STUDY ON THE DETERIORATION AND CONSERVATION OF THE VAULT OF THE ROOM OF PLENARY SESSION OF THE TOWN HALL OF SEVILLE

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Abstract

The present work is focused in the study of some materials used in the construction of the singular vault of one of the most beautiful rooms in the Town Hall of Seville (Spain), the plenary session room.

The formidable vault, constructed in stone, is divided in 36 coffers with a magnificent sculpture of a king or queen of "Castile and León" (Spain) in each one.

The first purpose of the study is setting the nature and composition of the stone, mortars and patinas since these characteristics have influenced in their conservation state, and the weathering factors that have caused the stone alteration.

The following experimental schedule has been performed:

- Study of the deterioration indicators, to determine the state of conservation of the vault, the alterations factors present and the mechanism to eliminate or reduce them.
- Measurement of dampness and salinity of the stone.
- Thermo-hygrometric analysis of the environment.
- Chemical characterization of samples from the vaults.
- Petrographic and mineralogical characterization of samples using X-Ray Diffraction, IR spectroscopy and Polarized Light Optical Microscopy.

Most of techniques are non-destructives and results allowed a deep knowledge about the construction materials in this vault and an adequate intervention.

All samples correspond to bioclast arenitic limestones, with some differences between them.

The most important deterioration factors are related to the dampness and salts, which provoke disyunctions. Fractures fissures and fragmentations also appear related to the thermal changes.

Keywords: conservation, deterioration, stone, town hall, seville

1. Introduction

The plenary sessions room (*Sala Capitular*) has been the government center of Seville during the last 450 years. It is an extraordinary piece of architecture of the first half of the sixteenth century.

The room shows a slightly rectangular plant (10.94 x 8.27 m.), covered by a vault showing an orthogonal grid composed by thirty-six coffers which are decorated with Castilian and Leonese queens and kings (Figure 1).

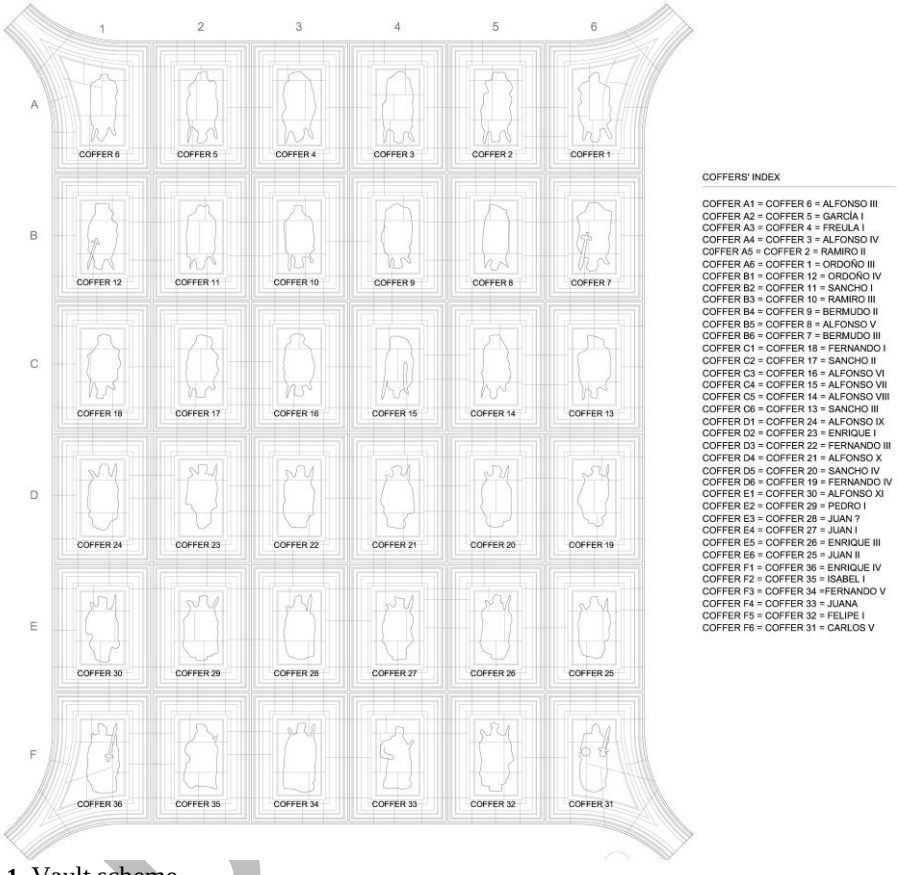

Figure 1. Vault scheme

In 2004 and 2005 some pieces of stone fell from the vault, so the installation of a protective net was necessary and a study of the materials was requested and an intervention project was performed. The results of the research are shown in this work.

