

International Journal of  
**A** Heritage  
Architecture  
STUDIES, REPAIRS AND MAINTENANCE



## Objectives

The **International Journal of Heritage Architecture** addresses a wide range of topics related to studies, repairs and maintenance of the built cultural heritage.

Technical issues on the structural integrity of different types of buildings, such as those constructed with materials as varied as iron and steel, concrete, masonry, wood or earth are discussed. Restoration processes require the appropriate characterisation of those materials, the modes of construction and the structural behaviour of the building. Of particular importance are studies related to their dynamic and earthquake behaviour aiming to provide an assessment of the seismic vulnerability of heritage buildings.

The Journal contributions aim to provide the knowledge to facilitate regulating policies. They also address topics related to historical aspects and the reuse of heritage sites.

Of particular interest is the study of Heritage Architecture in Asia, Islamic countries, Native American cultures and vernacular civilizations in Africa and Oceania. An important aim of the Journal is to investigate cross-cultural influences.

The Journal brings together contributions from scientists, architects, engineers, restoration experts, social scientists, planners, and economists dealing with different aspects of heritage buildings.



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Editor-in-Chief

**PATRICK DE WILDE**

Vrije Universiteit Brussel, Belgium

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## OBITUARY

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### Professor Carlos A. Brebbia



With profound sadness we announce that Professor Carlos A. Brebbia passed away peacefully on Saturday 3rd March 2018.

Carlos was born in Rosario, Argentina, where he completed his first engineering degree, after being educated at Military Colleges in Santa Fe and Buenos Aires. He spent two years after graduation as part of a small team setting up an Institute of Applied Mechanics. Following this he registered at the University of Southampton in England for a higher degree, arranging to carry out his research partly at MIT. This experience set up the basis for his long and close association with the USA.

After obtaining his PhD at Southampton University he worked for the Central Electricity Research Laboratories in the UK, a leading research establishment at the time. He left the Laboratories to take up an academic position at the University of Southampton where he rose from Lecturer to Senior Lecturer and Reader. During his time at Southampton he took leave to become Visiting Professor at many other Universities, including an academic year at Princeton. After having been appointed Full Professor of Engineering at the University of California, Irvine, he decided to resign his position and return to the UK to set up the Wessex Institute, of which he was the Founder and Director.

Carlos is renowned throughout the world as the originator of the Boundary Element Method, a technique that generates important research work at the Wessex Institute. He has written many scientific papers, been author of 14 books, co-author of numerous volumes and editor or co-editor of over 500. He also published two non-scientific books, "The New Forest. A Personal View" and "Patagonia, a forgotten Land". A book on the Paraguayan War in the 19th Century was a work in progress at the time of his death.

He founded several successful international Journals including the International Journals of Safety and Security Engineering, Design & Nature and Ecodynamics, Sustainable Development and Planning, Computational Methods and Experimental Measurements, Energy Production and Management, Heritage Architecture, Transport Development and Integration, and the new International Journal of Environmental Impacts.

He established two International prizes, the highly regarded Prigogine Medal for Ecological Systems Research, co-sponsored by the University of Siena; and the George Green Medal, supported by Elsevier and co-sponsored by the University of Mississippi.

Carlos ran a successful WIT programme of international scientific conferences in different locations throughout the world. He helped the Institute to develop academic links with first class institutions around the world, which has resulted in many more research programmes and collaborative projects.

Carlos held many special honours, including the Medaille de la Ville de Paris, Echelon Argent; Medaille of the Masonnet Foundation, University of Liege, Belgium; Fellow of the Institution of Mechanical Engineers in the UK; Fellow, and Founding President of the American Society of Civil Engineers UK Chapter; Honorary PhD at the University of Bucharest; Fellow of the Royal Society of Arts; and Member of the European Academy of Sciences and Arts.

In parallel with his academic career, Carlos was a highly successful entrepreneur and founded the Computational Mechanics International Ltd group of companies in 1976. This group's activities have grown to include software development, engineering consultancy, property investment and publishing. The group works closely with WIT and is responsible for the publishing programme of the Institute which includes, in addition to the conference proceedings, a series of monographs and edited books by some of the foremost scientists in the world.

