Realised on a relief, inaccessible on different sides, it presents large sizes and is arranged in a double wall: a more external one at a lower level supporting the soil morphology, and a more inner one, positioned near the top of the relief. The latter, in a regular shape, presents spaces in its inner side with a supposed defensive or residential function. The characterising elements are the fortified tower and the system of cisterns for the water supply. The type 04/04 is the residential fortress, ascribable to the period included between the end of the 13th and the beginning of the 14th century. This fortress has an emblematic power role. This led to choose a particularly visible site dominating the surrounding territory, as well as a more refined formal expression compared to the previous types. The complex has a double function: residential and defensive; it shows a wide planimetric development and is structured supporting the soil morphology, although a precise building plan is evident. More specifically, built on an easily accessible relief, this stronghold generally consists in a fortified wall provided with towers, quadrangular and circular ones, and a door allowing access to the inside, where there are several spaces, among which the palace and the palatine church.

4.2 Masonry techniques (VP, MSP)

Through a deep survey of the medieval fortified system, 31 case studies, as already mentioned, have been selected, representing the examined cultural environments. Thus, on these architectures, an analysis of the masonry structures and of their technological peculiarities was performed. Having identified more than a hundred masonries, significant for the building phases, they have been investigated with an archaeological approach, aimed to highlight the constructive, dimensional, material and structural specificities, through which the most relevant characteristics can be identified, and valid chronological local keys defined.

The classification of masonries has led to the definition of three macro-categories, according to the function of the placing (in rows; in sub-horizontal courses; "a cantieri"- arranged periodic horizontal levels). Furthermore, according to the shape and the processing type of the

stone elements (blocks, ashlar and rustic stones), any of them has been divided into two sub-categories. In the case of the “*a cantieri*” type, they have been defined according to the arrangement of the elements (horizontal; sub-horizontal; fishbone). In the following, the chronotypologies are described. The masonry type 1 is realised with blocks (1a) and ashlar (1b) arranged in rows. It is characterised by misaligned joints, often not as thin as the bases and only some show a recessed finishing. The use of wedges is common in the type 1.2. In some masonries, it is possible to observe the presence of ashlar characterised by bossage stone. This type is commonly employed for the realisation of bases and cantonal blocks of representative buildings such as the palace and the fortified tower, the towers of the wall systems and the palatine chapels, between the 12th and the 15th century, with different trends in the different parts of the island. The masonry type 2 consists of ashlar (2.1) or sometimes it is associated to rustic stones, arranged according to sub-horizontal courses. A common feature in the investigated textures is the concurrence of cantonal blocks in squared stone. Joints and bases are realised with abundant mortar. The use of wedges in stone or brick fragments is common, either to fill the interstitial voids or to allow more regularity to the masonry. This texture is used for the construction of the main walls in fortified towers and, in some cases, for the bases and the inner spaces of fortified palaces. It was adopted in a period circumscribed to the 12th and 13th centuries in the northern area and in Gallura. However, in the 14th century it can be also found for the construction of inner walls in some fortified complexes of Logudoro, strictly connected to the Ligurian culture. Moreover, this typology is present in structures dating back to the 13th century, with a plant deriving from the first phase of the *Giudicati*, but with a successive Pisan frequentation, and in the 14th and 15th centuries, in relation to the first phases of the Aragonese conquest of the island, especially in the southern area. The masonry type 3 consists of rustic stones of several shapes and sizes, arranged according to periodic horizontal levels, known as “*a cantieri*”. This texture is generally used for the realisation of cisterns and for the curtain walls of castles, as well as the walls of boroughs and fortified cities, with continuity between the 12th and the 15th century. The “*a cantieri*” masonries with bosses and scales arranged in fishbone pattern (masonry type 3.2) are usually employed to realise the highest portion of the walls, in the internal facings of the structures realised in the 12th-13th centuries in the southern area.

4.3 Materials (MSP)

The macroscopic characterisation *in situ* of the investigated structures allowed to underline the lithological, morphological and chromatic characteristics of the stone elements, of the lodging mortars and the plasters, as well as of the bricks. Besides, by comparing the lithological nature of the masonries with the geological and lithological peculiarities of the area where the examined architectures are placed, the study has made important historical and material relationships between the case studies and their context⁶. More precisely, in the north-eastern part, historically corresponding to the *Giudicato* of Gallura, masonry structures are realised with ashlar, bosses and rustic stones of lithotypes characteristic of the granitic and metamorphic area: granite in a grey to pink colour; metamorphites in light and dark colours; and material related to rhyolitic veins in a porphyric structure of a dark colour. In addition, some defensive structures situated in southern Gallura - an area marked also by the presence of calcareous and volcanic outcrops -, are present masonries characterised by limestone bosses, in a white, grey and yellow colour, and dark basalt ones. On the contrary, defensive structures in the north west of Sardinia, corresponding to the historical region of Logudoro, are marked by very diversified stone materials in relation to the variety of lithotypes, of volcanic and sedimentary nature, characteristic of this area. Specifically, near Gallura, masonry structures are realised with ashlar, bosses and rustic stones of pink granite, granites and metamorphites of a grey colour, ignimbrites of a pink colour, as well as trachyandesites of a grey-green colour and quartz phyllades in a red hue. In the central-northern area of Logudoro, masonries are realised with ashlar, bosses and rustic stones of carbonate lithologies, characterised by a yellow-mustard colour or by a grey-white colour, and of dark basalt. In southern Logudoro, instead, masonries are usually realised with ashlar, bosses and rustic stones of sandstones, tuffaceous and volcanic conglomerates, of a yellow-grey colour, and sandstones, andesites, ignimbrites and basalts with colours from grey-green to pink-violet. The same diversification of lithologies, of volcanic and sedimentary nature, are present in the fortified architectures of the area historically corresponding to the *Giudicato* of

