Elucidating northern Sardinia's fortified heritage through traditional masonry and historical materials

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Abstract
In medieval Sardinia an important system of around a hundred fortifications was built for varying defensive purposes. This paper, part of an ongoing research focused on the study of this system, takes an interdisciplinary approach to the investigation of traditional masonry techniques and historical materials used between the 12th and 15th centuries in Northern Sardinia. In particular, 3 of 40 defensive structures distributed on this territory, have been selected as representative of a specific historical and cultural context: the Castles of Pedres and Della Fava, and Re Baldo Palace. Archaeological and material surveys were conducted in order to elucidate the formal, spatial, dimensional, technological, and constructional values of these sites as well as to reconstruct the architectural evolution that marked the history, not only of these fortifications, but also that of the surrounding territory, with the aim to recognise this heritage, which was ignored for a long time, as heritage to be safeguarded and enhanced.

Parole chiave
Middle Ages, northern Sardinia, defensive architecture, archaeology of architecture, geomaterials, masonry.

The study[1], here proposed, focuses on making a contribution to tracing the history of local architecture through the knowledge of traditional masonry techniques and historical materials used in fortifications built between the 12th and 15th centuries in northern Sardinia, in order to enhance understanding of the heritage of medieval fortifications and traditional architecture, and, therefore, to allow a compatible and sustainable project for its conservation and enhancement. As is well known, fortifications and great cathedrals were key elements of the medieval landscape and are a fundamental component of European identity (Kaufmann and Kaufmann, 2004, pp.13-15; Rao, 2015). Understanding the role and significance of medieval fortifications and their evolution over the centuries elucidates the development of the society and settlement, the dynamics of the diffusion of technical culture, and, consequently, the function of specific architectural and masonry techniques.

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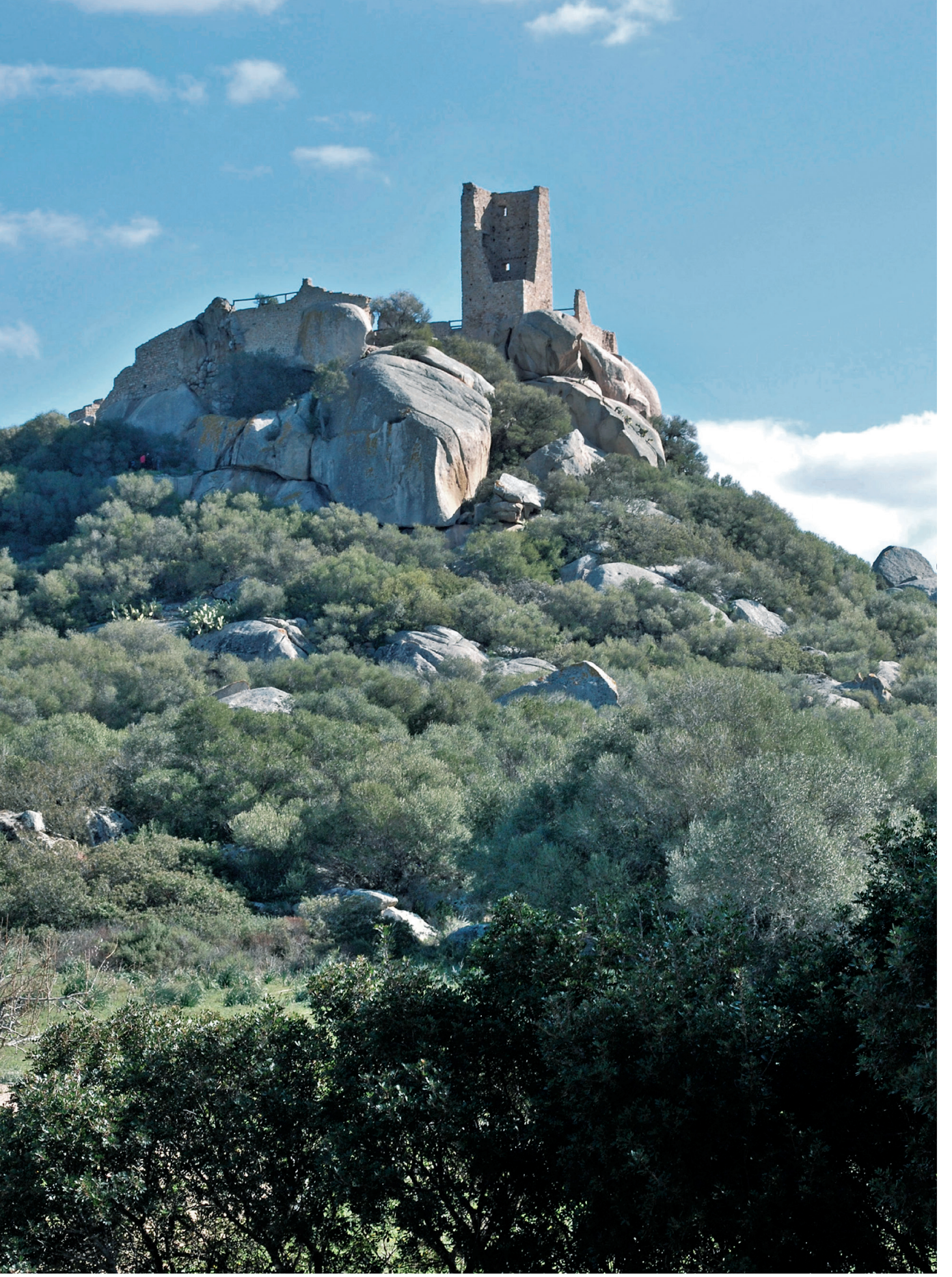


Pedres Castle

Della Fava Castle

Re Baldo Palace

The construction, evolution, and function of defensive structures diversified during the medieval period, and region to region, there are definite links to the evolution of society and technology, which triggered the process of settlement and the transformation of the social landscape (Kaufmann and Kaufmann, 2004; Rao, 2015; Rocchi, 2010). Additionally, Sardinia's fortification system made a similarly significant contribution. From the 12th century, defensive structures were built by local authorities for the control of territory and consolidation of their power. However, from the 15th century, several structures lost their defensive function and were gradually destroyed or neglected as new fortifications were built with different functions and in other locations.
Sardinia's contemporary heritage of medieval fortifications consists of numerous structures, including castles, fortified cities and villages, towers, and palaces, all characterised by varying architectural, formal, and material features depending on their location, age, and construction phases. The considerable variety of this heritage is linked to complex historical events and cultural influences as well as a heterogeneity of locations and local materials. These circumstances make it necessary to territorially circumscribe the research to two areas: northern (Pirisino, 2017a; Pirisino, 2017b) and southern Sardinia (Pintus, 2017a; Pintus, 2017b). This study focuses on the analysis of 3 fortifications out of the 40 distributed throughout the northern Sardinia: the castles of Pedres and Della Fava, and Re Baldo Palace (figg. 1-3).

pagina a fronte
Fig. 1
Pedres Castle, Olbia (SS).
sopra
Figg. 2, 3
Della Fava Castle, Posada (NU).
Re Baldo Palace, Luogosanto (SS).

