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# Mapping of mortars and ashlars in watchtowers of Reconquest Ages in Cuenca District, Spain

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## Abstract

In the inner tablelands of Spain, in Cuenca district, at only 150kms south east from Madrid we can discover a dense net of watchtowers, dated on the last years of the XII century, scattered all over the territory. These enigmatic constructions, following the results of the presented, research have a Muslim origin and a Christian maintenance, due to their control of the territory and bonded with the regulation of the displacements of livestock during the seasons. Have they a military or a civil function? Both of the possibilities are documented...at the same time, a part from a morphological and typological developed study, the search has opened an interesting study about the features of the mortar and the ashlars used in the district during the Reconquest Ages. The direct analysis shows the use of specific masonries, both for religious, and for civil constructions, made by manageable ashlars, set in regular rows, with a deep filling of lime mortars. These mortars, rich in lime, as the chemical analysis show could guarantee the good performances of the walls during the ages, in spite of the use of sedimentary and low quality limestone ashlars. The result of the research is a useful “pattern book” of the masonries of the watchtowers and Reconquest buildings in the district, throughout the centuries and during their reparations.

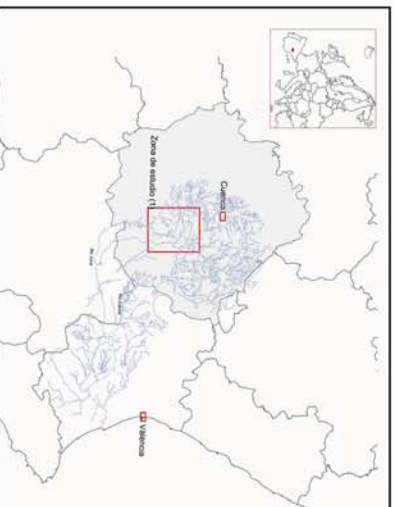


## 1 The context and the object of the study

The study spreads out a wide area of the *Cuenca* Province territory, in an inner district of the interior flatland of Spain, close to a river district (called *Júcar* and *Cabriel* river basins). A series of towers appears throughout this extended hill-waved landscape: *Piqueras*, *Barchin*, *Olmeda*, *Chumillas*, *Hornubia*, *Gasca*, *Buenache*, *Solera Valhermoso* villages give evidence of the presence of well conserved or ruined free standing towers. The surface, that the study includes, is an area of approximately 50,000 hectares. For this reason, due to the huge extension of the analysed territory, some planned and scheduled stages of study were recommended. Definitely this research is opened to different disciplines that allow to go deeply into the origin and role played by these towers along the Ages.

The study begins with the comprehension of the area where the towers are built with reference to physical, climatical ecological and geological aspects.

After this regional vision, the work tries to focus on historical *data* and sources, to establish the construction age of the towers, their features and their relation with other detached buildings of the area (like churches, for examples).



**Fig. 1** the context and localization of the towers

The road links, are important elements to consider in the anthropological study of the area, because these connections completely cross Cuenca's Province throughout the centuries. The historical paths, bonded with the local cattle raising economy, are fundamental for the complete comprehension of the evolution of the landscape and for the understanding of the presence of the towers. From the first Iberian villages to the ancient Roman's routes net, from Visigothic legacy to Muslim/Christian employment. Always, throughout History, the trades and the woollen activities feed the maintenance of the territory and its roads links.

Therefore the towers would be connected with these cattle historical routes, above all from the Reconquest Ages. This term refers to the eight centuries during which the Christian kings of the Spanish kingdoms gradually reclaimed their country from the Moors, who had invaded the Iberian Peninsula. Nevertheless King *Alfonso VIII*, considered this area, in his advance towards on the South, as a strategic location. The monarch comes up to the Province, with the support of the Military Order of *Santiago*, in the year 1177, being especially interested in the management of the tolls of routes and passes.



**Fig. 2** A tower example: the case of study of *Valhermoso*

The territory where the towers are located has been so little altered by such external agents like, infrastructures or human changes through the ages. For this reason the group of towers is an untouched and great example of defensive typology in the Region. They are still identical watchtowers along the topography of the county. The analysis has shown that the towers present some repeated features, visible in all the cases of study. For example the location of the watchtowers is always on top of reduced rocky platform, their situation is constantly in a narrow valley close to a creek or river. In each case of study the towers are flanked, by routes, ways or paths which are tracing in general with a specific orientation.

As a matter of fact, the position of the buildings is always related to the cattle raising roads, usually crossing the Peninsula from North to South.