Whilst we grieve the enormous loss of our Founder and Chairman, whose hard work, determination and achievements during his career are truly inspirational, we know that his earnest desire was for all that he has worked tirelessly to build over many years, to continue to flourish. To this we are firmly committed and so we welcome the continued and future collaboration of our friends and colleagues around the world.

Carlos is survived by his wife, Carolyn, his son Alexander and daughter Isabel, and six grandchildren.

# GENESIS AND DEVELOPMENT OF THE COASTAL DEFENCE SYSTEM OF THE IONIAN BASIN IN THE MEDITERRANEAN SEA

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## ABSTRACT

To understand the history of the coastal defence system of the Ionian basin of the Mediterranean sea, as it was arranged in the territory and its architectural characteristics, it is necessary to analyse the phenomenon of fortifications widespread among Basilicata Calabria and Sicily (Southern part of Italy). The historical events and the continuous pirate raids, from the 6th century onwards, have made it mandatory to upgrade defence, making it efficient with new weapons and new coastal construction, in a suitable position of the sighting tasks, reporting and defence. Following the census operated by the historian Santoro, in particular the coastal defence, is grouped and categorized into two major categories: the first one consists of reading defences, the Towers, intended for primary protection but at the same time limited and temporary; the second one, identified by more significant characters, Fort and Redoubt, to face the enemy. The first category, stands out on the coast (Tyrrhenian sea) of northern part of Calabria, as well as on the coast of Basilicata, has quadrangular structures, with typical battlements and gun holes; while, on the Ionian side, they had a circular watchtowers based truncated cone-shaped. The most important defensive structures on the Ionian basin of the Mediterranean Sea is the Strait of Messina, which has always played in its history an important cultural and commercial role. To address this situation, between 1884 and 1914, a tactical 'secret' system was developed, the 'FortinoUmbertino', with its particular defensive system that included a long defensive trench line of about 40 km. The studies, therefore, have highlighted places of another urbanity and another memory that still summarize by small 'military library', a topic rich and very articulate of over 900 years of history fortified, where men and professionals of the time give us a contribution of the highest historical level on defence systems.  
*Keywords: coastal towers, military architecture, defence systems.*

## 1 INTRODUCTION

Knowledge is certainly the first prerequisite to architectural preservation, restoration and reuse, even more if looking at the knowledge problems of a fortified architecture, because it opens the door to further scientific and operational specialization [1].

There is no doubt that entering into the merits of architectural safeguarding general problem involves having an accurate information, in general and in particular; the cultural character of a technician will be more effective as much as the professional will have a capacity to have an increasing level of cultural and scientific information capacity [1].

Information and knowledge are a fundamental contribution to reach a development operation. This is the project design ideology. The aim is to explain the various facets present in the analysed district, giving a minimal bibliographic contribution [1].

## 2 METHODOLOGY

The preservation of these historical, artistic, archaeological and architectural testimonies cannot ignore the knowledge of their actual foundation and their analytical and scientific study [2]. The contextualization of the Ionian and Tyrrhenian coast happens through an investigative tool: the cataloguing. In the whole process, this tool performs a territorial reconnaissance activity, aimed not only at identifying and describing the individual asset, but also at

recognizing the relationships between them, in relation to the historical-cultural context and to the micro-systems present, which are created to defend the stretches of coastline attackable on different parts.

A data sheet has been prepared, based on the methodology defined by the ICCD – Central Institute for Cataloguing and Documentation, with the following organic forms [3]:

1. Identified data [4]: the data allow the recognition of the object [5].
2. Descriptive data: the data are deducible from the direct observation of the object, they also provide indications about the territorial-environmental context [6].
3. Analytical data: examining all the components, the data allow a greater degree of detail on the asset [7].
4. Historical data [8]: the data are connected to the cultural framework of the cataloged asset, to its historical and constructive events [9] and to the transformations in time and it allows us to value the metric and geometric characteristics of the cataloged asset.
5. Iconographic element [10]: it provides an immediate and objective representation of the asset, making 'a representation or faithful description' of the asset [11].

The aim of the survey comparative analysis is to explain systematically, following scientific observation and measurement criteria, the variations of the architectural-defensive phenomena, found in different historical units.

