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The geomaterials of the Argentario coastal towers (Tuscany-Italy)

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Abstract

The Argentario peninsula, sited in Southern Tuscany, already attended by Etruscans and inhabited by the Romans, during the XIIth century became property of the Aldobrandeschi family whose domains were extended to the whole Southern Tuscany.

In 1414 Argentario and the neighboring territories passed under the rule of the Republic of Siena which built a first system of fortifications against the barbarians.

In 1557 all the Senese territories passed to Cosimo I de’ Medici allied with the Spanish crown which reserved for himself a small coastal strip comprising Orbetello, Talamone, Argentario, Capalbio and part of the Elba island, forming the State of Presidi. The military connotation of the territory was improved, building new coastal towers and numerous fortresses.

In this contribution, the study of the building materials (ashlars and bedding mortars) of two selected towers (Capodomo and Calamoresca), is presented trying to find the relationship with the local supply in stones for lime and for ashlars.

Moreover the archaeological study of the masonries has been carried out in order to understand the history of buildings evolution.

Furthermore a survey of state of conservation of the buildings was performed in order to point out the guidelines for compatible conservation.

Keywords: Argentario, geomaterials, mortars, Tuscan coast, conservation

1. Introduction

In this contribution, within an historical and architectonic context, the study of the geomaterials and state of conservation of two defensive towers in Argentario peninsula is presented.

Argentario, sited in Southern Tuscany, already attended by Etruscans for its safe docks in their maritime trades, was inhabited by the Romans, as evidenced by the ruins of Cosa (273 BC), on the hill of Ansedonia and by the luxurious residence of the Domitii Enobarbi family, in Santa Liberata.

After the fall of Roman Empire, the Argentario history became confused with that of the surrounding areas, controlled by Barbarians, Byzantines, Lombards until the coming of Carlo Magno. During the XIIth century, Argentario became property of the Aldobrandeschi family, important noble family whose domains were extended to the whole Southern Tuscany.

In the period of the Senese Republic (XV- XVIth centuries), the first systematic fortification of the peninsula, against the barbarian invasions that became more and more frequent and devastating, was realized. In 1557, following a military defeat, all the territories of the Senese Republic passed under the rule of Cosimo I de’ Medici allied with the Spanish crown. In the agreements of this alliance, Philip II of Spain successor of Carl V, reserved for himself a small
coastal strip comprising Orbetello, Talamone, Argentario, Capalbio and subsequently part of the Elba island, that formed the State of Presidi. Philip II improved the military connotation of the territory upgrading the network of existing coastal towers and with the constructions of numerous and mighty fortresses: from 1563 to 1571, under the impulse of the Spanish viceroy of Naples Pedro Afan de Ribera, 17 coastal towers were realized in the territories of Orbetello and Argentario (Fig. 1). The Spanish rule ended in 1707, leaving deep urban and architectural traces (Della Monaca, 1996; http://www.capodomo.it/Torri/torri-index.htm).

At present some of the towers are completely restored and placed in private property, others are in ruins.

Our research is concentrated on the ruins of the Towers of Capodomo and Calamoresca, both in bad state of conservation. In particular the following aspects have been investigated:
- archaeological study of the masonries in order to understand the building history;
- study of the building materials (ashlars and bedding mortars) trying to find the relationship with the local supply in stones for lime and for ashlars (Fratini, 2016; Pecchioni, 2011);
- survey of state of conservation in order to point out the guidelines for interventions compatible with the structures, materials, history and aspect of the buildings.

2. Materials and methods

Stone ashlars and raw materials used for the realization of bedding mortars, plasters and floors were investigated with mineralogical and petrographic methodologies (Pecchioni, 2015). Powders obtained from each typology were analysed with a PANalytical diffractometer X’PertPRO with radiation CuKα1 = 1,545˚A, operating at 40 KV, 30 mA, investigated range 2θ 3-70°, equipped with X’Celerator multirevelatory and High Score data acquisition and interpretation software so as to determine the mineralogical composition; optical microscopy in transmitted light was performed on thin sections (30 microns thickness) with a polarised light microscope (ZEISS Axioscope.A1) equipped with a camera (resolution 5 megapixel) and dedicated image analysis software (AxioVision) for evaluating the microstructural parameters. The archaeological analysis of the towers was carried out by highlighting the physical relations between the different portions of the buildings and trying to understand the stratigraphic relations of the anteriority and posteriority existing between them (Arrighetti 2012).

Thereby it was possible to propose a constructive story and a characterization of the constructive systems used over time.

3. Results and discussion

3.1 Tower of Capodomo

It is a square tower which had probably three floors. At present only the basement and the first floor are still standing (Fig.2)

Externally the tower is characterized by a buttress that runs along its entire perimeter ending with a cornice marking the position of the flooring of the first floor. The building technique can be classified as a coursed square rubble masonry (Dipasquale, 2016), characterized by the use of roughly dressed stones, well cut corner stones and thick layers of bedding mortars. This buttress differs from the
upper masonry for some specific architectonic elements like the corner stones, the cornice, the windows and doors frames. In such cases the stones are well dressed with a finished surface (Fig.3).

![Fig. 3 – Tower of Capodomo: the corner stones and the cornice](image1)

Inside, the tower is constituted by a ground floor where a tank is located (currently empty but still plastered) topped by a barrel vault, sustained by another adjoining room, also vaulted, currently filled by masonry debris owing to the collapse of the overhanging portion Above, a well preserved two-layers mortar flooring (two distinct construction phases) is visible (Fig. 4).

![Fig. 4 – Tower of Capodomo: the two layers mortar flooring](image2)

A layer of mortar (tied to the floor) rising along the interior walls for about 20 cm, testifies stratigraphically a constructive continuity between the two elements. Even the plasters of the walls show evidence of at least two distinct phases (Fig. 5).