All of them attend to a typology of free standing tower with a regular rectangular layout, with small imbalances due to irrelevant adjustments to the topography. Their height changes according to their state of conservation. It's quite frequent to recognize a main access, around 5 m of height, with an arch shaped by rough stones.

It's quite difficult to recognize a tower in an absolutely well conserved state; anyway, with the studying of some examples, like *Cervera o Piguerras* [13] towers, it is possible to recognize the battlements, their maintenance and their evolution.

The study of modulation and proportion of these buildings is also quite interesting. We have witness of the employment of a module, of 47 cm. This module would fit with the measure of the "cubit" of Castille, called *cardo*. (In reference to the human dimension that measure from the elbow to the top of the finger).

## 2 Historical notes

So when can we go back into the centuries to discover the beginning of the construction of these buildings? In the early stage of expansion of the Christian kingdoms, at the end of the XII C., the area was exploited with clearly commercial lenses. Furthermore the Military Order of *Santiago*, as an estate to the service of the kingdom, starts the maintenance of the previous Muslim emplacements [2, 4]. The towers would play the rule of "body of vigilance" of the great extension of territory towards the South of the Peninsula. At the same time their function was to guarantee and control the correct development of pastures, the forest management, and the control of the passes [10].

On the other hand, the reference of historic documents would testify as the towers (so as to detail the *Valhermoso* one) are maintained and repaired with the arrival, in the Region, of the military order of *Santiago* (1234).

The function of these Towers, therefore, is deeply related to the control of the routes and passes more than that with an exclusive warlike function.

In the analysis of possible visual relations among these buildings, it is verified that the watchtowers are not connected to one another.

Visual basins are generated from each tower, thanks to the management of the cartographic information (going on from a two-dimensional vision to a three-dimensional one) Two hypotheses appear from each type of building visibility: diurnal, within a distance of 15 km, and night visibility, within a distance of 30 km.

The overlapping of these visual basins on the 3D model, confirms that the towers are not visually connected.

Rather on the contrary, the visual basins are complementary, covering the surface of every municipal area [2, 3]. This might confirm the watch role of the buildings in the control of the territory, based on visual complementation and complete managing of lands.



### 3 Constructive features and details

The study tries to focus on the masonries of the towers so as to date the buildings through disciplines like constructive analysis, stratigraphy and petrography.

The walls are perfectly built with horizontal rows by ashlars, proceeding from quarries near to the emplacement. We can recognize different raw materials, depending on the local availability, sandstones, limestones; conglomerates are used with no distinction in the masonries. The walls are received with lime mortar and arid of variable granulometry; in occasions ashes are used to improve the hydration.



Fig. 3 Masonries study: type of ashlars, disposition and technique

The walls are formed of two external faces formed with rows, of 25 cm of height, as previously indicated. Among them there's a huge filling formed of pieces of minor granulometry, wastes of stones and pebbles. In some points it is also possible to estimate that the filling is formed of regular layers of approximately 10 cm of thickness.

The process of study started with the comparison of the towers, not well dated, with some buildings, with a precise dating. In the area, churches and military constructions were used as references of masonry constructions and finishing.

The towers always present a regular disposition of ashlars; of 25x20x20 cm, well shaped especially in the corners. It is not so common that in this area of study, you should see such well ordered and set masonries [6,8]. We can see that Muslim buildings (IX-X C.) are used to be built with a filling core [1], but with bigger rough stones, of 50x25x30cm, disposed in variable vertical/horizontal rows. At the same time the churches and the castles dated after the Reconquest (from XIII C.) present the same measure of ashlars, but not so well disposed in regular rows. The masonries are more irregular, with a not so clear disposition of ashlars and with a more unmethodical pattern. Going through the centuries we can also see how the

corners are progressively well shaped (XIV-XV C.) with carved ashlars and keystones of the arches.

The final contribution to the demonstration of the homogeneous nature of this set of medieval towers is provided by the petrographic analysis of the mortars.

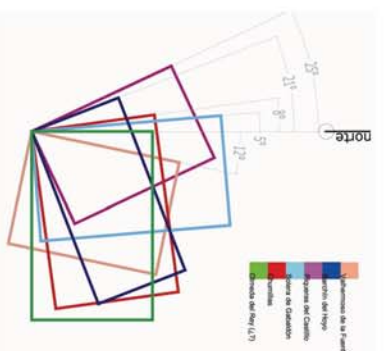


Fig. 4 study and reflections about modules and orientation of the towers

#### 4 Lime mortars: results and discussion

The analysis results from the 14 samples, selected from the 7 towers analysed, are quite uniform and homogeneous.