### 3 DEFENSIVE SYSTEM

There is a close relationship between the fortification historical knowledge and the morphology of the territory [2]. This combination is the most important character of those architectures, such to constitute a discernible character than the other [2]. In fact, defence architectures, often, have constituted established systems on the territory based on temporal, spatial and relational needs, taking a fundamental importance in the study of the single fortified building, not only for these needs, but because their subsistence conditioned the permanence [2]. The territory knowledge, essential for urban planning and to face conservation and architectural restoration problems of any architectural asset, cannot do without the identification of the system and the fortification network in a certain place [1]. The research theme concerns the existing fortification analysis on the territories adjoining with the Ionian Sea and the Tyrrhenian Sea.

#### 3.1 Basilicata

Fortified architecture is one of the most outstanding Lucanian architectural expressions (Fig. 1). The regional settlement structure in the high middle age is characterized by the retreat of the inhabitants from the coastline, originated by the insecurity of the territory after the cleavage of the Empire [11]. The inhabited nucleuses, surrounded by precarious masonry structures, are grouped around fortified structures, conceived as extreme defence. During the Lombard period, the territory changes, and it is characterized by the presence of numerous Castra of which, to date, significant traces remain only in documents located in Tricarico, Acerenza, Matera, Montescaglioso, Melfi and Venosa [11].

The Norman Conquest and the subsequent establishment of the Southern Kingdom determine a radical change in social relations and in landscape, political and military order.





Figure 1: Location of Lucan fortifications (Santoro, 2015).

The territory is divided into fiefdoms granted to the various militia of the Norman army led by the Altavilla [6], the main conquerors of Basilicata with political and administrative centre in Melfi. Strongholds and remains of Norman fortifications, although amplified and transformed in the Angevin and Aragonese age, are traced in many countries of Basilicata, for example Montescaglioso and Pisticci [12].

With the sunset of the Norman monarchy [12], there is the conquest of the Swabian Kingdom and Emperor Federico II realizes an ambitious program of fortification of the most exposed borders of the Kingdom: the north, the Adriatic coast and Sicily.

After the death of the Emperor, the Angevin monarchy was established. The dynastic change makes a grand fortification program of the southern coast, more and more insecure due to the Turkish and Muslim raids [11]. Series of towers are built along the coastal lines, regularly interspersed at an average distance of about 10 km, from Naples to the Strait of Messina and then along the entire Ionian and Adriatic coast [11]. In Basilicata, the Aragonese coastal towers system was intact [11].

With the establishment of the Spanish viceroy, castles and strongholds suffer radical changes transforming themselves into comfortable urban residences suitable for defence but also such as residence for the Baron, occupied in the administration of the feud.

In the last decades of the 18th-century Barons, Countes and Marquis reside, more and more permanently, in the Capital, giving the local administration of castles and palaces to procurators and to greedy and rapacious agents [13].

### 3.2 Calabria

A great part of the history of the city, the oldest in the region, is written in the 400 fortified structures [14], which belong to the Calabrian defensive system (Fig. 2): the Towers and Castles, that evoke the pitfalls of the most ferocious pirates, but also the different dominations suffered by the region of Calabria and a feudality that has never disappeared in a region that offers and hides different ways of life, with the inhabitants faces sometimes such as Saracens or Grecians or Arbëreshë or Waldensians, but united by that religiosity sometimes Byzantine, typical of the Calabrian citizens [15].

A very important moment is the landing of the Greeks on the Calabrian coasts, which create a fortified circuit ‘Geländemauern’, a perimeter wall that encloses a larger area, around the urban settlement that controlled all the favourable positions, for defence. Examples are Crotone, Locri, Caulonia and Reggio Calabria [16].

During the Iron Age, Bruzi formed a new league that had its centre in Consentia, actually ‘Cosenza’ and, in less than a century, the Brettii settled in numerous small villages a few kilometres away from each other, interspersed with strongholds, called oppidum, in which the highest social classes met. After the Western Roman Empire cleavage, Mar Nostrum’ waters

