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The Universitat Politècnica de València, Valencia, Spain, hosted the 2021 Conference of the RECH Group, which took place from 04th to 06th November. The RECH Meeting is the only Biannual conference about Chromatic Reintegration and is organized by RECH Group in collaboration with another host institution. The RECH6 was organized by the Instituto Universitario de Restauración del Patrimonio (IRP). This sixth conference was held in a completely digital environment due the effects of the disruptive era of COVID-19.

The RECH Group would like to express their gratitude to the Conference committees and to all the people and institutions that, in various ways, make possible the Conference. However, special thanks are due to Executive Committee, from the Universitat Politècnica de València, Spain, in the names of Antoni Colomina Subiela, Beatriz Doménech García, Ignasi Gironés Sarrió and Mónica Espí Pastor, and to Francisco Juan Vidal, atual director of Instituto de Restauración del Patrimonio, Universitat Politècnica de València, for hosting and supporting the Conference. Lastly, we would like to thank all the conference participants for their contributions which are the foundation of this conference.

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AUTHORS INDEX

FOREWORD

It is now fully accepted that chromatic reintegration is a discipline of great interest, a scientific study about colour itself, methods and techniques to apply that colour. The history of the chromatic reintegration is probably as old as artworks creation. In the beginning often driven by the painters and artists, now performed by conservators-restores, involving physicians and other scientists or investigators. But the decision to reintegrate or not to reintegrate is usually more complex than yes or no. As stated by Helmut Ruhemann and Friedländer there is for each case, for each work, a new solution, which will satisfy both the public, which seeks aesthetic sensation, and the conservation and restoration professional. However, it is important to note that this issue depends on the socio-cultural environment in which it is set.

The chromatic reintegration is relevant not only for the conservation and restoration, but also for all the people that want to see an object without colour losses. RECH6 aimed at promoting forward-looking approaches that combine engagement and enjoyment with effectiveness in developing knowledge and skills, and hence fostering ways of overcoming the challenges that the area has been facing. The Meeting was a forum to enhance deep and multicultural discussions on issues like: Contemporary criteria on chromatic reintegration, Chromatic reintegration: museums and private context, Documentation of chromatic reintegration process, Materials and techniques experiences, Digital technologies as resources for the chromatic reintegration process. The panels offered an opportunity for getting some insight into ways forward regarding the challenges that chromatic reintegration face in the present century. Thirty-seven communications and fourteen posters were presented at the Meeting. The full papers that are present in these proceedings were double blind refereed by members of the Scientific Committee and many of them were reviewed and improved by their author(s) before being accepted. Altogether, they offered a rich and multifaceted picture of the Conference theme. Is important to mention that the content and ideas conveyed by them as well as the language used are the authors' own responsibility.

Ana Bailão
Founder of RECH Group

INDEX

TOPIC 1: Contemporary criteria on chromatic reintegration

TOPIC 2: Chromatic reintegration: museums and private context

TOPIC 3: Documentation of chromatic reintegration process

TOPIC 4: Materials and techniques experiences

RECH 6
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TOPIC 1

Contemporary criteria on chromatic reintegration

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THE SILVER LINING: PRELIMINARY RESEARCH INTO GOLD-COLOURED VARNISHES FOR LOSS COMPENSATION IN TWO 19TH CENTURY SILVER GILDED FRAMES

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ABSTRACT

Golden varnishes appear on frames, furniture, wall hangings, leatherwork, panel paintings, mural paintings, and polychromy, and were applied to white metal gilding to imitate gold and other semi-precious materials. Despite the number of examples in cultural heritage there are few publications that discuss the ethical considerations of treating coloured silver gilded surfaces. The chromatic reintegration of gold-coloured varnishes on white metal gilding present specific material and technical challenges. In 2021 the Art Gallery of New South Wales (AGNSW) treated two identical late 19th century silver gilded frames for portraits by Joseph Backler from the Australian collection. In addition, a third portrait required the fabrication of a reproduction frame identical to the others. Conservation of the frames presented an opportunity for carrying out experiments into coloured coatings for loss compensation on silver gilding exploring applications for select conservation paints, dyes, and synthetic resins as substitutes for shellac. The results of experiments demonstrate that with the right application Liquitex Soluvar Gloss Varnish, Laropal A81 and Paraloid B72, present gloss levels and visual film forming properties comparable to shellac coatings when applied to burnished gilding. Additional tests with various dye colours illustrate that Orasol ® dye mixtures in colours Yellow 2GLN, Yellow 2RL, and Brown 2GL are reliable colour imitations for traditional gold-coloured varnishes. Although this research is preliminary, it may inform the selection and application of appropriate retouching materials for compensating losses to burnished silver leaf and golden varnishes in gilding conservation.

Keywords. Golden varnish; Silver gilding; Golden ® MSA; Orasol ® dyes; Gilding conservation; Frames conservation.

1. INTRODUCTION

1.1 Background

The imitation of gold using coloured varnishes applied to silver and tin leaf has been practiced since antiquity. The earliest documented recipes for golden varnishes record the use of egg yolk, animal glues, gums and drying oils mixed with organic dyestuffs, inorganic pigment, and animal bile [1] [2] [3]. From the 17th century permutations of recipes expanded to include spirit-based natural resin and shellac varnishes that became very popular during the 19th and 20th centuries. Shellac was popular for its ability to form a fluid, durable, and flexible high gloss finish and for its inherent yellow and orange lac dye present in unrefined grades of shellac [4]. The shellac could be further doctored with synthetic dyes making it a versatile gold-coloured varnish material. As shellac ages it becomes more permeable to water and increasingly yellowed, embrittled, and less soluble [5] complicating its removal from cultural materials [6] [7]. The use of shellac to replace varnishes on gilded surfaces is less recommended with respect to contemporary conservation ethics of reversibility, of differentiation of original from interventions, and in consideration of its poor long term ageing properties.

Whilst it is true that silver and tin gilding was intentionally used in some cases for mechanical strength and decorative effect [8] [9], reducing the

costs of gold is perhaps the most recognised reason for the widespread establishment of these surrogate gilding techniques. Traditionally, the gilding was burnished to a mirror finish before applying a coloured varnish although matte gilding was also used to create a satin finish to contrast with burnished passages. This gilding scheme is prevalent in Baroque and Rococo polychromy and for period gilded frames.

Several authors have discussed silver leaf gilding in particular reference to Latin America, Northern Europe, Portuguese, and Spanish religious art [10] [11] [12] chartered the development and material evolution of some coloured varnishes for silver leaf in Europe with a focus on 16th-18th centuries and earlier period treatises [13] [14]. It is recognised that due to the ability for these coloured gilding schemes to go undetected, there is growing interest in the microanalytical identification and characterisation of faux gold gildings [15] [16] [17] [18] [19]. Case studies that examine compensating losses sustained to original-coloured coatings on gilded objects using non-traditional materials and methods is not as researched in practice.

Treatment approaches to compensating losses to these types of gilded surfaces can be daunting. In addition to finding compatible coloured varnish systems suitable for gilding, there are challenges of surface preparation and application of materials which have a significant impact on the intended surface effect. On the flat areas of frames the distinctive lay lines from gilding are visually apparent, especially if areas are tarnished or the coloured coating has faded. The in-gilding and in-glazing of losses without causing brush marks or shifts in tone and colour convergences is technically demanding. Depending on the condition of the gilded object, conservators may need to replace or infill multi preparatory layers for water gilding, select a suitable metal leaf replacement for in-gilding silver, choose appropriate gilding techniques, and may need to burnish passages before a coloured varnish can even be considered. These foundation layers are critical to the visual success of a highly reflective surface that creates the illusion of burnished gold.

1.2 Research aims

In 2021 the AGNSW treated frames for two 19th century Victorian family portraits titled Portrait of a young girl with flowers (1861) and Portrait of a young girl holding a book (1861) by Joseph Backler. The frames are silver gilded on black bole with thin matte gilded slips with burnished cavetto, and burnished primary moulding with pressed metal ornament relief corners. The golden varnish medium on both frames was identified as orange shellac through complimentary analyses of Fourier Transform Infrared Spectroscopy (FTIR) and ultraviolet light cross section microscopy (Figure 1).

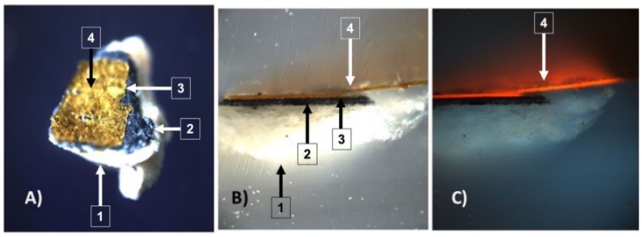

Figure 1 – Cross-section sample of frame for Portrait of a young girl holding a book. (A) sample viewed under stereomicroscope before embedding in cross section, (B) cross section of sample under visible light x400 magnification, and (C) cross section viewed under ultraviolet light x400 magnification. Sample shows stratigraphy of gesso ground (1), black bole (2), silver leaf (3), and orange shellac (4).

The frames had sustained losses to gesso, bole, silver gilding, and shellac coating, and areas of silver leaf had tarnished beneath the golden varnish. The frame for Portrait of a young girl holding a book had lost its original slip. To determine a treatment approach to compensate losses to ground, gilding, and original golden shellac varnish, several experiments were carried out on traditional water gilded sample mock-ups and metal token samples gilded non-traditionally [20] using aluminium leaf. Tests were carried out with various paints, dyes, and resin materials as substitutes for shellac, and a third portrait in the series required a reproduction frame identical to the original frames.

2. MATERIALS AND METHODS

2.1 Criteria for selecting materials for experiments

There are stable synthetic resins commonly used as picture varnishes in conservation that possess relatively low molecular weights and high refractive indexes which give optical properties to the coating akin to natural resin varnishes [21] [22]. Such resins may be suitable to imitate shellac however the difficulty is in finding a combination of resin, solvent, and colourants that are compatible in a system more optimal for gilding. Systems of lower polarity are better suited for gilding preparations which can be sensitive to more polar solvents [23] [24] [25]. Such considerations are important not only for application but also for any possible future removal of these coatings. If using dyes in resin formulations, it is necessary to select a solvent of intermediate or higher polarity to form a stable emulsion with even colour dispersion as more polar solvents are required to satisfactorily wet pigments and dyes in solution. Orasol® dyes have applications in conservation treatments to imitate coloured lacquer [25] and depending on the colour, they have demonstrated results of very good or excellent lightfastness [26]. Their disadvantage is that they are soluble in lower alcohols, glycol ethers and ketones [27] which are more polar solvent systems. Some paints developed for conservation use such as Gamblin colours and Golden ® Mineral Spirit Acrylics (MSA) are soluble in low polar solvents and compatible with Liquitex Soluvar varnishes as they are based on similar poly (n-butyl methacrylate) polymers [28] so could be said to be preferable for gilded surfaces.

Materials were selected to test based on the following criteria:

- stable and reversible with no observable visual change to the gilding;
- lower polarity system preferable;
- colour match with the original surface;
- workable consistency of application: good levelling or brushing, colour dispersion, adhesion, saturation, and clarity;
- suitable for mirror (burnished) and satin (matte) finish;
- retain lustre of burnished gilding after applying coloured coating;
- appropriate finish in one level application or ability to layer to the correct finish;
- possibility for additional isolation layer over original gilding, before application of coloured varnish.

2.2 Preparation of traditional water gilded samples

Traditional water gilded samples were constructed from blocks of radiata pine sealed with 1-2 coats of rabbit skin glue: water size (1:6) followed by the application of between 10-15 coats of traditional gesso prepared with calcium carbonate with 8wt% - 5wt% (w/v) rabbit skin glue: water. The gesso was strained through cotton gauze before being brush applied to the sample, left to dry between each subsequent layer, water applied to reactivate gesso for wet sanding, left to dry and then further sanded until smooth. The final few coats of gesso, once brush applied, were smoothed with fingers to reduce air bubbles before final dry sanding. A size layer of gelatine: water (1:14) was applied to seal the surface followed by between 6-12 coats of black bole prepared with gelatine size between 1:14-1:20. The bole was also strained through cotton gauze to refine consistency, brush applied to the surface, left to dry between each layer then sanded to a polished finish with nylon scourger and wiped with microfibre cloth to remove residues. A 10% (v/v) ethanol: water solution was applied with a synthetic sable brush followed by application of loose metal leaf applied with gilders tip. For tests, several metal leaf types were experimented with for colour matching the frames including: 13ct white gold, 18ct gold**,** 16.7ct green gold**,** 20 ct citron gold**,** 23ct gold leaf. Samples of silver leaf gilding were also prepared for reference. The gilding was tampered with cotton wool and after touch dried some samples were burnished with agate while others were left matt.

2.3 Preparation of non-traditional gilded samples

A set of small metal tokens were gilded non-traditionally, coated with one layer of acrylic dispersion Plextol B500 (ethyl acrylate and methyl methacrylate co-polymers) diluted 2:1 with water: ethanol (4:1) that was brush applied, activated with exhalation, and gilded with aluminium leaf. To compare the appearance of traditional silver gilding with non-traditional aluminium gilding on the same traditional ground preparation the following sample was prepared: traditional sample water gilded with silver leaf and burnished on one half of the sample whilst the other half of the sample was non-traditionally gilded with aluminium leaf on dilute Plextol B500 (Figure 2A).

Table 1.1 – List of varnish materials tested in experiments on gilded samples

Material	Polymer classification	Preparation
Laropal ® A81 (BASF)	urea-aldehyde resin	20% (w/v) 1-methoxy-2-propanol or M-xylene
Paraloid B72 (Rohm and Haas)	copolymer of ethyl methacrylate (EMA) and methyl acrylate (MA)	20% (w/v) 1-methoxy-2-propanol or M-xylene
Liquitex Soluvar Gloss Varnish	n-butyl and isobutyl methacrylates-combination of Paraloid B-67 and F-10.	direct with paints
Liquitex Soluvar Matte Varnish	n-butyl and isobutyl methacrylates, fumed silica	direct with paints
Golden ® Polymer Gloss Varnish with UVLS	methyl methacrylate and n-butyl acrylate copolymer emulsion	direct with paint
Reglarez 1094	hydrogenated hydrocarbon resin	white spirits with 2% (v/v) HALS Tinuvin ® 292
Arkon P-90	hydrogenated hydrocarbon resin	20% (w/v) white spirits

2.4 Materials selected for experiments

The varnish materials selected for experiments are presented in table 1.1 and the paint and dye materials tested in the experiments are presented in table 1.2. For initial experiments paints were thinned with solvent, mixed with proprietary varnishes, and mixed with resin varnish solutions of Laropal ® A81 and Paraloid B72 prepared at 20% (w/v). Solutions of Regalrez 1094 and Arkon P-90 were also prepared with addition of 2% (w/v) hindered amine light stabiliser (HALS) Tinuvin ® 292. The elastomer Kraton™ G1650 was

Table 1.2 – List of paints, pigment and dyes tested in experiments on gilded samples

Material	Polymer/pigment classification	Colours
Golden ® Mineral Spirit Acrylics (MSA)	poly (n-butyl methacrylate)	Quinacridone Red Light (PR 207), Quinacridone Gold (PO48), Nickel Azo Yellow (PY150), Burnt Umber Light (PBr7), Carbon black (PBk7)
Gamblin colours	urea aldehyde paints	Transparent Earth Red (PR101), Transparent Earth Orange (PY42/ PR101), Transparent Earth Yellow (PY42), Indian yellow (PY83), Ivory black (PBk9)
Golden ® PVA colours	Vinavil ® Raviflex BL5S poly (vinyl acetate) polymer	Nickel Azo Yellow, Quinacridone Gold, Quinacridone Red, Quinacridone Nickel Azo gold
Golden ® High Flow Acrylic (HFA)	acrylic emulsion paint (polymer unspecified)	Quinacridone /Nickel azo gold
Ciba Geigy Orasol® dyes (BASF)	metal dye (1:2 chrome or cobalt complexes/metal free monoazo dye -Yellow 4GN)	Yellow 4GN (Yellow 146), Yellow 2GLN (Yellow 88), Yellow 2RLN (Yellow 89), Brown 2GL (Brown 42), Brown 6RL (Brown 44), Orange G (Orange 11)
Ciba Geigy Microlith ® dye	diarylide yellow with ethyl cellulose carrier resin	Yellow R-2A (Yellow 1550)
Dragon's Blood dry pigment		

omitted from the varnish used in experiments due to unavailability of the material during tests. As these varnish solutions are not compatible with any colourants they were tested as clear top coatings superimposed on other materials. Further experiments conducted after treatment of the frames explored applications of Orasol ® dye tinted resins. Each dye colour with the addition of dragon's blood dry pigment was mixed at 3wt% dye to 20% (w/v) resin varnish solutions. Dyes at 1% (w/v) and 0.5% (w/v) concentrations were also tested to compare for colour strength.

3. RESULTS AND DISCUSSION

3.1 Compensating gilded losses on original frames

Initial investigation into the frames revealed that the ground layers were able to be burnished through the shellac coating in adjacent areas of loss. Taking advantage of this, it was decided to fill the lacunae with gesso and bole in preparation for traditional water gilding. This method enabled a more seamless transition to the correct level of reintegration with the existing burnished leaf without any need to artificially recreate surface shine through non- traditional gilding methods. Although various metal leaf gilding was considered the aluminium leaf appeared dull when compared with burnished silver (Figure 2A). 20ct citron leaf whilst closer in hue to the golden varnish, was by itself not adequate to simulate the appearance of a golden varnish. When colour was then later tested on citron gilding it lacked the depth and clarity achievable on white metal. It was ultimately decided to in-gild the frames with the 13carat white gold leaf (figure 2B). This was a very close match for the frame slips where the coloured coating had presumably faded, and it was the closest substitute for silver leaf while being comparatively more stable.

3.2 Reproduction frame for the third Backler painting, Portrait of Elizabeth Collins (1861)

The reproduction frame for the third painting, Portrait of Elizabeth Collins (1861) was constructed by AGNSW Reproduction Frame maker to the same design as the original frames and water gilded with the same white gold leaf used to in-gild the sister frames. In keeping with traditional period frame making practices, the golden varnish was formulated from shellac coloured with spirit-based dyes (figure 3). White lac was used to ensure better clarity based on experiments carried out on gilded samples with shellac reference materials, this was the best likeness for the original shellac and provided an additional reference for colour matching a coloured coating system for the two original frames.

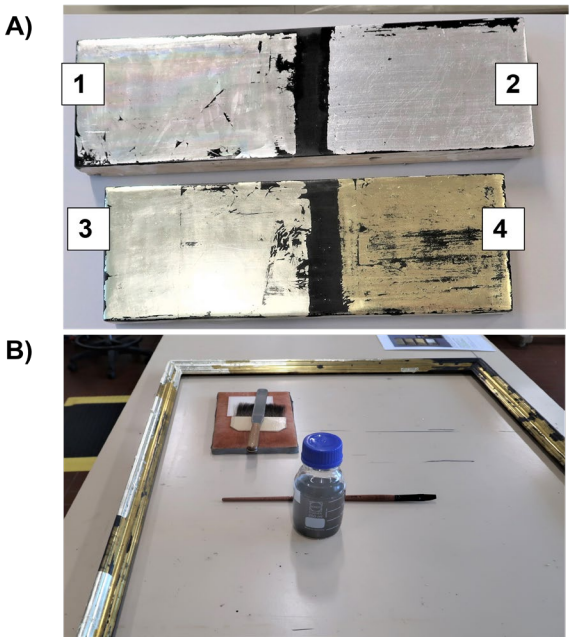

Figure 2 – A) Samples of various metal leaf tested in experiments. (1) burnished silver leaf, (2) aluminium leaf, (3) burnished 13ct white gold, (4) burnished 20ct citron gold. B) in-gilded frames with burnished 13ct white gold leaf

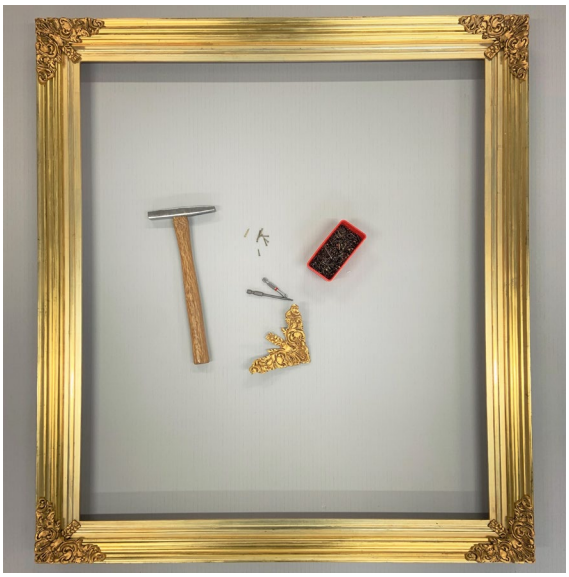

Figure 3 – Reproduction frame for the third Backler painting, Portrait of Elizabeth Collins (1861)

3.3 Results of tests into coloured coatings and varnishes

The results of gold-coloured varnish systems tested in experiments are presented in table 2. Most paint systems performed to a certain degree for golden colour depending on the desired hue but generally have a more limited colour selection and performed less well for saturation and clarity when compared with dye tinted resins. The application of a clear top coat of Regalrez 1094 or Arkon P-90 varnish whilst introducing gloss did little to improve clarity, and over top of Soluvar Gloss varnish , A81 and B72 did not have a demonstrable change to gloss levels.

3.3.1 matte gilding

The Golden ® PVA and MSA paints performed the best for a matte finish. The PVA paints were weakly saturated, had fewer colours for accurate colour matching in addition to requiring polar solvent. A top layer of Regalrez 1094 and Arkon P-90 over the PVA paints increased gloss and marginally improved saturation but did not achieve the right level of depth and clarity. MSA paints thinned with mineral spirits or Shellsol D40 produced sheer light golden washes. MSA paints with Soluvar matte varnish produced similar results. Both were appropriate to apply to matte gilding although when used without varnish brush marks were visible. In the case of the Backler frame slips this was an advantage as the original coating also had brush marks.

Table 2 – Results of experiments evaluating the appearance of gold-coloured coatings on gilded samples

Sample[1]	**Material**[2]	**Results**[3]				
		colour	***saturation***	***layering***	***sheen***	***clarity***
		Reference samples				
TS/b/silver leaf TS/b/13ct TS/m/13ct Token	Orange shellac	GY	S/V	N	G G M G	CD* CD* CD CD*
TS/b/silver leaf TS/b/13ct Token	Coloured lac	E	S/V	N	G	C
		Initial experiments				
TS/b/13ct TS/m/13ct Token	MSA	GD	W	N	M	CD
TS/m/13ct Token	MSA/SM	GD	W/V	Y	M	CD
Token TS/b/13ct TS/b/20ct TS/b/23ct	MSA/SG	GD	W/V	Y	G	SC
TS/b/13ct	MSA/SG +	GD	W/V	Y	G	SC
Token	MSA/SG/ Regalrez	GD	W/V	Y	G	SC
TS/b/13ct Token	Gamblins/SG	L	M/V	Y	G	SC/CD
TS/b/13ct	Gamblins/A81	L	M/V	N	G	SC/CD
TS/b/13ct	Gamblins/B72	L	M/V	N	G	SC/CD
Token	PVA	L	W	N	M	CD
Token	PVA-A81	L	W	N	SG	CD
Token	PVA-B72	L	W	N	SG	CD
Token	PVA/Regalrez	L	W	N	G	CD
Token	PVA/Arkon P90	L	W	N	G	CD
	PVA-B72/Regalrez	GD	W	N	G	CD
Token	HFA	GY	M/V	Y	G	C
Token	HFA-B72	GY	M/V	Y	G	C
Token	HFA-PGUVLS	GY	M/V	Y	G	C
TS/b/13ct	MSA/SG, HFA	GD	M/V	Y	G	C
Token	dyes/pigment-A81	E	W	N	G	C
Token TS/b/13ct	MSA/SG, dyes/pigment/A81	E	GD	Y	G	SC/C
		Further experiments				
TS/b/silver leaf TS/b/13ct Token	dyes-A81 dyes-B72	E	S/V	N	G	C
TS/m/13ct		E	S/V	N	M	CD
TS/b/16.7ct		E	S/V	N	G	C
TS/b/18ct		GD	S/V	N	G	C
TS/b/20ct		TY	S/V	N	G	SC
TS/b/23ct		TRO	S/V	N	G	SC
TS/b/13ct	Iso MSA/dyes-A81	E	E	GD	G	C
	Iso B72/dyes-A81	E	E	GD	G	C

1. TS (traditional water gilded sample), b/ (burnished gilding), m/ (matte gilding) 13, 16.7, 18, 20, 23, (ct gold leaf), Token (non-traditional sample gilded with aluminium leaf on dilute Plextol B500 2:1 water ethanol (4:1).