2. Experimental

2.1 Deterioration factors

A comprehensive study of deterioration factors in the entire surface of the vault was performed.

The conservation state can be described as good. However, there are punctual serious deteriorations which made necessary the intervention project.

Most of the deterioration mechanisms present in the vault are related to the volume increase in pores and gaps that provoke disgregation usually associated with loss of stone material; and patina, warping or swelling, deformations without loss of material. In some areas there is a little grain disgregation and pitting.

Fractures, fissures and fragmentations are related to quick temperature changes or vibrations. Excoriations are related to holes for studs and sometimes to sampling of previous interventions.

Such as the most important deterioration factors are related to the migration of moisture and salts, with its cycles of wetting-drying, crystallization, dissolution and hydration-dehydration, an environmental thermo-hygrometric study was carried out and salts and dampness of the stone were measured, and the results are provided in the following sections.

2.2 Thermo-hygrometric study

A continuous monitoring of temperature and humidity was performed from March to June of 2006 at four heights: + 6.00m, + 6.15 m, + 6.55 m and + 6.90 m. The obtained values are given in Figures 2 and 3.

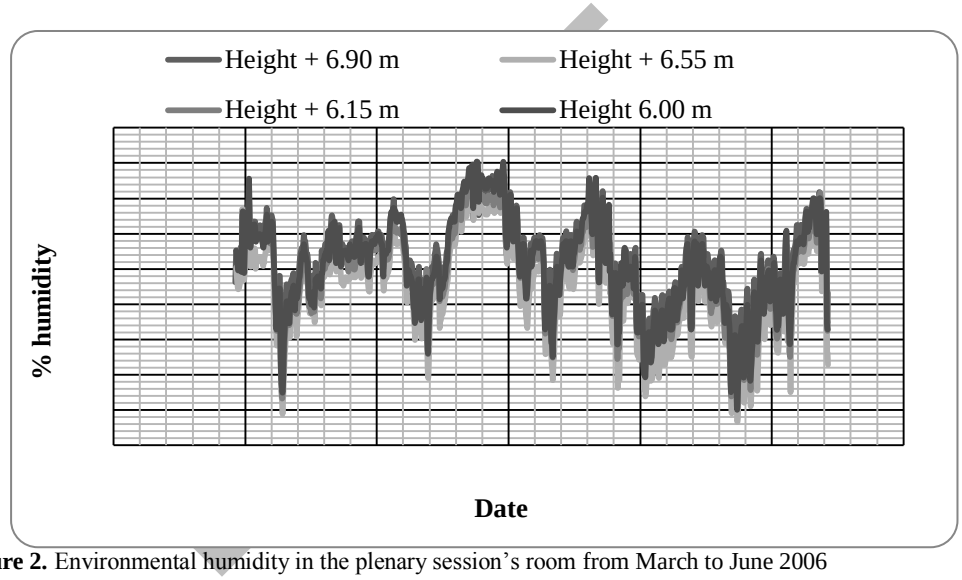

Figure 2. Environmental humidity in the plenary session's room from March to June 2006

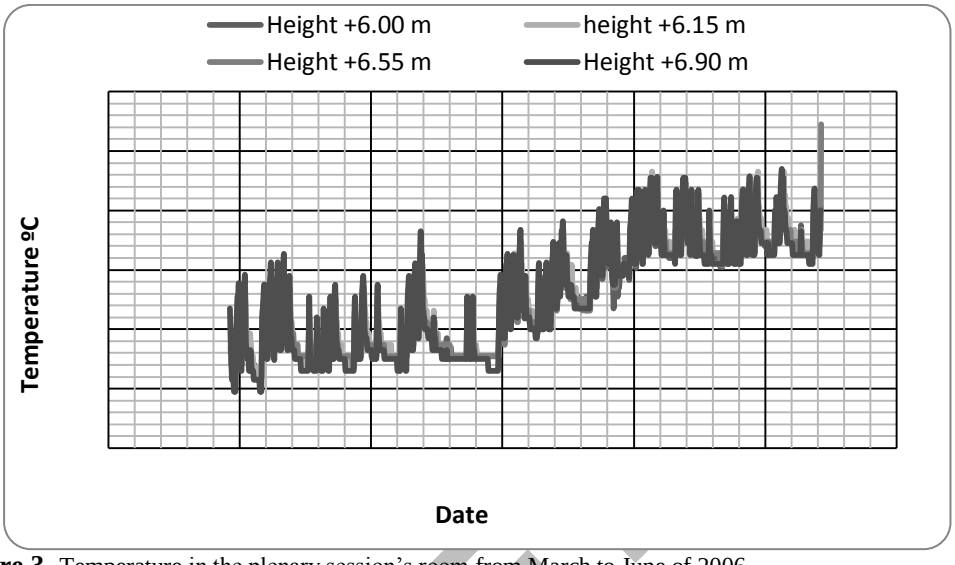

Figure 3. Temperature in the plenary session's room from March to June of 2006

Important deviations of temperature and humidity occur in certain specific dates, especially on Thursdays, when the plenary sessions are usually celebrated.