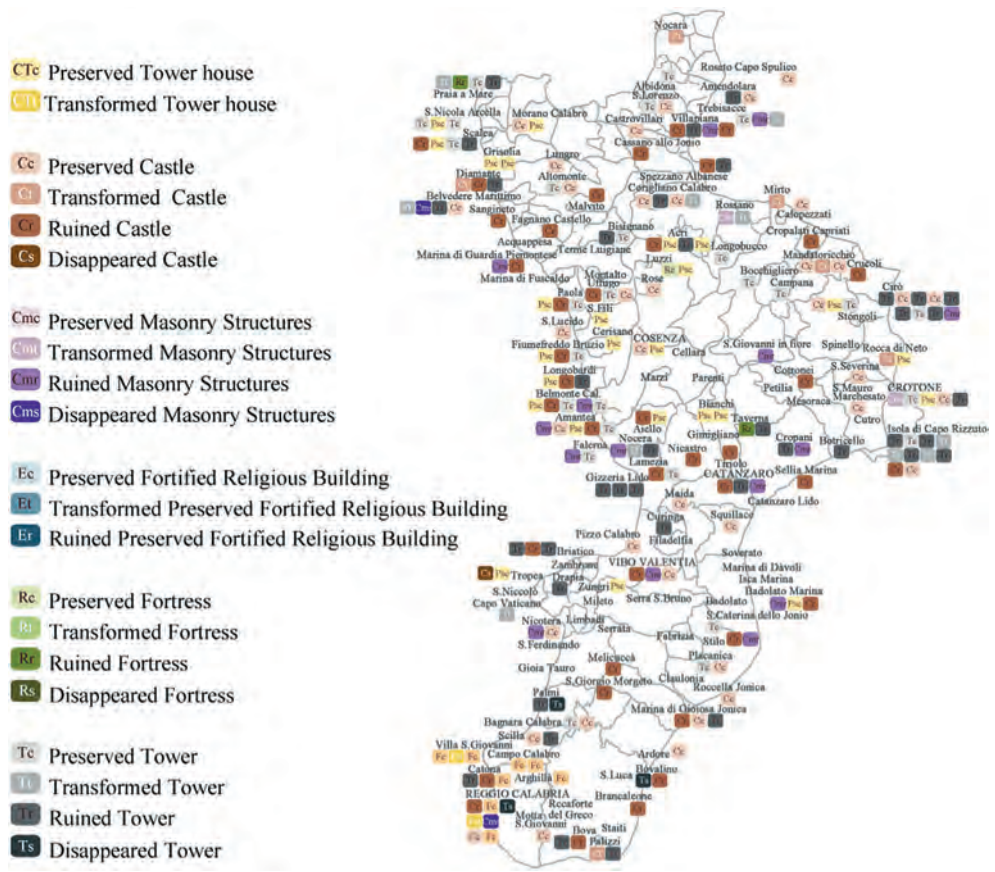


Figure 2: Location of the Calabrian fortifications.

are no longer guarded and piracy starts again. As well as the Lucanian lands, also for Calabria the mountains welcome several hill and mountain fortifications.

Between the end of the 8th century and the beginning of the ninth Bruzi's lands became the theatre of many Muslim–Christian battles [14].

Until unity is achieved, which happens with the definitive Norman's triumph, there are many autonomous forces, with maritime cities, ducats, dynasties, single governors, monks and abbots, leaders and various energies, which are oriented to perpetuate over the years the echo of their war deeds: Capuani, Benevento, Gaetani and Amalfi, Byzantines and Saracens will make these lands in a zone of conquest. With the advent of the Men from the North, the Latin typological presence is defined: *urbes, castra, castellia, casalia* and *motte* [16].

In the Calabrian fortification history [14], a decisive passage is the advent of the Swabian domination. The emperor empowers the system with the pre-existing fortresses renovation and with the construction of new castles, with rectangular or quadrangular planes adapted to the shape of the land and bordered by four corner towers joined together by curtain walls [15].

The Angevins start the construction of further fortified buildings. The new castles are enriched with circular towers capable of implementing a flanking defence in addition to the frontal defence. In this century, there is an extensive construction of defence systems, which consisted in throwing heavy stones that produced devastating effects on the Turkish settlements [15].

#### 4 COASTAL DEFENSIVE SYSTEM

In the 17th century, the coastal defensive system became the new precautionary and improving defence principle, adapting to the new resistance requirements needs, dictated by new weapons [9]. The military atlas made is based on cards created by a long archival and historical analysis, which took place in the Superintendencies of Potenza, Matera, Cosenza and Reggio Calabria (Figs. 3 and 4) and it registers, describes and classifies coastal fortifications in the analysed area. From the survey, it is possible to notice the coastal defensive system methodological progress [7], which occurred over time with a radical typological differentiation of the towers present in the territory (Fig. 5).