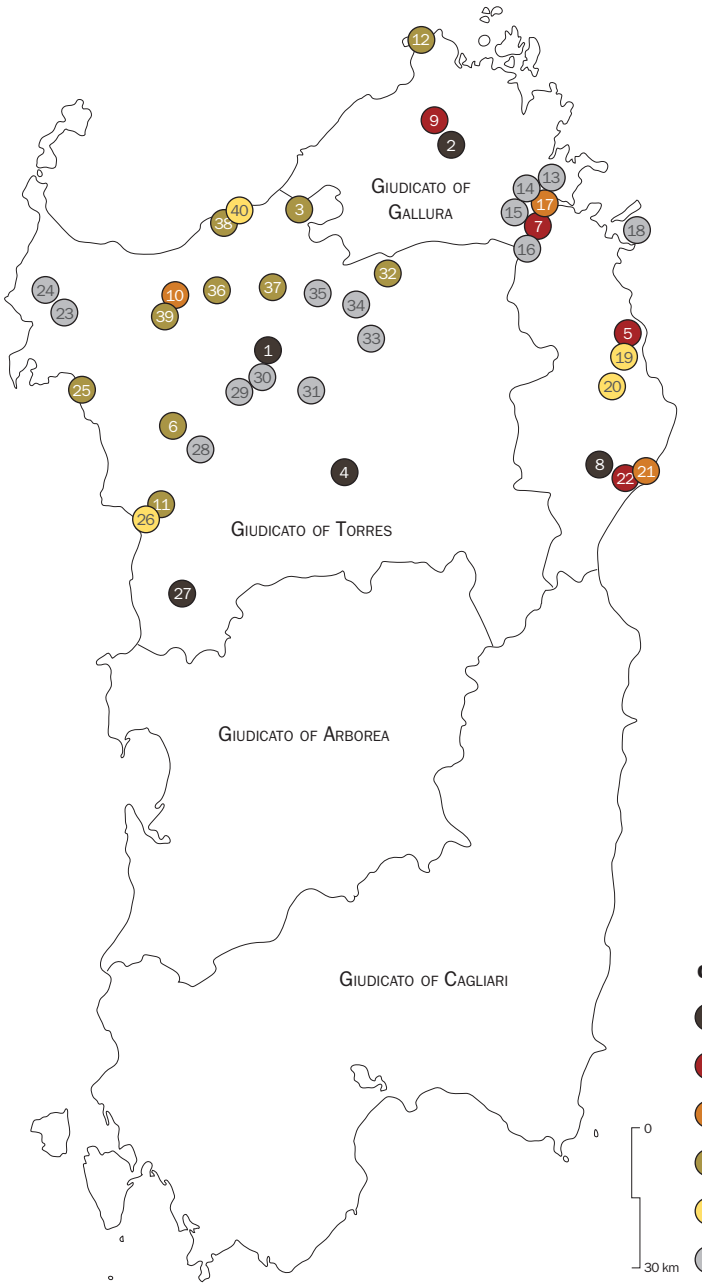
p. 61
Pedres Castle and the surrounding landscape, Olbia (SS).

The research started with a systematic identification of fortifications through bibliographic, archival, cartographic, iconographic sources, and surveys in situ. The 3 structures selected are representative of a specific geographical and historical context and their selection was influenced by the degree of decay and accessibility. The historical and architectural profiles have been analysed through the chrono-typological features of their mineralogical-petrographical aspects. The aim of the in-depth examination was to gain an extensive architectural knowledge of the structures in order to understand their formal, spatial, dimensional, technological, and constructional values as well as to reconstruct the construction phases that marked their history.
The examination achieved two goals: the chronological relationship between these historical buildings was defined; and the compositional aspects of historical materials were characterised, yielding knowledge of the traditional masonry techniques used in northern Sardinia at that time, as a guide for an appropriate conservation design.

pagina a fronte
Fig. 4
Chronologies of the fortification system of northern Sardinia.

Medieval fortified landscape

The northern Sardinia is a wide area, represented by two quite different historical subregions, known locally as *Gallura* and *Logudoro*, in the northeast and northwest, respectively. Morphological and lithological characteristics as well as the historical and cultural legacies of this area have had a significant influence on and given rise to the specific cultural identity of these places; patterns of settlement have influenced the origin, evolution, and organisation of the area's historic defence system; and masonry techniques and construction technology have affected architectural development.
From a historical and cultural point of view, between the 12th and 15th centuries, these territories were better known as the *Giudicato of Gallura* and the *Giudicato of Torres*. Indeed, after the year 1000, Sardinia was divided into four kingdoms (locally known as *giudicati*): *Calari, Torres, Arborea*, and *Gallura*. Having originated from the same institution, the four *giudicati* shared identical administrative and territorial organisations (Ortu, 1996, 2005; Casula, 2015); nevertheless, their routes through history are markedly different, particularly the two northern subregions that form the basis of this study. The two areas were one kingdom for a short period (1235-1238), however, *Gallura* was closely linked to the Visconti, a Pisan family, and then to the authority of the municipality of Pisa; and Logudoro was initially subject to the influence of Genoa. After the death of Adelasia, last heir of the Logudorese kings, in 1259, the territory was divided between a few protagonists, including the Doria, family from Genoa, and Malaspina, the Lunigiana family, which, over the decades, had obtained numerous lands from the local authorities.
With the establishment in 1297 of the Kingdom of Sardinia and Corsica under the Aragon Crown and the consequent and gradual rise to power of the Aragonese, both territories experienced several armed conflicts for dominance over the island between the Aragonese and local authorities, particularly the Arborea and Doria families. These conflicts came to an end in 1448, with the final victory of the Aragon Crown. Concerning chronology, it is possible to date only those fortifications ascribable to the 12th through 15th centuries (fig. 4). The systematic analysis of the fortification system identified different phases of its origin, its development and its evolution, of the phenomenon called *incastellamento* (Soddu, 2015). In Sardinia, as in Europe and Italy, castles and villages were key elements of settlement and the transformation of the landscape. Over the centuries, the fortified complexes evolved in function according to



1 | Ardara
2 | Balaiana
3 | Casteldoria
4 | Del Goceano
5 | Della Fava
6 | Monteleone Rocca Doria
7 | Pedres
8 | Pontes
9 | Re Baldo
10 | Sassari
11 | Serravalle
12 | Longosardo
13 | Cabu Abbas
14 | Sa Istrana
15 | Padulaccio
16 | Olova
17 | Civita
18 | Molara
19 | Posada
20 | Siniscola
21 | Orosei
22 | Sa Prejone Betza
23 | Pisano
24 | Monteforte
25 | Alghero
26 | Bosa
27 | Montiferro
28 | Bonuighinu
29 | Capula
30 | Montesanto
31 | Monte Guighe
32 | Monte Acuto
33 | Olomene
34 | Castro
35 | Orvei
36 | Osilo
37 | Chiaramonti
38 | Bellavista
39 | Aragonese
40 | Castelsardo

changing military and social requirements, so to investigate these structures as serving exclusively military functions is extremely simplistic; they also facilitate economic and social readings of the territory. Studying the phenomenon of *incastellamento* is vital to the reconstruction of the regional specificity of different periods and modes of traditional architecture (Rao, 2015). Comparison of different fortifications yielded common, specific formal and morphological features. Thus, it was created a typological classification for the defensive structures closely related to Sardinian *incastellamento* (Giannattasio et al., 2018a; Pirisino, 2020a).