So, temperature and humidity were measured in one Thursday in which a plenary session was celebrated.

The evolutions of temperature and humidity during the whole day show that the temperature increases early in the morning, probably due to the heating system (and the corresponding decrease in humidity). From 9.30 a.m., the starting time of the session, the humidity increased up to the 14.30 a.m., probably when the sessions ended.

Probably there is a direct relationship between the disjunctions in the vault and changes in temperature and humidity. Therefore a climate control is necessary to reduce the changes in humidity and temperature, and especially the possible condensation, and high humidity values.

2.3 Dampness and salinity rates in stone

The dampness and salts inside the stone were measured. The obtained values of both dampness and salinity rates are presented as indexes on a scale of 0 to 100. They have a qualitative value, useful for comparisons between areas or dates. Measurements are shown in Figures 4 and 5.

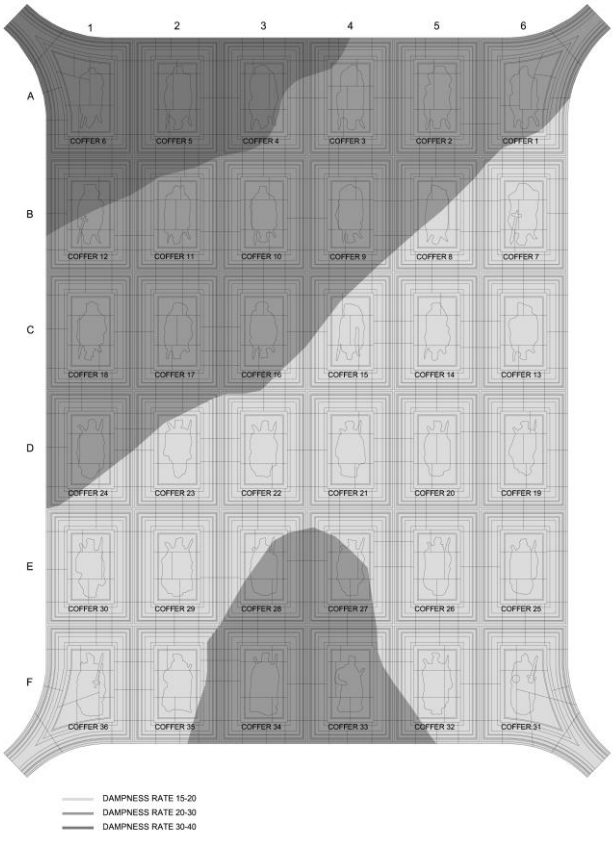

Figure 4. Dampness rate in the stone of the vault

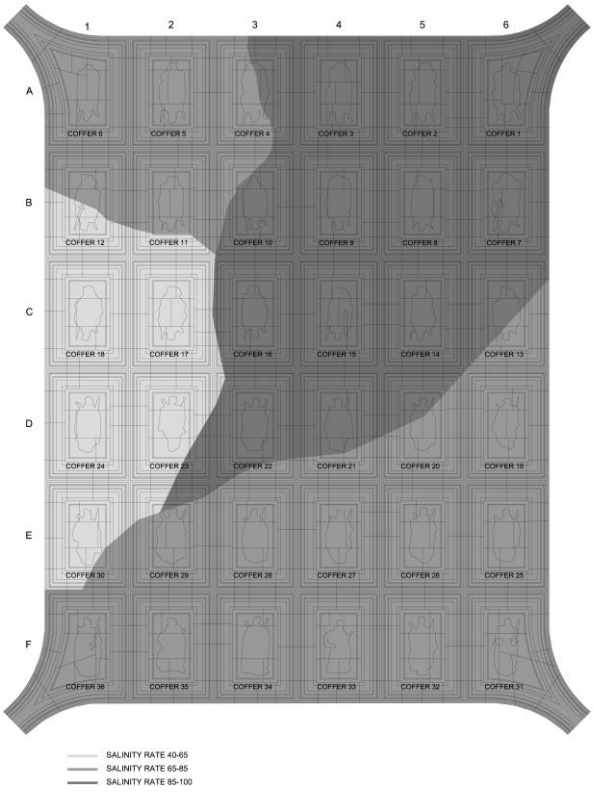

Figure 5. Salinity in the stone of the vault

2.4 Mineralogic-petrographical study

Three samples of stone in different conservation grades were taken to perform the mineralogical-petrographic analyzes (Table 1).

