



## POLYCHROMY OF LATE GOTHIC CIVIL ARCHITECTURE: A WORLD HERITAGE MONUMENT CASE IN SPAIN

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### ABSTRACT

The Silk Exchange of Valencia, Spain, is one of the best examples of late Gothic civil architecture in Europe, and was declared a World Heritage Monument by UNESCO in 1996. Prior to cleaning and conservation, technical examination identified the original pigments used to paint the walls, keys, vaults, arches and columns in the main hall, the Contract Hall. Cross sections of remnants of original colour (blue, green, red, gold, etc.) were investigated with optical microscopy, scanning electron microscopy with energy dispersive X-ray analysis, X-ray diffraction techniques and UV light. The study has revealed that the original paint today remains only in very limited areas. Evidence for a later maintenance operation of repainting was also found in the inscription that runs around the Contract Hall. The information has been very useful for deciding on the cleaning and conservation process.

**KEYWORDS:** Historical buildings, Pigment analysis, Repaints, SEM-EDX, Walls paintings, World Heritage Monument.

## INTRODUCTION

Built heritage can be subject to severe deterioration and in many cases successive interventions throughout its life, which are not always documented.

Preliminary analytical study of the original materials, (colour, pigments, binders, salts, etc...) is of great importance in the restoration of heritage monuments. Information obtained by analytical techniques is not limited exclusively to characterize the materials used, but in this study process is usually discovered earlier interventions are difficult to detect if not made these analytical.

Before describing the Silk Exchange building itself, it is useful to include a few brief notes about the city of Valencia, Spain, in the fifteenth century. It was a time of extraordinary artistic and literary development and of such commercial prosperity in Valencia that commerce became the basis of economy as the city became a fundamental point of exchange in the Mediterranean area. The City council (Consell General de la Ciutat) decided to build a sumptuous building to replace the old merchant's exchange building (Antiga dels Mercaders) which existed around 1344 or 1346. The Silk Exchange, built between 1483 and 1548, is a late Gothic style civil building in the city centre that, as its name suggests, was originally used for trading in silk (Fig. 1).



Figure 1. Main façade of the Silk Exchange (Valencia, Spain).

The Silk Exchange was declared a World Heritage Monument by UNESCO in 1996 because "the site is of outstanding universal value as it is a wholly exceptional example of a secular building in late Gothic style, which dramatically illustrates the power and wealth of one of the great Mediterranean mercantile cities" (UNESCO).

Construction officially began in 1483 as stated on the shield or coat of arms on the southeast corner of the building which reads "the noble city of Valencia with the desire to finish my excellency, began me on the fifth of February 1483". The building occupies a rectangular plot.

The Contract Hall was built in only fifteen years (1483–1498) hence the Latin inscription written in gold letters in a band running along all four walls extolling the union of ethics and economy: *Inclita domus sum annis aedificata quindecim. Gustate et videte concives quoniam bona est negotiatio, quae non agit dolum in lingua, quae jurat proximo et non deficit, quae pecuniam non dedit ad usuram eius. Mercator sic agens divitiis redundabit, et tandem vita fructur aeterna*, (I am a famous house which was built in fifteen years. Fellow-citizens, try, and see how good is trade whose words are without fraudulent intent, that swears to its neighbour and does not fail him, that does not give up its money in usury. The merchant who lives in this way will abound in riches and in the end will enjoy eternal life).

The Contract Hall is a magnificent hall, in Flamboyant Gothic style like the rest of the ensemble. The interior is divided into three main aisles by five rows of slender spiral columns ending in elegant vaults. The Contract Hall (35.60m x 21.39m x 17.40m height) is also called the "Hall of Columns" due to its 24 spiral columns, 8 slender freestanding columns and sixteen columns embedded in the paraments of the hall (Fig. 2-a). The simplicity of the plain walls is only interrupted by a broad horizontal band at 11 meters high (Fig. 2-b).



**Figure 2:** a) The Contract Hall. b) Horizontal band in the Contract Hall.

This magnificent building was and is a building of great importance and content. Now it is used for exhibitions, conferences and other cultural activities.

