# PAST AND PRESENT OF THE EARTHEN ARCHITECTURES IN CHINA AND ITALY

Edited by
Loredana Luvidi, Fabio Fratini
Silvia Rescic, Jinfeng Zhang

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This series of volumes comprises research outputs that have been achieved due to the financial contribution of the National Research Council of Italy (CNR) and the the Chinese Academy of Cultural Heritage (CACH) within the context of a Bilateral Agreement of Scientific and Technological Cooperation between these two Institutions.

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Front-page image captions

1. TECLA (Technology and Clay) 3D printed house by WASP and Mario Cucinella Architects, Massa Lombarda, Ravenna, ITALY (2021)
2. Ruins of a vernacular building in Sant'Omero, Abruzzo, ITALY (by Dalila Fortunato and Anna Jaroszewski, 2020)
3. Ruins of Gaochang ancient city, Xinjiang Province, CHINA (by Fabio Fratini and Loredana Luvidi, 2016)
4. Keziergaha beacon tower (Han Dynasty) in Kuche city, Xinjiang province, CHINA (by Center of Conservation of Xinjiang Cultural Heritage, 2020)

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# FOREWORD

Gilberto Corbellini
*Director, Department of Social and Human Sciences, Cultural Heritage, National Research of Science of Italy - CNR*

In 2015 CNR and CACH initiated their collaboration, which introduced, next to the bilateral research project programs, also a book series on China and Italy. This volume is the fourth publication in this series.

The research carried out within this bilateral project and discussed in the contributions of this book deals with the conservation of earthen architecture, widespread in many regions of China and Italy, as well as in other countries of the world. These buildings represent a very perishable cultural heritage due to the low durability of earthen artefacts towards atmospheric agents. Therefore, their existence is in danger because it is difficult to consolidate the earth without causing further damage to the original material.

In China, earthen artefacts comprise wall structures, whole cities and monumental or historic buildings of great value. Their characteristics differ from one territory to another, in relation to the geographical context in which are located and the cultural environment. There is also a diffused vernacular architecture of lesser value that gives character to each territory making it different from any other, but at serious risk of disappearance. Urbanization and the aspiration of people to conditions of better comfort has meant that the countryside has become depopulated with the abandonment of houses that are disappearing without maintenance.

The collaborative work between CACH and CNR researchers aimed at identifying products and methods suitable for the conservation of the earthen material which characterize this architecture. The earthen architecture of Italy is different from the Chinese one and generally present in vernacular heritage. It is a little-known cultural asset but through its study it will be possible to enhance and preserve this architecture which testifies to the wealth of technological-cultural diversity of man's housing adaptations to changing environmental contexts.

The challenges faced by the CACH - CNR joint research project have been and are an important scientific growth ground for ISPC, the CNR Institute dedicated to the study of the conservation and enhancement of cultural heritage in a multi- and interdisciplinary perspective.

Scientific methods and new technologies are now used to improve the understanding of building technologies, conservation aspects and enhancement of this architectural heritage, whose knowledge for a long time was based only on historical and socio-anthropological studies.

Chai Xiaoming
*Director General, Chinese Academy of Cultural Heritage – CACH*

Based on the bilateral cooperation framework between CACH and CNR, five selected projects have been initiated and launched in 2016. To show and exchange the achievements of cooperation, both sides plan to jointly edit a series of academic publications. This book, I am glad to see it as the fourth collection of papers growing out of the bilateral cooperation, includes papers on both sides' achievements in researches of history, existing status, conservation and perspectives in earth architectures in China and Italy.

Earthen sites is one of earliest kind of human remains. They show not only our past, but also future. Through the bilateral cooperation, as shown by the papers in the book, refreshing and inspiring light have been shed on complex issues concerning conservation and valorization of earthen sites, the theme of which indeed deserves academic comparison from multi-cultural perspectives to comprehend the evolution of research, conservation and management under different social contexts.

