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The influence of tabaire stone on military architecture: the case of Cartagena (Spain)

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Abstract

Cartagena, which is located in the western Mediterranean, has privileged geographical conditions. It is surrounded by the Mediterranean Sea in the south and the west, and in the north by a lagoon, which is currently dry. Its unique topography has allowed the development of the population since ancient times. Since prehistory, people have used material resources at their disposal in the environment, to meet different needs: survival, protection and construction. As far as building materials are concerned, quarrying has been an important source of supply for cities. Each region has its own sedimentary rock, Cartagena's one is tabaire. It is a calcarenite stone extracted from Canteras, which is close to Cartagena (Spain). An important part of the archaeological and architectural heritage of the city was built completely or partly with this material. A large number of blocks have been provided to build the main architectural heritage of Cartagena, including military structures, for over two thousand years. In the present study, we analyze the presence of such significant building material for the city of Cartagena, particularly in its military architecture. For this purpose, we have developed a methodology based on the analysis of military buildings and fortified heritage, in which we have noticed the presence of tabaire stone, with the aim of studying the exploitation of this material and its impact on the military architecture of Cartagena and its history.
Keywords: tabaire stone, military architecture, fortified heritage, architectural heritage, Cartagena.

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1 Introduction

The preferential geographical position of Cartagena (Figure 1), which is located in the southeast peninsula off the coast of North Africa and near Gibraltar Strait, and the exceptional topographic conditions of its port have resulted in various Mediterranean cultures occupying its territory over the past two millennia. Fortifications that are preserved today in the city and its surroundings are the significant physical evidence of each of these cultures. Thanks to this heritage, Cartagena is considered to be one of the most important cities to understand the origin and evolution of military architecture and its typologies in the Mediterranean.

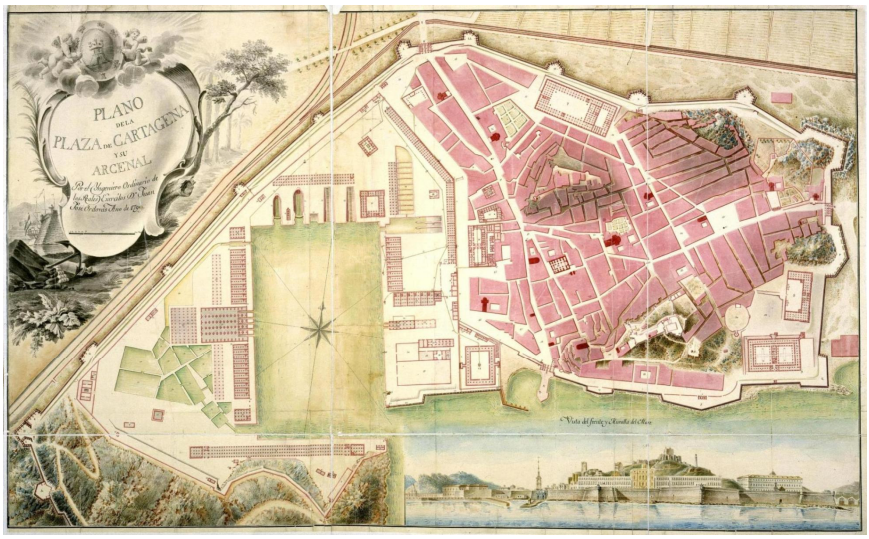

Figure 1: Map of Cartagena and its Arsenal (1799) (Ordovás [1]).

Over recent years extensive studies have been developed about its fortified heritage. Most of them study the diverse nature that allowed having a wide notion about specific aspects of their origin and evolution [2–12]. A current topic that arouses lots of interest in the field of construction and history is the study of building materials, which have been placed in important buildings of a city. Those responsible for the design and construction of various fortifications in each historical period have been aware that the use of materials in works responds to several factors such as technological developments, economy of each time, resistance, durability, speed of execution, etc.

Within the scope of the thesis, which is being developed, a study of one of these materials, tabaire stone (Figure 2), is being studied, specifically its use in military architecture. Tabaire is a calcarenite stone whose quarries are located close to Cartagena.