On the northern Tyrrhenian coast of Calabria, such as on the coast of Basilicata, there are coastal buildings with a better defensive system, quadrangular, with typical merlons and embrasures; while, on the Ionian side, there are, almost exclusively, lookout circular towers with a truncated conical base. This consideration is inspired by two main factors:

1. The most important economic centres positioned are on the Tyrrhenian side; in fact, important examples are 'squares' such as Tropea, Amantea, and Scalea. Further confirmation of the Tyrrhenian hegemony are also the Tyrrhenian routes which were, however, more favourite than the Ionian ones by commercial vessels. It is clear analysing the ancient nautical charts, full of toponyms on the Calabrian Tyrrhenian coast differently from the Ionian coast.
2. The morphology of the territory. Generally, the square towers rested on parallelepiped block as base, with the function of distributing better the weight. The circular type, needed more substantial soil, more or less rocky, to guarantee its static characteristics.

With the advent of reticulated retrocarial artillery [8], there is a drastic revision of all fortified structures: from the light elements to the heavy ones, the Forts.

**ARCHIVE SHEET: Torre Bollita n. 01**

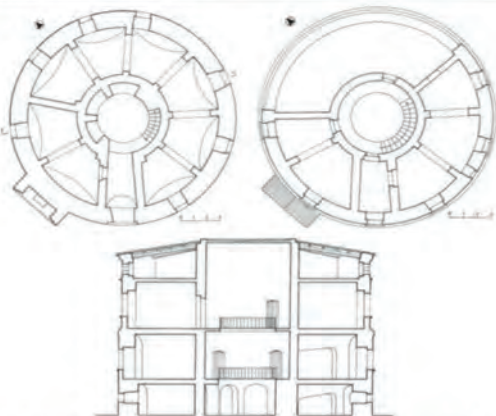

<b>LOCATION</b>	<b>DOCUMENTATION FOR ARCHIVE</b>																						
<b>Region</b> Basilicata																							
<b>Coast</b> Jonico																							
<b>City</b> Novasiri (MT)																							
<b>HISTORY</b>																							
<b>Year Built</b> Prior to XVI century																							
<b>Year Out of Use</b> XIX century																							
<b>CULTURAL DEFINITION</b>																							
<b>Author</b> Vicerè di Napoli De Toledo																							
<b>Typology</b> Tower - Prison																							
<b>Protected site</b> Yes																							
<p><b>Interventions reference</b></p> <p>It was built in order to protect against the invasions by turkish pirates. It was a "cavallara" tower as it was hosting the royal guards on horses; when turkish ships were spotted, these guards used to run to the settlers in order to let them move to a safe location in the forest or in towere itself.</p>																							
	<p>Plant view first and second floor; Longitudinal Section [Bubbico L, Caputo F, Tataranno A_ Il sistema difensivo in Basilicata, le torri costiere].</p>																						
<b>PHOTOGRAPHICAL DOCUMENTATION</b>	<b>STRUCTURAL DEFINITION: Components</b>																						
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>System</b></td> <td><b>Structural System</b></td> <td>Original artefact: Load-bearing masonry construction that rises on two levels, with a patio Shape: Circular Intervention: Construction of 3rd and 4th floor.</td> </tr> <tr> <td><b>Military System</b></td> <td>Openings: oval ports. Defense system: ground floor without openings Sistema di difesa: entrance at the opposite direction of the downhill. Defense system: entrance located on the second floor</td> </tr> <tr> <td rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Vert. Structure</b></td> <td></td> <td>Building shell: River pebbles.</td> </tr> <tr> <td style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Horiz. Structure</b></td> <td>Roof covering: pitched, mantle with coppi. Frames: wooden on the top floor</td> </tr> <tr> <td rowspan="2" style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Coll. Vert.</b></td> <td></td> <td>Internal stairs: archways and vaulting. Exetnal stairs: wooden, removable</td> </tr> <tr> <td rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);"><b>Preservation</b></td> <td><b>Historical Refurbishm</b></td> <td>Yes</td> </tr> <tr> <td><b>Current Refurbishmer</b></td> <td>No</td> </tr> <tr> <td><b>Preservation</b></td> <td>Medium</td> </tr> <tr> <td><b>Status</b></td> <td>Compatible use</td> </tr> </table>	<b>System</b>	<b>Structural System</b>	Original artefact: Load-bearing masonry construction that rises on two levels, with a patio Shape: Circular Intervention: Construction of 3rd and 4th floor.	<b>Military System</b>	Openings: oval ports. Defense system: ground floor without openings Sistema di difesa: entrance at the opposite direction of the downhill. Defense system: entrance located on the second floor	<b>Vert. Structure</b>		Building shell: River pebbles.	<b>Horiz. Structure</b>	Roof covering: pitched, mantle with coppi. Frames: wooden on the top floor	<b>Coll. Vert.</b>		Internal stairs: archways and vaulting. Exetnal stairs: wooden, removable	<b>Preservation</b>	<b>Historical Refurbishm</b>	Yes	<b>Current Refurbishmer</b>	No	<b>Preservation</b>	Medium	<b>Status</b>	Compatible use
	<b>System</b>		<b>Structural System</b>	Original artefact: Load-bearing masonry construction that rises on two levels, with a patio Shape: Circular Intervention: Construction of 3rd and 4th floor.																			
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<b>Current Refurbishmer</b>		No																					
<b>Preservation</b>		Medium																					
<b>Status</b>		Compatible use																					
<p>1_ Prospectus, sea view [Photographic record of 2_ Prospectus North [Photographic record of 3_ Prospectus South [http://www.mondimedievali.net]. 4_ Prospectus North [http://www.mondimedievali.net].</p>																							
<b>SOURCES AND DOCUMENTATIONS</b>																							
<p>Bubbico L, Caputo F, Tataranno A_ Il sistema difensivo in Basilicata, le torri costiere; Archivio Fotografico della Soprintendenza Beni Ambientali e Architettonici_Potenza; Faglia V_ Tipologia delle torri costiere nel regno di Napoli.</p>																							
<p>UNIBAS_Ing.Edile Architettura_ Studentessa Falco Marinella, 28176</p>																							