As much as I am pleased to see the book, I look forward to continuing and deepening this kind of bilateral exchanges with more and more fruits growing out of it. Therefore, CACH would like to further our cooperation with CNR and provide all necessary support, to strengthen and advance conservation communication, and cultures behind.

# INTRODUCTION

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The National Research Council of Italy (CNR) and the Chinese Academy of Cultural Heritage (CACH) during the past three years (2016-2018) carried out a Joint Research Project on "Assessment of innovative methods for the conservation of earthen surface". The project was carried out by the Institute for the Conservation and Valorization of Cultural Heritage (ICVBC) of the CNR that since 1st October 2019 was suppressed to join the new Institute of Heritage Science (ISPC-CNR). The ISPC deals with the study of the conservation and enhancement of cultural heritage with a multidisciplinary approach, which take advantage of scientific methods and new technologies together with historical and social aspects.

The subject of this Joint Research Project was a real challenge and continues to be so. Actually if the decay of building stone materials exposed to the external environment still represents one of the main threats to monuments and architecture all over the world, a fragile architecture such as the earthen one, is in a situation of increased risk considering the climate change problem and the increased rainfall intensity.

Earthen architecture is a type of construction almost unknown to most of the inhabitants of the developed countries and when it is talked about it, is most often in a derogatory way (i.e. "poor mud houses"). Actually, the earthen constructions are spread in many countries and constitute a testimony of skills and habits of peasant civilizations. Earth is one of the oldest materials used in architecture. It was widely used in ancient Egypt and in the civilizations of Mesopotamia and it is mentioned in the Bible (Book of Exodus 5, 6-8). The constructions of Iran, Afghanistan, Yemen, Iraq, Morocco and Mali testify that earthen architecture has evolved and specialized until reaching a remarkable technical perfection (vaulted systems, domes, multi-storey buildings, decorated surfaces). About 30% of the world population lives in earthen buildings.

Earthen buildings are present also in Europe: Germany, United Kingdom, Spain, Portugal, Poland, Hungary, Romania, Baltic countries. In France 15% of the rural population lives in earthen buildings. In Italy, earthen architecture is present in Sicily,

Sardinia, Calabria, Basilicata, Abruzzo, Marche, Tuscany and Piedmont. Similarly, throughout the western part of China, along the Silk Road, earth is the most widespread building material, both in civil and monumental architecture and in fortifications. It is therefore a type of architecture that for good reason constitutes an important cultural heritage, both from a material and immaterial point of view due to the social implications relating to the construction of the buildings which often involves entire communities.

For some decades, however, we have witnessed the gradual abandonment of earthen buildings, because they are considered unhealthy and unsafe, incompatible with the modernity that people are looking for. In addition, there are three other aspects that hinder the use of earth: it is a material whose application requires specific knowledge and skills; it is a fragile architecture that requires scheduled maintenance which, if it fails, leads to decay; modern building standards are still very restrictive and do not favour the use of earth in architecture.

For all these reasons, preserving earthen architecture and ensuring its existence over time is a real challenge. Experiments are needed to identify the means by which to improve its resilience, so as to foster both the preservation of the existing earthen heritage and a more widespread use of earth in new constructions.

This book, in addition to contributing to the dissemination of knowledge of earth architecture in China and Italy, examines the conservation techniques used in the respective countries and the researches that are being carried out to improve these interventions in order to make them more durable and compatible with a material as delicate as earth. The new opportunities that the earth architecture can have in future in the two countries are also illustrated.

Ultimately, this book is an attempt to bridge the gap between the science applied to Cultural Heritage and the real meaning of the so-called "cultural asset".

Cultural heritage is the result of sensitivity, thought, expectations and skill of men and women stratified over the centuries who, with their identities and personalities, have built the reality in which we live today and with the help of science we want to contribute to its preservation.

