Abstract: During 2016, the Croatian Conservation Institute carried out a demanding conservation and technical research on a 15th century gilded polychrome stone relief from Dubrovnik, attributed to Pietro di Martino da Milano (c.1410-1473). The process proved to be a valuable opportunity to better understand the materials degradation and the techniques used by the Master. Due to the difficulty of determining the existence of impregnation and ground layers, two experimental reconstructions were created as part of a student project – one based on the interpretation of research results obtained during the conservation treatment, and the other based on art technological source research, namely the Cennino Cennini’s recipe, CLXXIV. The aim was to evaluate the effectiveness of these layers on the final gilding and to get an insight into the Master’s experience via the “learning-by-doing” method. The experimental results indicate that the cause of the damages and the consequent fragility of the original relief, might have its origin in the absence of impregnation and ground layers.

Keywords: gilding, stone relief, historically based reconstruction, ground layers, Cennino Cennini’s recipe CLXXIV

Dorado sobre un relieve de piedra del siglo XV de Dubrovnik: estudio técnico vs. Receta de Cennini

Resumen: En 2016, el Instituto Croata de la Conservación, ha levado a cabo un exigente trabajo de conservación y pesquisa técnica, de un alto-relevo dorado del siglo XV, proveniente de Dubrovnik y atribuido a Pietro di Martini da Milano (c. 1410-1473). La intervención, ha probado tratar-se una valiosa oportunidad de mejor entender la degradación de los materiales empleados y de las técnicas empleadas por lo Maestro. La dificultad de identificar la existencia de las camadas de impermeabilización y de preparación, han levado a dúas reconstrucciones experimentales como parte de un proyecto de estudio – una de las reconstrucciones se ha basado en la interpretación de los resultados de pesquisa obtenidos durante la intervención de conservación y restauración, y la secunda en pesquisa histórica y tecnológica, nombradamente la receta de Cennino Cennini, CLXXIV. El objetivo ha sido la evaluación de la influencia de las dos camadas iniciales en el comportamiento del dorado, permitiendo en simultaneo una visión de la experiencia del Maestro, basada en una metodología de “aprender-haciendo”. Los resultados experimentales muestran que la causa de los danos y fragilidad del dorado original, podrán ter su origen en la ausencia de las capas de impermeabilización y preparación.

Palabras clave: dorado, alto-relevo en piedra, reconstrucción histórica, camadas preparatorias, receta de Cennino Cennini CLXXIV

Douramento de um relevo de pedra do século XV de Dubrovnik: estudo técnico vs. Receita de Cennini

Resumo: Ao longo de 2016, o Instituto Croata da Conservação levou a cabo um exigente trabalho de conservação e pesquisa, de um alto-relevo em pedra dourado e policromado, datado do séc. XV, proveniente de Dubrovnik e atribuído a Pietro di Martino da Milano (c. 1410-1473). A intervenção revelou-se uma oportunidade para melhor compreender os processos de degradação dos materiais e as técnicas utilizadas pelo Mestre. A dificuldade em determinar a presença das camadas de impermeabilização e preparação, levaram a criação de duas reconstruções experimentais, como parte de um projecto académico: a primeira reconstrução baseou-se na análise dos exames laboratoriais efectuados durante a intervenção, e a segunda teve por base uma pesquisa histórico-tecnológica, nomeadamente a receita de Cennino Cennini, CLXXIV. O objectivo foi o de avaliar a necessidade das camadas preparatórias no douramento, permitindo ainda experimentar o trabalho do Mestre, na forma de “aprender-fazendo”. Os resultados experimentais apontam para que uma das possíveis causas de alteração do douramento e consequente fragilidade, tenha a sua origem na ausência das camadas de impermeabilização e preparação.

Palavras-chave: douramento, alto-relevo em pedra, reconstrução histórica, camadas preparatórias, receita de Cennino Cennini CLXXIV
Introduction

Over the past few decades, a lot of attention has been given to the research and the preservation of European polychrome and gilded stone altarpieces, sculptures and architectural objects. Although Croatian cultural heritage is rich in these kinds of objects, many of which are dated from the Renaissance period, in the literature there is a significant lack of comprehensive studies on the original construction methodology and polychrome schemes of the surviving artifacts. However, valuable information on material characterization and layer build-up, in particular on isolating sealant and preparatory layers, can be found in Andreuccetti (2008), Brecoulaki (2014), Bordignon et al (2008), Castelnuovo-Tedesco and Soultanian (2010), Skovmøller et al (2016) and Weeks (2006).