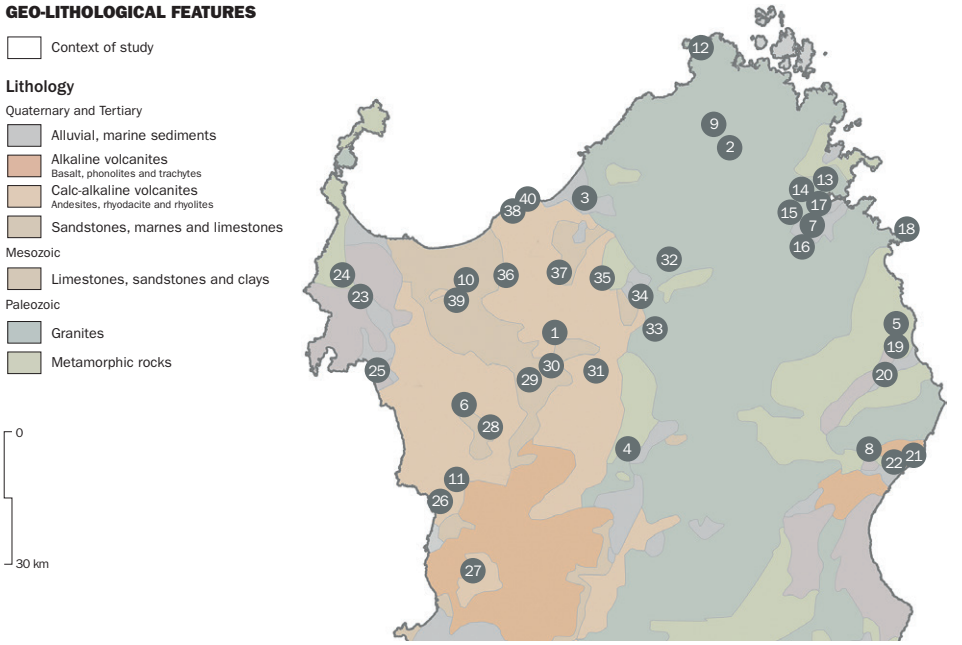


Fig. 5
Lithology of the northern Sardinia and localization of the fortification (a). View of particular link bet.

1 | Ardara
2 | Balaiana
3 | Casteldoria
4 | Del Goceano
5 | Della Fava
6 | Monteleone Rocca Doria
7 | Pedres
8 | Pontes
9 | Re Baldo
10 | Sassari
11 | Serravalle
12 | Longosardo
13 | Cabu Abbas
14 | Sa Istrana
15 | Padulaccio
16 | Olova
17 | Civita
18 | Molara
19 | Posada
20 | Siniscola
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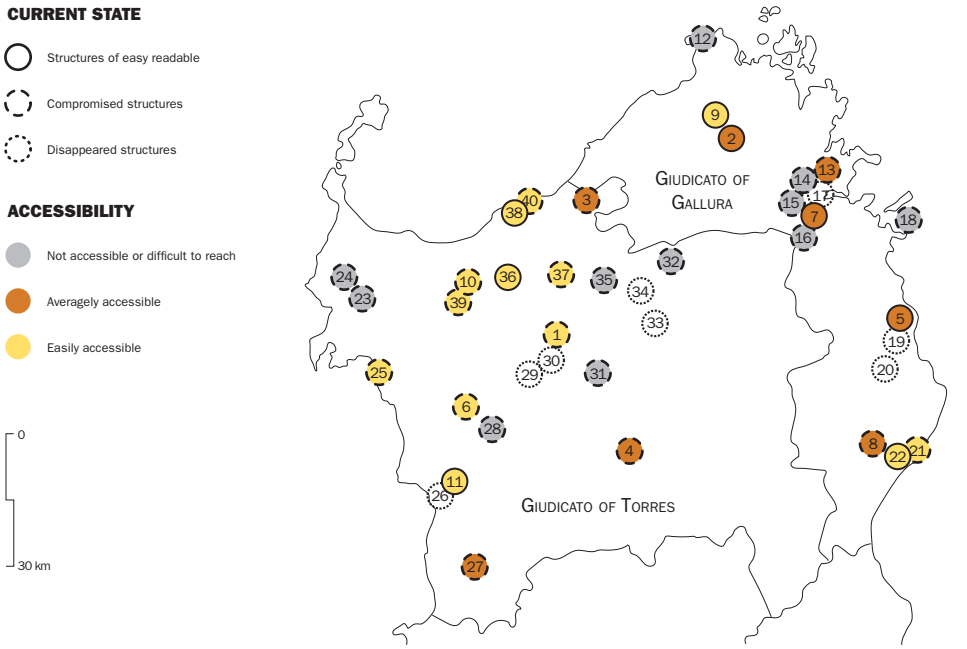
32 | Monte Acuto
33 | Olomene
34 | Castro
35 | Orvei
36 | Osilo
37 | Chiaramonti
38 | Bellavista
39 | Aragonese
40 | Castelsardo

01 | Bosa, Serravalle castle, particular of the fortified wall in vulcanic rock ashlars

02 | Olbia, Pedres castle, particular of the tower in granitic rock ashlars

Fortifications and territory

The north-eastern Sardinia is homogeneous even though there are numerous granitic outcrops that create a rather complex morphology with various territorial and landscape features (fig. 5). This area has morphological, territorial, and cultural peculiarities unique to this part of the island, so much so that it represents a stand-alone subregion. The northwest, on the contrary, shows more complexity, defined by the different geo-lithological features that influenced historical events in this subregion. Enriched by a series of plains enclosed by hills, this area is characteristic of a volcanic landscape, with volcanic outcrops of a calc-alkaline and alkaline nature composed respectively



1 | Ardara
2 | Balaiana
3 | Casteldoria
4 | Del Goceano
5 | Della Fava
6 | Monteleone Rocca Doria
7 | Pedres
8 | Pontes
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33 | Olomene
34 | Castro
35 | Orvei
36 | Osilo
37 | Chiaramonti
38 | Bellavista
39 | Aragonese
40 | Castelsardo

Fig. 6
Current state and accessibility of the fortified heritage of norther Sardinia.