Figure 2: Tabaire blocks in the Roman Theatre of Cartagena (left). Detail of the stone, where fossils can be seen (right).

Technical challenges are taken into consideration during the construction of military buildings; the application of the most advanced knowledge of each time (scientific and technical) is needed for the resolution (Peñalver Martínez [15]). In the present study, a military inventory is exposed. The fortifications, in which the presence of tabaire stone is detected, are included and all of them are positioned in a map of location too. Finally, in the case study the development table, which considers the analysis of these constructions in depth, is exposed.

2 Methodology

In order to notice the presence of tabaire stone in the military architecture of Cartagena, an inventory of military heritage of the city has been developed. With that aim, firstly it was necessary to conduct a literature search process. Historical documentation, which is stored in the municipal archives in Cartagena and Murcia, was analyzed. Then, the constructions were classified according to their historical period. Building Heritage can be classified into three historical periods to maintain consistency (Rodríguez Nuere [18]). The first one is referred to Prehistory and Ancient History; the second one to the Middle Ages; and the third one to the Modern or Contemporary Age, in which due to the widespread use of gunpowder, a change develops in military tactics and logistics, thus giving rise to a repertoire of new constructive ways. The following table shows the main buildings that are part of the military heritage located in Cartagena, they are chronologically ordered and typology, chronology and historical period of each one are also included.

Once the main property comprising the Military Heritage of the city was identified and classified, we proceed to the study of archival documentary, in which it is possible to know the structural characteristics of each building. The following graph (Figure 3) shows the constructions which are included in Table 1. Those in which the stone object of this study is noticed are highlighted.

Table 1: Main military heritage located in Cartagena.

Ref	Construction	Typology	Chronology	Historical period
1	Muralla Púnica	Fort	s. III a.C.	Ancient History
2	Muralla Romana Republicana	Fort	s. II a.C.	Ancient History
3	Castillo de la Concepción	Fort	s. XIII	The Middle Ages
4	Torres costeras	Fort	s. XVI	The Modern or Contemporary Age
5	Casa de la Pólvora	Building	s. XVI	
6	Casa del Rey	Building	s. XVI	
7	Muralla de Carlos I	Fort	s. XVI	
8	Muralla de Felipe II	Fort	S. XVI	
9	Baterías de costa (1st step)	Fort	s. XVII	
10	Muralla de Carlos II	Fort	s. XVII	
11	Real Arsenal de Marina	Building	s. XVIII	
12	Baterías de costa (2nd step)	Fort	s. XVIII	
13	Real Hospital de Marina y Anfiteatro de Autopsias	Building	s. XVIII	
14	Fuerte de Galeras	Fort	s. XVIII	
15	Fuerte de Moros	Fort	s. XVIII	
16	Fuerte de Atalaya	Fort	s. XVIII	
17	Muralla de Carlos III	Fort	s. XVIII	
18	Cuartel de Antigones	Building	s. XVIII	
19	Real Parque y Maestranza de Artillería	Building	s. XVIII	
20	Cuartel de Guardiamarinas	Building	s. XVIII-XIX	
21	Baterías de costa (3rd step) (Design O'Donnell)	Fort	s. XIX	
22	Cuartel Defensivo de Fajardo	Building	s. XIX	
23	Fuerte de San José/ Despeñaperros	Fort	s. XIX	
24	Gobierno Militar	Building	s. XIX	
25	Castillo de San Julián	Fort	s. XIX	
26	Baterías de costa (4th step) (Design Krupp)	Fort	s. XIX	
27	Baterías de costa (5th step) (Design Vickers)	Fort	s. XIX	