# RAW EARTH ARCHITECTURE IN SARDINIA: SULCIS AS A CASE STUDY

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Keywords: Phoenician colonization, Raw Earth, Sardinia, Sulcis, Medau, Furriadroxiu

## INTRODUCTION

Raw earth buildings have been built and are still present throughout Italy (Achenza, Cocco 2015), but Sardinia, more than any other part of the country, has retained the characteristics of its pre-industrial agro-pastoral culture, preserving a large number of raw earth settlements that demonstrate the continuing historical use of this material for building (Angioni, Sanna 1988; Melis, Albero Santacreu 2017, with bibliography).

The following paper analyses the situation in Sulcis, an area located in the south-west of the island. An association, the "Museo diffuso dell'insediamento sparso" ("Territorial Museum of Scattered Settlements", hereafter "Territorial Museum"), founded in Santadi, has the aim of conserving and promoting settlements built using mixed techniques – i.e. using both stone and adobe – which are known as *furriadroxius* and *medaus* (Sanna, Cuboni 2008).

The earliest documented use of raw earth as a building material is found in the Pre-Pottery Neolithic B (9600-8000 BP) context of Jericho in the Near East (Aurenche 1981). In Sardinia adobe has been used by the local population since the Neolithic/Chalcolithic. For example, it has been identified by archaeologists in the village of Su Coddu/Canelles (Selargius, Cagliari) (3400-2850 BP), in southern Sardinia (Melis 2010; Melis, Albero Santacreu 2017). Adobe and rammed earth floors can also be found in Nuragic contexts from the Bronze and Iron Ages. Two cited cases are those of Su Cungiau 'e Funtà and Nuraghe Pidighi, both in the Oristano province, in the central-west of the island (Sebis 2007; Usai 2013). Other earthen architectures are from Santa Anastasia of Sardara, Monte Olladiri, Monte Zara of Monastir and San Sperate, in southern Sardinia (Ugas, Usai 1987).

Earthen architecture accompanied the Phoenicians as they spread towards the central-west Mediterranean and the Atlantic from the 9th century BC (Aubet 2001; Bondì et al. 2009). It has been found in all areas colonized by the Phoenicians. In North Africa most evidence comes from Carthage, while in Spain it is found in Mediterranean Andalusia, e.g. at Morro de Metzquitilla and La Rebanadilla (Jaquin et al. 2008; Sánchez Sánchez-Moreno et al. 2018, fig. 2). Furthermore, in Cadiz, on the Atlantic side, recent excavations have produced some very interesting results (Gener Basallote et al. 2014). In Sardinia, the technique of building adobe walls on a stone foundation has been found in all areas settled by the Phoenicians. In Sulcis, for example, this technique already existed in the earliest phases of Phoenician colonization.

Sulky, the first Phoenician settlement in Sulcis (Fig. 1), was founded on the island of Sant'Antioco in the first half of the 8th century BC, and the excavations in the settlement have led to the discovery of covered square rooms flanked by courtyards, arranged at right angles (Unali 2017).