The *de visu* macroscopic analysis of the mortars (14 samples) shows homogeneous and porous matrixes. The tonality is the characteristic of major differentiation of the samples, variable between the range of pink and brownish colours[14].

There are also visible some ceramic fragments and impurities, carbonate crusts not well grounded, with an average size of 1.2mm. For this reason the mortars are not so smooth and with a grain texture. The analysis done on the samples are the following ones:

##### *MO (Optical microscopy)*

Optical microscopic methods are commonly applied using a polarising petrographic microscope to study thin section material. In this case, although the binder diffraction is mostly very good identification of the type of binder (gypsum, lime or gypsum and lime) is mostly possible.

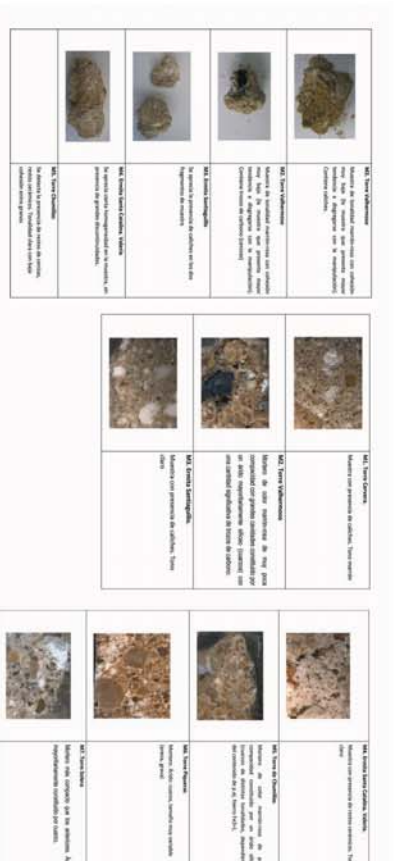


Fig. 5 example of the mapping of the mortars (macro-micro analysis)

#### SEM (scanning electron microscopy)

Using SEM, the structure of the tower mortars can be analysed at high magnifications and three dimensions on rough, broken surfaces to directly visualize the components of the mortar. SEM analysis is important, in this way, for the characterization of very fine-grained lime mortars, and the higher magnifications allow the recognition of the micro-structure of hydrated hydraulic phases.

#### FTIR (Intra-Red spectroscopy)

By using Intra-Red spectroscopy, especially Fourier Transform Infra Red spectroscopy, in addition to the identification of the main mineral phases in a binder, small quantities of admixtures and additives can be identified. In general this method relies on the interaction between applied infra-red radiation and the molecules in compounds.

Thanks to the results of the study, we have witnessed that the mortars are mainly composed of a microcrystalline binder of calcium carbonate  $\text{CaCO}_3$  (without traces of  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) and the aggregates are constituted by quartz matrix and a low proportion of clays. This latter one is in charge of the tonality of the mortars (depending on the content of  $\text{Fe}^{3+}$  the mortars can turn into a brownish/pink colour). All the samples contain, in a different percentage, nitrate-bearing grounds that were identified so much in the sample to hand, as with the FTIR.

In general the granulometry (reduced, with approximate values) suggests a very similar proportion of dry: binder around 9:1. So, finally we can describe the samples as mortars with binding material and finely crystallized calcite, well carbonated. Otherwise the aggregates are mainly calcite consisting of coarse clastic quartz grains...



## 5 Conclusion

Generally, the constructive system of the towers, the way of their implantation in the landscape, their dating, their relation with road links are fundamental keys for their study.

At the same time the uniform and “standardized” mortars used in the walls, the ashlars, their dimensions, modules and features... are other basic elements of comparison and study.

The research tries to focus on these buildings not as isolated elements, but as a group of monuments, deeply related and rooted to the landscape and the territory.

This might relate to the proper system of land organization of the Santiago Military Order. At the same time this perfectly articulated system gives solution to the problem of the management of big territorial extensions, where the density of population was especially low.

Another important documentary evidence to confirm the unit of this set of towers, is based on several constructive features, visible in the buildings.

The towers answer to a constructive basic system, which is closer to the beginning of a Romanesque architecture of repopulation, than to constructive Gothic systems, as it was claimed at some point.

The new settlers of the *Reconquest*, devoted themselves to execute their works with great solidity but without great technical complexity [3,15]. To this one, another reference might be added: the clear influence of Roman and Muslim legacies that should have influenced the new settlers at the end of the XII C.

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#### Agreements:

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