A 15th century gilded polychrome stone relief from Dubrovnik, part of a pulpit depicting four Dominican Saints (Peter of Verona, Thomas Aquinas, Vincent Ferrer and Margaret of Hungary), underwent a laborious technical study and conservation treatment in the Split Department for Conservation of the Croatian Conservation Institute in 2016 [Figure 1]. The treatment was carried out with the primary intent to present the relief in its original appearance by removing several campaigns of overpaint. Since the relief was attributed to Pietro di Martino da Milano (c.1410-1473) (Fisković 2003: 29-48), this offered a valuable opportunity for understanding the degradation of the materials he used, as well as the technological choices of the original production. This paper will focus on one particularity of the analytical research – the difficulty of identifying the original isolation and ground layers. The aim is to answer practical questions regarding the construction of the gilding and whether or not this could be the proximate cause for the damage of the original gilding.

Methods

According to Castelnuovo-Tedesco and Soultanian (2010: 229), published studies about the polychrome and gilded stone objects from Italy and France, frequently reveal the presence of a distinct ground, usually identified as lead white, with or without an indication of isolation layer between this layer and the stone surface. They have argued that the lack of a ground layer, as it is presumably the case of the relief from Dubrovnik, is an unusual feature and it may reflect the influence of Venetian practice (2010: 230). This information is very interesting in the context of Pietro di Martino’s working methods.

In order to further investigate this subject, two experimental reconstructions were made using historically informed materials – one based on the information of the paint samples taken during the conservation treatment and the
ORIGINAL POLYCHROMY ANALYSES

<table>
<thead>
<tr>
<th>Technical studies</th>
<th>Location</th>
<th>Detected features/elements</th>
<th>Possible materials/pigments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual observation</td>
<td>Architectural elements</td>
<td>Red layer under the gold leaf, Absence of ground layers (?)</td>
<td>Red clay (bole)</td>
</tr>
<tr>
<td>Cross-section</td>
<td>Flesh tones</td>
<td>As, Pb, Zn, Fe, Ca, Hg, Mn, K</td>
<td>Realgar/orpiment, lead white, azurite/malachite, umber, ochres</td>
</tr>
<tr>
<td>X-Ray Fluorescence</td>
<td>Architectural elements</td>
<td>Fe, Pb, Mn, Ca, Cu, Sr, Ba, Hg</td>
<td>Bole, umber, organic black, calcium carbonate, lead white, azurite, red ochre, vermilion</td>
</tr>
</tbody>
</table>
Table 2: Cennino Cennini’s recipe: analyses and interpretation (Zohil et al. 2019).

<table>
<thead>
<tr>
<th>Course of action</th>
<th>Required materials</th>
<th>Required tools</th>
<th>Noted features</th>
<th>Execution details (Reconstruction No. 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Preparation of the surface</td>
<td>/</td>
<td>/</td>
<td>Procedure: “Sweeping and cleaning the surface of a figure”</td>
<td>Tool: cotton fabric, bristle brush</td>
</tr>
<tr>
<td>a) First layer sizing</td>
<td>Animal glue “usual size”</td>
<td>/</td>
<td>Temperature: “get it boiling hot”</td>
<td>Type of heating: bain-marie</td>
</tr>
<tr>
<td></td>
<td>Linseed oil “cooked and brought to perfect condition of making a mordant”</td>
<td>Dish</td>
<td>Proportions (linseed oil to liquid varnish) - 3:1 - “mix a third of liquid varnish with it”</td>
<td>Cooking time: ca. 15 min</td>
</tr>
<tr>
<td></td>
<td>Liquid varnish (?)</td>
<td>Tamis” (strainer)-for sifting the charcoal</td>
<td>Procedure and temperature: “Boil it all together thoroughly”</td>
<td>Temperature: ca. 60°C</td>
</tr>
<tr>
<td></td>
<td>Pieces of oak “or male-oak charcoal”</td>
<td>or minever or charcoal</td>
<td>Amount of grind charcoal: “make enough of them[siftings] in this way to serve your purpose”</td>
<td>Proportion: 45 ml linseed oil (+ 18 drops of siccative) + 15 ml mastic varnish</td>
</tr>
<tr>
<td></td>
<td>Egg yolk (1)</td>
<td>Sponge</td>
<td>Procedure and temperature: “when it is quite hot, take a dish, put the siftings of the charcoal into it; After this, put this mordant: mix it up well, and apply it:”</td>
<td>Amount of grind charcoal: 4 sticks</td>
</tr>
<tr>
<td></td>
<td>Animal glue (same as above)</td>
<td>/</td>
<td>“Put it [figure] somewhere to dry thoroughly in the wind or sun”</td>
<td>Application: one coat</td>
</tr>
<tr>
<td>2. Impregnation layers</td>
<td></td>
<td></td>
<td></td>
<td>Tool: bristle brush</td>
</tr>
<tr>
<td>b) Second layer</td>
<td>Mordant:</td>
<td>Bristle or minever brush – for application of the prepared impregnation layer</td>
<td></td>
<td>Drying time: ca 14 days</td>
</tr>
<tr>
<td></td>
<td>Linseed oil</td>
<td>(?)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquid varnish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Animal glue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Egg yolk (1/2/3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dust of pounded bricks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ground layers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) First layer</td>
<td>Animal glue (same as above)</td>
<td>Slice (spatula / palette knife)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gesso grosso</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Egg yolk (1/2/3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dust of pounded bricks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Second layer</td>
<td>Animal glue (same as above)</td>
<td>Palm of a hand brush</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gesso sottile or “gilders’ gesso”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Egg yolk (1 - 7)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Poliment – base for gilding
Tempered bole
(same as for panel)