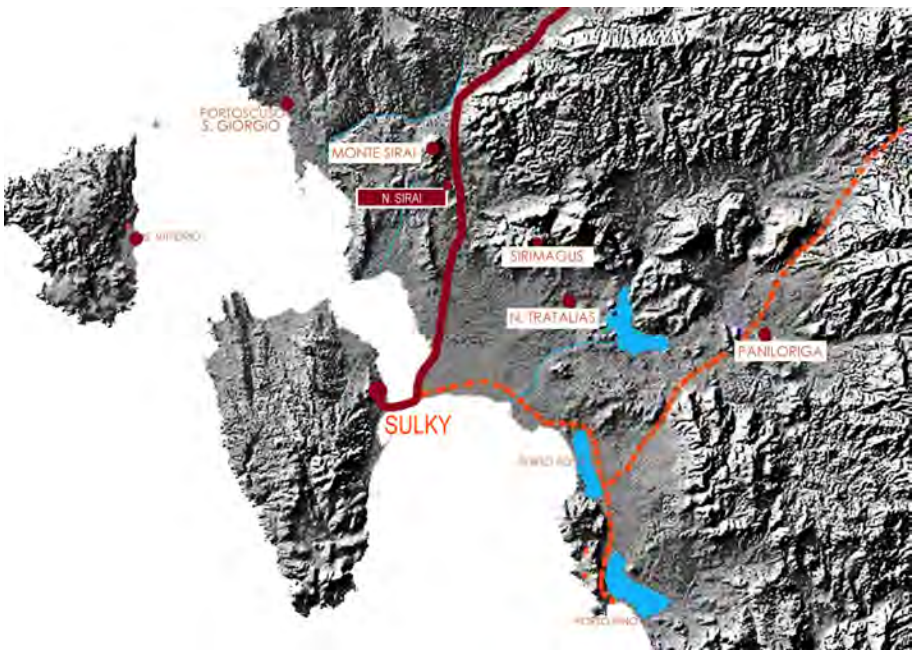


Fig. 1 Phoenician and Punic Sulcis (Perra 2013)

These rooms were built using medium and small-sized stones, bound with a mud binder and forming the base of an adobe wall, while the floors were made of rammed earth. As early as the second half of the 8th century BC, there was a movement of people from Sulky towards the hinterland, leading to the control of large parts of Sulcis being shared with the local population (Botto et al. 2014). The building

techniques that the Phoenicians used in Sulky have also been found in the newly established centres such as Monte Sirai (Guirguis 2013), the fortress at Nuraghe Sirai (Perra 2018) and Pani Loriga. Concerning the last site, the excavations carried out by the Institute for Studies on the Ancient Mediterranean (CNR – ISMA) from 2006 (Botto et al. 2010) have revealed a settlement founded by the Phoenicians at the end of the 7th century BC, which reached a considerable size at the beginning of the 5th century BC, following the military occupation of some parts of Sardinia by Carthaginians (Botto et al. 2016; Botto 2017).

Pani Loriga hill rises above the nearby settlement of Santadi, where the "Territorial Museum" operates. The long experience that the ISMA team has gained through its many years of excavation at Pani Loriga has been of fundamental importance in reconstructing the history of earthen building across the territory. This has led to a close collaboration between the archaeologists working at Pani Loriga and the members of the "Territorial Museum" association to promote common projects for the safeguarding and promotion of raw earth structures in Santadi and the surrounding areas.

## THE "TERRITORIAL MUSEUM" ASSOCIATION

The association aims to help the people living in Sulcis to rediscover their past identity and cultural heritage through the safeguarding and promotion of places and landscapes of historical interest. By making this heritage visible, the "Territorial Museum" has defined new spaces for art, learning, knowledge, residential use and improved quality of life. Furthermore, the visibility of cultural objects and their new "uses" can help make residents more aware of the advantages of safeguarding and promotion by involving them in such activities. The mission of the "Territorial Museum" is to make the local culture better known and more appealing to people and to disseminate new evidence and research through a variety of communication channels. The "Territorial Museum" encourages the development of thematic itineraries throughout the territory by involving existing museums. The final aim is to create a network of museums and culturally interesting places through the development of a region that has much to offer both culturally and economically.

As mentioned above, the "Territorial Museum" covers the whole of Sulcis, but in this first phase it operates around Santadi. As part of its activities, the "Territorial Museum" is working to halt the continuing degradation of historical scattered settlements. The model is that of "minimum-cost" interventions, which involve cleaning the buildings or objects and making them secure and visible. Promotion, on the other hand, is carried out through the restoration of the settlements to their original use.

One way in which the "Territorial Museum" is making the archaeological and cultural heritage of Sulcis better known is through a website (www.museodiffuso.org). Other organizations operating throughout the territory are the Autonomous Region of Sardinia (Regione Autonoma della Sardegna), research centres, universities and

the "Earthen Cities" (www.terracruda.org) national association, which focuses on earthen housing and to which the "Territorial Museum" makes explicit reference in its activities.