of ignimbrites and basalts. The varied lithologies produce peculiarities in the building materials found in these subregions, peculiarities both in the composition of the masonry structures and in the chromatic quality of the architecture. Several monuments, including churches and castles built during the Middle Ages, liven up the landscape of Sardinia with the differently coloured materials used in their construction (fig. 5).
The northeast is characterised by a natural fortified system of hills and wilderness and has a significant defensive heritage consisting of 16 defensive structures, located mainly along the coast; whereas the northwest consists of 24 fortifications, homogeneously distributed throughout the vast and productive territory. The locations are all strictly related to their function, situated in strategic positions. In fact, for explicitly military reasons, they were frequently built along the oldest and most important roads or along territorial borders, whereas others were built as protection for the local populace. Some structures occupied uninhabited landscapes, but others were closely linked to rural or urban settlements, influencing their evolution and development.
Based on the conditions of a site, these structures can be divided into three categories (fig. 6): first, structures that clearly show the design of the original architectural complex; second, structures that have completely lost their original inner form; and third, structures that have disappeared. There are eight of these lost structures in the third category, but their presence is evinced by sources and place names.
Surveys *in situ* highlighted a few issues closely linked to the accessibility of these fortifications. For instance, some defensive structures are situated on private property; others, due to their defensive function, were built in very inaccessible places.

Their inaccessibility has, presumably, determined their more rapid deterioration and consequent disappearance. In fact, this study has shown that the most accessible fortifications are also those that, in the last 50 years, have seen the effects of restoration and/or archaeological research, and so have been preserved in better condition (Giannattasio et al, 2018b).
In the most cases, the restoration efforts intervened to consolidate a structure and restore it to wholeness. In particular, *mastio* and towers have benefited more from such interventions (Pintus, Pirisino, 2019). In some cases, after consolidation, a structure was intentionally left as a ruin. Several structures have been the subject of archaeological investigation (Milanese, 2010; Pinna, 2004). However, a few defensive structures serve a real function, such as exhibition spaces or museums. Many fortified complexes have become archaeological and tourist sites, managed by cooperatives and delegated by the municipalities. These are used to control, manage, and maintain these areas. In other instances, unfortunately, these sites are closed or apparently abandoned.

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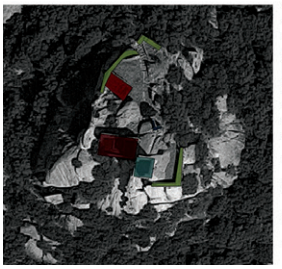
Fig. 7
Pedres Castle, Olbia (SS). Schematic of the fortified complex with the identification of the buildings; view of the different defensive structures.
Fig. 8
Della Fava Castle, Posada (NU). Schematic of the fortified complex with the identification of the buildings; view of the different defensive structures.
Fig. 9
Re Baldo Palace, Luogosanto (SS). Schematic of the fortified complex with the identification of the buildings; view of the different defensive structures.

Case studies
The 3 fortifications analysed in this study are representative of their specific historical context and location. They are built in the first half of the 13th century and are closely linked to the Visconti, a Pisan family. Pedres Castle and Della Fava Castle are situated atop hills, where they dominate the surrounding flat landscape, placed there for the earlier purpose of controlling the mouths of rivers and the most important harbours. Re Baldo Palace, the unique surviving example of medieval palatine architecture, is situated in the heart of Upper Gallura. Pedres Castle (Amucano, 1996; Pirisino, 2018; Pirisino, 2020b) and Della Fava Castle (Giannattasio et al., 2017b; Giannattasio et al., 2018a) were abandoned after they lost their defensive function, and Re Baldo Palace (Pinna, 2004; Pinna, 2005; Pirisino, 2020c), situated in a rural medieval village called Villa Santu Stevanu, was probably abandoned in the 14th century.
The architectural design of the two castle is almost identical (figg. 7- 8). They are articulated on two curtain walls: the first is totally missing, while the upper one has an irregular plan. Inside the upper curtain wall, there is the *mastio*, a rectangular structure with a few cisterns in ruin. In both castles, the *mastio* shows a quadrangular plan. The northeast and southeast sides of the Pedres *mastio* are preserved. The tower was probably divided into four levels, as marks inside it, such as corbels and holes, suggest. On the southeast side is the entrance to the *mastio* (3.70 m high). It is aligned with a window and an embrasure. In Della Fava Castle, the fortified tower is located in the western part of the castle and is 20 meters high. On the eastern side of the tower, about 4.50 meters high, is the entrance. At higher levels, a window and a tight embrasure are aligned. Some sections of the crenelated parapet have survived.
The ruins of Re Baldo Palace (fig. 9) are located inside an articulated complex at the centre of the medieval village of Santu Stevanu. During recent archaeological investigations (2001-2002), the complex was brought to light; it has a rectangular plan, and it is composed of about 20 structures arranged around a courtyard. Situated at the southeast corner is the quadrilateral construction called the Palace of King Baldo. Two levels of this building are preserved. The first one includes a scarp basement. Access is from the upper level on the northwest side via external stairs. About 70 meters from the complex are a circular structure, perhaps a furnace, and a church dedicated to Santo Stefano, which dating to the 18th century.

a

b

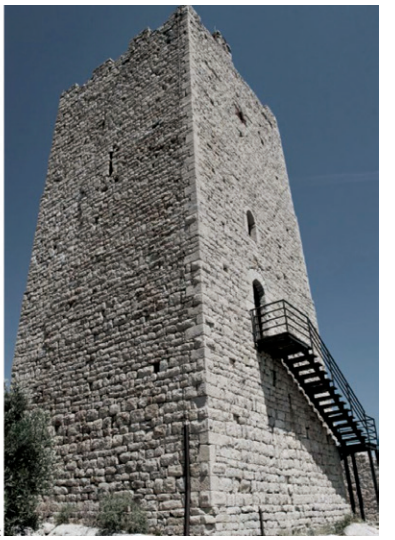


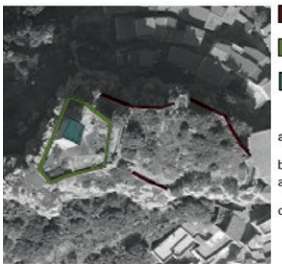
Fortified Wall
Aula
Mastio
Cistern
Bunker
a | *Mastio*
b | *Aula*
c | Cistern
d | Bunker

c

d

a





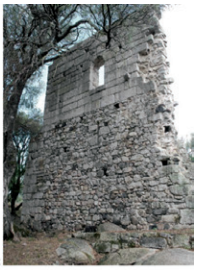
Fortified wall
Fortified wall
Mastio
a | Fortified wall
b | Fortified wall and cistern
c | *Mastio*