2. MSA (Mineral Spirit Acrylic), MSA/SG (MSA with Soluvar Gloss varnish), MSA/SG+ (repeated layers), PVA (Golden ® PVA colours), HFA (Golden ® High Flow Acrylic), PGUVLS (Golden ® Polymer Gloss Varnish with Ultraviolet Light Stabilisers, dyes (Orasol ® and Microlith ® dye complexes), 'coloured shellac' (white lac with spirit-based dyes), IsoB72 (Isolation coating of Paraloid B72, Iso SG (Isolation coating of Soluvar Gloss varnish) IsoSM (Isolation coating of Soluvar Matte varnish.

3. L (limited colour selection available to colour match accurately), GY (good colour but can be very yellow), TY (not suitable colour match-too yellow), TRO (not suitable colour match- too red/orange), GD (good selection for colour matching), E (excellent selection for colour matching), N (not able to be layered without resolubilisation), Y (yes can layer the same material), S (strong), S/V (strong/variable), W (weak), W/V (weak/variable), M (moderate), M/V (moderate/variable), G (glossy), SG (semi-glossy), M (matte), C (clear), SC (semi-clear), SC/C (semi-clear/cloudy), CD (cloudy), CD* (can be cloudy unless dry heat applied).

3.3.2 burnished gilding

The MSA paints were difficult to work with when compared to other paint systems, they were very viscous, sticky, and greasy, and problematic to evenly dissolve in varnish even when firmly ground and mixed. It was found that soaking the paint in the varnish over a period of a few days noticeably improved the colour dispersion and ability to brush out. The paints were weakly saturated but had the potential for producing good colour mixes and saturation could be improved when mixed with Soluvar Gloss varnish allowing for subsequent layer applications (waiting minimum 2-3 days in between coats). It was however difficult to retain clarity of the underlining gilding past three applications, and after this the finish was still not complete to fully reintegrate with the original shellac coating.

Gamblin colours mixed with Soluvar Gloss varnish were comparable with MSA paints and Soluvar and presented similar gloss levels. The yellow colours selected in the Gamblin range however produced matt finishes when applied to burnished gilding and without a yellow the resultant colour mixture was too orange to be appropriate for accurate colour matching. It was also not possible to superimpose dye tinted resins over Gamblins as they have the same solubility.

Experiments showed that Golden ® HFA paint tended towards an inherently yellow golden colour that may be too yellow depending on the area to colour match. The paint performed very well for clarity and had good colour saturation and gloss. Its low viscosity was ideal for glazing, it dried fast, and could be layered to deepen the hue. For concerns of its use directly on gilding it could be mixed with B72 varnish or layered successfully over a protective coat of B72 or Soluvar varnish. It also performed very well mixed with Golden ® Polymer varnish with UVLS.

3.4 Results of removability tests after 4-6 weeks

Removability tests were conducted on gilded samples with solvent dampend cotton swabs 4-6 weeks after application of coloured coating. All materials used in tests were removable including the shellac reference samples as these were un-aged. The average removal time was 2-3 rolled passes with swab with little observable change to gilding. The exception was removing shellac on non-traditional aluminium samples, where the methylated spirit swelled the surface and disrupted the gilding in the process of removal. The PVA paints with B72 varnish were found to require more passes as the coating was more stubborn and uneven to remove in the first attempt. It is expected that over a greater period of time these materials would require more passes with solvent swabs or other solvent cleaning systems to remove.

3.5 Compensating losses to golden varnish on Backler frames

3.5.1 retouching matte gilded slips

Based on successful experiments with paints for matte gilding it was decided to use MSA paints thinned with shellsol D40 to colour the in-gilded passages on both slips (figure 4 B). The most successful colour match was achievable with a 2:1 mix of Burnt Umber Light and Nickel Azo yellow.

3.5.2 Combined approach to retouching burnished gilding

The HFA paint was promising for colour, saturation, gloss and ability to layer however considering the extent of retouching required on the frames it was decided to explore potential for dye tinted conservation resins. At the time of treatment the dyes available were

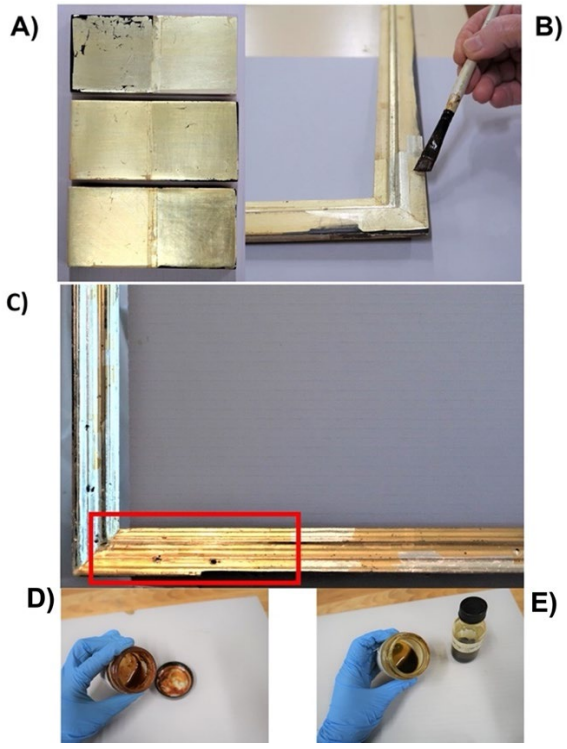

Figure 4 – A) Samples of traditional matte and burnished 13ct gold leaf testing MSA paints. B) Retouching the matte gilded slips with MSA paints. C) Combined approach to retouch burnished passages using MSA with Soluvar Gloss varnish (D) followed by dye/pigment tinted A81 resin glaze (E)

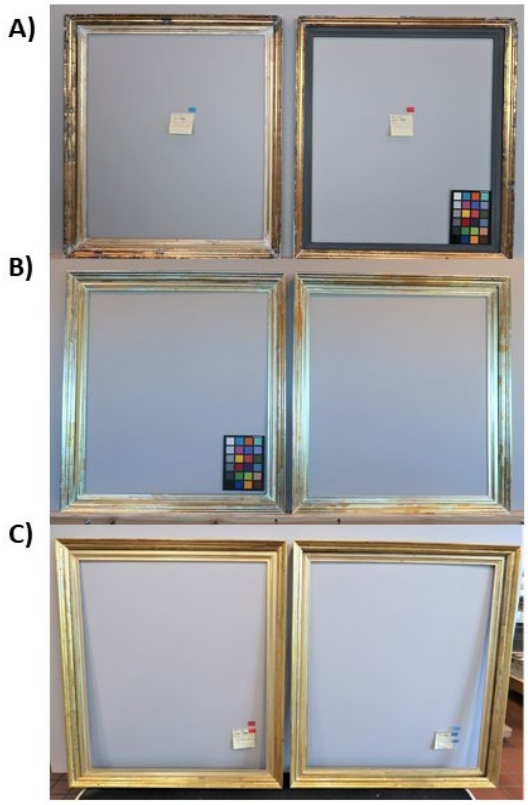

Figure 5 – A) During the treatment to infill and prepare a new slip, B) in-gilding and burnishing and C) after applying golden colour treatment to in-gilded passages.

Orasol ® Brown 2GL and Microlith ® Yellow 2-RA. In the absence of a red dye the dry pigment dragon's blood was added with these in A81 solution to produce a more accurate colour match. The tinted resin had good colour accuracy, gloss, and clarity but when applied on its own was too transparent and did not have adequate coverage to convincingly replicate missing areas of shellac on the frames. It was not possible to layer dye tinted varnishes without risk of resolubilising the previous layer. Tests exploring applying a tinted resin superimposed on top of a previous alcohol insoluble MSA/Soluvar varnish application resulted in improved coverage a good colour match with appropriate clarity. It was therefore decided to use a combination of paint and dye tinted colouring systems to achieve the right level of finish on the frames.

MSA paints mixed with Soluvar Gloss varnish were applied to burnished areas in two thin successive applications (waiting 2-3 days in between) and later followed by a thin application of an Orasol ® and dry pigment tinted Laropal ® A81 resin glaze (figure 4C). It was not possible to completely disguise the appearance of lay lines from gilding or disruptions from tarnishing, however, an application technique consisting of applying colour to the middle of the in-gilded passage and brushing outwards on both sides helped to mitigate this issue, producing a softer transition. This was particularly important for the dye tinted glaze which has less working time and requires rapid and decisive application. The result was less colour convergence with original shellac finish and a more harmonised general presentation (figure 5).

3.6 Further experiments with Orasol ® dye tinted resins

As the dyes demonstrated superior performace for colour saturation and clarity, a number of further experiments were undertaken after treatment of the frames to explore the potential for several of these

dyes for use in future treatments (Figure 6). Both A81 and B72 resins with dyes were comparable, although it was observed that B72 had shorter working time when compared to A81. The consequence is that they could cause visible brush marks an uneven colour dispersion if not applied quickly and evenly. The dyes have a diverse colour palette and were highly saturated requiring very little dye to varnish. The 3wt% dyes were too strongly concentrated and solutions of 1wt% and 0.5wt% dye to resin still retain impressively strong chromaticity. Any one of the dye mixes tested produced a suitable golden varnish although, based on tests, colour mixes of 1:1 Yellow 2GLN (mid shade) and Yellow 2RLN (reddish yellow) had the most promising balance of yellow to orange/red for most accurate mid-shade gold imitation. The addition of dyes such as Brown 2GL (yellow brown) or Brown 6RL (dark red-brown) can modulate the shade to match various colour temperatures of metal leaf, patinated, or aged gilding.

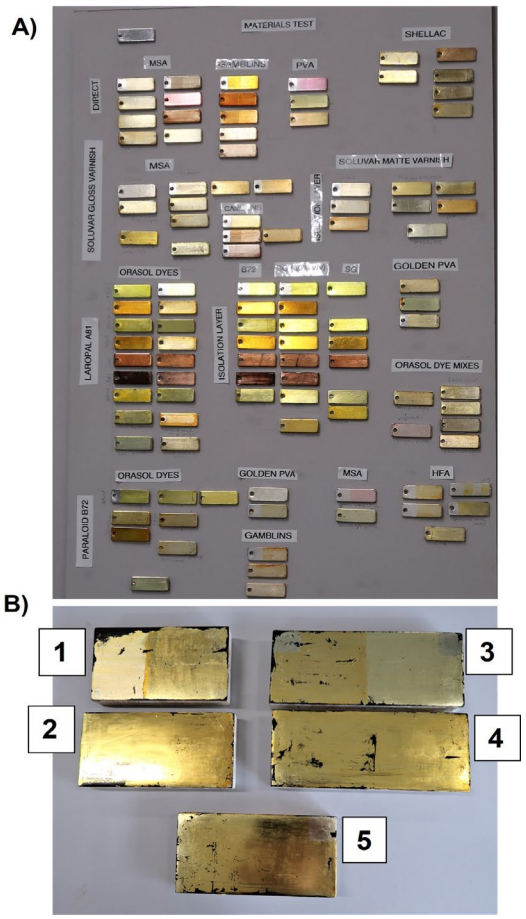

Figure 6 – A) Sample metal tokens gilded non-traditionally with aluminium leaf on Plextol B500, swatch testing each paint and dye colours (in varying concentrations), and colour combinations. B) Traditional water gilded samples prepared with gesso and bole gilded with 13ct white gold leaf and burnished. Comparing coloured coatings of (1) orange shellac (reference sample), (2) coloured white lac (reference sample), (3) combined system of MSA: Soluvar Gloss varnish followed by dye tinted Laropal ® A81 varnish, (4) MSA: Soluvar Gloss varnish (x 3 layers), (5) dye tinted Laropal A81 resin

3.7 Experiment with isolation layers with golden varnish

A traditional 13ct gilded and burnished sample was coated on one side with 30% (w/v) Soluvar Gloss varnish: white spirits and the other side coated with 20 % (w/v) B72: M-xylene. After drying a golden varnish of Orasol ® dyes in Laropal ® A81 was then applied over the top and the results of each side of the sample compared (figure 7). The results show little discernible difference to the quality of the gilding between each side however in the case of the Soluvar Gloss varnish, due to the differing polarities of the varnish and dye resin solution, a slight hydrophobicity of the glaze was observed to occur on the surface. This irregularity is so small and depending on the condition of the gilded surface it may not be noticed. If this is a concern however a very small percentage of wetting agent can be added to the varnish to lower the surface tension of the coloured varnish for better wettability and adhesion. It was observed that the application of an isolating layer improved brushability and adhesion of dye/resin solutions, in addition to protecting the gilding.

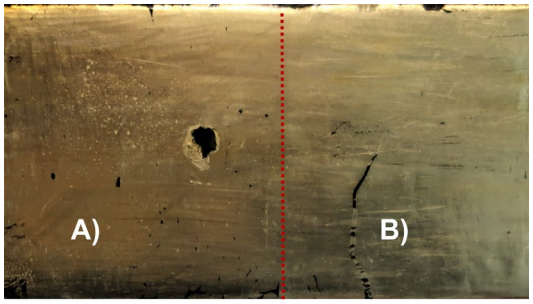

Figure 7 – Isolation layer tests on gilded burnished sample with A) Soluvar Gloss varnish and B) Paraloid B72 after application of A81 dye tinted golden varnish.

4. CONCLUSIONS

The chromatic reintegration of golden varnishes on white metal gilding are technically challenging to treat. As demonstrated through experiments, the qualities of a coloured varnish system applied to gilding, relies on both the underlining gilding preparation as well as the physical and chemical characteristics of the varnish or coating materials and the technique in which it is applied. It is challenging to find varnishes and colourants that are compatible in a system that is optimal for gilding and that satisfies criteria for retouching such a demanding surface finish. With a combined approach however, it is possible to find solutions that may be adapted to suit the treatment context and object requirements.

The result of experiments demonstrates that with the right application, Liquitex Soluvar Gloss Varnish, Laropal ® A81 and Paraloid B72 present gloss levels and visual film forming properties comparable to shellac coatings when applied to burnished gilding. It was difficult to achieve the right colour, gloss, and coverage, while still retaining translucency and clarity with paints and varnishes alone. Most paints tested were found to be weakly saturated when mixed into varnish systems and caused some matting to the surface even if gloss and colour criteria could be satisfied. The exception to this were Golden ® HFA paint which were comparable to dyes for colour saturation and clarity but are an artist acrylic emulsion paint not specifically designed for use in conservation. Golden ® MSA paints were successfully used to retouch the matte gilded slips whilst a combined paints, varnishes and dyes approach was required to unify losses in the original shellac varnish on both frames.

Experiments show that dye tinted resins outperform all materials for colour selection, saturation levels, and clarity but tend to be transparent when used in isolation which can be problematic to achieve correct level of finish. Additional tests with various dye colours illustrate that Orasol ® dye mixtures in colours Yellow 2GLN, Yellow 2RLN and Brown 2GL are reliable colour imitations for traditional gold-coloured varnishes. These qualities were a faithful imitation for the shellac reference samples and reproduction frame.

The results of this research have informed the conservation treatment of the Backler frames while further experiments have identified materials that are applicable for restoring lost golden finishes on both matte and burnished gilding. These dye colours have been recently successfully used in frame treatments in the Art Gallery of new South Wales International collection. Although this research is preliminary, it is hoped that is may inform the selection and application of appropriate retouching materials for compensating losses to burnished silver leaf and golden varnishes in gilding conservation.

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INTERVENTIONS IN URBAN CENTERS: QUESTIONS ABOUT CHROMATIC (DIS)INTEGRATION

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ABSTRACT

This work aims to launch a critical perspective on the intervention actions undertaken lately in the historic center of the city of Uberaba – a medium size city in the countryside of the state Minas Gerais, Brazil. The central region of the city is made up of a set of buildings from the eclectic period that share space with modern buildings around the city's main square – Rui Barbosa Square. This square underwent several changes over time, highlighting the weaknesses in the construction of a heritage landscape in this territory, which supports collective memory. That said, we are interested in the contemporary transformations carried out in this region, which are related to both the market logic and the regulations regarding the clearing up the facades of historic buildings, such as the removal of advertising boards from stores. These reforms introduced new colors to the region, raising questions about the criteria (or lack thereof) for chromatic definition. The appeal to the use of strong colors without surveys or appropriate restoration techniques generates noise in the urban landscape. In this sense, we can ask ourselves if the advance in the promotion of heritage built by the public authorities can result in a tendency to trivialize the urban set. Specifically in this text, we will focus on the analysis of trivialization processes in urban sets of historical interest from the chromatic aspect, using comparative analyses, with structure analysis keys for the development of an initial critique of the cultural heritage in Uberaba.

Keywords
Chromatic reintegration; Urban heritage; Trivialization processes; Uberaba.

1. INTRODUCTION

The revaluation of historic centers in Brazilian cities, as a result of their real estate value, has expanded intervention actions in historic urban areas in recent years. These interventions many times respond to immediate actions related to new uses, private interests or to promote public administration. We emphasize that cultural heritage in Brazil shares a recent history, marked by conflicts, idealism and preservation.

It's necessary to contextualize the production of contemporary cities and the relation to patrimonialization processes. In this context, heritage is understood as a resource for economic exploitation. This characteristic is related to the neoliberalism rationality, where history, culture and memory can be transformed into merchandise (CHANDLER; PACE, 2020) [1]. In this sense, the urban context could represent all the conflicts inside the heritage conservation. In this text we will concentrate in the contemporary interventions that results in changes of colors and uses that do not follow scientific topics or statements of restoration principles, which has as an emblematic example in Brazil, the requalification of Pelourinho, in Salvador.

In 1990's Lina Bo Bardi went to Salvador to develop a project for the recovery of the historic center, Pelourinho. She presented a project that the methodology of intervention was focused on the maintenance of the local population. She developed two pilot projects and returned to São Paulo. With the possibility of the World Heritage classification by UNESCO, the economic values of Pelourinho were improved. For this reason, the public administration decided to change Lina's project and used expensive

materials and techniques to make this transformation, what corrupted Lina's original proposition and became responsible for one of the biggest processes of gentrification in Brazil.

Marcelo Ferraz that worked in Lina's team has a criticism about this requalification process. He emphasized the chromatic transformation, he said that the non-rigorous choice of colors created a scenery that never existed there, and the Pelourinho effect spread across the country. Another point that the author highlighted is the economic appeal of this strategy that expelled people who used to live in this area:

"A varied pastel color palette was applied to houses, something that never existed there, replacing the white or brownish ocher of the old city. With the publicity and the success of the recovery marketing, the 'Pelourinho effect' spread across the country, in historic cities or not, where homes began to be painted à la multi-flavors 'ice cream parlor'. Traditional and expensive techniques and materials were used raising the value of the properties, making the possibility for the return of the residents even more remote – low-income citizens who, since the beginning of the process, were expelled from Pelourinho". (Marcelo Ferraz, 2008 – free translate) [2].

The project of requalification of Pelourinho is still in progress. The color composition of Pelourinho attracts tourists' eyes. We can observe that the economic are the strongest value, followed by the cultural value and how they are in conflict in the sense that the economic interests are stronger than the others, reducing the heritage to a tourist attraction.

The Pelourinho effect spread across a city in another state, the city of Uberaba. It is a medium city in the countryside of Minas Gerais, with about 300.000 citizens. Uberaba is a younger city, from the mid XIX century. The text will focus on the main square of the city - Rui Barbosa Square. This place has been through some important transformations, which show us how even though this square has the commercial, historic, cultural and social importance, its consolidation is fragile. It had different uses and projects along the XX and XXI centuries. In 2018, the square passed by another transformation. In this recent transformation it had changes in pavement, a proposal of clearing up the facades by the removal and reduction of the signboards. The policy of clearing the façade tried to put the architecture in evidence, but the owners didn't have technical assistance. So after the signboards removal, the architectural problems were masked by the new painting. The colors chosen were defined to promote brands and stores instead the concern with architectural preservation.

If, on the one hand, we have a set of historic buildings that resist the layers of time, on the other there is a trivialization of these spaces resulting from urban and architectural interventions. Solutions that were influenced by other emblematic examples in the country or by actions to promote the businesses located in these buildings.

2. MATERIALS AND METHODS

For the analysis of the chromatic transformation of the patrimonialized urban territory, it was developed a methodology that involves an overlapping of values over space. Specifically in this research, we will focus on the analysis of trivialization processes in urban sets of historical interest from the chromatic aspect, using comparative analyses. For that, we are using structure analysis keys for the development of an initial critique of the cultural heritage in Uberaba.

In the diagram bellow, we can see these three values - social, cultural, and economic - and some processes and characteristics related to them. In the intersection of these values, we have what I am calling a heritage atmosphere. In this heritage atmosphere we have a complex overlapping of layers and different interests. I will use this diagram to analyze the construction of territory as heritage and its visual aspects, to illustrate how the values could be related to the chromatic transformation.

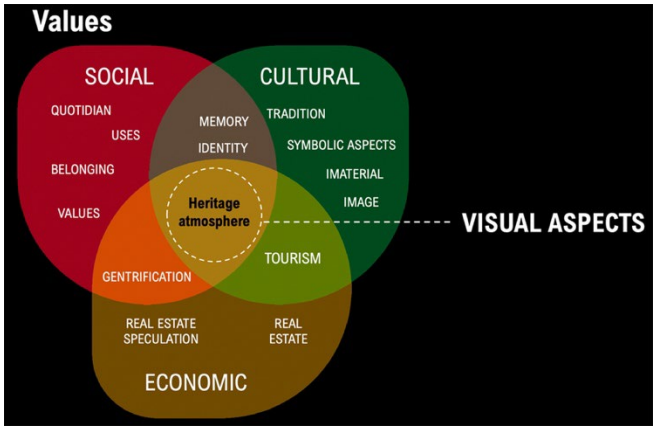

Figure 1 – Diagram of analyses.

Another important aspect for analyzing the impacts generated by chromatic changes is related to the uses and changes of buildings over time. In this sense, we

will use some reading keys to identify such transformations.
For Muñoz (2008) [3], the process of banalization of the urban is, among other aspects, related to the emptying of this space of its symbolic contents, thus being transformed into sceneries. Therefore, we will consider this perspective for the critical construction of a look at the urban landscape that surrounds Rui Barbosa Square in Uberaba.

3. RESULTS AND DISCUSSION

The field survey carried out through observation and the production of photography allowed us to identify the recent changes in the buildings that make up the urban landscape of Rui Barbosa Square. Comparing the photographs with the diagram of the values that form the heritage atmosphere, we identified weaknesses and conflicts between these values, especially the valorization of aspects related to the real estate market. For a better understanding of the impact of these transformations, we have divided them as follows:
- Transformations related with new uses and replacing buildings. We highlight in these changes the needs generated by contemporary ways of life.
- Fast changes of uses and their relationship with new uses, a characteristic that is motived by immediate needs and fragile planning.
- Non-rigorous solutions with visual appeal, what could have direct relation with the last topic. The immediatism of needs or the lack of long-time planning results in interventions that do not follow rigorous conservation and restoration methods, the only concern is the visual impact.
- Architecture in evidence, with the new policy of clearing the façade, architecture assumed a major role in the physical composition of the landscape
- Finally, the trivialization processes, which is a result of all transformations mentioned above.

3.1 Replacing buildings and uses

First, we will see one of the common transformations during the history of the square, the action of replacing buildings. We can see in the picture above new modern buildings that replaced eclectic architecture, during the process of city modernization. In the photo bellow, we can see changes in the use of the old cinema and its situation nowadays. The building is used by a candy store and the signs of the old cinema were erased.

These transformations show the power of economic value that manages to impose itself in the face of the preservation of old buildings. In this sense, there is an instability between spheres which results in a fragile heritage atmosphere.

Figure 2 – Assembly made with diagram of analyses and photos of buildings transformation in Uberaba-MG. 2021.