## THE SCATTERED SETTLEMENT

Sardinian scattered settlements are very ancient and can be found across the whole territory. They are generally of an agro-pastoral nature and used as dwellings for individuals or groups of people linked by family or community. These communities produced a multi-centred system of scattered settlements located near the main resources. This is a process that started during the later Middle Bronze Age (15th-14th centuries BC) and intensified during the following Recent and Final Bronze Ages (12th-10th centuries BC). The scattered settlement reached its zenith with the Nuragic culture and is identified with its greatest architectural expression, the *nuraghe*, which is found throughout the Sardinian landscape. Scattered settlements continued to exist after the *nuraghi* ceased to be built and were mostly abandoned. With the Early Iron Age (930-730 BC), the reorganization of the Nuragic communities is shown by the development of villages, temples and sanctuaries (Usai 2015). In this phase, the interactions between the local populations and the Phoenicians and the opening of the island to international trade led to the exploitation of the territory's resources and brought about a reorganization of the connections between the coastal areas – where the first urban centres developed – and the inland areas.

Scattered settlements have survived in the inland areas of Sardinia up to modern times, when we have the first indications of rural structures known as *furriadroxius* and *medaus* (Mistretta 1966; Sanna et al. 2008).

The *furriadroxius* and *medaus* are small, rural, agro-pastoral settlements, usually built in raw earth, which can accommodate a limited number of interrelated families. *Furriadroxius* and *medaus* are both well-defined and easily identifiable types of scattered settlement: the former are one-storey shelters or dwellings for arable farmers; the latter are two-storey houses for pastoral farmers. The *furriadroxius* were the typical type of house in Sulcis until the mid 1990s, but at the same time they look back to what must have been the organizational and social structures of the Nuragic people.

In Sulcis, the scattered settlement was partially abandoned in the first decades of the 19th century, with the start of the mining industry and the creation of utopian "mining cities", to which a good part of the local population moved (Peghin, Sanna 2009). It is interesting to note that, even as the economy changed from agriculture to industry, the new living spaces, particularly the smaller mines of Rosas (Narcao) and Orbai (Villamassargia), continued to use traditional construction methods, and raw earth allowed for the creation of a new type of settlement system: the mining *furriadroxius*. These buildings are different because, although they were built in raw earth, they were constructed near the mines, rather than near the *nuraghi* or in the

agro-pastoral areas. The mining *furriadroxius* demonstrates that such settlement patterns and traditional techniques continued to be employed independently of the type of economy (farming, mining) to which they were linked.

Nowadays the *furriadroxius* and *medaus* have mostly been abandoned, although several settlements are still in use. Intervention has now become urgent, because earthen buildings rapidly disintegrate if not constantly maintained.

The Sardinian Regional Landscape Plan (Regional Law No. 8 of 25 November 2004) considers the "scattered settlement" system to be an aspect of territorial development. In particular, the *medaus* and *furriadroxius*, which are concentrated in the Sulcis area, represent a historical/cultural resource to be safeguarded and promoted.

## RAW EARTH

Raw earth as a historical building material (Sanna, Atzeni 2007) – together with its processing, use and end products – is currently being studied as a means to promote the economic development of the territory through its cultural heritage. The use of raw earth can be studied not only for the recovery and restoration of historic buildings (as envisaged in current planning) but also for the construction of new buildings, which would have the advantage of being eco-friendly and improving quality of life (Minke 2000; Mileto et al. 2012; Gauzin – Müller 2017). In the district of Sulcis, such activities join others that have already been planned or are being planned for the development of new methodologies and bio-building products, which use natural substances such as algae, straw, flax, cork and sheep's wool as inert materials that improve the mixture's performance (Sanna 1993; Cuboni, Sanna 2013).

Thanks to private funding, the "Territorial Museum" has started to rebuild and renovate in raw earth, creating renewed interest both in this material and in the scattered settlements themselves. Further interest is created by the fact that *nuraghi*, *furriadroxius* and *medaus* are usually found in upland areas of outstanding natural beauty, where they might be used as either permanent or touristic dwellings.