| Proportions (?) |
| Procedure: “lay it with tempered bole as you do on panel” |
| Temperature (?) |

5. Gilding
Gold leaves

| Proportions (gilder’s clay paste mixed with animal glue (7%) in volume 1:2.) |
| Temperature: ca 40°C |
| Tool: kolinsky sable-hair brush |
| Application: two coats |

— Reconstruction No. 2 - based on Cennino Cennini’s recipe (M., CLXXIV)

The historically informed Reconstruction No. 2, was made with ten cutaway sections representing crucial steps of the process described in the recipe [Figures 4 and 5]. Each layer was made following Cennini’s instruction as shown in Table 2. Where original materials could not be found, contemporary equivalents were used. It is important to note that the data omitted within Cennini’s recipe – for example the method for preparing the first impregnation layer, as well as the gesso grosso and gesso sottile – was compensated with the data found in his other recipes for panels and anconas (Cennini 1960: 59, 69-73, 79). The information was also enriched with important findings from other sources (Uzielli 1998, Broecke 2012, 2015).

Results and discussion

How important would have been if Pietro di Martino had used the impregnation and ground layers when gilding the stone relief? The only way to find out was to explore these coatings in two different experimental reconstructions: No.1, executed in the presumed manner of Pietro di Martino, without any intermediate coating between the stone and poliment, and No.2, with six different coatings beneath the poliment as prescribed by Cennini.

Figure 2.- The making process of Reconstruction No. 1: (1) stone carving, (2) poliment polishing, (3) gold leaf application.

Figure 3.- Reconstruction No. 1. Description of the cut-away sections: (1) stone surface, (2) poliment, (3) gilding.

Figure 4.- Reconstruction No. 2. Description of the cut-away sections: (1) stone surface, (2) traces of sculpting tools, (3) first impregnation layer (sizing), (4) second impregnation layer (linseed oil + mastic varnish + charcoal), (5) third impregnation layer (animal glue egg yolk), (6) first ground layer (animal glue + gesso grosso + egg yolk), (7) second ground layer (animal glue + gesso sottile + egg yolk), (8) second ground layer after polishing, (9) poliment, (10) gilding.
Furthermore, both reconstructions demonstrated that the execution time was strongly influenced by the type of the sealant and preparation layers, in particular their drying time. Reconstruction No. 2, with impregnation layers containing linseed oil and egg yolk, was much more time consuming in comparison to Reconstruction No. 1. The heat of the impregnation coatings, frequently emphasized by Cennini, was found to influence the penetration qualities of the coatings, while the charcoal and brick dust affect the colour and the texture. Another noticeable difference was the surface absorption during the application of the red clay (bole) and paint. Reconstruction No. 1, showed reduced levels of absorption in comparison to Reconstruction No. 2. Also, during the application of the gold leaf, Reconstruction No. 1 demonstrated a significantly lower level of adhesion to the surface. Attempts to polish the leaves resulted in cracking due to the limited levels of surface elasticity. Regarding the final appearance, Reconstruction No. 1 scattered more light, owing to the visible texture of the stone, while Reconstruction No. 2 displayed a uniform shine, which emphasized the decorative embellishment of the gold leaf.