3.2 Fast changes of uses – colors related with uses

Another change that was observed is related to the fast changes in use and how colors are used to highlight the transformation. These two photos were taken in an interval of two years, and we can see the use of color to show the new use. Nowadays the building is used by a beauty salon, so they chose pink to represent the new use. The constant transformations in the city center are consequence of instability of the market and the valorization of the area, which imposes a permanent dispute over the territory. In this case there isn't any concern about restoration criteria. Once again, the economic value is decisive in the consolidation of the heritage atmosphere.

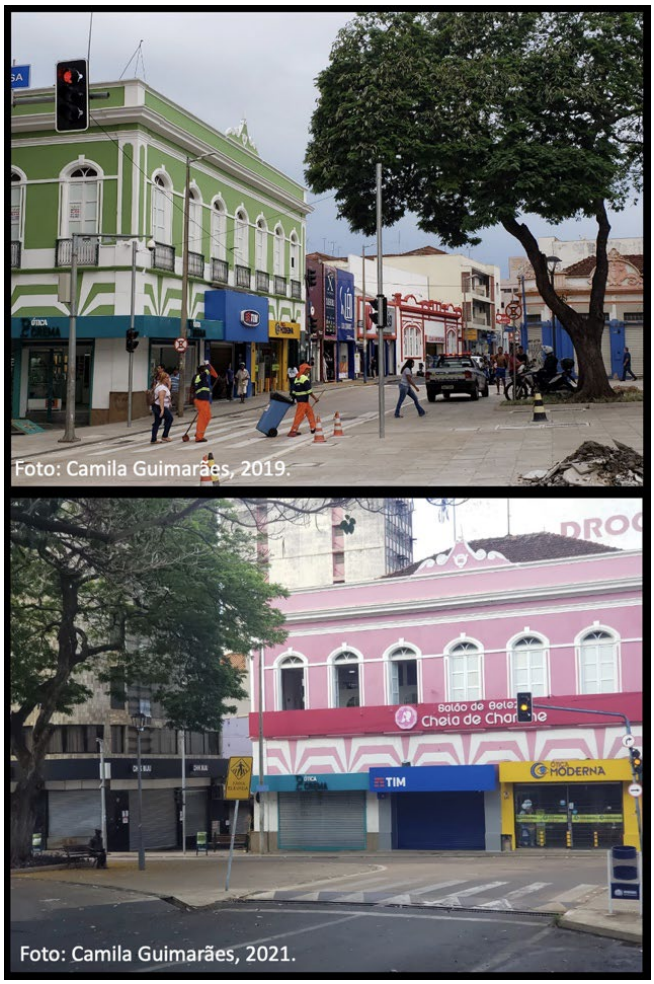

Figure 3 – Assembly made with two photos of buildings transformation in Uberaba-MG. 2019.2021.

3.3 Non-rigorous solutions – visual appeal

Another situation observed in the analysis of the chromatic changes in the buildings that make up the Square is related to the lack of rigor of the solutions adopted and how the bright colors were chosen to highlight the buildings, in a wrong way, and to hide architectural problems such as infiltrations.

We can see the color transformation of this house (Figure 4), influenced by the transformation of the other commercial and public buildings in the square. This represents the visual appeal with non-rigorous solutions. In this example we can see how the choices are made by particular intentions rather than technical actions.

The assembly bellow with three versions of the same picture illustrates the importance of chromatic composition in shaping the urban landscape, as well as for strengthening (or weakening) the perception of the building as a support of collective memory.

In the first picture we have the original landscape, without digital manipulation. We can see how the orange building stands out in the landscape. In the second picture we left only the orange building with color. In the third photo, we have the removal of the color of the building, resulting in a more homogeneous landscape of the set of buildings.

Another problem of these interventions is related with the documentation of the processes of intervention. As stated by Camilo Boito (2008) [4], it is necessary to document the entire intervention process. In this sense, we realize that changes in the colors of buildings are not addressed by the government with the necessary relevance to understand the building – in its entirety – as a historical document.

For this reason, it's important to understand that some choices are necessary in the process of building restoration. As Viñas (2021) [5] observes, it is impossible to maintain the original aspect related to aesthetic characteristics while respecting the layers of time. In this sense, it is necessary that all decisions consider the relationship between the community and the values associated with the building, as a way of enhancing the preservation and conservation of the local heritage.

Figure 4 – Assembly made with three photos of a building color change in Uberaba-MG. 2021.

3.4 Architecture in evidence

The policy of clearing up the facade is an important instrument for valuing the passage of time in buildings as well as for the architecture revaluation. In Figure 5 we can see the pedestrian street near the square after and before the last intervention. The clearing up of the facades improved the visibility of the architecture and the cultural aspects related to the past. These photos show how important the intervention is. Now we can see the architecture structure.

The problem of this intervention is related to the lack of assistance, which results in the use of bright colors to promote brands and masked the architecture problems. The poor maintenance highlighting problems with infiltration, the concert just with the facade, could left the rest of the building in worse condition.

Figure 5 – Assembly made with diagram of analyses and photos of the pedestrian street near the Rui Barbosa Square (actual situation and before the clearing up the façades). 2021. Fonte: The second photo in the right side: Google Maps, 2017.

3.5 Trivialization/Banalization processes

The selection examples located in the Rui Barbosa Square are a fragment of what is happening with urban historic centers in cities in Brazil, especially those one that aren't big or metropolitan cities.

The transformations we have seen in this research illustrate the current process of heritage trivialization. This specific process is conditioned by the pressure of real marketing and fragility of public policy.
The concern only with the urban scenery constituted by historic buildings reinforces practices that exclude symbolic values linked to material goods. In this sense, the changes generated by disputes between commercial establishments to stand out in the territory reinforce the practice of actions without scientific rigor about chromatic interventions.
According to Delgado (2020) [6], some renovations of historic centers are based on the perspective of selling an image of the city. An image that is simplified insofar as it is used as a brand logo or just to get the attention of tourists. This situation places heritage in the field of disputes between the trivialization of urban space and the representation of symbolic values that are associated with the local population.
Another relevant point for the process of trivializing of the heritage territory is related to current demands and the lack of long-term planning, which result in actions without justification for immediate solutions.
We can see in the Figure 6 the demolition of a building preserving only the facade. This building used to have medical clinics next to a traditional hospital. The new use after the demolition was a parking lot. We see the erasure of historic buildings for new immediate uses. This example is the maximum limit of the trivialization of the urban landscape.

Figure 6 – Building with only the façade preserved – near Rui Barbosa Square. 2019.

4. CONCLUSIONS

We have some conclusions about this analysis. The contemporary uses of heritage buildings are related to economic values and visual appeal instead of cultural and social values, which weakens the population's perception of their cultural heritage. The process of trivialization of the historic center is related with transformation of culture in merchandise, a characteristic of neoliberalization of city production.
So, we have a new landscape, with new color composition, that is more related to economic concerns than the architecture history, without any technique of restoration even in the protected buildings.
The non-rigorous uses of color could weaken heritage as a support of collective memory, privileging its commercial value. Which shows us an important challenge on how to understand our recent heritage and how to preserve it for future generations.

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REMOVE, REPAINT OR RETOUCH: SHOULD THE COMMUNITY DECIDE? THE CASE OF THE OUTDOOR MURALS OF THE RIACHOS VILLAGE, PORTUGAL

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ABSTRACT

This paper discusses the conservation of murals in Riachos, Portugal. Created in 2012 and 2016 by amateur painters in the context of a religious and ethnographic festival called "Benção do Gado", a cattle-blessing event. The condition of these murals has deteriorated due to their outdoor location, poor choice of materials used and lack of maintenance. Those murals give meaning to the village, a sense of identity and uniqueness to the local community. These are the reasons why the community should be considered in the process of preservation.

This study was conducted using mixed methods, with data gathered from a community survey, interviews with stakeholders and documentation of the current state of the murals. This research argues for a close relationship between conservators and the murals' authors and the local population. The preservation project should create a balance between current ethical and scientific conservation practices and the voices of the community from whom those cultural manifestations belong, using them as part of the conservation process.

Keywords
Conservation; Retouch; Outdoor murals; Community art; Mural painting.

1. INTRODUCTION

The ethnographic murals in Riachos, a village in the centre of Portugal, were initiated in 2012 as part of the religious and ethnographic festival "Benção do gado". With great meaning for the local community, this event enhances cultural pride and local traditions. The paintings were carried out on facades and walls of several houses by amateur artists. In 2016, new murals were created and some of the existing ones have undergone works. Currently, there is a set of approximately 60 murals. As community murals, they are not simply portraits and scene representations on walls but have become a relevant catalyst for local identity in public space. The preservation of these outdoor murals faces particular challenges. Subjected to adverse climate conditions, the state of good conservation can be put at risk in a short period and their lifespan can be short. On the other hand, conservative guidelines for street art are still missing and outdoor murals preservation is still an open topic in the conservation field.

The goal of this paper is to urge reflection on the conservation challenges of Riachos' ethnographic outdoor murals. This research is part of the "MurArte" project, an interdisciplinary study covering historical research, documentation, and scientific investigation into mural materials and techniques. As several types of "intervention" methodologies have been put forward such as repainting (partial or full) or the replacement of some murals (to create a new one in the

same place) the intangible values must be assessed, in order to understand the importance of the intervention process. How to conserve the immaterial value of these mural paintings? Who should be responsible for the conservation? The authors or the conservators? Who decides the intervention criteria? What is the role of the players involved: the author, the owner of the wall and the community?

Therefore, the aim is to raise awareness among the local community to the need of recognising and appreciating the murals as well as adopting some basic intervention criteria. The continuity of these murals is closely linked to the direct action of the painters and the community, which sees their identity represented in these murals.

1.1 Murals: context

Located in the centre of Portugal, Riachos has a past strongly rooted in agriculture, an activity that continues to be economically relevant. The growing interest in its rural history is shown in the way the local community preserves and values its traditions. One of the best examples is the Cattle Blessing Festival, a religious and ethnographic event that happens every four years, with great meaning for the local community as a motor for enhancing cultural pride. It is a typically religious festival in honour of Saint Silvestre, patron of farmers, fields and animal protector. This Festival is a form of showing gratitude for the harvests and the health of the cattle [1].
It was in the context of this Festival that the idea of creating the murals arose in 2012. That year, a group of residents from the Santo Antonio's neighbourhood were looking for an original idea to adorn their streets. In the previous edition, in 2008, the streets were mainly ornamented with sunflowers in vases placed along the streets of the whole neighbourhood. At that time, Pereira Jorge, the director of the Núcleo de Artes de Riachos (NAR), an association of local amateur artists and craftsmen, took the initiative to produce mural paintings with ethnographic themes [2]. This initiative involved about 20 painters to produce around 40 murals on exterior walls and facades of houses located in Santo Antonio's neighbourhood.
The themes for the paintings were agreed by the authors and focused on renowned local figures, rural activities, religious symbols, legends and customs. Old photographs and images from the local history books were used as references.

In 2016, the circumstances in which the murals were created were different. Previous murals still existed (with very few exceptions that have been destroyed in the meantime) and had been largely accepted by the local community and by the festival visitors. Despite the lower participation of only 12 painters that year, there were better conditions for the creation of new murals, expanding the intervention area to new streets and for a planned intervention in terms of themes and places to be painted [1, 2].
Keeping the idea of a "Riachos' ethnography" as a background theme, more elaborate themes emerged. This time there was greater attention to the representation of the human figure through the portrait of genuine people and groups, as seen, for example, in the production of an extensive mural representing a group of local folk dancers (see Figure 1).

Figure 1 – Zé Manel Triguinho, Folk dancing group "Os Camponeses", 2016, Largo M. S. Serôdio, Riachos.

On the other hand, murals have been created in places of greater visibility in the urban context. This is another reason for the greater technical and aesthetic concerns.

1.2 Murals: materials and techniques

None of the mural's authors had previous experience in making outdoor murals and very few had prior technical or artistic training beyond the easel painting workshops at NAR.
The paintings took a few weeks to be made, as most painters were only available to paint after working hours and at weekends. Some authors mentioned the difficulties of painting outdoors on very hot days, so most of the paintings were done late in the afternoon, as Teresa Lopes noted: *It was very hot. I painted in the afternoon, on Sundays and days off, my painting partner at that time was out but gave me guidelines, so*

I did it my own way just as I felt [T. Lopes, personal communication, written testimony to the authors, October 2021].
The fact that this work was made for public display, the personal skills and demands of each scene required some collaboration between painters. Nevertheless, each painting carried the personal signature of the artist and date of the painting (some painters carried out more than one painting) [2].
In 2012, there was no concern with the preparation of the surfaces to be painted. No protection layer was applied as there was no concern with the permanence of the murals beyond the period of the festival. This time, an attempt was made to clean and cover surface imperfections. After that, the wall area was covered with a layer of white acrylic paint.
Preparatory drawings were made in some murals as a basis for the creative process (Figure 2).

Figure 2 – Manuela, "*Descamisada*", 2016, Rua do Sargaço, Riachos. Execution of the mural.

The murals were made with acrylic paints applied with brushes, rollers, and sponges.
In 2016, the growing recognition of the murals by the community has led to a greater concern for their future and preservation. There was greater preparation of the substrates and varnish was applied over the final work.

1.3 The conservation of the murals

A large part of the murals has conservation problems resulting from environmental conditions.
The deterioration of the support is the most frequent cause of mural alteration. Subjected to constant freeze-thaw cycles, capillary rise and thermal fluctuations, mural supports are largely affected.
In some cases, salt efflorescence and crystallisation are cracking and lifting the pictorial layer. In some cases, the detachment of the pictorial layer is evident, due to a loss of connection with the preparation layer or between the preparation layer and the support (Figure 3).
Occasionally some murals show small fissures in the support and degradation of the pictorial layer.
The presence of large quantities of water retained in some of the walls has caused the development of microorganisms, as seen in figure 4. Here a layer of varnish was applied over the painting, which effectively prevents the development of these microorganisms.

Figure 3 – Detachments of the pictorial layer. F. Gorjão and Tess, "*Sunflowers*", 2016, Bairro de Santo António, Riachos.

Figure 4 – Zé Manel Triguinho, folk dancing group "Os Camponeses", 2016, Largo M. S. Serôdio, Riachos (detail).

Murals have been greatly affected by light since Riachos has a great solar exposure throughout the year. Murals have a direct and constant exposure to ultraviolet rays which contributes to paint colour fading. Depending on the orientation of the walls and the quality of the materials used, this effect is visible. It's also known that acrylic paints used on outdoor surfaces may break down over time and are not ideal for architectural support [3].
Actions of vandalism were not identified on the murals, possibly due to its wide acceptance from the community, as will be explained below.

Only one event of deliberate destruction occurred on a large mural composed of five panels due to house construction. Also, partial damage on walls was detected resulting from maintenance or repair works on the walls.

Due to the reasons mentioned above, in 2016, the murals painted in 2012 showed extensive deterioration. That was the reason why, in 2016, in addition to the creation of new murals, a significant number of previous murals were retouched.

In some cases, these retouches were not carried out by the author of the mural, as Teresa Lopes reported: […] *Restoration made in May, by me Dadinha, with authorization from the author in 2016, and signed by me in 2016* [T. Lopes, personal communication, written testimony to the authors, October 2021]. However, those interventions were recorded on the murals with the date and signature of the interventions author (Figure 5).

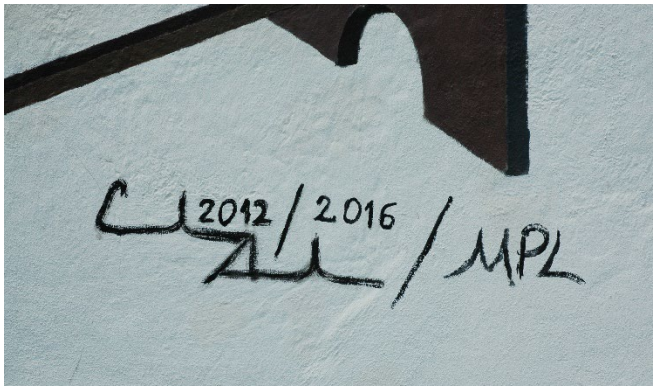

Figure 5 – Example of dating and signature in a mural retouched by different authors.

2. METHODOLOGY

It was known that the community members played a determinant role in mural preservation, since awareness of their murals increases their chances of survival, as does an early assessment of problems and timely intervention [3]. In 2020, a community perception survey was undertaken. The survey was carried out with the local population of Riachos or residents and 237 responses were collected. The survey was conducted from the 8th to the 19th of July and contained 11 questions. It aimed mainly to:

- Determine how murals were currently perceived by the local community;
- Gain a better understanding of the community's views on how murals should (or not) be preserved [1].

Respondent's perceptions will be critically analysed to understand the murals' value and the critical issues surrounding their preservation as both tangible and intangible heritage.

Existing documentation on murals was gathered and the context of their creation was determined by interviews with the main stakeholders [2].

Mural inventory was based on the methodologies already established [4,5]. The authors were invited to participate in this task since the preservation methodology should be based on the history of the murals and the context in which they were placed. Authors filled out an inventory form collecting information about the theme, creative process, techniques and materials, the conservation care taken, and finally the author's perspective on the future preservation of the mural. These textual descriptions were crucial to determining the author's beliefs, opinions, and emotional connection with their work.

3. RESULTS AND DISCUSSION

3.1 The community role

The survey allowed to understand the respondents' perspective on the preservation of murals, as they are recognised as cultural heritage. It was possible to perceive that those murals have a transforming role in the urban landscape of the village. 92.9% said that they enjoy and appreciate the presence of the murals and 96% think murals capture a sense of art. Murals also have a high impact on socialisation among individuals. 82% of respondents indicated that murals are a frequent reason for conversation between family members, friends, or acquaintances. 78% of the respondents believe that mural painting in Riachos defines, reflects, and disseminates local culture, and 70% see murals as a form of local identity.

76% strongly agreed that murals are perceived as a wider form of local development.

The last question of the survey was related to the context of the preservation of the murals. The participants were asked about the cases in which mural destruction would be admissible. Surprisingly, over 55% of total respondents agreed with the destruction of a mural in case of a poor state of conservation.

What is valued by the respondents is the mural's function as a support for an iconographic message, the most important to preserve. What it seems to suggest is that if time and its agents degrade a mural to the point where it is not perceptive, its function is lost, and the community easily accepts its finitude and its ephemeral character. In other words, it means that once a mural begins to deteriorate due to its exposure to environmental agents, its significance for the community decreases.

Another layer of ephemerality is established by the close relationship between the mural's placement, on exterior walls, and the function of these places. The original purpose of the architectural support may seem to overlap with the support of a work of art, for a significant number of respondents. In fact, 44% agreed with the mural destruction whenever the owner of the wall wants it. And 43% agreed if the need for a new building arises.

However, the destruction of the mural without a formal communication or any explanation to their authors seems not to be well accepted by them. See the testimony of Ana Isabel Moreira, author of a destroyed mural: [my] *mural was destroyed. The wall was demolished and in its place is now a house. I was never informed of this. One day I went to see the painting and it was no longer there! I consider it a great disrespect and lack of consideration from the owner. Since he authorised the painting, he could have informed the author* [A. I. Moreira, personal communication, written testimony to the authors, August 15, 2021].

This is related to the strong sense of authorship, shown in a very affirmative way in the signatures. According to Carlos Nuno, the feeling of authorship is particularly manifested in the cases of destruction of the murals, as seen above by the testimony of Ana Isabel Moreira. Also, as Carlos Nuno noted, it is stated by authors that, in the case of conservation treatments, the author should be always consulted [2]. Otherwise, if the author believes that his mural has been adulterated, he will want to remove his signature from the painting.

In addition to this feeling of individual authorship, there seems to be a sense of collective belonging in the local community. One of the factors that contributed to this was the process of creating the murals. The creation of the murals, which took several days, allowed a very close observation by the residents. This scrutiny was not only done passively, as simple spectators but actively, interacting with the painters, giving suggestions, comments, and requests [2]. This would have created a feeling of collective authorship.

The community revealed a sense of pride in the murals as a materialisation of collective memory, especially in a village where few other historical-artistic public resources can be presented as cultural values [2].

3.2. Treatment options: who decides?

The risk of degradation of these murals is real and it is necessary to think about how to minimise it: a) because of their exposure to the various agents of degradation; b) because the degradation makes it difficult to read out and makes them more susceptible to elimination or replacement. The poor condition of the mural can lead to a loss of its function/value because it no longer represents part of the community's history.

Drescher points out that a project to preserve community murals is complex because it involves the community, the authors, and conservators-restorers [6]. These stakeholders are involved and with varying visions of what is intended or should be preserved.

In the case of the murals of Riachos' village, it is understood that the success of its conservation depends on the consultation of the various players involved, in order to understand the concerns of the population and authors and what they believe to be more important to preserve (see figure 6). The conservators-restorers will be expected to bring the technical knowledge to the community to effectively solve some of the problems. It is not only technical problems but also the need to guide conservation and restoration interventions according to mural function and community expectations. On this topic, Drescher, to answer the question "Which Murals Should Be Saved?", and looking only at the murals themselves, the following aspects should be taken into account: a) the wishes of the community, b) mural art history, c) aesthetics, and d) the artist's canon [6]. In the context of the murals of the Riachos village, aesthetic or artistic values have greater meaning not for the novelty or artistic relevance, but rather for the meaning of self-representation [2]. These facts play a decisive role in the community's need to conserve murals. It is not a question of deciding which murals to keep, but in this case, the state of conservation may be decisive in that "option". The results of the survey reveal the concern about the good condition of the murals, as we have mentioned above.

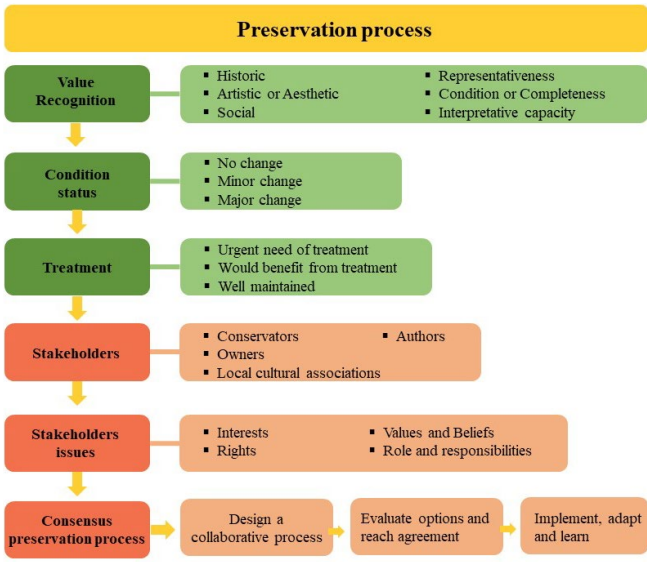

Figure 6 – Diagram of the steps within the consensus preservation process.

The documentation of the existing conditions of a mural is the first step to preserving this cultural heritage. Showing a great deal of variety, the state of conservation of the murals is influenced by factors such as: 1) the nature of the support (housing, wall, etc.); 2) whether the space is occupied or vacant; 3) prior care in the preparation of the wall; 4) orientation; 5) materials used in painting; 6) existence of a protective layer. The priority in the preservation of the murals should be to keep the maximum number of murals. This implies the identification of murals at risk and the concrete actions to be developed, such as the application of a layer of protection.

One of the most interesting mural paintings (from the artistic point of view and the themes represented) was carried out on a wall that presents problems of crystallisation of soluble salts and, consequently, the detachment of the chromatic layer. The risk of mural loss is great if remedial measures are not taken soon. Another case concerns a set of murals painted in 2012 that, due to the author's death, was not retouched/repainted in 2016. These murals show greater colour fading.

Many of the murals painted in 2012 were repainted or retouched in 2016 by the authors themselves, or in collaboration with others, as said earlier. These interventions were carried out with the objective of "improving" the perception of the murals. In the future, will there be space for collaboration with conservators-restorers? What proposals can be designed together for their sustainable preservation?

Whatever the options are, they must always consider the immaterial values perceived by the community. Smith suggests that heritage "is a cultural process that engages with acts of remembering that work to create ways to understand and engage with the present, and the sites themselves are cultural tools that can facilitate, but are not necessarily vital for, this process." [7] and because of that, as Brajer points out "the ultimate goal of conservation is not to preserve the material aspects of a particular object, but to retain or improve the meaning it has for people." [8].

4. CONCLUSIONS

During this research, it was recognised that the author's views and the information about the mural painting process could support decision-making in conservation practices. Also, through an online survey, it was possible to better understand the meaning of the murals to the Riachos community: 1) the meaning and value attributed to the murals; 2) the poor state of conservation is the main reason for the devaluation of a mural; 3) which practices have already been adopted for the conservation of these murals.