b

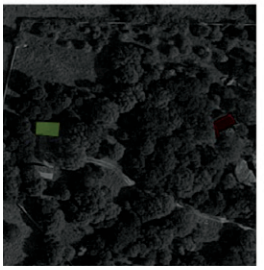
c

a

b

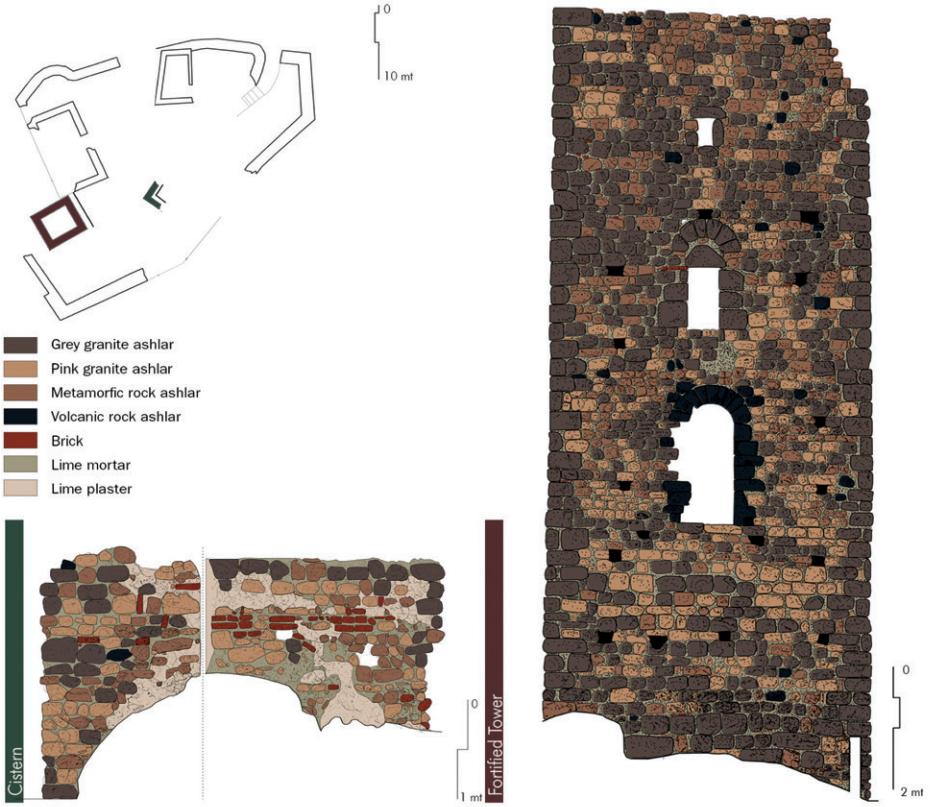


c



Re Baldo Palace
S.Stefano Church
a | Façade N-E
b | Façade N-W
c | Façade S-W
d | Palace interiors
e | S. Stefano Church

e



Mapping of materials

Fig. 10
Pedres Castle,
Olbia (SS).
Fig. 11
Della Fava Castle,
Posada (NU).
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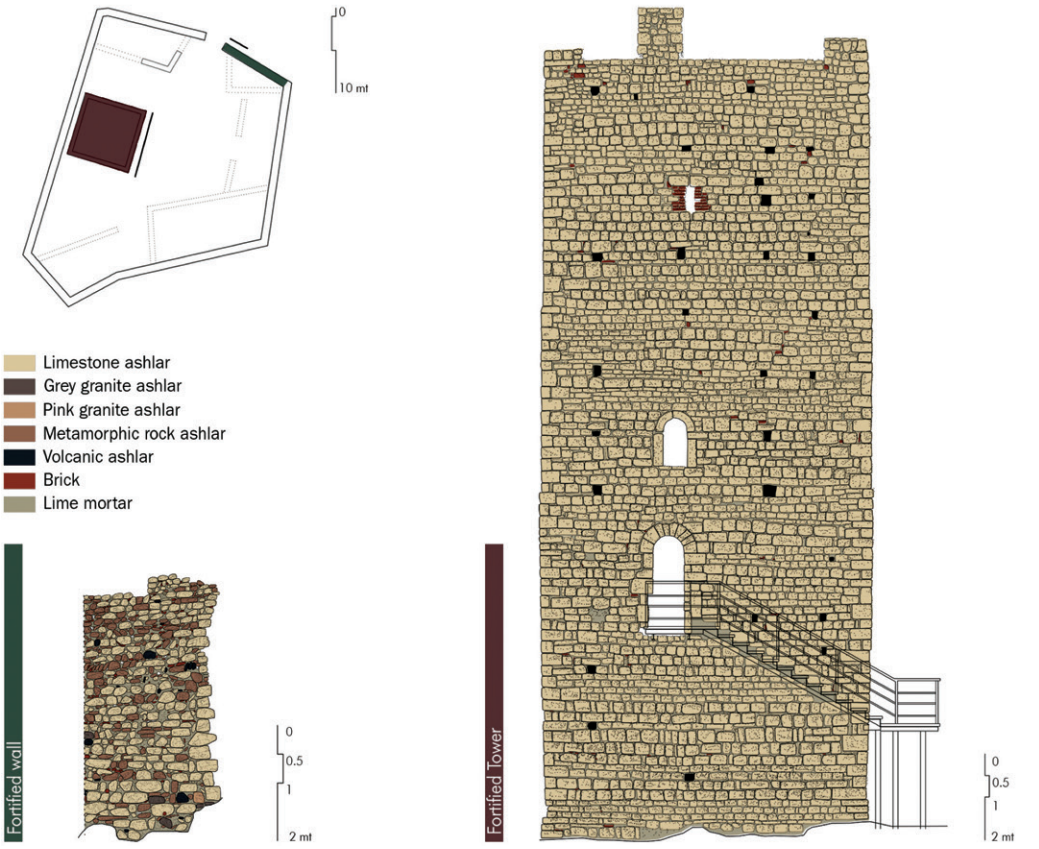
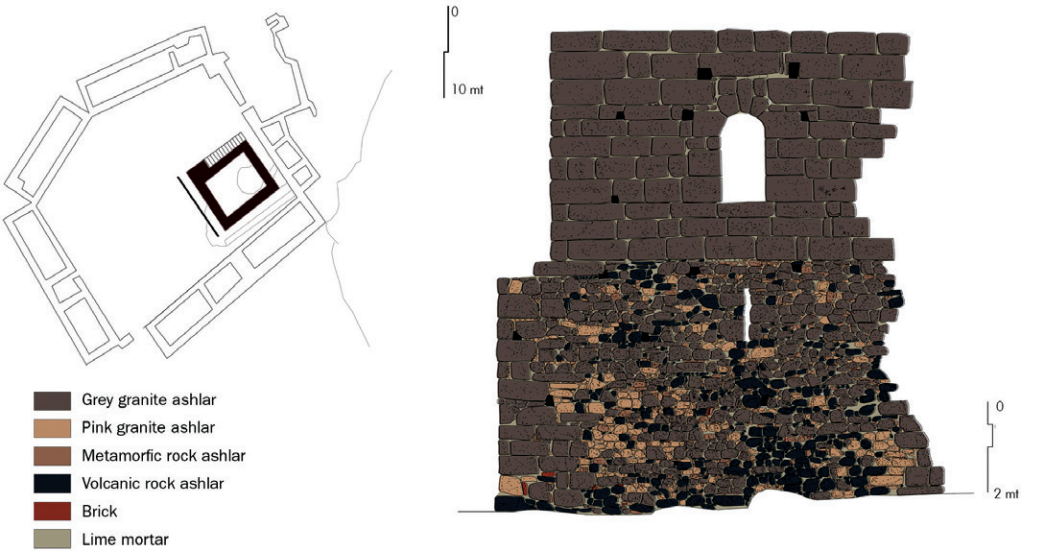
Fig. 12
Re Baldo Palace,
Luogosanto (SS).