**Conclusion**

This project gave a valuable insight into the working process and methods of Early Renaissance sculptural gilding. It has also provided an opportunity to imagine the original embellishment of the damaged areas of gilding.
as well as the highly decorative appearance of the entire relief after its production. In spite of certain limitations of this investigation, the project has demonstrated that the impregnation and ground layers could have been a time-limiting factor for Pietro di Martino. Furthermore, it has indicated that the cause of the damages and fragility of the original relief, might be the absence of these coatings. On the other hand, re-creating Cennini’s recipe illustrated the high level of knowledge and artistic skill needed for this process. In the future, both reconstructions can be analysed and compared as a set of reference samples, to explore chemical interactions and durability of the applied layers.

Acknowledgments

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Both reconstruction projects were carried out as part of the practical course on “Technical analyses and historical reconstructions” at the UMAS, taught by Sandra Sustić, PhD. Co-mentor and consultant on both reconstructions was Vinka Marinković, PhD.

Suppliers

Rabbit Skin Glue (made from rabbit hide). Fine grind (63028). Kremer Pigmente GmbH & Co. KG, Hauptstr. 41 - 47, DE 88317, Aichstetten, Germany.

Linseed oil for oil paint (Art. 5840650). Maimeri (refined linen seed extract). Industria Maimeri S.p.a., Via Gianni Maimeri 1, 20060 Bottelino di Mediglia (MI).

Drying medium for oil painting (Art. 5816626). Industria Maimeri S.p.a.. Via Gianni Maimeri 1, 20060 Bottelino di Mediglia (MI).

Artist drawing charcoal. PENKALA. Tvornica olovaka, školskog i uredskog pribora, Zagreb d.d., Poljačka 56, 10090, Zagreb, Hrvatska.

Mastic Varnish (1:2 dissolved in double rectified turpentine), UV Stabilized (79350). Kremer Pigmente GmbH & Co. KG, Hauptstr. 41 - 47, DE 88317, Aichstetten, Germany.

Knauf Modelliergips. Knauf Gesellschaft m.b.H., Knaufstraße 1, A-8940 Wißenbach bei Liezen, Austria

Charbonnel Gilders Clay: LeFranc & Bourgeois Charbonnel Extra Fine Gilder’s Clay Base (bole premixed with water). Magasin CHARBONNEL 13, Quai Montebello F-75005 PARIS.

Appendix: Cennino Cennini recipe M., CLXXIV (1960: 118-119)

(…) Into your hands comes a stone figure, large or small; you wish to lay it in burnished gold. For this you follow this method: sweep and clean your figure up nicely; then take some of the usual size, that is, of the strength with which you gesso anconas; and get it boiling hot. And when it is boiling so, put a coat or two of it over this figure, and let it dry out well.

After this, take pieces of oak or male-oak charcoal, and pound them; and take a tamis, and sift the dust out of this charcoal with it. Then take a sieve fine enough for grain such as millet to go through, and sift with charcoal, and put the siftings aside; and make enough of them in this way to serve your purpose. When this is done, take the linseed oil, cooked and brought to perfect condition for making a mordant, and mix a third of liquid varnish with it. Boil it all together thoroughly.

When it is quite hot, take a dish; put the siftings of the charcoal into it. After this, put in this mordant: mix it up well, and apply it with a good-sized bristle of minever brush evenly to every part, and all over the figure or other job. When you have done so, put it somewhere to dry thoroughly in the wind or sun, as you please.

When your figure is good and dry, take a little of this same size. Put into it, if there is one glassful of it, one yolk of egg. Mix it up well; and while quite hot, take a bit of sponge; soak it in this tempera, and, with sponge not too full, wipe and rub over every place to which you applied the mordant and the charcoal.

(…) Then when you wish to go on with your work, take gesso grosso and size, tempered in the same way you gesso the flat panel or ancona, except that I want you to put in, according to the quantity, one or two or three egg yolks; and then lay it over the job with a slice; and if you mix up with these things a little dust of pounded bricks it will be so much better. And apply this gesso two or three times with a slice, and let it dry thoroughly.

When it is perfectly dry, scrape it and clean it up, just as you do on panel or ancona. Then take gesso sottile or gilders’ gesso, and temper and grind this gesso with the same size, just as you do for gesso on panel, except that you must put in a certain amount of egg yolk, not so much as you put into gesso grosso, and begin by putting the first coat on, lay the gesso with a brush, four or six coats, just the way you apply gesso on panel, with the same method and
References


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