The creation of these murals is recent, and the community is involved in their conservation. It is a practice based on repainting and retouching on the authors' initiative. There has been a positive evolution in the introduction of practical measures to extend the durability of new murals.

However, much remains to be done. A mural toolkit should be designed to provide guidelines for the creation, maintenance, and care of murals. A regular documentation project of the murals must be implemented to record the evolution of their conditions and to minimise their decay. Preservation policies must be defined having into consideration how the local community determines the mural's lifespan, how they make collective decisions about repainting, retouching and removing murals, and how stakeholders participate in their process and decisions.

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CRITICAL AND ANALYTICAL APPROACHES IN A CONTEMPORARY MURAL PAINTING' RETOUCHING PROCESS: THE KEY STUDY OF MURALS BY ANTONIO CARENA

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ABSTRACT

This paper focuses on critical and analytical approaches behind the reintegration process in the conservation project of two contemporary mural paintings designed by Antonio Carena and located in the outdoor contemporary museum of Piscina in Italy. Moreover, there will be evaluated materials and techniques applied, in this selected case study, where contemporary criteria on chromatic reintegration, still connected to a case by case situation, confirm that the aesthetic presentation of a work of art is the phase of the restoration in which the exquisitely critical nature of the intervention is best expressed, since it implies a scientific plan at the basis and the objective critical judgment of the operator which is called to interpret some formal, visual and historical values of the work of art, acting on them. Finally, there will be analysed theoretical and technical methodologies to explain how scientific criteria, which are also objective and based on the visual perception of colour by the human psyche and its consequent aesthetic elaboration, passes through a scientific-critique interpretation of the constituent materials in the work of art.

Keywords
Carena; Chromatic reintegration; Contemporary mural painting; retouching techniques; synthetic polymers; natural polymers; pilot methodology.

1. INTRODUCTION

This study wants to introduce the first results in the retouching process of two contemporary murals by Antonio Carena, located in the open-air contemporary art museum of Piscina in Italy. The conservation project was achieved between June and July 2021 by ICR (Istituto Centrale per il Restauro), in collaboration with two conservation companies, developing specific solutions in choosing critical and analytical approaches for the reintegration techniques of these two mural paintings.
The research is still in progress: in time, the materials applied and the methods selected for the application will be monitored to understand their behaviour related to their specific outdoor context and to the original ones in order to develop an appropriate ordinary maintenance plan.
The project Piscina Arte Aperta, which was born in 1991 from a brilliant idea of a local painter, was yearly developed by a group of artists, curators, art critics, designers as an important artistic manifestation strictly connected to its territory.
The aim was to create an intimate and urban open air art gallery collection for the community, enriched in time, and now constituted by almost 70 contemporary complex artworks.
Nowadays Piscina Arte Aperta is legally recognised as an open-air contemporary art museum that winds its polymateric and complex Cultural Heritage through the squares and streets of the town.

1.1 The open-air museum of contemporary art in Piscina: conservation history

Piscina Arte Aperta (P.A.A.), developed as an open artistic process, involved in 10 years of activity established and emerging artists which lived and worked in the Piedmont region reaching the heritage of 70 works between 1991 and 2002. Piscina is a small town in the hinterland of Turin, a large industrial city in Northern Italy. A museum-laboratory, born as a "cultural operation", in which the theoretical discussion and the creative happening prevailed upon the open air exhibited collection that the promoting group defined "the concrete and material outcome - and perhaps - at least in its surviving component, not even the most relevant "[1]. In fact, the project itself implied the acceptance of a progressive degradation of the works in the open air, "a strongly - and deliberately! - degradable heritage...

Many artists invited to Piscina (perhaps most of them) made this eventuality one of the reflections to the basis of the work to be carried out"[1]. With no tourism or "urban redevelopment" aims, the project lived in the relationship with the artists, the citizens and the territory. Since the first editions of the event, the promoting group has sought the relationship with the population, through public dissemination initiatives, temporary exhibitions, publications, activities in schools. The promoters keep a rich documentary archive that allows us nowadays to reconstruct the evolution of a spontaneous event: search for funding, selection of artists, publicity of the event, administrative aspects. Undocumented but told by the protagonists are the episodes of vandalism, removal, destruction of works [3]. Despite the curators' approach of accepting an inevitable deterioration of the works exhibited *en plein air*, a formal request for generic "protection" was required from the private owners who accepted the exhibition of works on the outside of their houses, without any obligation to restore or maintenance [4].

The institutionalization of the P.A.A. project in a public municipal museum owned by the Municipality of Piscina in May 2021 led to the pilot restoration of, among others, the work of Carena

1.2 The artist and its poetic

Antonio Carena (1925-2010) was born in Rivoli and made his debut in the art world in the mid-1940s. The artist began his career by creating informal artworks to reach a lyrical and also pop hyper-realism in the Sixties with his *Cieli*, "aerographic skies", artworks realized with airbrush on different types of supports: from bodywork to perspex, canvases, walls. The artist used to ironically define his artworks as "*cielagioni*" or "*cielismi*" (a sort of italian pop name-game for his "skies"). He was also a precursor of the so-called *graffiti writing*, developing an art made by unique and repetitive signs, as the clouds, more real than the reality. The anti-naturalistic and hyper-realistic realization of the Skies leads Carena's art to the limit of the conceptual, in which the surface is homogeneous, mirroring, without imperfections, according to a similar principle to that of monochromes.

Carena's activity in Piedmont is widely documented: he painted Cieli on the vault of the staircase of the Contemporary Art Museum of the Castello di Rivoli, 1984, now hidden by a repainting, at MACAM in the village of Maglione (TO) in 1991 and in the one of Borgo Campidoglio (TO) in 1998 [5]. The intervention for Piscina Arte Aperta involved the artist in the first edition of the 1991 event, invited by the artistic director Francesco Preverino to participate with the utmost freedom of expression. In *Due trance di cielo*, 1991, Carena adapts its iconic "brand" in a site-specific work, painting the buffered windows of a private residence, playing with the reality of the place, in which a glimpse of the sky illuminates a blind window like a theatrical backdrop. The work underwent deterioration quite quickly, in particular in the right panel, as shown in a 2001 photo [6].

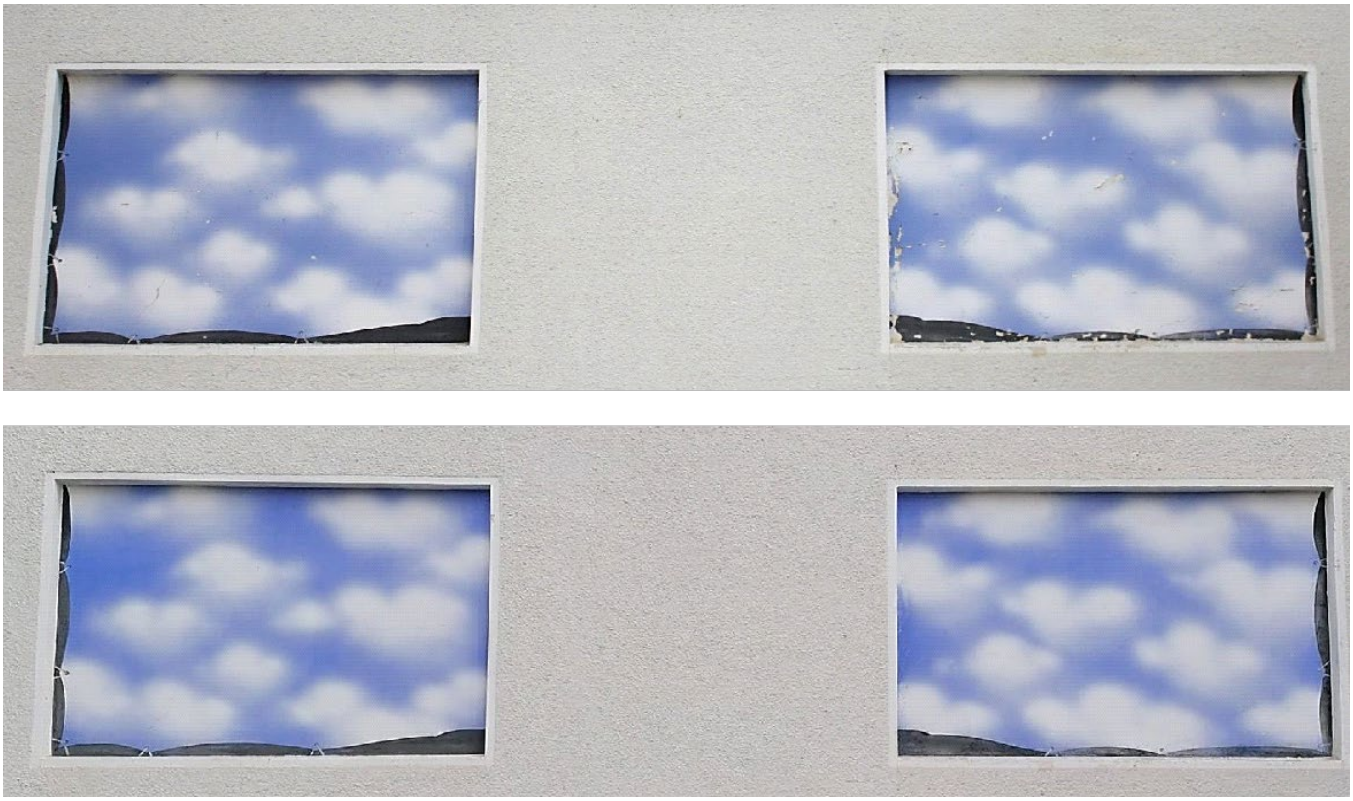

Figure 1 – Upper image: Carena murals before the conservation project. Lower image: the murals after the ICR restoration.

1.3 Conservation issues and conservation history: the social and legal recognition of the murals in the ephemeral outdoor context

Generally talking, an open-air museum is constituted by three main factors: the outdoor context and the community that differently interact with the artwork which needs to be socially and legally recognised as artwork and, therefore, as part of Cultural Heritage and Cultural Landscape [7].
Infact, the main conservation issues related to the murals were connected both to natural and anthropic decay processes linked to the principal risks of the outdoor context: the natural risk (with direct or indirect causes) like the exposure to the sun, rains, winds and strong thermo hygrometric changes typical in the environment of the north of Italy, and the anthropic risk, with direct or indirect causes too, more related to the interaction with the community.
In this specific case, the degradation problems connected to the anthropic interference can be named as an unconscious vandalism, or a lack of care, due to the partial forgetfulness of Piscina Arte Aperta Cultural Heritage in time. Nowadays, the community and the municipality itself are more mindful of the unpredictable outdoor context and their fragile rediscovered heritage after the conservation project.

2. EXECUTIVE TECHNIQUES AND STATE OF CONSERVATION

The murals, called *Due trance di cielo*, measure about 1,08 m² each one and were painted during the first artistic manifestation of Piscina Arte Aperta in 1991. These aerographic skies are revealed from two curtains tied to nails fixed along the perimeter of two fake windows. The tromp l'oeil reproductions of these hyper-realistic and mirroring skies ironically reveal their fiction three times leading the paints to the limit of the conceptual.
Carena painted its skies in two outdoor blind compartments of a private building that recalls the shape of two windows.
The artists used different synthetic paints that differently interacted with the outdoor context. Infact,

the blue of the skies is a VeoVa based paint layer, while the white of the clouds is a paint sensitive to the water whereas the black of the curtains is, instead, an acrylic paint (FT-IR by Giancarlo Sidoti: ICR official chemist).
The outdoor risks mentioned above caused different decay problems, especially on the right mural, also related to the differential alteration caused by the overlapping of diverse synthetic paints which tend itself to develop delamination and deformation processes in all the layers, due to the intrinsic executive techniques.
Moreover, diffuse spots in the white layer of the murals, due to some previous roadworks performed too close to the latters, were detected on all the surface (anthropic risk).
Also natural decay processes were identified like: presence of incoherent deposit (especially organic nature), *lacunae* and micro *lacunae* in the pictorial film (blue and white colours) and in the primer (avana colour), cracking and detachments of the pictorial film (different typologies according to the rigidity of the specific pictorial layer), lack of adhesion of the pictorial film from the plaster, lack of cohesion of the white's clouds and in the blue of the skies, diffuse spots in the white layer due to the swelling of the binder caused by the water extraction and biological colonization (black spots diffused in the central area of the right mural).

3. MATERIALS AND METHODS: THEORETICAL AND TECHNICAL PRINCIPLES IN THE REINTEGRATION PROCESS OF CONTEMPORARY MURALS

3.1 Critical and analytical approaches in the reintegration process of mural paintings

The aesthetic presentation behind every reintegration process in the conservation of mural paintings is always based on critical and analytical conservation approaches.
Therefore, also contemporary criteria on chromatic reintegration are still connected to a case-by-case situation, where the aesthetic presentation is the phase of the restoration in which the exquisitely critical nature of the intervention is best expressed because it implies a critical judgement of the operator, in order to interpret some formal, visual and historical values of the work of art, acting on them.
Infact, the operator's judgement and its consequent action must be based on precise theoretical principles that guarantee that the reintegration will move on a track of univocity in methods according to objective values. For this reason, at the basis of the reintegration intervention, there must be a specific plan founded on scientific criteria which are also objective and based on the visual perception of colours by the human psyche, and its consequent aesthetic elaboration, which passes through a scientific-critique interpretation of the constituent materials in the work of art. In the history of restoration, two different theoretical orientations have always been opposed: the first one, more linked to the educated context of academia, has considered the work of art a real material document enhancing its historical value and underlining the need for preserve its originality; the other, linked to the antiquarian world, was instead more interested in the figurative and aesthetic message of the work of art in restoring the original figurative idea through typological and stylistic comparisons and analogical procedures. Only with Riegelian [8] thought and with the more systematic Brandian theory [9], the opposing forces of the two different positions will be recomposed in a theory whose critical and methodological rigour still remains unsurpassed. Also, in contemporary cases.

3.2 Theoretical and technical principles in materials and methods selected

Therefore, preliminarily to the practical intervention there was developed a specific reintegration plan supported by scientific criteria and by the state of conservation of the paintings. The latter, especially the right one, were affected by a massive presence of different typologies and shapes of lacunae that prevented the correct perception of the original figurative message based on perfect and mirroring skies. As well known, the perception of the lacunae in our psyche depends on their weight and it's also related to their colours. Moreover, this perception is related to their collocation in the space of the paintings too, as well as the distance or proximity between the lacunae themselves. Therefore, the process of the reintegration began choosing to close micro lacunae that were located, as diffuse spots, everywhere on the white layer of the clouds due to some splashes of water because of previous roadworks that were performed too close to the murals. The operation re-created the conclusion of the intangible clouds in the skies. After that, the ones located in the proximity of the natural

reading of the paintings in an occidental way (from left to right and especially where the dark colours were related to the light colours, as in the curtains) were retouched in order to obtain a surface more and more mirroring; after that, the process continued closing the larger one in the centre of the paintings until all the figurative message was regained. The methodology in applying colours was entrusted to the restorer's ability, or rather to his sensitivity, to perceive and evaluate the chromatic accordance between colours and light related to the perspective in viewing; infact, one of the hardest difficulties, in case of the retouching of monochromatic paintings (or similar), is represented by the disturbance generated due to the reflection of the light on the materials. This visual alteration, called "metamerism"[10], was particularly evident also in this key study because Carena skies are pictorially builded by monochromatic colours, therefore thanks only to technical skills was reached a good retouching result and balance in order to eliminate, or at least attenuate, the effect.

The technical reflections on the decay process of murals, composed by different synthetic paints, were focused on the experimentation of synthetic materials too that were tested before the intervention on mocks up. All these materials needed to present specific characteristics reported below:

- The necessity to select conservation materials appropriate in the retouching operation of mainly polar solvents' sensitive paints on walls.
- The requisite to use reintegration products that would allow to perform a retouching intervention to fill the thickness of the blue synthetic pictorial film of the skies.
- The necessity to obtain an almost transparent and immaterial veil for the reintegration of the white clouds layer with opposite solubility to the original one.
- The use of materials reversible or, at least, retractable and compatible with the chemical-physical characteristics of the original one.
- The requirement to obtain filler and reintegration materials for the lacunae builded with the alternation of apolar and polar system (with opposite solubility to the original one).
- The similarity to the original one in terms of chromatic gloss.
- The use of products compatible with the outdoor context and their thermo hygrometric conditions in progress.

Table 1 – Different types of binder selected.

TYPE OF BINDER	CHARACTERISTICS	SOLUBILITY
Arabic gum (watercolours Winsor and Newton)	Natural polymer Polysaccharide	Water
Laropal A81 (*Gamblin Conservation Colours*)	Synthetic polymer Urea–aldehyde resin T_g = 49-57°C	Aliphatic hydrocarbons

The binders selected were two: Laropal A81 and watercolours (table 1).

The technical application of the materials is all specifically described in the table 2 and were based on pigments added in Laropal A81 (an urea - aldehyde resin) and/or a modification of the *Gamblin conservation colours* line, with the addition of ZnO in order to be recognisable by UV fluorescence and other additives as TiO_2 to reach a good hiding power for the white of the clouds. Infact, Laropal A81 is well known in the world of restoration for having been selected as a binder for the colour line *Gamblin Conservation Colours* [11-12]. There is bibliographic evidence which attests their use in outdoor context, with final protective on the top; moreover, this resin shows a great hiding power similar to the thick original paint film. Finally, LA81 also showed opposite solubility from the original one and good reversibility or retreatability. The other materials selected, in order to obtain a semi-transparent layer for the retouching of the white clouds were watercolours. The latter, whose binder is gum arabic, were chosen too in order to obtain a correct juxtaposition of apolar and polar materials on the painting [13]. Moreover, watercolou

Table 2 – Reintegration System selected: based on the alternation between apolar and polar materials.

TRIALS AND TESTS IN THE REINTEGRATION SYSTEM			
COMPOSITION BINDER + PIGMENTS	**APPLICATION METHOD**	**REMOVAL METHOD**	**OBSERVATIONS**
N1. BLUE COLOURED FILLER: GCC cerulean blue + minimum quantity of white ZnO	wet spatula in white spirit to facilitate the spreading of the filler.	Removal of the filler: by swab with Ligroin and methyl ethyl cheton and with the aid of the scalpel.	-Medium workability. -The primer underneath can be spotted during the removal process. -Mimetic reintegration recognizable by the use of UV fluorescence.
N.2 BLUE COLOURED FILLER: 60:40 ratio between acrylic lighten filler (cromix) + GCC cerulean blue + white ZnO **WHITE PICTORIAL FILM** (medium lacunae) GCC white TiO_2 mixed with ZnO **WHITE PICTORIAL FILM** (micro lacunae) White watercolours W&N ($ZnO+TiO_2$) **POLYDIMETHYLSILOXAN**: Final Protective layer	wet spatula in white spirit to facilitate the spreading of the filler. Retouching Brushes of different sizes	-Removal of the protective: by swab with Ligroin. -Removal of the watercolours: by swab with water. -Removal of the filler: by swab and with the aid of the scalpel with Ligroin and methyl ethyl cheton	-Medium workability -Difficult removal of the filler: too much plastic. -The primer underneath can be spotted during the removal process. -Mimetic reintegration recognizable by the use of UV fluorescence. -Possible biological colonization.
N.3 BLUE COLOURED FILLER: 50:50 ratio between acrylic lighten filler (cromix) + minimum quantity of white ZnO + blue ultramarine watercolours W&N (gum arabic binder)	wet spatula in water to facilitate the spreading of the filler.	Removal of the filler: by swab and with the aid of the scalpel with methyl ethyl cheton and water.	-Medium workability -Easy removal with polar solvents but too close to the solubility of the original one. -The primer underneath can be spotted during the removal process. -Mimetic reintegration recognizable by the use of UV fluorescence. -Possible biological colonization.
N.4 WHITE FILLER: 0.9g micronised $CaCO_3$+ minimum quantity of white ZnO+ 2,3 g Laropal A81 **WHITE PICTORIAL FILM:** (micro lacunae) white watercolours W&N ($ZnO+ TiO_2$) **BLUE PICTORIAL FILM:** GCC (Laropal A81 ultramarin blue) **WHITE PICTORIAL FILM** (medium lacunae) GCC (Laropal A81 white TiO_2 mixed with ZnO) **POLYDIMETHYLSILOXAN:** Final Protective layer	wet spatula in white spirit to facilitate the spreading of the filler. Retouching Brushes of different sizes	Removal of the filler: by swab and with the aid of the scalpel with ligroin or white spirit.	-Good workability -Easy spreading of the filler -Safe removal in comparison to the solubility of the original one. -Mimetic reintegration recognizable by the use of UV fluorescence
N.5 WHITE FILLER: 0.9g Meudon White + minimum quantity of white ZnO + 1,3 g Laropal A81	wet spatula in white spirit to facilitate the spreading of the filler.	Removal of the filler: by swab and with the aid of the scalpel with methyl ethyl cheton and water	-Hard workability -The filler is too sticky and glossy due to the excessive amount of the binder. -Mimetic reintegration recognizable by the use of UV fluorescence

are commonly used and selected for pictorial reintegration in the world of conservation because, in time, they have shown versatility since their transparency allows proceeding by glazing operation. They are soluble in water and therefore they are reversible. Nevertheless, even though they are often discarded for the reintegration of synthetic paint films, as they are not sufficiently hiding, they were used in combination with apolar materials in the outdoor context with final protective on the top.

4. RESULTS AND DISCUSSIONS: MOCK-UPS FOR THE APOLAR AND POLAR REINTEGRATION SYSTEM

The reintegration process of Carena murals was, then, performed by choosing the alternation between apolar and polar materials, all reversible one with the other.

The mock-ups were evaluated to test the reversibility of the system, as shown in figure 2 and table 2.

Figure 2 – Mock-ups during the removal process of test n.2.

Moreover, at the very basis of the retouching process there was surely the choice to separate the layer of the filler from the one of the pictorial film. Infact, test 1, 2 and 3 - where filler and pictorial film was builded by a unique coloured layer - showed medium workability especially because the primer underneath could be spotted during the removal process. Moreover, the addition of cromix lightened filler was too close to the solubility of the original one and the latter is not suitable for the use in outdoor context due to probable biological colonization. Test n.5 was, instead, excluded because the aggregates were too similar in granulometric terms and the consequence was that the filler resulted too sticky and glossy due to the excessive amount of the binder. Test n.4, with an aggregates/binder ratio of the filler 1:2 and based on 0,9 g of micronised $CaCO_3$ plus a minimum quantity of white ZnO added on 2,3 g of Laropal A81, was the best solution both in terms of application and materials selected. The white filler was applied wetting a spatula in white spirit to facilitate its spreading in all the lacunae and, after that, a layer of ultramarine blue of GCC. Micro lacunae of the white pictorial film of the clouds (located on the original blue layer) were retouched with white Winsor and Newton (W&N) watercolours based on TiO_2 with the addition of ZnO in order to be recognisable by UV fluorescence. While medium lacunae of the white pictorial film (located on the blue and apolar LA81 layer) was regained with the application of white GCC based on Laropal A81 too with TiO_2 with the addition of ZnO. The reintegration was performed with brushes of different sizes in order to be as mimetic as possible of the surrounding surface and to attenuate the metamerism phenomena.