Figure 3: Type sheet – cataloguing of the light coastal defence system.

**ARCHIVE SHEET: Batteria da Costa Poggio Pignatelli n. 03**

<b>LOCATION</b>		<b>DOCUMENTATION FOR ARCHIVE</b>																																						
Region	Calabria																																							
Coast	Tirreno																																							
City	Campo Calabro (RC)																																							
<b>HISTORY</b>																																								
Year Built	1888 - 89																																							
Year out of use	Not specified																																							
<b>CULTURAL DEFINITION</b>																																								
Author	Staff of the Armed Forces																																							
Type	Umbertian Forts																																							
Protected site	Si																																							
Interventions reference	Layout and system typology are the same as Batterie di Matiniti Inferiore; the only differences can be found in the longitudinal size which appears smaller.																																							
<p>Plant view and cross section as-designed [ La fortificazione permanente dello Stretto di Messina. Storia, conservazione e restauro di un patrimonio architettonico e ambientale].</p>																																								
<b>PHOTOGRAPHICAL DOCUMENTATION</b>		<b>STRUCTURAL DEFINITION: Components</b>																																						
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Figure 4: Type sheet – cataloguing of the heavy coastal defensive system.



Figure 5: TOWERING – historical analysis.

This is because the wars were won when the attacker was in possession of technologically innovative weapons for which the defender had not provided appropriate countermeasures. In fact, in order to oppose this new condition, the fortified structures are strengthened by the insertion of ditches, embankments and escarpment walls but, even more, there is the tendency to lower the buildings that try to be less and less visible to the enemies [17]. So there is the formation of entrenched fields.

Of all entrenched fields projects, including those made in the territories of Mestre [18], Verona and Terni, the UmbertiniPeloritani and Aspromontani Forts remain one of the most impressive works built, for the number of forts and territorial extension [17].

The design of this system, obtained from the planimetric distribution of the forts, gives back a more logical and complete general form on the Peloritano side, where the 14 structures are arranged on three directions, clearly distinguished according to the altitude, which gravitate around the Antennamare fort and follow the coastline trend [17].

On the other hand, there is the aspromontan system design, which, although responding to the same logic, is less complete. Probably it, rather than being the opposite equivalent of the Pelorite system, was complementary, covering with its nine forts the points left most exposed by the first (Fig. 6).

Moreover, evolution progresses and strategies change constantly, especially in the military field.