The use of bush-hammering during late nineteenth and early twentieth restoration almost completely removed any paint from the stone. The object of this paper is the study of original polychromy of walls, columns, keystones, vaults, arches and the band around the walls of the Contract Hall in the Silk Exchange building, Valencia, Spain. The study used different analytical techniques well suited for characterizing the inorganic pigments used in wall paintings in some historical Gothic buildings in the Mediterranean area (Manzano et al., 2000; Rampazi et al., 2002; Roascio et al., 2002; Genestar and Pons, 2003; Ajó et al., 2004; Katsibiri and Boon, 2004; Casadio et al., 2005; Fiorin and Vigato, 2007; Skapin et al., 2007a; Daniilia et al., 2008; Skapin and Robret, 2010b; Durán et al., 2011).

## MATERIALS AND METHODS

The study used optical microscopy, scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDS), X-ray diffraction (XRD) techniques and ultraviolet illumination.

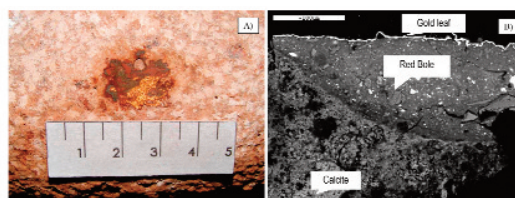
Micro-samples of small fragments of pigment and ground from around already damaged areas were mounted in epoxy resin (SpeciFix-40) and polished as cross-section to obtain stratigraphy of the layers. Samples were examined with a Nikon SMZ 10A optical microscope. For SEM-EDS analysis, samples were vaporised with carbon to make the material conductive.

Pigment elemental analysis was carried out using a JSM-6300 scanning electron microscope operating at 20 kV, with backscattered electron mode under vacuum, equipped with a Link energy-dispersive X-ray microanalytical system, lifetime 100 s. The software was Oxford Link Isis. Crystalline compounds were determined using a Philips (PW1830) XRD diffractometer with X'Pert software.

Ultraviolet illumination was used to detect possible repaints in the inscription that runs around the Contract Hall.

## RESULTS AND DISCUSSION

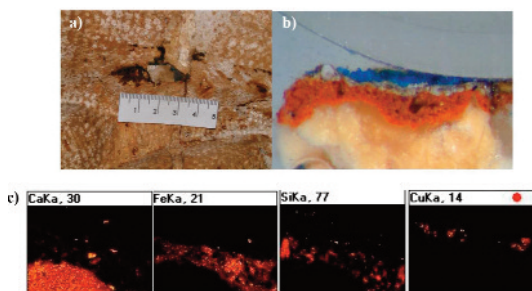
The presence of gold leaf was observed in traces of paint on arches, vaults, and keystones, always on red bole (Fig. 3a-b). Red bole, also known as Armenian bole is an iron-rich material (hematite compound) particularly suitable for applications such as substrates for water gilding where a high surface polish is required. This finding is in line with bibliographic documentation stating that the Contract Hall was built with terraces and in 1516 the vaults were damaged by humidity caused by infiltration from the roof. A tile roof was constructed to prevent further damage and the master Anthoni Ribesaltes was given the task of repainting. After the intervention, the keys and arches were coated with gold leaf.



**Figure 3:** a) Gold over red bole (scale in cm). b). Cross section. Backscattered electrons image.

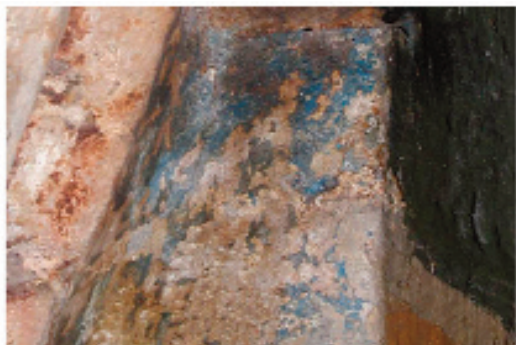
Blue pigment remnants corresponding to azurite pigment were observed in the keys and vaults on a thin white lead layer. The Fig. (4) shows the distribution of elements in a sample. According to

documentation in 1498 the vaults were painted with gold stars on blue by master Marti Girbes to simulate the sky (a common practice in similar Gothic buildings).