⁶ The high variety of regional lithotypes, in general characterised also by a wide chromatic variation, has been solved in this specific case with reference to the geological maps drawn up by ISPRA, on a scale 1:100.000, for the whole regional territory, and on a scale 1:50.000, whose publication is still partial.

Arborea. More precisely, masonries of the castles situated in the northern part are characterised by ashlar, bosses and rustic stones of calcareous and volcanic lithologies (material with a phonolitic component; basalts and rhyolites with chromatisms varying from dark black to purplish-blue and dark pink). By contrast, in the central area, masonries are realised with limestones and calcarenites of a light grey colour, sandstones with marly components, of a grey-green colour, and only in some cases with basalt, in a colour varying from grey to pink. As far as the southern area is concerned, corresponding to the *Giudicato*-of Cagliari, it can be noticed that the episodes affecting the southeast area are characterised by masonries built with ashlar, bosses and rustic stones of granites and metamorphites in a colour tending to pink. However, it is interesting to highlight the presence of a defensive structure realised with bosses and scales of *bardiglio* marble, characterised by a grey colour and the presence of white streaks. The masonries of the fortifications situated in the central part are mostly realised, instead, with lithologies corresponding to limestones - more commonly the Cagliari ones, used in two variations locally called *pietra Cantone* and *pietra Forte*-, meta-limestones and sandstones; as well as calco-alkaline volcanite of a grey-green colour - locally called greenstone of Sanluri -, andesites and basalts. Finally, masonries of defensive strongholds located in the southwestern area consist in lithologies of a volcanic nature, in particular basalts, limestones, and sandstones from San Vito, in a grey-greenish colour, reddish meta-sandstones, schists and argillaceous schists. Later, in a second phase of investigation, a reasoned sampling has been carried out of the artificial stone material, according to what provided for by the standard rules (UNI 11176/2006). Several samples of mortar beds and plasters have been taken, on which a petrographic investigation has been performed on thin sections integrated by X-ray diffractometry analyses on powder samples. The interpretation of images in thin petrographic section with the polarising light optical microscope has allowed distinguishing mortars according to the type of binder, to the nature of the aggregate, the relationship between binder and aggregate, the origin of the aggregate and its composition, as well as the textural and granulometric characteristics. The examined samples are characterised by a binder made of air-hardening lime with a structure from micritic to micro-sparitic. The mineralogical composition, determined through the analyses in X-ray diffractometry (XRD), is strictly connected to the lithological context of the site. These petrographic analyses have highlighted mortars characterised

by aggregates prevalently of a siliciclastic nature, or by aggregates of a volcanic and sedimentary nature, according to the emerging lithological formations. The presence of *cocciopesto* (fragments of earthenware mixed with lime and sand) can be noticed in some mortars coming from specific structures of the fortified complexes, such as cisterns. The quality of mortar beds and plasters depends not only on the mineralogical composition of the binder and of the aggregates, but also on the workers. The slurry shows the presence of unburned and lime lumps, of shrinkage fractures and reaction rims.

Conclusions

The in-depth investigation of the fortified system built during the 12th -15th centuries in Sardinia allowed us to underline technologies and processing procedures belonging to different constructive cultures in order to recognize different chrono-typologies. In summary:

- the typological classification for the defensive structures is closely related to the phases of Sardinian *incastellamento*, and the analysis highlights the relationship between Sardinian fortifications and those found in other European countries, although the dating of the Sardinian ones is later;
- masonries 01 and 03.1 have been widely used with continuity from the 12th to the 15th century. In particular, the first one has been employed for the construction of towers and *mastio*, the towers of fortified cities, palaces and palatine chapels, and the second one for cisterns and urban walls. On the contrary, masonries 02 and 03.2 was less widespread: the 02 has been used only during the 12th-13th centuries, mainly in Gallura, and during the 14th century for the construction of inner walls in some fortified complexes of Logudoro, whilst in the southern area this typology is present in structures dating back to the 13th century and to the 14th and 15th centuries, in relation to the first phases of the Aragonese conquest. The masonry 03.2 is usually employed to realise the highest portions of walls, in the internal facings of the structures realised in the 12th-13th centuries in the southern area;
- regarding the material aspect, the fortifications were generally built with materials corresponding to those available on site.

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