5. THE REINTEGRATION PROCESS OF CARENA MURALS: TECHNICAL AND THEORETICAL CONCLUSIONS

In conclusion, the fillers were all based on LA81 resin, used as binder at high concentration [14], mixed with white aggregates while the pictorial film - composed by monochromatic thick blue and impalpable white - have been reconstructed by using alternatively Gamblin Conservation Colours and watercolours in order to obtain again that clear mirroring effect of the aerographic skies that is at the very base of the figurative message of the work of art. The addition of a minimum quantity of ZnO both in all white fillers

and in white pictorial film was necessary to be recognisable from the original one by using UV fluorescence. Finally, the reintegration system was protected with the application of a polydimethylsiloxane on the top. Therefore, larger lacunae of the blue and white pictorial film have been mimetically integrated with the aim of regaining the visual perception of the hyper realistic skies concluded in their own colour and in their own shape: same chromatic tone and value. Micro lacunae of the pictorial film have been closed by glazing, with watercolours, with the same chromatic tone and value compared to the original one. All the reintegration products were opposite to the solubility of the original ones, respecting the reversibility of the intervention, of the original one and of its conservation history, while the use of fluorescence materials was necessary to perform a mimetic retouching process identifiable with the aid of UV lamp. The theoretical conclusions were based on critical choices balancing the aesthetical and historical nature of the artworks. Infact, the interruptions in the figurative text produced by losses, lacunae and micro - lacunae prevented the correct perception of the articulation figure-background. The losses, which had their own shape and colour, were perceived by observers as foreign bodies appearing as "figures" relegating the painting to act as a "background" to the lacunae themselves. It was necessary then to reintegrate as much as possible to define again the correct articulation figure-background of the abstract and repetitive aerographic skies. The operation was fundamental to re-establish the identity, lost or ambiguously readable, of one colour compared with the other and to regain the ironic illusionistic tricks given by trompe l'oeil reproductions of mirroring skies and their hyper-realistic fictions in viewing. The historical nature of the murals were respected using compatible and recognizable materials compared to the pictorial film; this passage was fundamental for the future reversibility or retreactability of the intervention and to guarantee the authenticity of the original materials in the mural paintings. This key study represents one of the research steps for the retouching process of "plastic on walls" in outdoor context. In future, the conservation materials applied will probably be part of a specific and differential decay process connected to the outdoor context. Therefore, the materials selected and applied for the reintegration of Carena murals in the open-air contemporary art museum of Piscina will be studied and monitored in a future technical maintenance plan and will be part of a biggest research in retouching materials from the ICR Mural Painting Laboratory in order to develop more trials in the retouching field of synthetic paints on walls to establish an ICR institutional protocol for the specific reintegration process of public art in outdoor context.

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RECH 6

TOPIC 2

Chromatic reintegration: museums and private context

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THE PICTORIAL TREATMENT OF THE 18 TH CENTURY PAINTED LAMBRIGGIO IN THE ALCOVA ROOM OF PALAZZO CHIABLESE: METHODOLOGICAL APPROACH, TECHNICAL SOLUTIONS AND RETOUCHING

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ABSTRACT

This paper illustrates the results of the diagnostic campaign, the problems that emerged and the choices made during the 2019 intervention in the *Alcova* room of Palazzo Chiablese, paying particular attention to the phase of aesthetic restitution of the polychrome wooden *lambriggio* with panels dated to the second half of the 18th century.
The radical changes in the intended use of the environment during the 19th century, associated with the destruction that occurred during WW2, left indelible wounds on the painted artefacts. In particular, the panels have undergone repeated treatments such as to conceal, in some cases, the 18th century paintings, creating a strong visual discontinuity. The pictorial activity included diversified technical solutions, modulated according to the specific problems encountered: small retouching alternated with extensive reconstructions based on historical photographic documentation and on direct comparison with the decorative elements of the most preserved panels.
In compliance with the conservative history of the artefacts an overall recovery project was developed aimed at the search for a new aesthetic unit capable of coherently communicating with the remaining fixed furniture and mobile environment.

Keywords
Aesthetic presentation; Lambriggio; Tratteggio; Rococo style; Retouching techniques; Paintings on panel

1. INTRODUCTION

The conservation and restoration activity concerned the whole *lambriggio* covering the lower portion of the interior walls of the so-called Sala dell'Alcova, in Palazzo Chiablese, Turin. The ensemble, dating back to the second half of the 18th century, is decorated with the technique of oil paint on wood.
The treatment, which involved an articulate cleaning phase that will not be covered by this contribution, has also faced delicate issues relating to the aesthetic presentation of the artefact, such as what technique, materials and methods to be used for retouching.
The operational choices were based on a preliminary study aimed at investigating the artefacts from a historical and material perspective, seeking to find a retouching methodology which could meet the needs of the single panels and at the same time harmonize coherently with the solutions adopted on the other decorative elements of the room.
The main focus was to find a compromise solution, able to enhance the quality of the decorative motifs of the

artefacts, preserving at the same time the opportunity to appreciate their complex conservation history.
Moreover, the conservation activity has been directed towards a renewed unity, essential to attribute to the *lambriggio* the correct role in the complex decorative apparatus of the boardroom in which it is located.

1.1 Historical-artistic context

In 1753, Carlo Emanuele III assigned the palace adjacent to the royal residence, in the heart of the "command area", to his cadet son Benedetto Maurizio di Savoia, duke of Chiablese [1]. The renovation and expansion of the apartments was entrusted to Benedetto Alfieri: although his projects remained partly unfinished, his intervention involving the partial demolition and raising of the pre-existing structure bestowed on the palace its current interior and exterior appearance.
Two decoration campaigns were carried out in the grand apartments, respectively in the years 1756-1758 and 1760-64, involving the rooms facing towards the royal square which were organised in a double enfilade functional to the ceremonial necessities. Alfieri also supervised the gilded stucco decoration, matching the refined boiserie and furniture made according to French models by équipes of craftsmen who worked also on other royal sites. The pictorial decoration of the rooms of Palazzo Chiablese, visible mainly on the large over-doors, also sees the involvement of some of the leading figures of the pictorial culture in the court of Turin at that time.
Characterised by half-pilasters in the corners and "flying doors" covered in mirrors with carved and gilded frames, the Galleria Alfieriana is adorned with over-doors, a fire-screen and the *lambriggio* decorated with "groups of different flowers" by the painter Michele Antonio Rapous [2]. The decorative apparatus is marked, in the following centuries, by complex conservation vicissitudes linked to the change in use of the room, which in 1850 is transformed into a bedroom with an adjoining alcove. In these revival phases, the most important event is the introduction (1883), of the splendid desk made by Pietro Piffetti in 1756 originally intended for another part of the Palace. The devastation caused by the Anglo-American bombing (1943) strongly compromised the state of conservation of many ornamental elements. In the post-war period, with the assignment of the palace to the Ministry of Public Education and its function as headquarters of the Soprintendenza per i Beni Architettonici del Piemonte, the environments of the piano nobile underwent drastic renovations including redistribution of the indoor areas and restoration activities. The archival documentation, the historical photos and the direct observation of the surfaces allowed to identify the traces of the different maintenance interventions involving the whole vault and the remaining wooden furniture of the *Sala dell'Alcova* (Fig. 1).

Figure 1 – Sala dell'Alcova, east and west walls before and at the end of the restoration works.

1.2 Notes on the technique

The *lambriggio* [3], having a linear length of 24 meters, is divided into 23 segments hosting 35 rectangular poplar panels characterised by a straight profile; the only exception is represented by three panels located in the corners having a curvilinear outline which complies with the wall mirrors placed immediately above to complete de décor of the walls. The panels, painted with flower wreaths, are placed inside a plastered and polychrome wooden structure articulated into half-pilasters, also in poplar. This structure, in addition to containing the panels, forms the plinth running across the perimeter of the room, including the splays and the walls beneath the windows, for a total height of approximately 80 cm from the ground level. All the wooden panels also present a simple moulded frame with rocaille motifs at the four corners, finished with burnished gold leaf applied following the water-gilding technique on a red-bole surface.

As with other 18th century *lambriggi* present in other aristocratic Piedmontese residences, the panels have, in direct contact with the wooden substrate, a linen textile characterized by a plain weave 1:1.

Of all the painted panels still present today, twenty-one show the 18th century decoration, characterised by a high pictorial quality, that differ from the decorative campaigns which followed. The flower motifs decorating the rectangular panels alternate compositions enclosed at the base by monochrome elements in rocaille style, with single or double wreaths overflowing with leaves and flowers. The pictorial technique, based on the use of powder pigments dispersed in an oil medium, presents fluid and flowing brushstrokes devoid of any hesitation, revealing the high level reached by Michele Antonio Rapous and his workshop, specialised also in this type of decoration.

The X-ray induced fluorescence (XRF) mapping of the painted surfaces and the visible light reflectance spectroscopy with optical fibres (Vis-RS) has allowed to reconstruct the rich palette of the artist that included most of the colours used at the time: lead white, copper green, Prussian blue, red lake, Naples yellow, cinnabar, oxides and natural earths. The use of green earth for the light-blue backgrounds has been revealed by the presence of green-bluish mineral celadonite.

The opportunity to further investigate some micro-samples of paint, through cross sections using SEM-EDX microscopy, has allowed to study the pictorial technique and characterise the nature of each paint layer. A rather simple succession of layers has been identified on top of the "incamottatura" cloth: first a single preparatory layer made of gypsum (calcium sulphate) followed by a very thin light layer, a sort of imprimitura, made of basic lead carbonate (lead white) and iron oxides (natural earths), above which the paint layers made of pigments in oil were applied. The flat monochrome backgrounds were made in two steps applying the colour directly on the ground, made of gypsum and animal glue: a first application with a green-yellowish colour and a second one with a colder light blue tone obtained by adding a few grains of celadonite.

The presence of large overpainting interventions carried out just a few decades after the completion of the cycle and involving almost exclusively the backgrounds, allowed to preserve sporadic traces of the original mid18th-century varnish consisting of a natural terpene resin, characterised by a pronounced phenomenon of oxidation and yellowing.

1.3 Study of the conservation history

Based on the elements acquired during the conservation treatment, and by cross-checking the data derived from the close inspection of each panel with the results of the multispectral and scientific analyses, the stylistic analysis and the observation of historical photos, it was possible to distinguish four main phases in which the painted panels and their containment systems underwent important changes. Certainly, the changes of intended use and the fact of belonging to the same decorative apparatus have favoured, over time, recurring treatments on the artefacts aimed at resolving degradation phenomena on one side, and on the other at adapting the artefacts to the new changes made in the conservation environment.

A first phase of aesthetic adjustment during which the backgrounds of all panels were painted of a more intense aquamarine hue than the original one, can be plausibly located between the end of the 18th century and the beginning of the following century. This paint application strikes for the high level of expertise with which the different flower wreaths and bundles were blocked out in order to avoid overlapping on the figuration.

During the second half of the 19th century important overpainting campaigns were carried out and new parts were added to adapt the *lambriggio* to the new set up of the room, which was transformed from a gallery into a bedroom with annexed alcove. In the occasion of this radical change in use, some panels were resized and

overpainted, especially on the backgrounds and in the apical leaf-portions, as it is possible to see on the concave panels under the corner mirrors. As attested by the historical photos conserved in the *Soprintendenza* archives, these retouches had already undergone a visible discoloration at the beginning of the 20th century.

Thanks to the XRF and FT-IR analyses it was easier to detect the 19th century retouches, identifying them both formally but also based on the presence or absence of specific pigments. For instance, the peculiar presence of chromium-based greens and the absence of red lake was observed, together with the continued use of pigments such as lead white, earths, vermillion red, Naples yellow and Prussian blue.

In this respect, the outcome of the X-ray investigation carried out on a panel located on the south wall, next to Piffetti's desk, proved very interesting (fig. 3). The panel in fact turned out to be made from an 18th century painting belonging to the same room, which was resized and overpainted in the second half of the 19th century A corner piece, located under the same furniture piece, was probably made in the same period, as it presents the same background colour characterised by a warmer nuance, tending toward ochre, obtained by mixing lead white and earth colours with an oil medium. It is interesting to note how this new decoration phase was made following the style and with the precise intention to imitate as convincingly as possible the previous decoration. This mimesis intention finds its roots in the desire to preserve the integrity of the existing decoration, harmonizing the new pictorial phase to the 18th century one from which it is inspired.

The last decoration phase, dating back to the first decades of the 20th century, involved the total remake of the panels on the eastern wall, next to the fireplace. These panels present a liberty-style decoration, very different from a formal and chromatic point of view from the original decoration and from the ones made at the half of the 20th century. As attested by the two panels at the right of the fireplace, also in this case the material was recycled for financial and practical reasons, either taking it from artefacts belonging to the same room or from monochrome panels present in other rooms of the palace.

The repaint layers of the backgrounds were made applying lead white, Prussian blue, copper or chromium based greens over another partial ground layer. The latter was applied to flatten the discontinuities of the planking caused by the light movements of the wood, from the centre to the sides.

Compared to the previous phases, the 20th century palette contained mainly copper based pigments, forming most of the green shades. Punctual analyses, carried out on some panels, have highlighted the presence of barium, an element associated with the use of blanc fixe (barium sulphate), used either pure or mixed with other pigments.

Among these interventions it is necessary to mention the post-war changes, carried out in the 40s when the Palace was transformed into the headquarters of the *Soprintendenza ai Monumenti del Piemonte*. This last significant restoration activity entailed mainly a functional recovery of the damaged structures, preferring a more conservative approach which did not include the reconstruction of the missing decorations. An evidence of this "archaeological" approach can be found in the basic form of some elements of the *lambriggio*, in which the wooden support was left visible without any pictorial finish.

Lastly, in the year 2000, probably due to the bad state of conservation of the *lambriggio* panels, a pilot project was launched with the aim to carry out the treatment on two painted panels from the western wall and related frames. The treatment report stored in the archives of the *Soprintendenza* and the direct observation of the artefacts were the keys to understand the procedures applied back then, which included: surface cleaning and the removal of discoloured varnishes from the painted surfaces, consolidations of flaking paint, infilling with gypsum and animal glue, retouching followed by a semi-gloss sprayed varnish.

1.4 Conservation issues and degradation phenomena

In general, the *lambriggio* presented a mediocre conservation state, attributable to the combination of several factors both of anthropic and environmental origin [4]. The panels and the related wooden structures showed, in fact, tangible signs of their complex conservation history. In addition to the damages linked to the use of the artefacts and their specific location, such as scratches, dents, abrasions and small breakages, some of the observed degradation phenomena derived from the lack of a proper ordinary maintenance and from the ageing of the non-original material applied during previous treatments. On top of the numerous layers of varnish applied unevenly during the previous conservation and maintenance treatments, there were conspicuous amounts of loosely bound particulate soil and surface matter.

Figure 2 – Detail of one of the panels: on the left an eighteenth-century floral motif in excellent condition used as a model for the reconstruction of a similar flower present in another panel. At the center a phase of the pictorial integration process, where it is possible to observe the pencil lines used for transferring the outline of the reference figure. On the right, the reconstruction intervention completed.

The presence of stains, concretions, humidity marks and drippings - probably caused by the unwanted contact with solvents used during recent consolidation treatments of the flaking paint - made the observation of the painted surfaces more difficult.
Most of the painted surfaces suffered from a slow but continuous phenomenon of de-adhesion of the paint layers and of the canvas. The latter in particular was detached from the wooden support in many points, forming convex bulges which represented a risk for the adhesion of the paint layer to the substrate. In some panels, such as the ones on the sides of the fireplace, the degradation was so pronounced that vast areas were faced in the first years of the 21st century.
Lastly, most of the painted surfaces, as stated before, were largely overpainted and/or presented localised retouches on the background and on the figuration. The discoloration of the latter was particularly evident in relation to the tones of the 18th century paint.

2. MATERIALS AND METHODS

2.1 Methodological approach and aesthetic proposal

The pictorial reintegration of the artefacts, together with the delicate cleaning process, was among the most complex phases of the whole conservation treatment.
The decision-making process which led to formulate the final proposal of aesthetic treatment, required a flexible methodological approach, able to respond coherently on one hand to the needs of the single panels, on the other to the choices taken for the conservation of the other elements of the same room (gilded frames, wall mirrors, stuccoes, wooden furniture, textiles).
The comprehension of the material and immaterial values, the evaluation of the environmental context in which the *lambriggio* is located and the balance among the elements involved, represented the starting point for the definition of the objectives of the treatment [5]. Without preconception the option was examined of using two different methodological approaches, that despite being diametrically opposite, represented an attainable alternative [6].
The question was raised whether directing our treatment towards the research of a philological reading as neutral as possible, or to support the fruition of the images through the reconstruction of the losses enhancing the expressive potential of the existing parts [7].
Our choice fell on this last option which however, opened the way to additional issues, having no easy solutions, concerning how and to what extent the integration should be carried out.
The proposal of aesthetic reintegration presented aimed at reaching an ambitious goal: enhancing the quality of the pictorial cycle, in particular the 18th century phase,

Figure 3 – Detail of one of the panels with the largest amount of paint losses: before the treatment and during the cleaning, infilling and reintegration operations.

without erasing the traces of their complex conservation history.

The choice was also supported by the compendious nature of these artistic artefacts, made to be enjoyed as part of a harmonious ensemble in an articulate decoration project.

With this in mind and considering the *lambriggio* as a whole, the choice was made to follow the approach of reconnecting as much as possible all the chromatic areas interrupted by losses [8], carrying out a formal and chromatic reintegration (Fig. 3).

The criteria behind the treatment of lacunae were the outcome of meditated evaluations, taking into account the analysis of the materials, the constant monitoring of the treatment results, and the collaboration between the professionals involved in the project [9].

In particular, the formal characteristics of the lacunae were examined, classifying them on the basis of the extension, position, typology, shape and quantity. The use of these criteria supported the study of the existing parts and allowed to identify precisely the most critical aspects.

Once the cleaning phase was concluded and the considerable extent of missing paint in four panels was acknowledged, we took into consideration the use of a philological methodological approach to be carried out through a "reassuring" aesthetic integration in a "toned neutral" colour. This choice would have also shortened the work timetable and limited the subjectivity averting any risk of falsification.

However, this proposal was not considered viable as it would have eventually introduced into the pictorial cycle new and imponderable values taking us further from the objective of a renewed potential oneness.

Before extending the chosen method to all painted panels, retouching tests were carried out in the areas with most lacunae and therefore also the most difficult to treat, trying numerous techniques each characterized by a specific aesthetic result. The tests included *tratteggio* with continuous vertical strokes, *tratteggio* with fragmented vertical strokes, *selezione cromatica* and *pointillisme*. Nevertheless, the material qualities of the original paint layer, such as its compactness, its polished appearance, the use of varied shades, the intensity and brilliance of the colours, all influenced our decision which favoured the use of *tratteggio* with fragmented vertical strokes. This technique proved very ductile allowing to operate effectively both in the monochrome backgrounds and in the figurative elements. The application of colour with the tip of the

brush in thin vertical lines, juxtaposed and overlapped, proved to be a valid instrument for the integration of large and small lacunae.

Figure 4 – Total and details of a panel before, during and at the end of the pictorial reintegration activity. In the detail in the center, we can observe the basic watercolor glaze with a first layer of vertical *tratteggio*.

The selected *tratteggio* technique allowed to obtain a convincing definition of the flower and vegetable elements which would have been impossible if the *pointillisme* technique, naturally producing blurred outlines, was to be used. As for *selezione cromatica*, which follows the original brushstrokes *ductus* and the shapes of the figures, proved unsuitable for our purposes. In fact not only the latter created confusion in the visual appearance of small decorative elements, but the choice of what direction the lines should have could have introduced an additional risk of subjectivity.
Last, even if the *tratteggio* with continuous vertical strokes could have been a viable alternative for the backgrounds, it did not work well for the figurative elements, as it did not comply with the heterogeneity of the decoration motives. The tests carried out using this technique resulted to be rigid and unable to dialogue harmoniously with the rest of the original decoration.

2.2 Materials for conservation

Winsor & Newton Professional watercolours in tubes have been used for retouching, and in particular: cadmium red, viridian green, ultramarine blue, ivory black, light red, Indian red, permanent alizarin crimson, terre verte, yellow ochre, raw sienna, burnt sienna, raw umber, burnt umber, sepia.
The selected colour palette, compared to the wide selection offered by the market, was limited to the above list in order to avoid, as far as possible, the use of pigments indicated in literature as unstable to UV radiation [10] [11]. However, it is worth mentioning how the *lambriggio*, located in the lower part of the wall in direct contact with the floor, is less exposed than other elements forming part of the *Alcova* to direct contact with the light radiation coming from the windows.
The same approach has been adopted also for the selection of varnish colours from the series Gamblin Conservation Colors, considered in order to reduce any interference which might arise among the different types of materials applied on the painted surfaces. In fact, in this case the urea-aldehyde resin (Laropal® A 81) which binds together the pigment particles, is the same which has been used for the intermediate varnish. In particular we used the following colours: Naples yellow light, titanium white, yellow ochre, cadmium yellow light, cadmium yellow medium, cadmium yellow orange, cadmium red light, cadmium red medium, raw umber, venetian red, burnt Sienna, transparent earth red, Indian red, alizarin permanent, cobalt blue, ultramarine blue, viridian green, chromium oxide green, ivory black.
As far as the choice of the solvent to be used to dilute the varnish colours is concerned, a binary mixture of 63.2% n-butyl propionate (n-BuOPr) and 43.6% Shellsol® T was made, having the same properties (evaporation rate and dissolving power) of xylene, the use of which is optimal for varnish retouching, but strongly discouraged for toxicity reasons.

The first layer of varnish, prior to the final retouching phase, was applied with a pad using the low molecular weight urea-aldehyde resin Laropal® A 81 from Kremer Pigmente, while the last coating was made with the low molecular weight aliphatic resin Regalrez® 1094 Gloss from CTS Europe. Both varnishes have been selected based on their optimal ageing behaviour according to the specific scientific literature, for their characteristic of being soluble in aliphatic solvents and removable, even after time, using low polarity solvents respectful of the conservation of the pictorial materials [12] [13].

3. RESULTS AND DISCUSSION

The planning of this phase of the treatment was made on the basis of a scrupulous study of the remaining parts, in particular considering the most problematic areas with vast lacunae. In these cases, a virtual reconstruction of the missing portion of paint preceded the retouching activity, taking as a reference the best conserved decoration elements [14]. The precious shreds of paint unveiled during the cleaning operations were essential in selecting the most convincing floral motifs, chosen on the basis of their shape, type and colour. They were virtually cut out and pasted on photos of the panels taken after the infilling phase.

These virtual reconstructions were crucial in evaluating the feasibility of the proposed reintegration method and in obtaining a first impression of the appearance of the panels after the treatment. Moreover, this graphic reconstruction offered useful elements to judge whether the integration activity could have included the areas with the highest amount of losses.

Following the indications of the *Soprintendenza* -which was in favour of the integration of all types of losses - the drafted proposal involved the restoration of the chromatic and figuration unity, making the integration recognisable and improving the readability of the floral motifs.

The opportunity to carry out such a type of reintegration was offered by the recurrence of similar decorations even in the most degraded panels. Moreover, the study of historical photographic documentation and in particular of the photographs taken at the beginning of the 20th century, when the painted surfaces were in the best condition, were fundamental in the reconstruction process (Fig. 5).

In some cases, as in the south-western corner *lambriggio*, the historical photos provided clear iconographic elements which were essential for an accurate and philological reconstruction of the figuration. Viceversa, where the historical documentation was lacking, the missing portions of the flowers were directly copied from the complete ones using tracing paper and graphite. In this way, the selected shapes were replicated on the surface of the infilling to integrate the remaining portions of original paint. A meticulous study was necessary in this phase in order to minimize the subjectivity component, which however is difficult to eliminate (Fig. 2).

The inpainting itself was carried out using watercolours, avoiding the use of white pigments thanks to the white base created by the infilling.

Figure 5 – Top left, detail of a panel in an early twentieth century photo useful for the reconstruction of the lost elements; alongside the same detail before the intervention; below during the stucco phase and after completion of the pictorial integration activity.

The retouch methodology included two different techniques depending on the type of lacunae which had to be treated. The larger lacunae - filled with Bologna gypsum and rabbit skin glue in a ratio 1:14 - were treated applying glazes of paint to reduce the brightness of the filled surfaces, set the general volumes and hint at the hues of the single decorative elements (Fig. 4). This first phase was very useful also to shorten the working time and have an immediate overview of the resulting reconstructed forms directly on the surface.

The vertical *tratteggio* was used to reintegrate, allowing to reconstruct the missing portions and at the same time denounce the reintegration [15]. This technique,

extensively described by Cesare Brandi in his Theory of Restoration, consists in juxtaposing and overlapping vertical lines of pure colours, forming in this way an identical chromatic tone to the adjacent one, used as a reference [16]. The use of pure colours as opposed to mixed ones, limiting also the overlapping, is recommended to obtain a vibrant and full tone.
Viceversa, the micro-abrasions were treated using a mimetic reintegration method, through glazes or small dots in order to chromatically connect the isolated portions of paint. The careful act of re-composing, carried out by connecting the small surviving islands of colour, has allowed to recover the integrity of the decorative motifs conferring definition to the figuration and greater fullness and compactness to the chromatic washes.

Figure 6 – Detail of a *lambriggio* panel before, during and after the conservation treatment.