**Figure 4:** a) Colour remnants (scale in cm). b) Microphotography 50X. c) Mapping of elements Ca, Fe, Si and Cu.

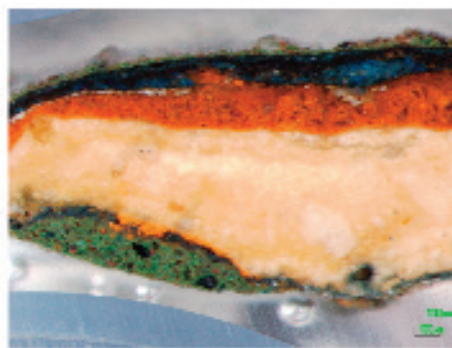
Green remains have been found in some arches corresponding to copper-based green pigment (malachite or verdigris) on white lead layer and remnants of some undocumented geometric decoration. Traces of blue (azurite) and red (vermilion) were found in columns with no previous documentation of polychromy (Fig. 5).



**Figure 5:** Colour remnants in column embedded in the wall.

As regards the inscription around the Contract Hall, an original band was found under the repainted one which is currently observed. Sample analysis has allowed a comparative study of both bands, establishing similarities and differences between pigment compositions. The pigment causing the exterior colour is azurite on a thin white lead layer which gives more light to the overlayer. Azurite

was the most important blue pigment in European painting during the Middle Ages and Renaissance because it produced a beautiful colour and was much less expensive than ultramarine. A greenish colour has appeared on the external pigment layer due to alteration in malachite. This pigment has darkened through exposure to sulphur fumes. Barium sulphate (barite), a compound frequently used as an extender, has been detected. Analysis of the ground white layer shows the presence of calcite. Below this layer, another blue layer was found with a similar composition to the upper blue layer, that is, malachite over azurite. The presence of this new blue layer indicates that a repaint with the same pigment, azurite, was done over the original band (Fig. 6).



**Figure 6:** Superposition of layers in the band.

The cleaning works have revealed the original figures. The design of the upper and lower part of the original band differs from the more recent band. The top part of the original band shows a mixture of foliage and there is a great difference between the bottom parts of the original and repainted bands. The original design had a greater sensation of three dimensions in contrast with the two-dimensional aspect of the more recent band (Fig. 7). The red color in the more recent band is due to hematite pigment, whereas, in the original decoration the red pigment was vermilion. Vermilion is a reddish orange long-lasting pigment with



excellent covering power. It was used throughout Europe from the 12<sup>th</sup> century, although it only became widespread in the 15<sup>th</sup> century when artificially produced alternatives started to become available.



Figure 7: Overpainting of original band (Ramírez et al., 2006b)

Where Latin characters are found the outer layer is made of a copper and zinc alloy known as brass (85% copper, 15% zinc). Brass has a yellow colour, somewhat similar to dark gold. The inner layer is made of yellow bole (goethite crystalline compound) and a ground calcite layer. Gold leaf was found underneath, corresponding to the original Latin characters.

Small differences in calligraphy were found using ultraviolet illumination. The overpainted band is lightly displaced in relation to the original band, whose gothic characters are much purer than the repainted one (Fig. 8).

## CONCLUSIONS

Cleaning and conservation works carried out recently at the Silk Exchange of Valencia,

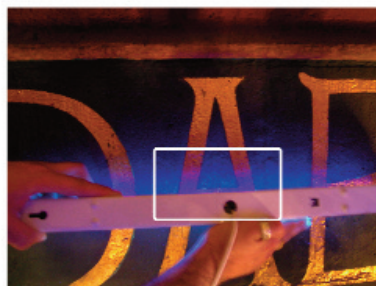


Figure 8: UV illumination of band.

Spain, have enabled study of the pigments used in the polychromy of the Contract Hall. The analytical information on pigments obtained with different techniques has allowed us to complete the documentation on the polychromy of this building and to verify the existing documentation.

In addition, beneath the broad horizontal band with a Latin inscription around the walls of the Hall of Columns a previously unknown original band was discovered with different decoration. The repainted band was probably painted during the late 19<sup>th</sup> Century restoration works. The information has been of great interest as documentation and cleaning to be performed.