So far, the restoration of earthen buildings has been carried out by the "Territorial Museum" by reusing local materials. In Sulcis, the alluvial deposits of gravel, sand, silt and clay, or loose earth can be found in all the valleys of the area. These materials have been used to produce mud bricks (adobe). All the settlements discussed – both urban and scattered – are ancient, and in all of them walls made of stone and of raw earth coexist. The size of the mud bricks (known in Sardinia as *ladiri*) and the building techniques associated with them were progressively standardized, demonstrating that such methods were the result of island-wide cultural sharings, especially in the intensively cultivated central-south plains. Thus, the standardization of the mud brick might be linked to the relationships between Sulcis and its bordering communities. *Ladiri* are made by combining earth with vegetal fibres, sometimes with the addition of lime, in varying proportions, depending on the type of earth used. The resulting

mixture is cast in a wooden formwork to create a rectangular block with a ratio of 1:2:4 (usually 10 x 20 x 40 cm). The mixture is then sun-dried. The materials used to make the *ladiri* are all sourced locally. Clay is often used to plaster the walls, which need to be protected from the rain to prevent them from disintegrating (Houben, Guillaud 1994; Achenza 2003; Achenza, Sanna 2009).

## THE RAW EARTH WORKSHOP

The "Territorial Museum" intends to set up a raw earth workshop that can meet the Museum's own production needs. The workshop is envisaged as a production and visitor site, an active part of the "Territorial Museum", with the capacity to stimulate interest and increase demand for raw earth products, supplying materials not only for its own projects, but also for ongoing recovery and restoration works throughout Sulcis. The aim is to encourage the growth of a new architecture in raw earth, not least because of the material's high thermal insulation properties and the energy savings that can be achieved by using it. The raw earth future workshop will therefore be a place where research will focus both on past history and on construction methods of the future. Indeed, the intention is that within the workshop new products for bio-architecture will be developed, as well as new forms of earth brick.

## RAW EARTH RESTORATIONS

One of the activities of the "Territorial Museum" has been to restore four raw earth buildings (two *furriadroxius* and two *medaus*) in Santadi and Nuxis. These buildings will be used for museum activities and, together with other historical *furriadroxius* and *medaus* found in the territory that have been identified as places of interest by the "Territorial Museum" (www.Sulcis.eu), will be a showcase for Sardinia's forgotten heritage (Fig. 2).

**Sa domu 'e Paxi**

The "Sa Domu 'e Pasc" (House of Peace), the headquarters of the "Territorial Museum", stands opposite the Archaeological Museum in Santadi and was built using mixed techniques: the foundations in stone and earth, and the walls in *ladiri*. With the aim of enhancing the structure, the house, which dates back to the end of the 19th century, has been restored to its original residential function. Most of the restoration work has been carried out using traditional techniques and materials, respecting centuries-old construction methods. The raw earth walls have been restored by consolidating the pre-existing ones. The "Territorial Museum" has kept all the photographic documentation of the various phases of the work and restoration (Figg. 3, 4, 5).

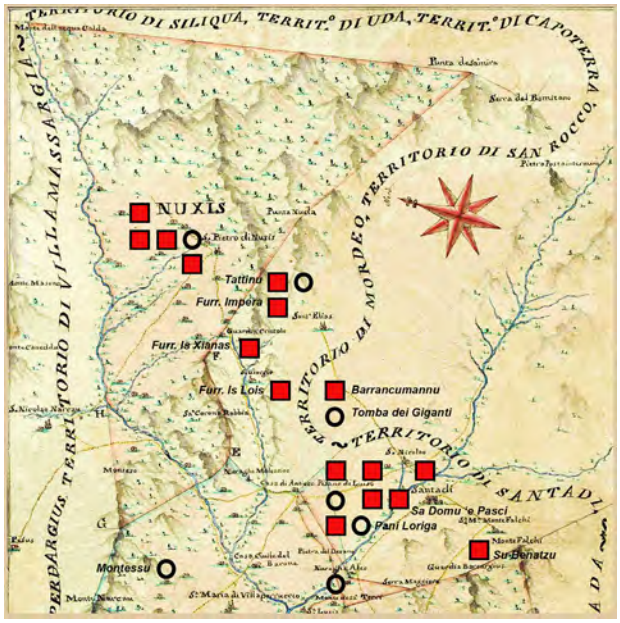


Fig. 2 Map of the places of interest of the "Territorial Museum" (including the completed restorations); those in and around Santadi are marked in red (adapted from Maina's map, unpublished)