![Fig. 5 – Tower of Capodomo: plaster residues](image3)

The access door to the tower is located at the first floor on the south side of the tower. In the following, the characterization of the stone materials and mortars is reported. The dressed stones of the masonry are made of calcitic grey marble with traces of dolomite - Unit of Cala Piatti (Middle-Upper Trias), outcropping in the area where the tower is sited, while the cornice and the corner stones are made of a brownish Cavernous Limestone belonging to the Unit of Cala Piatti (Upper Trias) (Fig. 6).

![Fig. 6 – Tower of Capodomo: the cornice made of Cavernous Limestone and the dressed stones made of calcitic grey marble](image4)

Concerning the mortars, different bedding mortars, the two layers of flooring mortars and plasters have been investigated. The bedding mortars of the wall nucleus show a calcic magnesian binder and an heterogeneous aggregate constituted mainly by carbonatic rock fragments (micro and macro crystalline), quartz, lumps and presence of earth residues (Pecchioni, 2015). The binder/aggregate ratio is 1/2-13 (Fig. 7).
The plasters show always a calcic magnesian binder (as indicated also by the presence of hydromagnesite and brucite, evidenced through XRD analysis). The aggregate is heterogeneous with the presence of carbonatic rock fragments (dolomite from XRD data), quartz, lumps, sometimes shale and silicatic rock fragments, crushed ceramics, earth residues and carbon (the latter not present in the plasters of the vault and of the oldest and more recent). The mix is fatter with respect to the bedding mortars (binder/aggregate ratio 1/1-1/2) (Fig 8).

Concerning the flooring mortars, the oldest layer show a calcic magnesian binder, an heterogeneous aggregate constituted by carbonatic rock fragments (micro and macro crystalline), crushed ceramics, lumps, earth residues and carbon; the second layer is similar but shows a great amount of crushed ceramics. The binder/aggregate ratio is in both cases 1/2-1/3; the top layer is constituted only by a calcic magnesian binder partially crystallized without aggregate.

3.2 Tower of Calamoresca

It is a square tower, composed of a single constructive phase, except for sporadic and punctual interventions of modern restorations, and characterized by a masonry realized with stones, split and put in place on uneven rows (uncoursed square rubble masonry) and well cut corner stones (Fig. 9).

The tower is characterized by a buttress that runs along its entire perimeter ending with a cornice marking the height of the flooring of the first floor. The dressed stone of the masonry (Fig. 10), the bedding mortars and traces of an ancient plaster (Fig. 11) were investigated. The dressed stones are made of dark grey dolomite with calcitic white veins belonging to the Unit of Cala Piatti (Upper Trias) outcropping in the area where the tower is sited, the cornice is made of Cavernous Limestone similar to that of Capodomo and the corner stones are made with a dark gray porous limestone.
Both mortars (bedding mortar and plaster) show a calcic magnesian binder (XRD data) and an heterogeneous aggregate constituted by carbonatic rocks (the same of the dressed stones), earth residues, quartz, and rare metamorphic rock fragments. The binder/aggregate ratio is in both cases 1/2-1/3 (Figures 12, 13). The XRD data confirm the presence of dolomite.

As for the state of conservation, as we have already mentioned, the two towers look like ruins. The stones of the masonry are in good condition because they are made of compact, highly durable rocks. Even the architectural elements in Cavernous Limestone of Capodomo are in good condition in fact, despite being made of high porous material, the pores are large and do not allow the salts carried by marine aerosol to develop destructive tensions while crystallizing in the porous space. The most delicate part of the masonry is constituted by the bedding mortars. In fact, the mortar joints, while presenting good cohesion, are eroded and this has caused the enucleation and separation of stone blocks, especially on the unprotected wall crests.

A conservative intervention should include a "light" structural consolidation eg. through tie hooping, a protection/reconstruction of the wall crests and sealing of the cracks but the extensive grouting of the mortar joints with a new mortar should be avoided unless extremely necessary. This may result in a complete change of appearance of the masonry, aesthetically incompatible with a conservative intervention. Moreover the complete sealing of the mortar joints would hidden the evidence of such a "precious" material as the original bedding mortar, closely related to the geological nature of territory (Pittaluga 2012; 2015).

4. Conclusions

Argentario has a remarkable lithological variety with cavernous limestones, marble and dolomite limestones, quartzose conglomerates, arenitic schists, micritic limestones, calc-schists etc. Then, there were numerous stone materials available but what is noteworthy about the two towers studied in this research (Capodomo and Calamoresca), is that only the materials in the immediate vicinity have been used. For the tower of Capodomo is in particular calcitic grey marble with trace of dolomite, very resistant to decay and well suited for the shaping of building stone blocks was used. For the tower of Calamoresca a dark grey dolomite with calcitic white veins was used for the dressed stones. Particular attention was paid to the cornice and to the corner stones of both towers for which the cavernous limestone has been chosen, due to its easier workability. Concerning the lime stone for the various types of mortars present, a dolomitic...
rock has been used which has allowed to obtain a magnesian binder capable of providing excellent mortar resistance characteristics to the mortars.

As for the conservation conditions, the two towers are in the state of ruins but the building materials are in good condition. The conservative problems are essentially due to the erosion of the mortar joints which caused the enucleation and falling of stone blocks, especially on the unprotected wall crests. A conservative intervention should include a "light" structural consolidation eg. through tie hooping, a protection/reconstruction of the wall crests and sealing of the crack. The complete sealing of the mortar joints with new mortar should be avoided because it could result in a complete change of appearance of the masonry, aesthetically incompatible with a conservative intervention.

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http://www.capodomo.it/Torri/torri-index.htm