Following the first part of the integration process, a thin layer of varnish was applied using a pad (100 g Laropal® A 81, 400 ml Shellsol® D 40 e 100 ml isopropyl alcohol) so as to saturate the colours and create a first protective layer [17]. The final glazes and chromatic harmony necessary to match the tratteggio areas with the original paint was obtained with varnish colours dissolved in a mixture of n-butyl proprionate 63.2% and Shellsol® T 36,8%. After the completion of the retouching activity, the surfaces were newly varnished using the low molecular weight resin Regalrez® 1094 Varnish Gloss diluted at 30% in Shellsol® D 40, sprayed on the surface with an airbrush. After the conclusion of the conservation of the entire Sala dell'Alcova, and following the re-installment of all the *lambriggio* elements in their correct position, an on-site treatment was necessary in order to reach the desired visual continuity to the ensemble. With this aim in mind it was decided to treat the plain wood panel through the application of an aquamarine green paint having a similar hue to the background of the original panel and to harmonize the different light-blue tonalities of the containment structures through the application of a watercolour glaze followed by a thin layer of microcrystalline wax (Fig. 6).

4. CONCLUSIONS

The aesthetic reintegration proposal on the 18th century *lambriggio* from the Sala dell'Alcova in Palazzo Chiablese (Turin) offered a chance to reflect on the topic of retouching. For example it showed how it is not correct to establish *a priori* a specific conservation methodology in the erroneous belief that a unique model - the best model – could exist and be applicable to any case. The experience has once again convinced us of the impossibility of erasing completely the subjective component from the treatment of lacunae and that this can only be reduced by relying on sound theoretical principles and valid scientific criteria.
In particular the understanding of the environmental context in which the artefact is located and the analysis of the material and immaterial values characterising the artistic artefact represented, in our case, useful instruments in guiding the planning of the aesthetic treatment phase, which has been dealt since the beginning free of any bias or mental limitation.
The adoption of a recognizable and flexible reintegration method allowed to enhance the quality of every single panel and to re-establish a new unity, essential confer to the *lambriggio* its correct role in the context of the ample decorative furnishing that characterises the representative environment of which it is part.

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RETOUCHES WITH HISTORY – CONSERVATION OF THE SACRED HEART OF JESUS BY ADOLF HERMAN DUSZEK AND ITS AUTHORIAL POST-WWII RESTORATION

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ABSTRACT

WWII left a great proportion of cultural heritage in Middle-Eastern Europe damaged. In the immediate aftermath of the war, there was neither necessary expertise, manpower nor resources to deal with such complex and total conservational challenges. Artists and craftsmen took to preserving and repairing the most darling objects of local heritage, leaving to us not only their original works, but also visible marks of the struggle to preserve them. Today, we are facing the task to preserve the multilinear story hidden behind those objects - their original body, wounds, and bandages, showing both the art of creation as well as the art of restoration to next generations. A great example of such a conservation effort is the story of The Sacred Heart of Jesus, painted by Adolf Herman Duszek in 1924 and restored by him after the war, in 1950. Over 70 years later, the painting required another intervention – mainly because of the bad state of preservation of the paint layer. The main challenge of this restoration was to find the balance between leaving the visible traces of the history of the object, the conservation ethics as well as the aesthetics and expectations of the recent owners. As it turns out, the impact of a private context is a significant aspect during the formation of the conservation programme. This paper discusses the need for compromises which had to be reached during the conservation of this particular painting.

Keywords: Zinc support; Retouches; Private context; WWII; Adolf Herman Duszek; Authorial restoration.

1. INTRODUCTION

1.1 Adolf Herman Duszek – author's profile

Adolf Herman Duszek was a talented and professional Polish artist. He was born in 1872 in Tomaszów Mazowiecki and died in 1964. Initially, he was studying in Warsaw, in a Drawing Class conducted by a famous Polish painter, Wojciech Gerson. In the course of his career, he was also studying and working in Vienna, Paris, Russia, and Hungary. For two years, between 1899 and 1900, he was a part of a well-known Munich School, and his activity was supervised by Stanisław Grochowalski. He later returned to Poland and remained an active artist, working in the area near-by Warsaw which was totally devastated during WWII. A. H. Duszek was also an old-masters copyist and a stained glass designer [1]. There are, however, scarce notes in which he was mentioned. Certain information is available in the Dictionary of Polish Artists and in some other resources, e.g. books, publications, and newspaper notes [2][3]. Local communities in Poland are very proud of possessing his works of art in their collections. Such information can be found on websites of many parishes. Still, as an artist, he has never won widespread popularity [4].

The fact that a lot of artworks had been destroyed, stolen or had changed their location during and after the War could contribute to such lack of recognition. Only a few of his works remained, and those appear from time to time in Auctions Houses. The other group of his paintings are those of a religious character, which are a part of the interiors of a few churches in Poland. The author of this article received a grant from Nicolaus Copernicus University in Toruń [5], which enabled researching the remaining paintings. Owing to this project, it can already be stated that another works by Adolf Herman Duszek are located in cities or towns such as Legionowo, Łódź, Nieporęt, Wola Kiełpińska and Zegrze.

1.2 Early information about the painting

Figure 1 – Painting before restoration.

The object of interest is a depiction of The Sacred Heart of Jesus. The image is painted in an oil technique on the zinc support, strengthened by the wooden frame, with approximate dimensions of 174×83 cm (fig.1). What was known at the initial stage of the conservation process was the fact that the image of Christ was made for a local parish in Poland as a typical altar painting created on a metal support. During wartime, the image received nineteen deliberate gun shots, which strongly damaged the painting. It can be said that the shots were fired from the front of the painting, because one of them shot through the metal plate into the wooden bottom bar. The most devastated part of the painting is the figure of Jesus Christ, especially the area of his torso and heart have been intentionally destroyed. More than a half of all shots can be found in the upper part of the body of Christ. Fortunately, the author – A. H. Duszek survived the atrocities of war and in 1950 decided to repair the painting by lining metal patches, filling the bullet holes and restoring the paint layer with an oil-paint technique. The author himself tells this story at the back of the painting with a meticulously calligraphed note – clearly stating the names and dates; notes from the back says (fig.2):

Painted and composed, by an artist
Adolf Duszek in Zegrze (north)
Anno Domini 1924, day 17th of June.

•

This painting – thoroughly repainted and improved by this painter A. Duszek in Wola Kiełpińska, in local church – during the time of the parson Stanisław Zając.
Anno Domini 1950, day 18th of July.

The painting was shot through in these places.

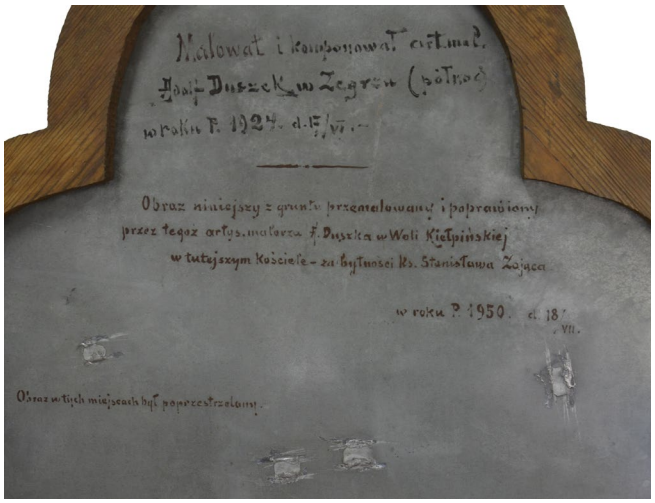

Figure 2 – Description from the back of the painting.

1.3. Further investigation and a third picture

Over centuries, artists have appreciated working on metal plates not only because of their durability [6], but particularly due to their gloss and a very even surface. Working on metal sheets requires significant painting skills. While working on canvas, the structure of textile allows losing some of the brush strokes and paint traces whereas on the metal surface every move of the brush is clearly visible [7]. This unique feature allowed finding out that beside the two paintings mentioned by A. H. Duszek at the back of the object, there must be something else. The surface of the painting was very uneven and from different angles, in a side light, a few impasto traces which do not fit the expected composition of the painting were noticeable. UV and IR examinations do not provide an unambiguous answer. Then, the X-ray radiography study was performed. This method reveals the hidden picture of two figures – an old man on the left and a second man on the right side of the painting. At first, it seemed to be a depiction of the Trinity, but the Holy Spirit as a dove was not really well visible under the subsequent layers of rays of light around the heads of the two depictions of Jesus. X-ray photographs also revealed the head of Christ first painted by A. H. Duszek. Apparently, it was slightly turned to his right side, while the current image of Jesus Christ is looking straight at the audience. Another difference has been shown in the somewhat different position of the hands of Christ (fig.3).

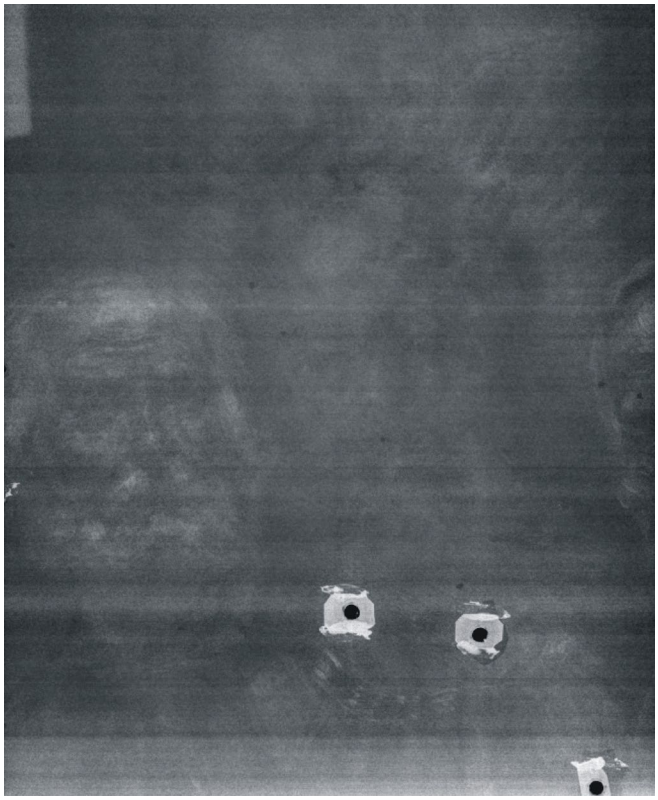

Figure 3 – X-ray photography with the visible head of the "first" Christ (slightly turned to his right side) and the head of an "old man" on the left side of the picture

For the purpose of further investigation, a decision to conduct the MAXRF scans was made. Hence, the composition of pigments allowed us to discern more details from the original painting. However, due to certain obstacles, this investigation took more time than initially expected. A private commission usually requires quick decisions and the work should be accomplished to meet deadlines. Thus, despite the discovery of the third and the original painting, the conservation programme had to be clarified, so that the conservation treatment can start, even though the stratigraphy analyses and MAXRF scans were not yet completely carried out.

1.4. Private context and the range of the intervention

Conservation programme is a part of an art conservator's work, which should be formulated after the plethora of instrumental investigations as well as the historical analysis. In the case of the interventions undertaken over the private collections, it is often one of the requested documents which on the one hand is necessary to sign a contract. On the other hand, it has to be developed usually just based on a visual evaluation of the object. That is one of the reasons why a conservation programme may alter while learning more about the object of interest. Owing to modern instrumental techniques, we are currently able to collect more information and investigate objects far more thoroughly than we could imagine not so many years ago. The biggest campaigns of works of art analysis are used by museums to extend knowledge about "their" masterpieces but also to interest the wide audience in a particular object or an artist [8]. Instrumental diagnoses, especially in the form of maps or high resolution photographs, are warmly perceived by tourists and followers from social media [9]. Moreover, specificity of museums allows conducting only the most essential conservation interventions to the objects, which very often do not cover a comprehensive restoration. The nature of exhibition

halls and the amount of objects – sometimes in a very different state of preservation, also gives the possibility for a proper description of each piece.

In contrast to institutionalised conservation projects, there are also private commissions both individual or, as in this case, those commissioned by a community. As the experience of cooperating with religious communities may show, altars should not stay empty for a long time. The same concerns common scaffolds inside a temple since they may turn out to be disturbing for praying people. This context is slightly different when tourist and famous temples are concerned; people attending them may be aware that the atmosphere of silence and calmness might be disturbed not only by visitors but also by years-long conservation works. For these projects, the budget is also adequate. The situation is significantly different in small, local church communities. For these reasons, the time for the conservator's work is significantly shorter, and the programme usually involves only the most important instrumental analysis. Furthermore, after renovation, objects have to be impressive and worthy to get back to worship.

In order to carry out the restoration the decision-making process about the further intervention was done on the basis of recommendations of several experts including NCU professors and the main restorer who was responsible for the conservation of the other parts of the interior of the church in Wola Kiełpińska. Based on the instrumental analysis of The Sacred Heart of Jesus and considering the previously addressed circumstances of the private context, a decision was made to leave all the traces of shots and their repairs made by A. H. Duszek. These gunshots occur mainly on the figure of Christ (fig.4). On the other hand, all the other unaesthetic fillers and putties which were put to fill the lacunas of the paintlayer in the parts of clouds and partially also in the background were to be removed to smoothen and calm the whole image. The conservation programme also included the removal of the yellowish varnish from the entire surface. The greenish and brownish glaze from the part of the clouds was also removed (fig.4). This decision was made because the glaze was put in a sloppy and non-rigorous way. It also allows us to get back the bright colours of the clouds.

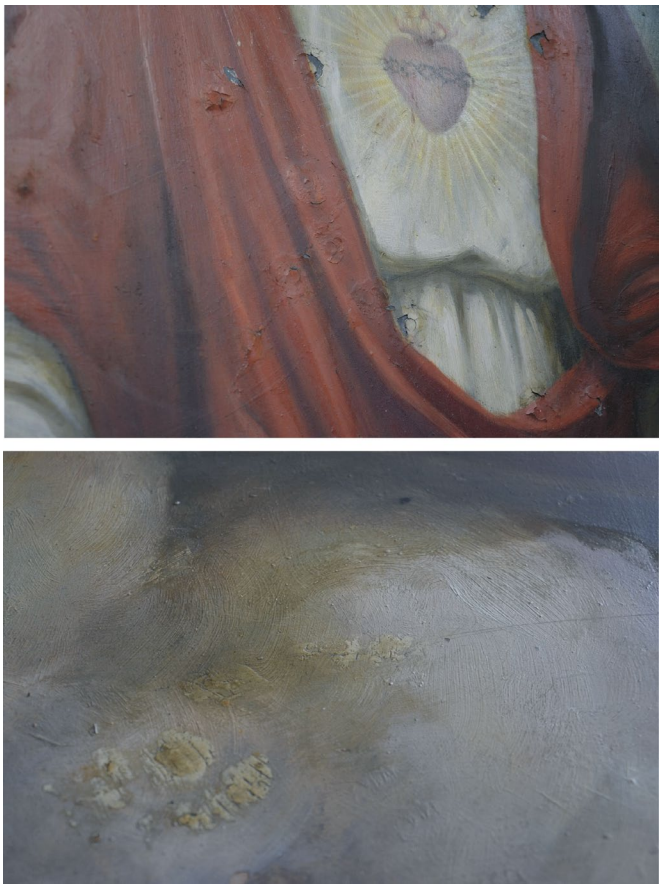

Figure 4 – Details of the painting: gunshot marks (above) and surface of the painting during the removal of a brownish glaze with well visible imprecisely applied filler (below).

A previous analysis showed that this brownish glaze was the only layer put on the top of the authorial fillings. It means that it was the Author's way to hide the imprecisely applied filler. The result of this compromise is that the colours of the clouds are from the first Duszek's painting but the figure of Christ is from the latter one. The process of the removal of brownish glaze is well presented in the bottom picture of the fig.4. Also, the wide and thick spots of the removed filler are well visible. Moreover, in the fig.5 it is shown how the cleaned parts of the cloud look like and in what area the new filler and retouches were applied.

2. MATERIALS AND METHODS

Considering the fact that The Sacred Heart of Jesus is a painting created on the metal support, choosing proper tools to conduct the conservation process was a challenge as over many years a lot of mechanical lacunas of the paint have appeared. Due to the topic of the 6th International Meeting on Retouching of Cultural Heritage, this chapter will be focused on the problematics of a chromatic reintegration of the paint layer. Since the structure of the described painting is a compilation of the three layers of depictions (supported by X-ray radiography and MAXRF analysis), some losses of paint were unconventionally deep. In addition, after many years, each of the surfaces of the painting was covered by dirt gathered during wartime. Some spots of wax and other tiny particles adhered to the image, too. After that, all of these pieces were covered by the following painting. To recreate this peculiar structure, a filler reach in aluminium powder was used [10]. The structure of the paint layer was recreated with the use of stainless-steel dental tools and scalpels. Because the paint layer was not only missing but also abraded, to visually reintegrate the surface of the painting, Kremer Pigmente paints were used. A set of highly pigmented paints dedicated for Art Conservators is based on a synthetic resin – Paraloid B-72. As a solvent, a mixture of two glycol ethers solvents:1-methoxy-2-propanol and di(propylene glycol) methyl ether, in 1:1 ratio was applied [11][12]. These paints ought to be well-known for their good quality: light and ageing resistance [13]. Their adhesion to the filler is satisfactory, and the colours are bright and vivid, so they match properly the surrounding created with an oil technique.

Another important aspect relates to the ability of changing density of these paints: it gives the possibility to imitate the missing brush strokes in the areas where there was no filler but the surface was abraded. Voids of paint made mostly by mechanical damages and scratches were restored by merging (fig.5). An intervention layer of retouching varnish (Talens, 004 Retouching Varnish) was first interposed between the pictorial layer and the reintegration, in order to remove the intervention more easily in the future, if necessary. This type of imitation style of retouches is also one of the consequences of the private context restoration and painting reinstatement to worship (fig.6).

Figure 5 – Detail of the painting before and after retouches.

3. RESULTS AND DISCUSSION

This article discusses the role of the private context in the process of a conservation programme determination by describing the very uncommon example of a multi-depiction painting with a remarkable type of damages which ought to be preserved. The Sacred Heart of Jesus prepared on a zinc support is a painting with a complex and tough history. Notes left by the author, Adolf Herman Duszek, at the back of the painting, describe the story of the depiction of the figure of Jesus made by him twice. The first image was painted in 1924 for a parish in Zegrze, Poland. After WWII, the painting was rescued from a devastated church and found its place in the neighbouring area, in the parish of Wola Kiełpińska. There, in 1950, the recent depiction appeared as a consequence of removing the marks which occurred during the last war. An instrumental analysis involving X-ray radiography and MAXRF scanning revealed the appearance of the third image which lies below the two ones mentioned before. Thanks to the X-ray radiography records, which shows another composition containing depiction of two men on both sides, it can be point to a different technical quality than that of the A.H. Duszek's. That is why it can be interpreted as a reuse of the metal support. The author of this chronologically first picture is unknown, but even though that the object is already after conservation treatments, further investigation

involving stratigraphy analysis and plethora of non-invasive techniques is still being conducted.

The contribution the painting makes to our discussion is that even with a rich and intricate history a piece of art has to be restored in a consistent and aesthetic way acceptable to church communities, after it is returned to worship. It requires a compromise between leaving the traces of gunshot wounds and their repairs, conservation ethics and the aesthetics and expectations of the recent owners. The obtained result is a painting which can be an embellishment of the church and, at the same time, it tells its story by visible marks of the past.

Figure 6 – Painting after restoration.

It is important to mention that churches inventory should not be considered a private property, but rather as a heritage deposit. Communities gathered around their temples are depositaries of the goods which survived from the past to our times. Therefore, it is so relevant to emphasize the roles and the great responsibility of these communities in the process of preserving our shared heritage. That is why there should always be a dialogue between a conservator and a customer.

4. CONCLUSIONS

The case of The Sacred Heart of Jesus is a captivating story of a painting which survived the First and the Second World War in the area where many fronts moved through. This painting is a real hero, an object which literally witnessed those times – not hidden or covered in an anonymous basement, but by receiving and absorbing all the hits from different enemies. Every time the given wounds have been healed, even though the appearance of the painting has undergone modifications. The recent owners – the community of the parish in Wola Kiełpińska, Poland, wanted to bring it back to its respective condition once again. Therefore, in 2021, the restoration process was conducted. The result of this conservation is a painting documented and strengthened as never before [14]. The restoration has been accomplished in a manner appropriate to the place of worship, although with respect to the markings of war. The performed intervention included imitation style of retouches which is considered to be the most adequate in this particular case. Finally, all the gunshot wounds of the picture have been preserved and conserved to be well-visible for next generations [15].

ACKNOWLEDGEMENTS

I would like to dedicate this work to its late co-author and my PhD dissertation co-supervisor – Mrs. Alina Tomaszewska-Szewczyk who secured this unique piece of art and enabled its conservation project. Her mastery skills were second to none in her field of expertise and she is a true loss to the artistic community.

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[10] A filler which was used is an epoxy resin enriched in aluminium powder. The detail specification of the used filler, its properties and the thorough discussion of its use in the wider context are a part of an ongoing research and will be disclosed publicly in a subsequent paper.

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[14] Due to the topic of the chosen panel of the conference (Chromatic reintegration: museums and private context), the main focus of the article has been on the ethics and aesthetics of the interventions to the object which already has been overpainted twice. Hence, it was not the author's intent to describe the entire process of conservation and investigation conducted to the A. H. Duszeks's painting. However it is worth mentioning that there has been a strong intervention to stabilize the painting. Most of the mounting elements did not fulfil their duties and functions. All the screws had been removed and replaced with ones made out of stainless steel. The broken wooden frame has also been strengthened by the stainless steel sheets, which was necessary because of the weight of the zinc support. That is why it can be said, that the painting is strengthen as never before. Furthermore, the photographic documentation taken before, during and after conservation treatments, as well as non-destructive analyses e.g. X-ray radiography and MAXRF gave the information which is still under interpretation and further analyses.

[15] This aim was achieved by sticking and stabilizing the paint layer flakes (with the use of Beva®371 binder), so the areas of shots are still clearly visible from the front of the painting. All the patches made by A.H. Duszek from zinc sheets are also well visible on the back of the painting. The entire process of conservation has been documented accurately.

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RYŪKYŪ ROUND LACQUER BOX: CHROMATIC REINTEGRATION METHODOLOGY

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ABSTRACT

An exemplar from the Ryūkyū Islands (Japan), this red lacquer circular box dates from c.1590 and is part of the collection of the National Museum of Ancient Art (MNAA) - Lisbon, Portugal [1-2].
The conservation and restoration intervention carried out at the José de Figueiredo Laboratory (LJF), considering its state of conservation with a high risk of lacquer detachment and consequent loss of a large part of the decorative elements, allowed the study and definition of methodologies, including in the treatment of chromatic reintegration [3]. Its condition, the type of intervention, as well as its subsequent placement on display, motivated the reintegration method chooses and its application, which aimed to improve the reading and decorative understanding of the box. The use of extra-fine quality gouache in the mimetic reintegration executed ensured the necessary compatibility and stability with its constituent materials.

Keywords
Ryūkyū; Box; Red lacquer; Chromatic reintegration; Gouache.

1. INTRODUCTION

This box (fig. 1) made mostly with red lacquer from the late 16th century and attributed to the Ryūkyū Islands (Okinawa), belongs to the MNAA's furniture collection (inv. 4 Cx) [1-2]. It is a circular box with a flat lid and base, and rounded sides. The base has a recessed rim and an inner edge to fit the lid [4].

The overall dimensions are 16 cm high by 46 cm in diameter.
The wooden support of *Erythrina orientalis* (L.) Murray (*deigo*) and clay, precedes the lacquer surface in red, Vermilion, (fig. 2) and black [2-7]. The gilded decorations (Au) represent vegetal and geometric elements [1; 6]. The inside of the box contains sprinkled metallic powders in its decoration [5].
A metallic plate, with the number *4* engraved, is applied inside the base, which is an old reference to its inventory number. In addition, the inscription *ESPERANCA LISBOA* can be seen on an old paper seal glued to the bottom of the base, identifying its provenance, the Convent of Nossa Senhora da Piedade da Esperança [2-4].