Materials and methods

The investigation started with a general analysis of the architectural complexes, conducted by means of indirect study and direct survey. The identification of fortifications was made through bibliographic, archival, cartographic, and iconographic sources. Many bibliographic sources were relevant to this study, including research conducted from history, history of art, and perspective of medieval settlement as well as results obtained through recent archaeological excavations whose subject was, in part, the heritage of fortifications in Sardinia. Moreover, important information about the state of conservation and restoration carried out in the second half of the 20th century have been deduced from the consultation of the photographic sources of the Soprintendenze archeologia, belle arti e paesaggio (Italian peripheral office with the institutional task of protecting, conserving and enhancing the architectural and landscape heritage) from the metropolitan city of Cagliari and the provinces of Oristano, Medio Campidano, Carbonia-Iglesias, and Ogliastra as well as the provinces of Sassari, Nuoro, and Olbia-Tempio. The systematic analysis of fortifications has allowed to identify a number of representative defensive structures, which it used to conduct a more thorough investigation of particular sites. Selected fortified architectures, as well as the 3 case studies here proposed, were analysed through architectural survey, the mapping of materials (figg. 10-12), masonry analysis (fig. 13), and mortar and brick investigation (figg. 14, 15). The masonry structures were analysed through an archaeological approach based on detailed representations at a 1:10 scale of a sample of dimension 1.20 m x 1.20 m, in order to highlight constructional, dimensional, material, and structural peculiarities and to define the most representative features, thereby establishing valid local and chronological keys. Consequently, the analytical and descriptive observations made from in-depth analysis of each sample were collected in a report and organised based on those macroscopic parameters that were significant in defining the typology of the different masonry features (Giannattasio et al., 2016b; Giannattasio 2020). In particular, it was identified material parameters, such as workability and the conformation of the stone elements, and cultural parameters, such as processing type and methods of setup.

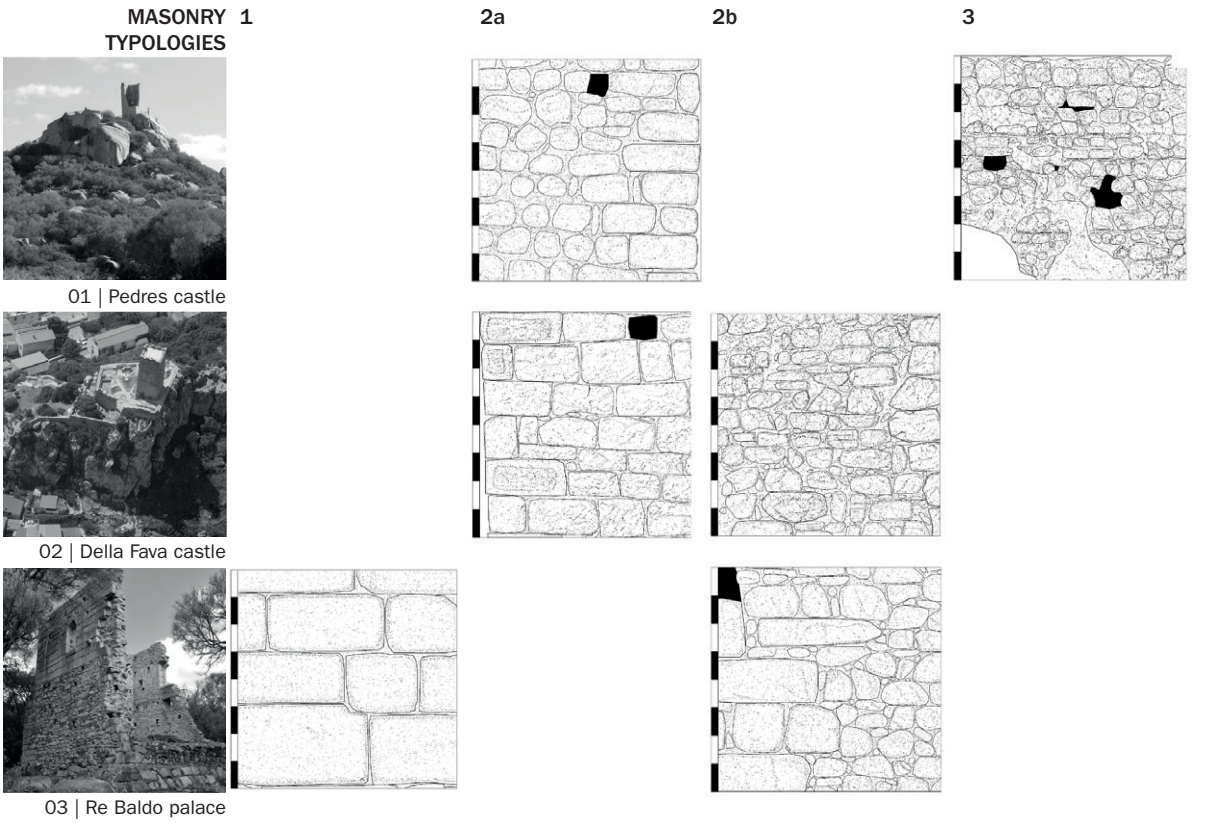


Fig. 13
Masonry analyses of the three case studies.

Specifically, the investigation of each masonry sample highlighted: the types of stone elements (squared, rough-hewed squared, and rough stone); the morphology, the dimension, and the assortment (heterogeneous, homogeneous) of the stone components; the processing type, the density, and the 'inner working' of the stones; the use of stone and brick wedges in order to fill in the interstitial segments and maintain horizontality; the presence and identification of periodic horizontal levels, called cantieri; and finally, the setup mode and the thickness of the vertical and horizontal joints. Whenever possible, the survey included walled sections. In such circumstances, the core type was examined based on its construction method.
The investigation protocol has also paid attention to the materials characterisation, significant element in the chronological definition of masonry structures.
Macroscopic characterisation in situ highlighted the following: the colour, lithological, and morphological features of stone, brick, bedding mortar, and plaster; the quality and the nature of mortars; and phenomena of alteration and decay. Subsequently, samples of thin petrographic sections were studied by optical microscope using transmitted light. This was integrated with X-ray diffraction analysis of powder samples, using a theta-theta type of X-ray diffractometer, Ultima IV Rigaku2.
This method allowed for the performance of several key methodological components: distinguishing mortars by type of binder, determining the nature of the binder, identification of the origin of aggregate and its composition, ascertaining the ratio between binder and aggregate, and identifying textural characteristics and grain size (Pecchioni et al., 2014; Giannattasio, 2020; Giannattasio et al., 2016a; Giannattasio et al., 2017b).