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## REFERENCES

- Ajó, D., Casellato, U., Fiorin, E., Vigato, P.A., (2004). *Ciro Ferri's frescoes: a study of painting materials and technique by SEM-EDS microscopy, X-ray diffraction, micro FT-IR and photoluminescence spectroscopy. Journal of Cultural Heritage*, 5, 333-348.
- Aldana, S., (1994). *La Lonja*. Consell Valencià de Cultura, Valencia, Spain

- Almela, F., (1935). *La Lonja de Valencia*. Valencia, Spain
- Bru, S., (1995). *La Lonja de Valencia y su entorno mercantil*. City Council of Valencia. Valencia, Spain
- Casadio, F., Colombo, C., Sansonetti, A., Toniolo, L., Colombini, M.P., (2005). Polychromy on stone bas-reliefs: the case of the basilica of Saint-Ambrogio in Milan. *Journal of Cultural Heritage*. 6, 79–88.
- Daniilia, S., Minopoulou, E., Demosthenis, F., Karagiannis, G., (2008). A comparative study of wall paintings at the Cypriot monastery of Christ Antiphonitis; one artist or two?. *Journal of Archaeological Science*. 35, 1695-1707.
- Durán, A., Perez-Rodriguez, J.L., Jimenez de Haro, M.C., Franquelo, M.L., Robador, M.D., (2011). Analytical study of Roman and Arabic wall paintings in the Patio de Banderas of Reales Alcazares' Palace using non destructive XRD/XRF and complementary techniques. *Journal of Archaeological Science*. 38, 2366-2377.
- Durman, R., (2002). Spiral Columns in Salisbury Cathedral. *Ecclesiology Today*. 29, 26-34.
- Fiorin E. and Vigato P.A., (2007). Teodelinda's tales at Monza Cathedral: A physic-chemical diagnosis of the pictorial cycle. *Journal of Cultural Heritage*. 8. 13-25.
- Genestar, C., Pons, C., (2003). Ancient covering plaster mortars from several convents and Islamic and Gothic palaces in Palma de Mallorca (Spain). Analytical characterization, *Journal of Cultural Heritage*. 4, 291-298.
- Gómez-Ferrer, M. and Zaragozá, A. *Gothic mediterranean*. www.gothicmed.es
- Katsibiri, O. and Boon, J.J., (2004). Investigation of the gilding technique in two post-Byzantine, *Spectrochimica Acta. Part B: Atomic Spectroscopy*. 59, 1593-1599.
- Manzano, E., Bueno, A.G., González-Casado, A., del Olmo, M., (2000). Mortars, pigments and binding media of wall paintings in the "Carrera del Darro" in Granada, Spain. *Journal of Cultural Heritage*. 1,19-28.
- Ramírez, M.J., (1999a). *La Lonja de Valencia y su conjunto monumental. Origen e intervenciones más relevantes: Siglos XV al XX*, Ph.D. Thesis. Polytechnic University of Valencia, Spain
- Ramírez, M.J. et al., (2006b). *Lonja de Valencia. Lonja de la Humanidad*. City Council of Valencia, Spain
- Rampazzi, L., Cariati, F., Tanda, G., Colombin, M.P., (2002). Characterisation of Wall paintings in the Sos Furrighesos necropolis (Anela, Italy). *Journal of Cultural Heritage*. 3, 237-240.
- Roascio, S., Zucchiatti, A., Prati, P., Cagnana A., (2002). A Study of pigments in medieval polychrome architectural elements of "Veneto-Byzantine" style. *Journal of Cultural Heritage*. 3, 289-297.
- Skapin, A.S., Robret, P., Bukovec, P., (2007a). Determination of pigments in colour layers of walls of some selected historical buildings using optical and scanning electron microscopy, *Materials Characterization*. 58, 1138-1147.
- Skapin, A.S. and Robret, P. (2010b). Identification of historical pigments in wall layers by combination of optical and scanning electron microscopy coupled with energy dispersive spectroscopy. *Advances in Imaging and Electron Physics*. 163, 141-163.
- Street, G.E., (1865a). *Some Account of Gothic Architecture in Spain*. Dent, London
- Street, G.E., (1926b). *La Arquitectura Gótica en España*. Saturnino Calleja. Madrid, Spain
- UNESCO. *La Lonja de la Seda de Valencia*. UNESCO World Heritage Centre.