Fig. 3 Sa Domu 'e Pasci, Santadi (SU), exterior of building before restoration (Photo Paolo Pasci)

Fig. 4 Sa Domu 'e Pasci, Santadi (SU), internal courtyard before restoration (Photo Paolo Pasci)

Fig. 5 Sa Domu 'e Pasci, Santadi (SU), exterior of building after restoration (Photo Paolo Pasci)

**Medau Palatini**

The *medau Palatini* is located at Is Lois at Santadi. Built mostly of raw earth, and having been abandoned for years, the *medau* was literally being washed away by the rain. As the damage progressed, so did its degradation. The rainwater had opened a breach of over 50 cm in the raw earth wall, near the corner of the building on the first floor, causing the partial collapse of the roof and putting the whole building at risk of collapse (Fig. 6). The walls in *ladiri*, having been appropriately shored up, have now been cleaned and repaired using local earth. Iron rods were added to ensure stability, as documented in other similar restorations (Fig. 7).

Fig. 6 Medau Palatini, Is Lois, Santadi (SU), detail of exterior of building before restoration (Photo Marco Bianchi)

Fig. 7 Medau Palatini, Is Lois, Santadi (SU), exterior of building after restoration (Photo Marco Bianchi)

**Raw earth ovens**

Part of the "Territorial Museum's" promotion of Sulcis's cultural heritage has been both to conserve the scattered settlements' characteristic raw earth ovens and to maintain a centuries-old tradition, still widely used in Sulcis. Wood-fire baked bread is one of the territory's typical products. *Cocoi* and *civraxiu*, two traditional types of bread from Sulcis, communicate a tradition that is deeply rooted and renewed every day. Indeed, bread and oil are two products that lie at the heart of annual popular festivals. During these events, the Santadi Ethnographic Museum, which is also built in the *furriadroxius* tradition of earth and stone, lights its oven.

Raw earth ovens are particularly important to the "Territorial Museum" as they are places where people come together. With the restoration of the Is Xianas and Tattinu de basciu ovens (Fig. 8), and those of the Sa Domu 'e Paxi and Is Lois (Fig. 9), the "Territorial Museum" has been able to demonstrate how quickly and easily ovens can be made from earth and straw. Renovating a raw earth oven may be a small act, but it is one that is very important in safeguarding the local cultural heritage. While from an economic point of view the cost of renovating an oven is minimal compared to that of restoring a whole settlement, in cultural terms it has great symbolic significance.

Fig. 8 Medau Tattinu de basciu, Nuxis (SU), raw earth oven during restoration (Photo Marco Bianchi)

Fig. 9 Medau Palatini, Is Lois, Santadi (SU), adobe oven (Photo Marco Bianchi)

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# PAST AND PRESENT OF THE EARTHEN ARCHITECTURES IN CHINA AND ITALY

The Bilateral project "Assessment of innovative methods for the conservation of earthen surface" was financed by the National Research Council of Italy (CNR) and the Chinese Academy of Cultural Heritage (CACH) for the period 2016-2018. The research undertaken by the two teams aimed to promote a better knowledge of the earthen architecture in China and Italy, exchange and sharing of experiences about methods, tools, protocols and best practices for the conservation of earthen materials. This fragile architecture, due to the poor durability of earthen materials against atmospheric agents, is in a situation of great risk considering also the problem of climate change

This book examines the historical use of this material for architecture, the different types of earthen construction in Italy and in China, the conservation techniques used in the respective countries and the researches that are being carried out to improve these interventions. New opportunities that the earthen architecture can have in future in the two countries are illustrated.

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