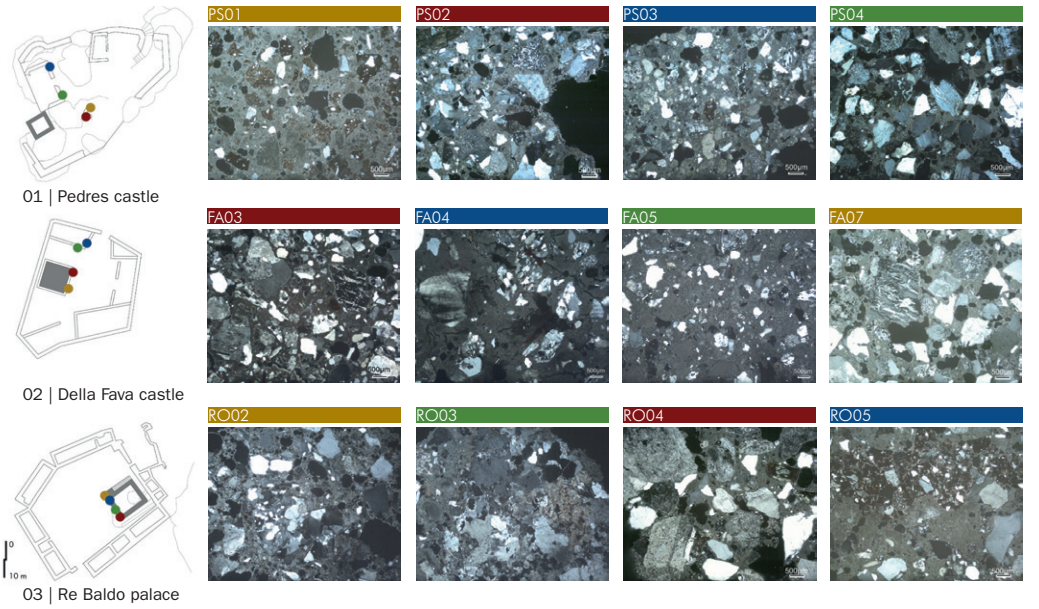


Fig. 14
Mineralogical-petrographic analyses of the three case studies.

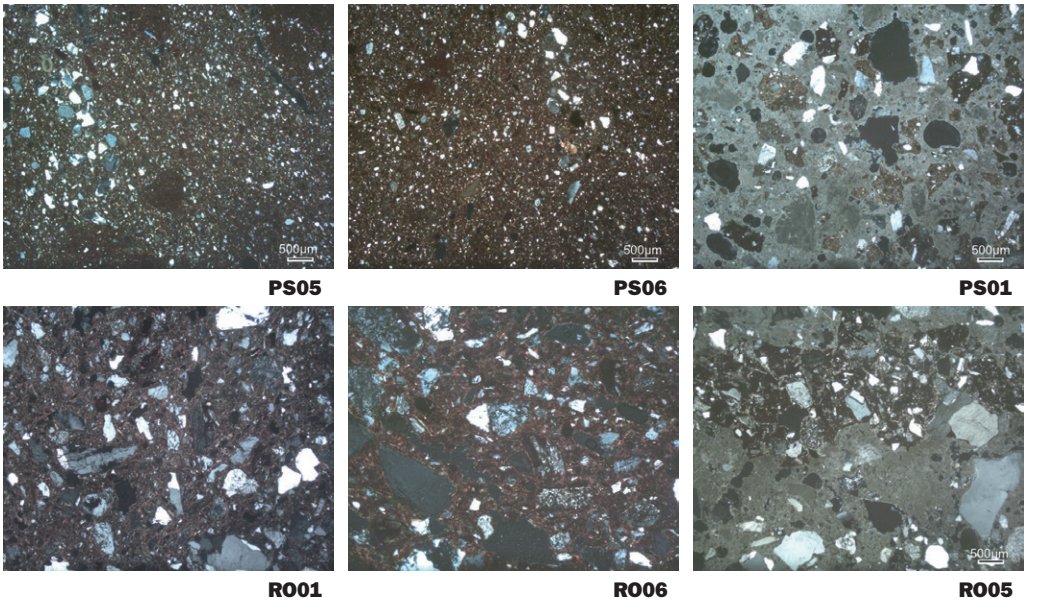


Fig. 15
Images of thin sections of bricks and mortars with coccio-pesto of the Pedres Caste (PS05-PS06) and the Re Baldo Palace (RO01, RO06, RO05).

The particular samples analysed were:

Pedres Castle: PS01-PS02-PS03-PS04 (Mortars), PS05-PS06 (Bricks)
Della Fava Castle: FA03-FA04-FA05-FA07 (Mortars), FA01 (Brick)
Re Baldo Palace: RO02-RO03-RO04-RO05 (Mortars), RO01-R006 (Bricks)

In conclusion, the systematic and comparative analysis and classification of architectures, masonries and materials has been carried out in order to highlight technologies and processing procedures and their material components belonging to different constructive cultures and to identify chrono-typological classes.

Results

The thorough investigation of the materials and masonry textures of the 3 case studies, added to their knowledge, highlighting important historical and material features that should be able to direct appropriate courses of action for the conservation of Sardinia's architectural heritage.

The analysis has permitted to highlight important historical and material comparisons between the lithological nature of the masonries and the geological and lithological peculiarities of the area where these architectures are located, underlining important historical and material relationships between the case studies and their natural and cultural context.

As a matter the fact, the fortified architectures analysed has been characterised by the use of materials mainly corresponding to those available on site.

Furthermore, it is possible to observe how the variety of the materials constituting the fortified In particular, the Pedres Castle (fig. 10) and the Re Baldo Palace (fig.12) were realised with blocks, ashlars and rough stones of grey and pink granite, metamorphic rocks, from light to dark colours and dark rhyolitic stone, rocks typical of the granitoid outcrops that characterised the Northern Gallura.

The Della Fava Castle (fig.11), however, in addition to grey and pink granite, metamorphic rocks, was built with blocks, ashlars and rough stones of white, grey and yellow limestone and dark basalt, from outcrops predominantly in the area surrounding Posada.

Regarding traditional masonry techniques, it was defined 3 typologies (fig. 13): 1) Squared or rough-hewed stone arranged in rows; 2) rough-hewed or rough stones arranged in sub-horizontal rows; and 3) rough stones in horizontal levels, called cantieri, composed of material from outcroppings in the area.