Figure 1 – Lacquer box. Before intervention. Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

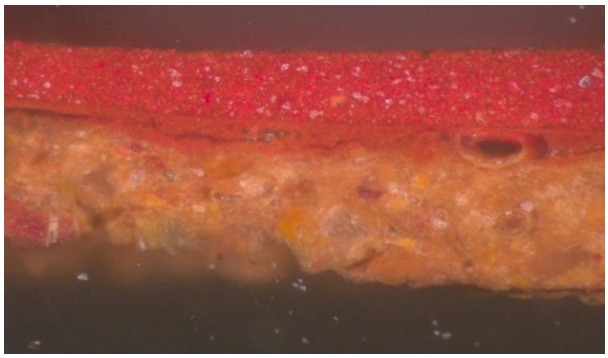

Figure 2 – Cross-section of red area (side of the box), 110x. Photo: Ana F. Machado (DGPC-LJF).

1.1 Lacquers from Ryūkyū

In Portugal there are several exemplars of this type of object *(tundabon)*, also known as "packaging boxes", to guard porcelains (Borges de Sousa, 2019, p. 65) [1].
Ryūkyū's lacquer production features influences from Japan, China Ming and Southeast Asia, attending to the established trade relations with the Fujian region [1-2; 8-9]. The utilisation of local woods, such as *Erythrina orientalis (deigo)*, was a constant, as can be seen for the structure of the present box [1; 7].
In China and the Kingdom of Ryūkyū, the production of red lacquer objects in the late 15th century became frequent [1]. However, there is a difference in the hue of the lacquer. The intensity of red of the Japanese islands was greater [1]. In addition, the gilded decorations, applied over red lacquer, become very appreciated in the 16th century [8].
In objects of the same type, the lid acquires decorative relevance because it has various elements placed in its centre [2]. Concerning the decorative grammar, "flowers, birds, landscapes and geometric elements ... windings and bands decorated with greeks" are usually represented (Borges de Sousa, 2019, p. 65) [1]. Specifically for the lacquer box under study, only floral and geometric elements, windings and traces of a band of greeks are observed.

1.2 Conservation and Restoration intervention

In the assessment of the conservation state, were noted: openings joints of the rims (fig. 3), support lacunae caused by xylophagous insects' action (fig. 3); high risk of lacquer detachment (fig. 4); polychrome layers lacunae (fig. 3); wear of the gilded decorative elements; high accumulation of aggregated dirt and biological colonization (fig. 5) [3].

An extensive area of polychrome lacuna was visible on the top of the lid, with only a few traces of decorative elements remaining (fig. 5) [3]. In this area, the biological activity was mostly over the surface of the clay structure, leading to it wear [3].
The action criteria of the conservation and restoration intervention were defined in collaboration with the museum. The main objective was to ensure the material stability of the object, not forgetting its aesthetic and artistic values. Therefore, several conservation and restoration treatments were carried out, such as fixing lacquer surfaces, mechanical and chemical cleaning, filling lacunae and chromatic reintegration [3].

Figure 3 – Opening joint, support and polychrome layers lacunae. Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

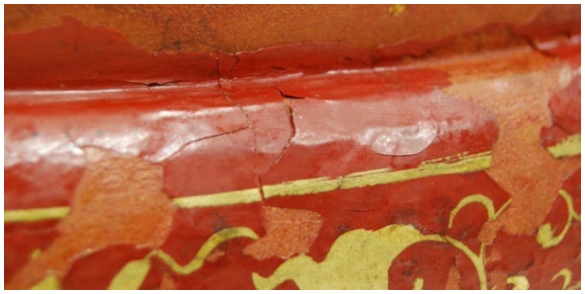

Figure 4 – Lacquer detachment. Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

Figure 5 – Box with extensive area of polychrome lacuna on the lid. Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

1.3 Mimetic Chromatic Reintegration

As it was not intended nor would it be possible to restore the whole of the missing original, the chromatic reintegration aimed to create the compromise of uniform the surface and improve the reading of the object [3].
The chromatic reintegration method chosen was the mimetic one. Its aim was to reproduce and apply the original surrounding colours (of clay or lacquer) on the lacuna areas identified [3; 10]. This reproduction was achieved by mixing of several paints on the palette until the desired tone was obtained [10]. The paints were choosen through of decomposing the original colours of the box [10].
Since the aesthetic concern was present in the intervention carried out, also motivated by its placement on display, from the optical point of view it was intended that the retouching was not perceptible to the general public and that its differentiation was ensured by the material applied, the gouache [3; 10].

2. MATERIALS AND METHODS

2.1 The Gouache

The Gouache is a paint technique characterised by its solubility in water and opacity, obtaining a matt effect in its application [11]. This is due to its composition, which includes white pigments or additives [11-12].
As for the binder, it may contain gum Senegal, gum Arabic or dextrin, the latter also of more recent use and as this case proves because the *Royal Talens* extra-fine quality gouache tubes, selected for this purpose, have it in their composition [11; 13-14].
The dextrin, a polysaccharide with low molecular weight obtained from starch, is a water-soluble polymer, thus ensuring its complete compatibility with the clay base of the box [14-15].
Therefore, the gouache technique was chosen for retouching due to the stability of the material applied, compatibility with the box's constituents, reversibility, texture and desired final matt finish.

2.2 Methodology

On the lid, attending the lack of decorative elements, it was decided only to homogenize the surface, reintegrating the wear spots of the clay structure to its colour (fig. 6 - arrow). On the rim of the lid and base, where most of the support lacunae were found, they were filled on the clay layers level and reintegrated to its colour (fig. 7 a-b). In these areas, to obtain a colour identical to the clay, were mixed some *Royal Talens* gouache paints: *Yellow Ochre (227), Magenta (397), Burnt Sienna (411)* and *Black Intenso (703)* [16].
To restore some of the decorative elements represented on the sides (lid and base), small areas were reintegrated with red colour, similar to the colour of the lacquer, and after were executed golden lines to reproduce the decorations (fig. 7 c-d). These lines chromatically resemble the original decorative grammar. To obtain the red colour, the *Royal Talens* gouache tubes *Vermilion (311)*, *Magenta (397)* and *Black Intenso (703)* were used. For the golden lines, the metallic colours were mixed from the same type of extra-fine gouache, *Light Gold (802)* and *Deep Gold (803)* [16].

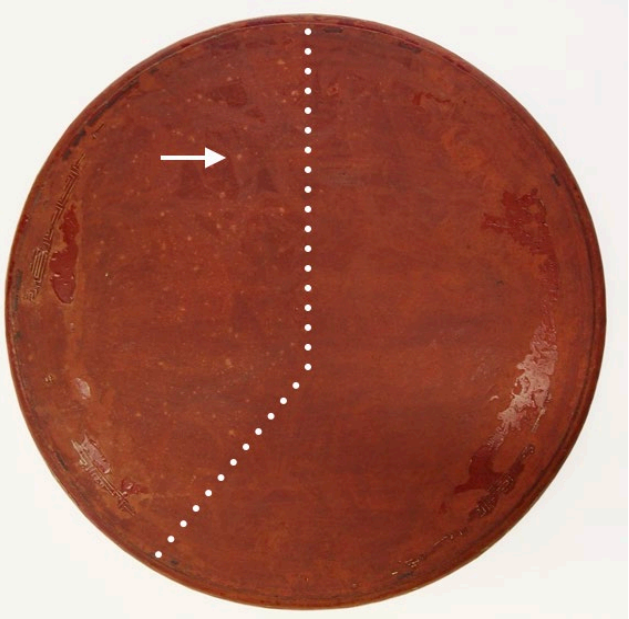

Figure 6 – Left - Before the chromatic reintegration; Arrow - small wear points. Right - After the chromatic reintegration. Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

Figure 7 – a) Before the chromatic reintegration of the filling area; b) After the chromatic reintegration (arrow); c) Before the chromatic reintegration of small areas; d) After the chromatic reintegration (arrows). Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

Figure 8 – a) Traces of the original decoration; b) Digital reconstruction. Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

3. RESULTS AND DISCUSSION

Considering that most of the reintegrated area corresponds to the colour reproduction of the clay, optically characterised by the absence of gloss, the matt effect of the gouache ensured its mimicry.

On the sides, the reintegration of all the missing decorative elements could have been reproduced according to the repetitive decorative grammar. In the reintegration of the lid, however, it would have been necessary to cover the entire clay surface in the red colour of the lacquer and to draw a band of greeks motifs based on the existing traces (fig. 8a). The digital reconstruction of part of the original decorative theme of the lid (fig. 8b), based on the graphic and documentary elements at our disposal, allowed us to realize that its reintegration would give a wrong perception of the object, since the composition of the central decorative elements would always be missing. As such, the mimetic chromatic reintegration carried out was based on a compromise. On the lid, we only opted for the reintegration of the fills and wear points of clay (disturbing elements to the reading), and on the sides we reproduced just some missing decorative elements, of small areas and previously chosen for the effect. In this way, it was possible to improve the perception of the whole (fig. 9-10).

Figure 9 – Lacquer box. After intervention. Photo: Luís Piorro (DGPC-LJF).

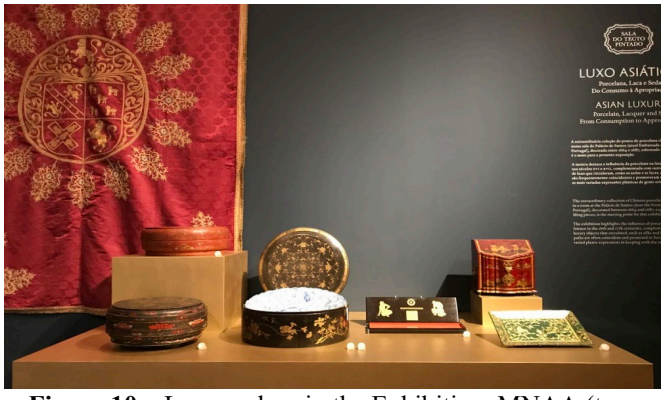

Figure 10 – Lacquer box in the Exhibition, MNAA (top left). Photo: Débora Sarmento and Margarida Cavaco (DGPC-LJF).

4. CONCLUSIONS

The conservation and restoration intervention ensured the stability of the box and the type of chromatic reintegration executed guarantees its greater artistic fruition. The choice of the mimetic method was mainly due to the strong aesthetic component patent in the intervention carried out, largely also motivated by its subsequent exhibition. The necessary imitation of colour, texture and absence of gloss was assured by the choice of a stable material and compatible with the box such as the gouache.

Its display in the MNAA temporary exhibition, *Asian Luxury. Porcelain, Lacquer and Silk - From Consumption to Appropriation*, and its inclusion in the respective catalogue only add further value to an object that was previously in the Museum's reserves, attending to its state of conservation [1-2]. The missing gilded decorative elements did not disturb the reading of the object and the whole exhibition, due to the visual effect achieved through the reintegration performed.

In future conservation and restoration interventions, the chromatic reintegration methodology followed here may be reproduced on objects of the same type with a vast extension of lacquer lacunae areas.

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RESTORATION OF POLYCHROME WOOD SCULPTURE: A CASE STUDY WITH HIGHLY WEAKENED POLYCHROME

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ABSTRACT

This article presents a case study of a polychrome wood carving sculpture representing Jesus Christ crucified. The piece belongs to the Chapel of Nossa Senhora da Glória, located in the district of Ressaca/Carandaí, Minas Gerais, Brazil. It was in a poor state of conservation, especially the very fragile polychrome, impairing the work. legibility. From the analysis of the state of conservation of the object, four important points were considered to support the proposed treatment: stability, reversibility, aesthetic legibility, and the potential oneness conceptualized by Cesare Brandi, which aimed at the stability of the material that would guarantee the potential oneness of the work without creating a historical and artistic falsehood. These points are directly linked to the modern techniques and resources used, as well as the intention to maintain the integrity and authenticity of the work. The entire polychrome process was of great importance to acquire its stability, due to the presence of four types of lacunae. Lastly, the chromatic reintegration, in which the pointillism technique was used, aimed to be distinguishable from the pictorial layer of the work. Therefore, this study aims to present the restoration process of a polychrome wood sculpture and, mainly, to demonstrate the importance of chromatic reintegration to insert and ensure aesthetic legibility and a potential oneness of the work.

Keywords
Polychrome; Stability; Wood; Sculpture; Pointillism.

1. INTRODUCTION

A polychrome wood sculpture representing a Crucified Christ was restored by the Fundação de Arte de Ouro Preto (FAOP) through the Applied Course on Conservation and Restoration. Ouro Preto Art Foundation works to preserve community collections, incorporating them as teaching materials in the training of technicians in conservation and restoration for the mentioned Foundation.

Figure 1 – Front and back of the polychrome wood sculpture before restoration. Photo: FAOP, 2015.

The piece of art in question was restored in 2015 and 2016 under the supervision and guidance of FAOP professor Mariah Boelsums and a team composed of three students in the training in the applied course: Juliana do Amaral Leopaci, Fernanda Bredariol, and Elen Rose Carvalho de Souza.

Concerning the sculpture, it came from Nossa Senhora da Gloria Chapel, located in the district of Ressaca / Carandaí, Minas Gerais. The Chapel is an "original and preserved example of the religious architecture of Minas Gerais from the colonial period" (p. 32) [1], in Rococo style, and simple features that approach the neoclassical composition. It is considered the oldest architectural reference in the city of Carandaí which dates to the 18th century, and, in addition, it became a place of expression of local cultural manifestations, highlighting the Nossa Senhora da Glória (Our Lady of Glory) annual celebration, which takes place every August.

Due to its peculiar characteristics and the values added to its history, the Chapel was listed as a historical landmark in 2008 by the State Council for Cultural Heritage - CONEP.

It is intended to address the criteria and techniques used for the chromatic reintegration of the sculpture representing Christ Crucified. Therefore, the construction technique and the state of conservation of the sculpture will be described, focusing on the aspects of its polychrome and, later, the theoretical and technical discussion about the chromatic reintegration technique used in the sculpture will be presented.

2. MATERIALS AND METHODS

This article reports a study of a sculpture from the Brazilian colonial period, in which it is possible to identify a great diversity of materials and construction techniques used, being considered as an example of polychrome wood sculptures from the State of Minas Gerais, highlighting the inseparable character between form and color existing in such pieces.

It is, therefore, a devotional sculpture representing the Crucified Christ. Such a sculpture falls into the category of a large image, that is, a sculpture *"(...) free in space, in general, it is worked on the front and back, allowing different points of view within the space in which it is inserted, not adhering to any fund, as a relief." (free translation, p.39)* [2].

It is characterized as an entire image in solid wood, without articulation, being considered a static work and formed by three main blocks: base, cross, and the figure of Christ.

In addition to the main blocks, the secondary blocks, which are formed by the two arms of the body of Christ – the left arm and the right arm - and by the two rods that form the structure of the cross - the vertical and the horizontal rods, stand out. There is also a metal plate with the inscription INRI (Iesus Nazarenus Rex Iudeum) fixed to the front face of the cross.

In this way, the sculpture is composed of seven blocks: base, vertical pole, and horizontal pole of the cross, metallic plate, body, and the two arms of Christ.

The use of blocks is a constructive resource that assures both the stability of the support - due to the positioning of the wood fibers - and the aesthetic improvement of the precise details in the carving of the sculptures. According to Coelho (apud BRUSADIN, free translation, p.144), the use of blocks begins in the mid-eighteenth century:

> *Sculptures made up of many blocks began to be made, with the main block being the most important part of the body, the other blocks forming arms, hands, or complementary items. This allowed for a more efficient and gentle way of carving some parts of the body, such as hands and fingers.* [3]

Regarding polychrome, which can be understood as *"(...) the cover or covers, with or without preparation, performed with different pictorial or decorative techniques, which totally or partially covers sculptures, architectural elements to provide these objects with a finish or decoration"* [4], it can be considered that the sculpture presents simple polychrome, as it does not present ornamentation or aesthetic details of technical complexity.

Methodologically, the study of the polychrome of this sculpture was divided into three parts: the figure of Christ, the base, and the cross; considering each of these parts presents different stratigraphies from each other.

To study the pictorial strata that constitute the polychrome of this sculpture, two techniques were used: the first, of a non-destructive character [5], was based on the organoleptic analysis of the loss areas of the pictorial layers, seeking to identify the strata from the lacunae that already exist in the work; and the second, of a destructive nature [5], was based on the opening of prospecting windows, in previously selected locations, to confirm the strata of polychrome. By using these methods, it was possible to know the polychrome of the piece, as well as to plan interventions based on the data collected.

Regarding the figure of Christ, the predominant pictorial technique was skin color, also known as carnation. In addition to the sizing layer and the preparatory coating, it was possible to observe, through the areas of pictorial loss, the existence of two chromatic layers in the flesh: one composed of a darker shade of pink and another underlying layer composed of a lighter shade of pink. Under the outermost layer of skin color, there were reproductions of bruises that were located on the hands, feet, knees, neck, shoulders, and both sides of the hips.
The perizonium drapery had an adhesive layer, a preparatory coating, and a pictorial layer in white, and the cord had a layer of golden glitter, which was oxidized.
Regarding the hair of the Christ, it had two pictorial layers, the outermost in black and the underlying in brown, in addition to the preparatory coating and adhesive layer.
The base and the cross had similar polychromes, consisting of an adhesive layer, preparatory coating, green pictorial layer, blue pictorial layer, and blue-grey pictorial layer. The only difference to be mentioned is that in the cross, there was an additional layer of brown color between the preparatory coating and the green pictorial layer.
Furthermore, the figure of Christ, which was the only part of the piece covered with varnish, presented a thin and yellowish layer of the material, arranged heterogeneously on the pictorial layer.

2.1. State of conservation

As this article focuses on the conceptual and technical discussions for the treatment of pictorial lacunae in the sculpture, the description of the state of conservation will be more detailed concerning polychrome, presenting in a very generic way the damage to the work's support.
That said, the support had damage related mainly to xylophagous insect infestation and the natural movement of the wood, which caused several fissures and cracks throughout the work. One-off interventions were also identified with epoxy resin on the fingers of the Christ figure and on the base, where there possibly had been a knot in the wood.
Regarding polychrome, the work was in a precarious state of conservation, with an excess of superficial dirt adhered to the entire length of the sculpture: in Christ figure, there was a high amount of polychrome loss, sometimes leaving the base of preparation or the exposed support, creating interruptions in the enjoyment of the work and considerable aesthetic noise; and on the cross and the base there were punctual losses of polychrome.
It is worth mentioning that there was a yellowish layer of oxidized varnish present throughout the figure of Christ, even over the pictorial lacunae, confirming that varnishing was done in a later intervention.

In general, all the pictorial strata of the sculpture were extremely fragile, in detachment, and with a high degree of cracking, especially in the figure of Christ since the base for the preparation of the skin color was powdery and exposed.
After the analysis from the organoleptic exam and the windows of prospection, we have detailed and classified the artwork conservation regarding polychrome, as follows: superficial and adhered dirt, oxidized varnish on the figure of Christ, pulverulence on the underlying pictorial layer of the carnation, cracking on the pictorial layer over the 3 blocks, loss of the preparation coat and detachment of generalized polychrome and repaintings with losses, cracking and paint lifting.

2.2 Intervention proposal

The kind of intervention proposed here ensures stability, reversibility of the materials used, aesthetic legibility, and the potential oneness that Cesare Brandi (1906-1988) postulates in his book *Theory of Restoration* [6]. According to Brandi, the history of the artwork must be respected, the extension of its useful life must be sought, and, above all, to allow its return to the place of origin or assign a new function or destination to the art piece are other factors that must be taken for granted. These four points are directly interconnected with the modern techniques and resources that were used in the restoration process of this artwork as we have sought to maintain the integrity and authenticity of the piece. Therefore, the intervention proposal was to:

I. fix the pictorial layer with priority
II. dismantle the artwork;
III. clean the artwork mechanically
IV. protect the piece against xylophagous insect infestation;
V. remove the epoxy adhered to certain parts of the pictorial layer and between the block fittings;
VI. remove the oxidized varnish;

VII. consolidate the support, in the loss of the base (deteriorated base), cracks, and fissure;
VIII. clean the surface mechanically;
IX. level the lacunae in the pictorial layer completely
X. complete and restructure the artwork support
XI. treat the metallic elements of the piece;
XII. do the chromatic reintegration using the pointillism technique;
XIII. apply a final coat of varnish.

3. RESULTS AND DISCUSSION

Here, the theoretical and conceptual criteria of conservation and restoration that permeated the intervention of chromatic reintegration in the lacunae in the polychrome of the sculpture of Christ Crucified will be discussed.

First, it is necessary to define lacunae as "interruptions in the figurative fabric of a work" (p.58) [7]. From the moment these lacunae gain prominence, they become figures and the work of art itself ends up in the background, establishing an inverted figure-background relationship and generating significant noises in the enjoyment of the work.

Cesare Brandi in his book *Theory of Restoration*, dedicates a chapter to the analysis of lacunae in works of art. For this, the author uses a concept of psychology called Gestalt and through the relationship between figure and background, one of the Laws of the Organization of Perception, he analyzes and interprets the lacunae in cultural goods. Brandi establishes, therefore, that from the moment the lacuna has the potential to invert the natural perception of figure and background in a work of art, the restorer must intervene to ensure the work regains its artistic potential so that it can be fully enjoyed without the presence of noise once caused by the mentioned lacunae. Thus, the author developed some chromatic reintegration methods that aim to neutralize the aesthetic interruptions of the lacunae.

The first method consists of the application of neutral paint, aiming at the relocation of the lacuna in the pictorial surfaces of the work of art. The second had the same principle as neutral ink, but it uses a low tone or undertone, changing the lacuna into a background for the figurative fabric.

The third method proposed by Brandi is based on the concept of differentiated reintegration, respecting the artistic and historical authenticity of the works, through the tratteggio technique, developed at the Instituto Central de Restauro, in Rome.

To assess whether lacunae are inverting the relationship of figure and ground in a work of art, we need to consider factors such as the constitution, location, extent, quantity, and typology of lacunae. For example, lacunae located in focal points of works are more likely to become figures and cause aesthetic noise. The amount, constitution, and extent of loss are also important factors because depending on the density of these factors, a work can end up being reduced to its lacunae, completely losing its potential oneness [8], culminating, in the limit, in a de-characterization that transforms the work into a ruin [9], where there are no longer enough elements of integrity and authenticity to reference an intervention of chromatic reintegration without forgery.

> *(...) for the moment, we must limit ourselves to accepting a ruin as the residue of an historic or artistic monument, which can be nothing other than what it is, and where restoration can only maintain it that way, using whatever techniques are required. Hence, the legitimacy of the conservation of a ruin lies in the judgment it receives on its historicity, as a mutilated but still recognizable witness to a work and a human event [10]*

Lastly, the typology of lacunae is another essential element for the analysis. According to Laura Mora [11], there are 4 types of lacunae: patina, pictorial layer, depth of preparatory coating, and, finally, the superficial gap of the pictorial layer or "usury".

From the analysis of all these elements and the relationships between them, it is possible to plan an intervention proposal considering first whether the lacunae are integrable or not and, second, if the lacunae can be reintegrated, the techniques to be used for the chromatic reintegration.

In the case of the sculpture of the Crucified Christ, the object of this study, the lacunae were more concentrated in the figure of Christ and presented a loss of more than 50% of the skin color. Regarding the typology of the lacunae, there were surface lacunae – loss by abrasion -, the pictorial layer – which leaves the preparatory coating exposed -, the depth gap – loss of the pictorial layers, leaving the wooden support apparent.

The location of the lacunae was also analyzed: the focal point of the sculpture is the figure of Christ and most of the lacunae were concentrated in that figure, in the face,

eyes, triangulation of the chest, feet, and throughout the entire length of the body of the figure of Christ.
After a careful analysis of the state of conservation from a technical and ethical point of view and considering all the historical aspects of the work of art, its devotional function/destination, and its place of origin composing the altar of a Chapel, it was concluded that the lacunae took the leading role in the fruition of the work and were causing noises that altered the potential oneness of the sculpture, interrupting the aesthetic reading and making the primary functionality of the work unfeasible. That said, we opted for the full leveling of the lacunae and the chromatic reintegration using a differentiated technique.