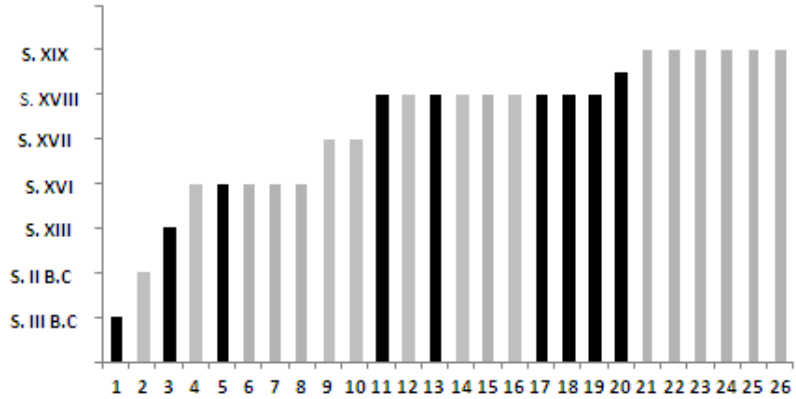

Figure 3: Top military buildings classified by historical periods.

Table 2 shows the distance from the original quarry to the studied buildings.

Table 2: Constructions in which tabaire stone is noticed.

Ref.	Construction	Quarry distance (km)	Tabaire stone location within the building
1	Muralla Púnica	6.7	Facade
3	Castillo de la Concepción	7.3	Vault
5	Casa de la Pólvora	5.7	Facade
11	Real Arsenal de Marina	5.8	Facade
13	Real Hospital de Marina y Anfiteatro de Autopsias	6.6	Facade
17	Muralla de Carlos III	6.2	Facade
18	Cuartel de Antigones	6.8	Foundation
19	Real Parque y Maestranza de Artillería	5.8	Facade
20	Cuartel de Guardiamarinas	6.2	Foundation

In the following map (Figure 4) the selected buildings are located. All of them are in the same area, which is close to the original quarry.

A systematic survey has been developed. It documented that tabaire stone is used in most buildings in both the facades and foundations. The material has a very porous structure, low mechanical properties and low surface resistance

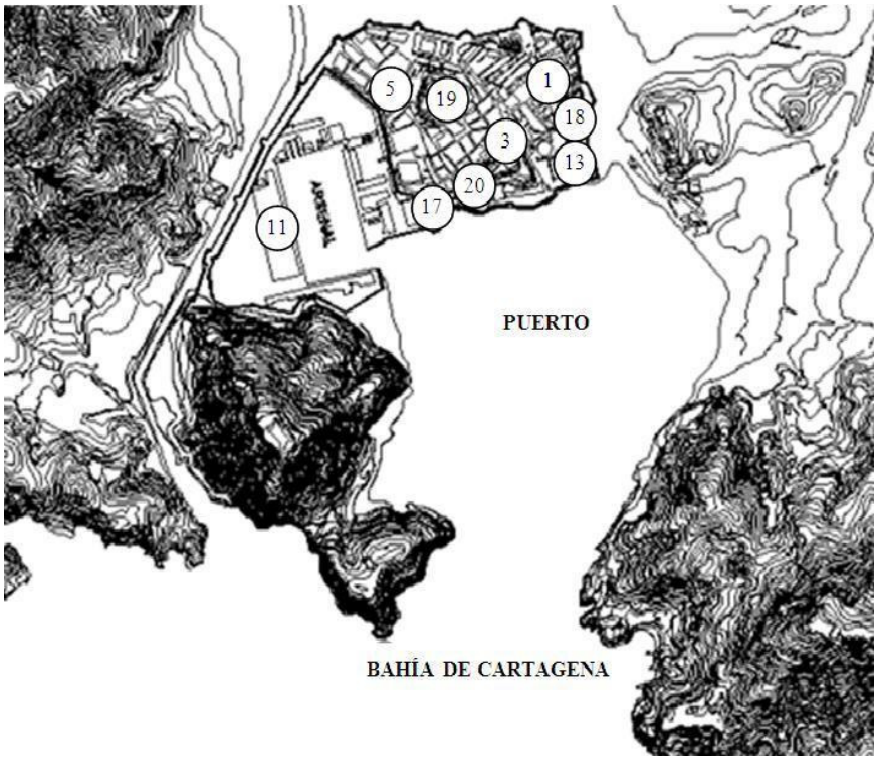

Figure 4: Location of military constructions, where tabaire stone is noticed. 1: Muralla Púnica, 3: Castillo de la Concepción, 5: Casa de la pólvora, 11: Real Arsenal de Marina, 13: Real Hospital de Marina y Anfiteatro de Autopsias, 17: Muralla de Carlos III, 18: Cuartel de Antigones, 19: Real Parque y Maestranza de Artillería, 20: Cuartel de Guardiamarinas.