Table 1. Description of the samples studied the Plenary Hall

SP1	Coffer 33. Highly deteriorated
SP2	Coffer 34. Medium deteriorated
SP3	Coffer 32. Low deteriorated

The techniques used for mineralogical-petrographic characterization were:

- X-Ray Diffraction (XRD) with a 1410 Phillips diffractometer with graphite monochromator (40 kV and 20 mA).

- Optical Microscopy Transmitted Light Polarized (MOP) of thin layers. A petrographic LEICA DMLP microscope was used.

The obtained results with these methods are shown in Table 4. All samples show quite similar mineralogical compositions (90% of calcite) but they could have different textures and/or carbonate compounds, so a more detailed petrographic study was carried out. Feldspars appear in different proportions and quartz in small quantities in all samples. Minor amounts of other minerals were also detected. On one hand phyllosilicates were detected probably related to mica or clay minerals that may play a role in the deterioration processes, especially in the case of expansive minerals. On the other hand gypsum was also detected in some samples. Gypsum may participate in the process of stone deterioration since it is a relatively soluble salt and may cause crystallization and solubilization cycles (depending on moisture content). All samples are bioclastic limestones with different grain size, matrix and cement proportion, and compaction degree.

Table 4. Mineralogical composition of samples (%)

	Calcite	**Feldspars**	**Quarzt**	**Others**
SP1	> 90%	7%	< 1%	Phyllosilicates
SP2	> 90%	5%	< 1%	Phyllosilic., gypsum
SP3	> 90%	< 5%	5%	Gypsum

Table 5. Petrographic characteristics

	Grain size	**Allochemical components**	**Matrix / cement**	**Porosity**
SP1	1-2 mm	(<40%) Globigerina, green algae, nummulites, miliolids	(> 50%) abundant micrite matrix. Significant losses for dissolution	High, modified from original due to deterioration
SP2	2-3 mm	(50% elem.sol.) Nummulites, coralline algae. Less abundant spines of brachiopods, lamellibranchs. Few Globigerina	(50% elem.sol.) Matriz micritica muy abundante. (50% elem.sol.) Abundant micrite matrix. Procesos de micritización. Micritization processes. Cemento (esparita) en poros Cement (sparite) in pores	High (20-25%)
SP3	<0,7mm	(<25%) Globirigénidos, miliolids, green algae No nummlites	(> 65%) abundant micritic matrix, not so much sparitic cement	High (≈20%)

3. Results

The stone used in the construction of the vault is a bioclastic calcarenite with limestone matrix and calcareous grains. According to the results all the samples come from the same geological formation, but textural and compositional differences of each sample show variations that may exist in the stone from the quarry horizontally and vertically, which is common in sedimentary rocks.

Related to the conservation state, the varieties with smaller grain size and more compact are the less alterable; and varieties with higher grain size, less cemented and more porous, the most easily deteriorated reversible, and that may require a more carefully consolidation treatment to return consistency to the material surface.

Attending the stone composition, the quarries and historical reference, the stone probably come from quarries of Morón or Utrera.

The most important deterioration factors are the humidity and temperature cycles, causing dissolution-crystallization cycles and hydration-dehydration of salts. The causes of changes are the large audience in the days of plenary sessions and the effect of heating-cooling of air that occurs at the time.

4. Intervention

The intervention actions were the following (Robador, 2009):

- Clean the stone surface
- Elimination of dissagregated mortars
- Consolidation of stone
- Structural reinforcement
- Establishment and recomposition of sculptures
- Recomposition of the mortar joints of the blocks
- Consolidation and fissure sealing

The techniques used for the restoration of the vault respect what for centuries has proved durable (Robador, 2002). The materials and techniques used originally that were effective have been reproduced. Traditional materials were used in the vault such as lime mortars and protective glaze.

In this project those elements were adapted (nature and composition) for each function: strengthening, restructuring, sealing, sealing and being compatible (physically, chemically and mechanically) with the stone.

The technique of applying lime mortars in thin layers remains one of the protection systems available in the art of creating and preserving this master vault, providing protection, light and color to its architecture.

References

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