Technique 1 is characterised by a certain regularity and, as is well known, is used mostly for the construction of more important buildings. In the 3 case studies, this masonry texture was used only in Re Baldo Palace. In particular, the upper level of this palace is characterised by squared stone masonry built from blocks of grey and pink granite and arranged in rows approximately 40-50 cm in height. The squared stones are also characterised by rounded edges and rounded corners. Joins and bedding mortars are not very thin.

Technique 2 consists of mostly rough-hewed stones (2a) or in rough-hewed stones in combination with rough stones (2b), arranged horizontally in what are called sub-horizontal courses. Technique (2a) is used for the construction of important elements such as the *mastio* and fortified walls of Pedres Castle and the *mastio* of Della Fava Castle. The masonry of Pedres Castle consists of blocks and ashlars of grey and pink granite and light to dark ashlars of metamorphic rock, arranged in two to three sub-horizontal rows (around 25-50 cm in height). In the *mastio* of Della Fava, rough-hewed stones are arranged in two to three sub-horizontal rows (around 45-60 cm in height) and are characterised by limestone ashlars of white, grey, and yellow. Bossage stones characterise some portions. Technique (2b) was employed in the building of the curtain wall at Della Fava Castle and in the base of Re Baldo Palace. Usually, this technique was applied using stone from a variety of lithologies. Indeed, the fortified wall of Della Fava Castle is composed of rough stone and ashlars of limestone, pink granite, and light to dark ashlars of metamorphic rocks arranged in two to four sub-horizontal rows (around 40-55 cm in height). The masonry at the base of Re Baldo Palace, is character-

ised by a scarp wall composed of rough stone, slightly squared grey and pink granite, light to dark metamorphic rock, and rhyolitic stone arranged in two to four sub-horizontal rows (around 70-80 cm in height).
A common feature of all 3 structures is the use of cornerstones, slightly squared and arranged in staggered rows, more or less horizontal, alternating wing and tip between the adjacent sides, so as to effectively sew the edges and obtain the best possible connection between intersecting walls and greatly strengthen the corners.
The use of wedges to fill in interstitial voids is very common, and it achieves a certain degree of regularity and geometry of arrangement in the sub-horizontal courses. The size of the rough-hewed stone elements varies depending on their position in the construction. In fact, accurate analysis of the masonry revealed the presence of taller elements in the lower sections of the structure and shorter elements in the higher sections, a device that gives greater solidity to the structure. Joins and bedding mortars are very abundant.
Masonry technique 3 was used only in the cistern at Pedres Castle. The technique makes use of rough stones of several lithotypes – grey and pink granite and light to dark ashlars of metamorphic rock – in various sizes and shapes, arranged in recurring horizontal levels (cantieri), usually occurring every two to three rows (around 20-50 cm in height). Many brick and stone wedges were used in order to fill in the interstitial voids and maintain horizontality. Joints and beddings are characterised by lavish mortar.
The bedding mortars of all 3 structures are white, quite compact, and very cohesive.
The observations of images of thin section under the optical microscope in transmitted light go the samples have put in evidence that the mortars are characterised by an air-hardening lime binder with a texture from micritic to micro sparitic.
It is possible to observe an aggregate of quartz and feldspar, often visible at a macroscopic level, and sometimes with the addition of crushed ceramic-like material that provides hydraulic qualities. There are visible instances of unburned lime inclusions and shrinkage cracks (fig. 14).
The X-ray diffraction analysis (XRD) has confirmed the mineralogical composition of the mortars.
The aggregate of the samples investigated are often very angular, angular or sub-angular. Thus, it can affirm that the mortar is been probably obtained by crushing of rock or minerals available on the same site of the fortification.
The samples PS01, PS02, and RO05 are characterised by a higher quality and by the presence of additives such clay brick fragments traditionally called cocciopesto, in order to improve the hydraulic qualities. This aspect underlines the greater care taken by the craftsmen for the construction of the specific structures of the fortified complex, such as the cisterns. The samples PS01 and PS02, indeed, belong to the cistern of the Pedres Castles, while RO05 concerns the masonry of the lower level of the palace.
Therefore, historic bricks have been often used as wedges, both for building vaults and for keeping the horizontal for the construction of the masonry structures.
Some samples (PS05, PS06, RO01, and RO06) concerning the bricks have been investigated macroscopically and by means an analysis in petrographic thin section under the optical microscope in transmitted light.
Macroscopically, they are cohesive and compact, distinguished by a coloration from light to dark red. In the samples R01 and RO06, the elements such as fillers and fluxes are easily visible.

In conclusion, the thin section under the optical microscope in transmitted light have allowed to observe the mineralogical composition of the bricks and to define relationship and affinities between they and the mortars marked by the addition of *cocciopesto* (fig.15).

Discussion and conclusion

The study begins from the awareness that the knowledge of historical, architectural, and cultural assets plays a fundamental role in their conservation. This purpose is fundamental in Sardinia which is a unique and vulnerable mosaic of natural and architectural assets. Its significant cultural heritage is the result of ages of complex human and nature interactions influenced by territorial, morphological, material, social, economic and cultural features and it represents a significant symbol of Sardinian identity. Furthermore, also due to few issues such as insufficient knowledge and inappropriate policies of enhancement, the historical and architectural assets are often subject to abandonment and exposed to alteration and decay phenomena. This is especially true for the medieval fortified heritage of Sardinia, composed of several structures that have lost their function and their perception in the landscape.

As mentioned above, in Sardinia, as well as in European context, medieval fortifications are often silent witnesses to our history. This long and articulate history is sometimes forgotten and destined for oblivion as the fortifications deteriorate into ruins. In order to avert this oblivion, it is necessary to create knowledge paths, which, through the study of architectural elements, masonry techniques, and materials, allow to recognise the value of these structures as witnesses. Such knowledge paths are fundamental to triggering a process of enhanced appreciation focused not only on a single structure, but also on the broader European system of fortifications from the same time period. So, expanding knowledge of architectural heritage, according to the cognitive protocol proposed here is an additional tool for the interpretation of architecture, which aids in understanding the intrinsic relationships that make up the material culture of a place through a comparison of various structures and their historical-cultural, and geographic contexts. This protocol contributes to the creation of a network between different realities, and relationships by evaluating the similarities and differences that highlight the technical, and constructional capacities specific to different social, and cultural spheres. This acknowledgment can be considered as phase of conservation of the cultural significance of a site, because of its aesthetic, historic, scientific, technological, landscape, and social value.

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Note

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In addition, the study is part of an ongoing research project, based on an interdisciplinary approach, and focused on the investigation of traditional masonry techniques of Sardinia (Giannattasio 2020).
[2] Analyses have been carried out at the LabMast and the DICAAR lab, with the support of the prof. Silvana Maria Grillo.

Della Fava Castle,
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