If the point of view from the fort checked the ships of the Strait, a higher point of view would have controlled the forts that guarded the ships. And so it was. The invention of the plane, like that of gunpowder, was destined to overturn the idea of war and, suddenly, the Umbertian forts were exceeded without even being put to the test of the facts. And, like a chess game, the king was shot down and the forts declined, at least only strategically [17].

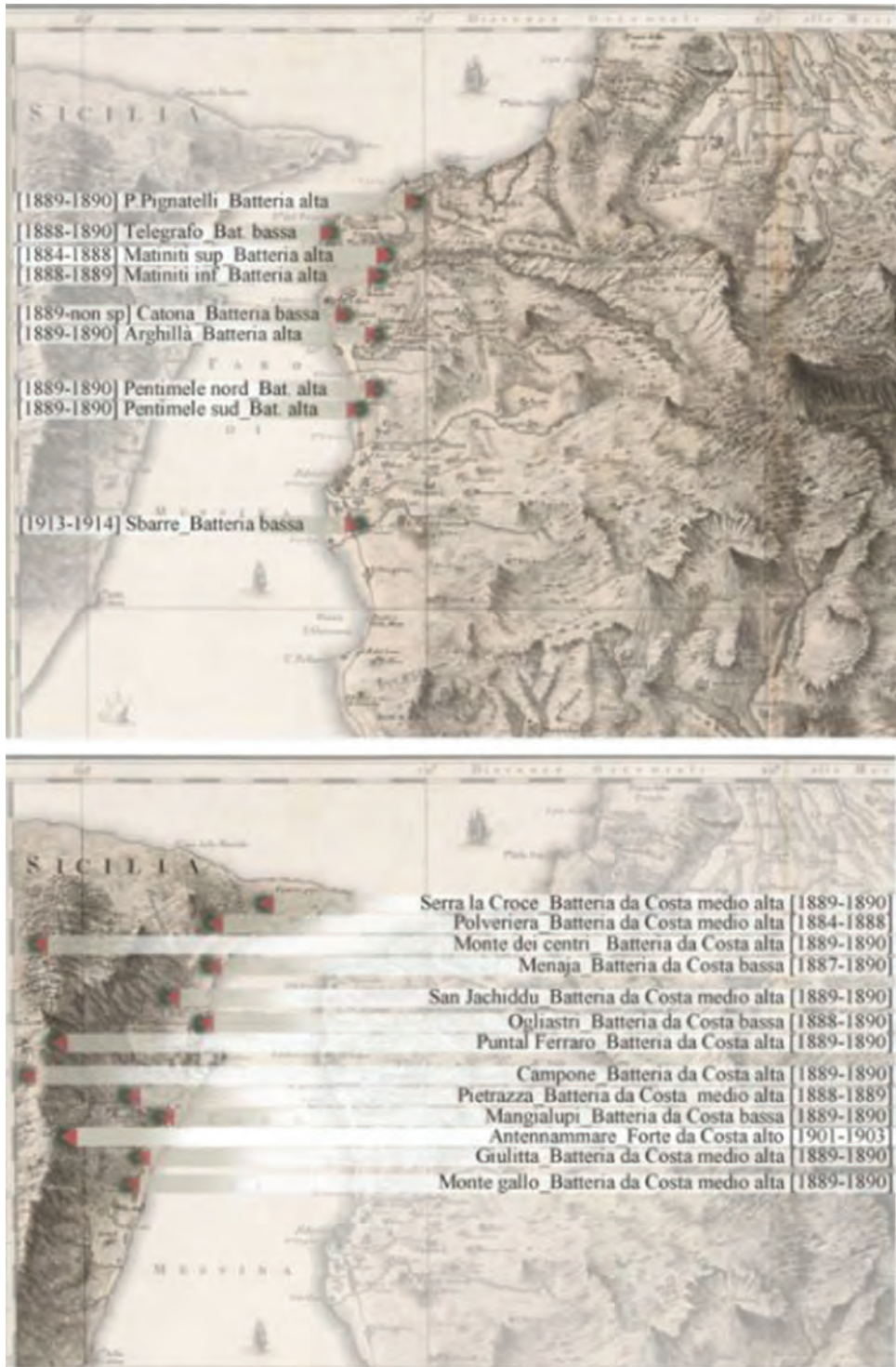


Figure 6: Type sheet – cataloguing of the heavy coastal defensive system.

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