(Lanzón and Piñero [16]). Being a very porous rock of high water absorption by capillarity it is degraded largely due to wet-dry cycles. This factor could be decisive when military engineers place it in foundation, where it is permanently in the presence of water. This stone has been usually covered by different coatings in order to improve its durability. However, sometimes it does not produce the expected result. Figure 5 shows the condition of the coatings in *Real Hospital de Marina*, where tabaire stone is visible.

Figure 5: Mortar coating (left). View of the support (tabaire stone) and presence of salts on the surface of the cement mortar (right) (Lasheras and Lanzón [17]).

2.1 Case study

In order to analyze in depth each of the selected military construction (Table 2), we proceed to the study by developing Table 3, where the main parameters for understanding the property in question are included. The table is divided into thirteen sections. The first one corresponds to the identification data, where, name, author and year are included. The second section is related to the specific physical location, as it concerns UTM (Universal Transverse Mercator) and cadastral reference. The third section is an aerial photograph where the exact place of location is stated. In the fourth item the type of construction, both formal and functional, is specified. The fifth section deals with degree of protection according to the Spanish Law 16/1985 about Historical Heritage. The sixth one clarifies the system of property ownership. In the seventh point it specifies the type of use which is developed in each construction, originally and currently. The eighth section describes the property in detail, brief history and main construction parameters. In the ninth paragraph the presence of tabaire stone is detected. After that in the tenth item the pathologies are described. These conditions will be explained in turn with the help of photographs, which will help to clarify the condition. Then, overall conservation status is determined and finally the visit date is recorded, to track when assessing the evolution of the conservation status and future intervention measures that could take place in the future.

Table 3: Main parameters to analyze selected buildings.

1	Identification data	Denomination	
		Designer	
		Year	
2	Location data	UTM	
		Cadastral reference	
3	Situation	Aerial photography	
4	Typology	Formal	
		Functional	
5	Level of Protection	Yes	Level 1
			Level 2
			Level 3
			Bien de Interés Cultural (BIC)
		No	
6	Property regime	Public domain	
		Private domain	
7	Use	Logistic	
		Defensive	
		Hospital	
		Others	
8	Property description	Historical review	
		Constructive description	
9	Location of tabaire stone	Specified	
10	Analysis of pathologies in tabaire stone	Alveolization/weathering	
		Shrinkage and cracking	
		External cementation	
		Alteration of the most exposed areas	
11	Pictures	Detail of pathologies	
12	Condition	Good	
		Deteriorated	
		Ruin	
13	Control data	Date of visit	

3 Results and conclusions

After the development of this research the following conclusions were obtained.

- The presence of tabaire stone is noticed in the military architecture of Cartagena, specifically in nine of the twenty seven buildings studied. This stone has been placed mainly on facades and foundations.
- Evidence of the use of the local component in the military architecture of Cartagena is evident from the very foundation of the city in the third century BC (Muralla Púnica), until the great works of fortification of the eighteenth century, when this building material begins to be replaced by other materials in the first half of the nineteenth century (Cuartel de Guardiamarinas).
- All buildings are located near original quarry. The distance between them and the quarry is from 5.7 to 7.3 kilometers.
- The developed model (Table 3), in which the parameters to analyze selected buildings are included, has proved useful to study military heritage. Allowing knowing the conservation of each building and the pathological processes that all of them have in common.
- After the visits, it can be said that the conservation of this stone, with so much value for Cartagena, can be improved. This building material entails an additional difficulty in any intervention, because of its heterogeneous properties and high porosity.

Theoretical foundations of the thesis are exposed in this article. New lines of investigation, such as studying petrochemical and mechanical properties of tabaire stone will be developed, with the aim of analyzing pathologies that can appear in this material and suggest intervention criteria for its conservation.

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