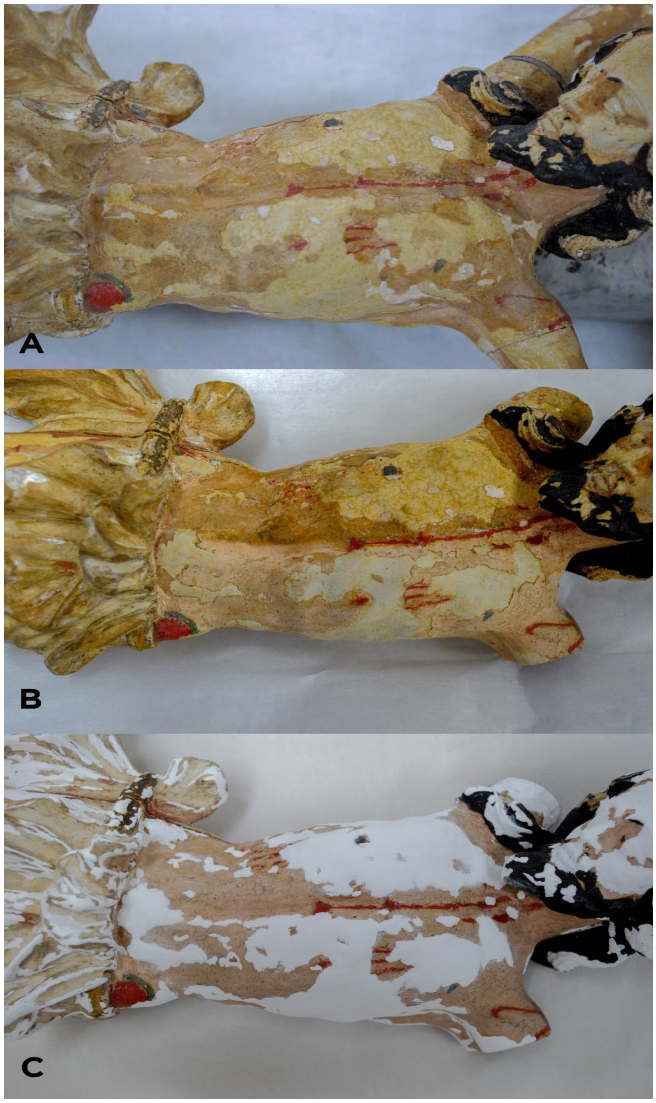

Figure 2 – (A) Figure of Chrisi with oxidized varnish; (B) Half of the left side with oxidized varnish and the right side with varnish removal; (C) Full leveling of the lacunae. Photo: BREDARIOL, F., 2016.

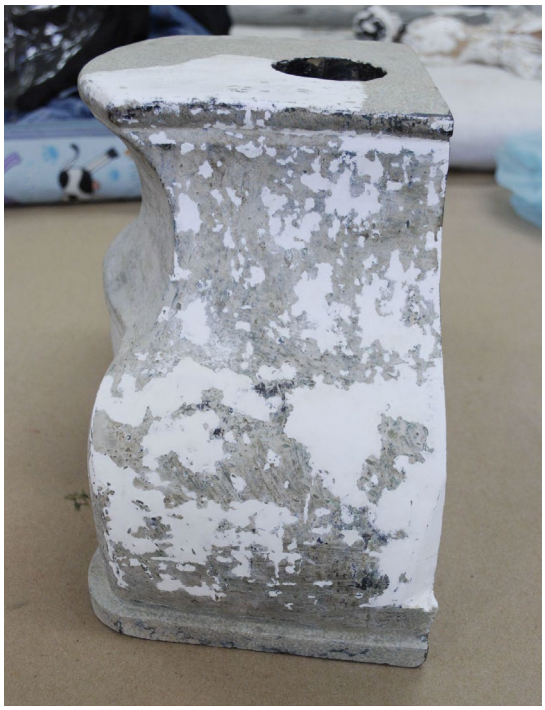

Figure 3 – Full leveling of the lacunae in the base. Photo: BREDARIOL, F., 2016.

This intervention was guided by the criterion of distinguishability in which *"[...] the intervention should be observed, but immediately recognizable, and without the need for special instruments, when a closer view is reached" (p. 47) [12]*. Article 12 of the Charter of Venice also emphasizes that *"the elements intended to replace the missing parts must integrate harmoniously into the whole, distinguishing themselves, however, from the original parts so that the restoration does not falsify the document of art and history"* [13].
The differentiated technique selected for chromatic reintegration was pointillism, derived from the decomposition of colors studied by Michel Eugène Chevreul (1786 – 1889), introduced in conservation and restoration in 1972.

> *It is a set of points of pure colors juxtaposed, adapting to old and recent paintings. Depending on the original pictorial surface or the texture of the support itself, the size and distance of the points, pointillism can result either in a differentiated or in an illusionist reintegration. In the latter case, the points made are so tiny that the human eyes cannot appreciate them without the help of an optical magnifying instrument.*

> *On a light background, where a thin layer of paint of a colder and lighter color than the original has already been applied, dots of color of different chromatic values are placed to recreate the shapes. (Free translation) [14]*

In the case of the sculpture in question, the choice of the appointed technique was possible because the lacunae presented chromatic references in the areas surrounding the polychrome were still preserved, allowing the reestablishment of the potential oneness of the work of art without creating a false artistic effect or a false history.

Figure 5 – Chromatic reintegration on the figure of Christ. (2). Photo:BREDARIOL, F., 2016.

4. CONCLUSIONS

The restoration of the sculpture of a Christ Crucified was based on interventions that ensured stability, integrity, authenticity [15], the reversibility of the materials used, aesthetic legibility, and its potential oneness [16].

After the full leveling of the pictorial lacunae, the process of chromatic reintegration began, using the juxtaposition of points in several pre-selected tones based on color theory criteria, based on the authentic tones of the areas surrounding the paintings. gaps and ensuring the integrity and legibility of the work while maintaining the distinguishability of the intervention.

Figure 4 – Chromatic reintegration on the figure of Christ. (1) Photo:BREDARIOL, F., 2016.

Figure 6 – Final restoration of the cross and the base. Photo: BREDARIOL, F., 2016.

Thus, the entire restoration process, both the support and the polychrome, was carried out in a way that ensured reversibility and stability, through the use of specific materials and appropriate techniques for chromatic reintegration, in line with the concepts, the guidelines, and codes of ethics in the field of conservation and restoration.

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WITH A LITTLE HELP OF MY FRIENDS. A HOPEFUL EDUCATIONAL METHODOLOGY ON RETOUCHING FOR CONSERVATION-RESTORATION STUDENTS ON WOODEN SCULPTURE

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ABSTRACT

Is it possible to mix and match the theoretical foundations of Cesare Brandi - internationally recognized - with the new theories of Muñoz Viñas for a new ethics of restoration, taking into account the suggestions of Paul Philippot, who was the first to deal with the restoration of wooden sculpture?
For educational purposes in restoration schools, is not easy to cover all these aspects of retouching, but it is important to find a method that allows students to acquire a solid foundation, and then to deepen the different aspects of the question, hopefully simple but at the same time effective.
The Author develops a proposal based on three basic cornerstones:
1. familiarity with the techniques of execution of the work of art and the materials of which it is composed (study of technical art history, and laboratory practice from painting to gilding);
2. study of the basic principles of the restoration theory;
3. practical experiments with the different techniques of pictorial integration (*tratteggio*, *selezione cromatica*, *selezione effetto oro*, dots, mimetic retouching), of the different retouching materials (watercolors, tempera, varnish colors, micaceous), and with protective coatings.
In all situations the basic theoretical principles are:
1. recognizability: the pictorial restoration must always be easily recognizable (also using modern technologies);
2. reversibility, i.e. the retouching must be easily reversible without endangering the original work.
Thus, the proposed methodology will be a useful tool to contribute and work on the wooden cultural heritage by including not only tangible aspects but also emotional, ideological and above all identity meanings.

Keywords
Wooden-sculpture; Education; Retouching; Theory; Methodology; Protocol

1. INTRODUCTION

For the past several years, I have been working in my university restoration courses to develop a useful protocol for the best possible presentation – and hopefully subsequent understanding – of a programme devoted to the so-called “final stage” of retouching polychrome wood sculptures.
I am well aware that in our so special profession it is ethically incorrect to speak of "protocol" (in the general sense) [1]. Indeed each object has its own characteristics and, accordingly, each project and each restoration intervention must necessarily fit it.
Nevertheless, I can state that young people who are dealing the topic of "restoration" for the first time need a simple and basic guide. What is still relatively easy with the technical-scientific aspects, becomes a bit more daring with the question of aesthetic presentation. Here, no arithmetically calculable formula will help: everything is in the hands of the restorer, his/her experience, his/her sensitivity and his/her passion acquired over time.

Retouching is the final moment of the restoration process, where skills are tuned to enhance all the tangible and intangible embodied and universally represented by a cultural asset.
For this reason, I am no longer willing to accept in a restoration report that laconic final sentence: "Recognizable retouching with reversible colors and final protective film". All this is not enough to give value to the innumerable qualities that an object possesses by representing a part of our heritage.
The recognition of all these values is therefore the starting point for structuring the foundations of our profession.

2. SETTING METHODOLOGY

This paper will focus more on the methodological approach of retouching than on its technical-practical aspect. The ability to perform a *tratteggio* or a *selezione cromatica* can be acquired through practise, but first and foremost – in my opinion – is the determination of the method.

Figure 1 – Practical retouching test: *selezione effetto oro*. Not the only possible solution.

Prof. Giorgio Bonsanti, former director of the Opificio delle Pietre Dure in Florence, recently commented at a conference on university programmes of restoration: "In the matter of retouching, Italians love theory, while abroad they are pragmatic."

I did my training and professional work in Italy, so it is easy to understand why Cesare Brandi was the preferred tutor for my theoretical and practical courses. But in the course of my career - especially that of a professor - I turned with particular interest and curiosity to practical experiences and training abroad.
So I have participated in congresses on wood sculpture and its techniques, in master classes dedicated to retouching (not only Italian *rigatino*!, better said *tratteggio*), in special conferences on retouching – like this one at RECH – and in workshops where I had the fruitful opportunity to exchange ideas and proposals with colleagues from different countries.

Figure 2 – With my students, visiting the historical Botanical Garden in Urbino: from raw material to polychrome sculptures.

All this not only opens my mind and favours my professional growth, but also becomes a useful tool for passing on new skills to my students, the future restorers.

2.1 The framework of the method

Coordinating the results of the acquired skills, providing them with an indispensable theoretical and ethical rationale, and structuring them for convenient sharing was not an easy task: it is still a work in progress and needs improvement.
To get support, I turned to some eminent and internationally known personalities whom I chose as mentors. I turned to them for the necessary help: first with a courageous but well-placed act of trust, then with increasing autonomy and awareness, appreciating their personal contributions and the possible synergy between them, turning to a modern interpretation.
I will mention here only four high-ranking and well-known personalities, but actually there are many more.

So I am also sincerely grateful to all my colleagues and friends with whom I always exchange ideas and suggestions with passion and enthusiasm. And last but not least, I thank all my students who, with their questions and innovative suggestions, help to structure my critical consciousness.

2.2 Cesare Brandi: each restoration requires an essential theoretical foundation

Cesare Brandi and his Theory of Restoration - translated into many languages - was and is the “croce e delizia” of all those who consciously engage in restoration (“croce e delizia al cor” as Alfredo sang to Violetta in the opera La Traviata by Giuseppe Verdi).

Brandi’s writings, first published in 1963, remain today the essential starting point for identifying the art object and thus for its conservation.
"Only the material of the work of art can be restored", a work of art composed of a double polarity "the historical demand" and "the aesthetic demand": these are, in short, the axioms on which Brandi’s theory is based.
Thus, any restoration intervention cannot exclude the passage of the work of art over time, otherwise it would go against its authenticity, as a twofold aspect, of material and form.
These are the characteristics of restoration which Brandi understands as a “critical activity” aimed at restoring the “potential unity” of a work of art [2].

One of many possible techniques to achieve this is the “tratteggio” retouching, which potentially recomposes the missing part of the image at the right distance, but easily recognisable as a close-up.
During his career as an art historian, philosopher, and director of the Istituto Centrale del Restauro in Rome, Brandi tested various retouching techniques and their practicality, devoting himself mainly to interventions on murals and easel paintings. In my opinion, this means that - if more time had been available - he would have also addressed the subject of wood sculptures and perhaps changed his approach to retouching once again. Who can say?
One of his most important statements, which prescribes the restorer to use "first the head and then the hands", also means that the *tratteggio* born in the Istituto Centrale del Restauro is only one of many possible techniques that can be used.

2.3 Paul Philippot: listen to the sculpture

Paul Philippot, a Belgian art-historian, was, along with Paolo and Laura Mora Brandi’s first fellows at the Istituto Centrale del Restauro, the first to address in a structured way the question of the restoration of wooden sculptures. Taking up the philosophy of his master, he placed particular emphasis on the scientific understanding of materials, but with a different approach to the position of the restorer: in his opinion, restorers must be educated and trained in both art history and science, while retaining the know-how and craftsmanship of the practice, rather than being a mere executor.

Philippot focuses on the issue of retouching and explains his thoughts in the essay “La restauration des sculptures policromes” [3] in which he states that:

1. Each sculpture has its own individuality, so absolute rules must be avoided in restoration.

2. losses in wood sculpture are not comparable to those in easel paintings, firstly because sculptures are three-dimensional, and secondly because in retouching losses in bare wood very often easily match gilded surfaces in the surrounding area, so that no in-painting is required at all.
   Philippot in 1970 wrote: «Les lacunes d’une polychromie ne sont pas davantage identifiables, du pont de vue esthétique, à celles d’une peinture. En effet, dans la mesure où s’est conservée la forme sculptée, il ne

s'agit que d'une *lacune relative* et non d'une *lacune totale* comme pour une peinture».

3. in summary, cleaning and retouching in the restoration of wood sculpture must be considered a onte-time process.

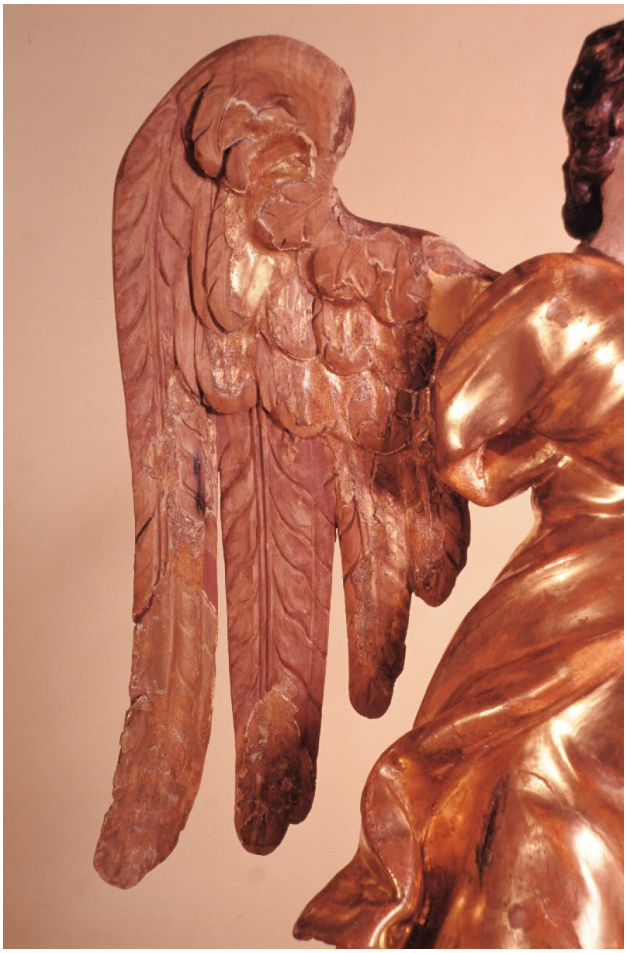

Figure 3 – A perfect match: bare wood and gilding. The value of three-dimensionality.

Basically, according to Philippot, it is the sculpture itself that provides the necessary information on how to proceed with the restoration. His seminal essay concludes with these recurring words: «La necessité de mesurer toute intervention en fonction de la reconnaissance et du respect le plus strict de la totalité et de l'individualité de l'œuvre, telle qu'elle nous est transmise à travers l'historie; et cela, qu'il s'agisse des opérations matérielles de conservation ou des aspects archéologiques et esthétiques de la restauration».

But is there a vocabulary that helps in translating the sculpture's language? After many years of practice, I can say that the answer is yes. At first, listening and translating can be quite a complex job, but the solution lies in using all of our educational tools. For example, if we are well educated, we can obtain information by recognizing different materials and techniques, by understanding the art-historical life of sculpture, its use over time, its liturgical role, or its value to those involved.

2.4 Agnes Ballestrem: the responsibility of the restorer towards the spiritual, religious and artistic life of the objects

In 2002 I had the honour of personally meeting this charismatic woman, along with Hans Cristoph von Imnhoff, Janet Bridgland, and Mara Nimmo, was one of the signatories of the ICOM-cc document "The conservator-restorer. A definition of the profession", which was presented at the triennial ICOM-cc Congress in Copenhagen in 1984 [4]. The aim was to set out the basic principles and requirements of our profession, which include the technical examination, presentation, and conservation-restoration of cultural objects.

The document focuses, among other things, on three issues that are very important to me:

1. any intervention on a historical or artistic object must be done in the order of all scientific methods;
2. interdisciplinary cooperation is of utmost importance;
3. documentation, publication, and sharing of actions serve to deepen knowledge and improve skills to best preserve the objects.

These statements may seem obvious, but sometimes it is useful to recall them because they are really at the core of a high-level education as required in our profession. Here they are:

3.4 The conservator-restorer must be aware of the documentary nature of an object. Each object contains - singly or combined - historic, stylistic, iconographic, technological, intellectual, aesthetic and/or spiritual messages and data. Encountering these during research and work on the object, the conservator-restorer should be sensitive to them, be able to

recognise their nature, and be guided by them in the performance of his task.

3.5 Therefore, all interventions must be proceeded by a methodical and scientific examination aimed at understanding the object in all its aspects, and the consequences of each manipulation must be fully considered. Whoever, for lack of training, is unable to carry out such examinations or whoever, for lack of interest or other reason neglects to proceed in this way cannot be entrusted with the responsibility for treatment. Only a well-trained experienced conservator-restorer can correctly interpret the results of such examinations and foresee the consequences of the decisions made.

3.6 An intervention on an historic or artistic object must follow the sequence common to all scientific methodology: investigation of source, analysis, interpretation and synthesis. Only then can the completed treatment preserve the physical integrity of the object, and make its significance accessible. Most importantly, this approach enhances our ability to decipher the object's scientific message and thereby contribute new knowledge».

2.5 Salvador Muñoz Viñas: tangible and intangible proximity to contemporary ethics

A new perspective on restoration theory is offered by Salvador Muñoz Viñas [5] of the Valencia university. He notes that classical theories - from Ruskin to Brandi - are characterized by their close ties to truth, with T capitalized.
He criticizes the key concepts (from classical theories) that still dominate today, especially: reversibility, universality and objectivity.
The result of his critique is the emerging contemporary theory of conservation which replaced the notion of function, utility, or value of the object to be restored with the notion of truth.
Muñoz Viñas ideas are, in short, a rejection of the new trend among restorers of the so-called "anthropological restoration." «Thus, conservation is done for the sake of the subjects: its users. The user of the object is any person for whom the object performs any function, be it tangible or intangible… Some objects of conservation are symbolic for many people, while others symbolize things for very few people. In any case, it is the people affected by a conservation process (the *stakeholders*) who would be considered when making the decisions… These ideas lead to the notion that conservation decisions should not be imposed, but agreed upon between affected subjects…».

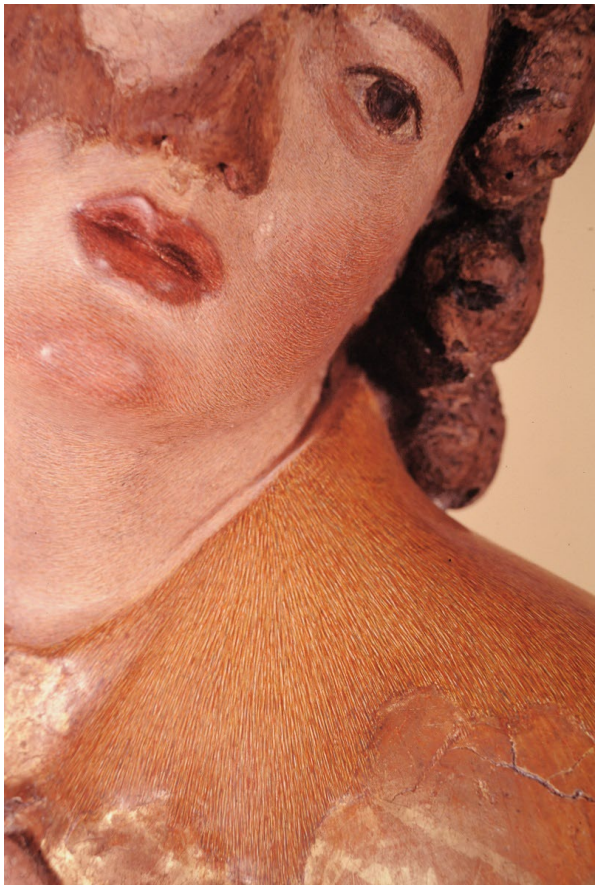

Figure 4 – St. John under the Cross. One of the 11 sculptures of the main altar of Santa Maria del Giglio in the Friuli region of Italy, saved from the 1976 earthquake destruction, and returned to the community.

Of course, the experts should be listened to, and their opinions will certainly have an effect on non-experts. However, their special authority over objects belonging to other people or to society as a whole exists only because the public recognises it, and this authority is not exclusive. The consensus demanded in contemporary restoration theory includes everyone to whom the object has meaning.
A restorer must take all of this into account in his or her work.

3. A HANDLY SCHEME FOR STUDENTS IN CONSERVATION

Is it possible to provide students with a simple and easy-to-use tool and a solid foundation for restoration practice in the aesthetic presentation phase? Because that is the core: an easy-peasy tool, hopefully fun to use.
Knowing well that simplification can be potentially dangerous, I nevertheless venture to make a synthetic proposal to be interpreted exclusively as a basic track.
So, what are the tools a student need to use for a conscious and contemporary approach to retouching?

- Be aware of the documentary nature of the object: historical, stylistic, iconographic, technological, intellectual, aesthetic and/or spiritual messages and data, tangible and/or intangible;
- Have practical skills in artistic techniques, supported by a broad knowledge of documentary sources and original objects;

Figure 5 – Gilding workshop, according to Cennino Cennini handbook: knowing by doing.

- Have a good sense of color and master for the various retouching techniques, especially the Italian ones (*tratteggio* and *selezione*);
- Be available for teamwork, and mediation between the different professionals and their instances (remember that the conservator-restorer is the perfect "catalyst");
- Be open-minded, up to date, and humble enough to understand all the instances of the object;
- have a passion for his/her work and a very special sensitivity;
- Be available for dissemination of the results for the professional, educational and personal development of all stakeholders, colleagues and young future restorers.

4. CONCLUSIONS

On the rainy afternoon of March 27, 2020, during the Mass celebrated by Pope Francis for the pandemic, according to ancient popular tradition, a crucifix stood out in the dark.
It is said of this wooden crucifix – kept in the church of San Marcello al Corso in Rome – that people carried it in procession for several days during the plague epidemics, at any time and in any weather, to perform the miracle. And so it happened many times.
At that time, as in the recent pandemic, Christ on the cross was the only friend who could be relied upon, because he too had known suffering, but had overcome death.
Beyond that there would be only pain and despair.

Figure 6 – Rome. Rain drops on pandemic.

Many restorers rose up that day: what a shame! How such a valuable work of art, a wooden sculpture – dating from around 1370 – guilty left out in the rain?

As a restorer which I also am, I fully agree with Pope Francis' decision (and I can understand that this can be strange). Also for me, the raindrops on the face of

Jesus – in this moment full of compassion – are the tears that he sheds for us and with us.

Can we all agree that this crucifix is merely a “work of art”?

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RECH 6
Valencia, Spain

TOPIC 3

Documentation of chromatic reintegration process

RECH6 - 6th International Meeting on Retouching of Cultural Heritage
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RECOVERY OF A SEVERELY DETERIORATED PAINTING: THE MARTYRDOM OF SAINT SEBASTIAN BY GIOVANNI SANTI (15TH CENTURY). INTEGRATIVE PROPOSAL

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ABSTRACT

This contribution examines a painting on wood: *The Martyrdom of Saint Sebastian*, by Giovanni Santi. This work of art is the altarpiece of the chapel dedicated to the saint, located in Urbino's Church of San Bartolomeo. The history of this work of art is inextricably linked to that of its conservation: initially, the artwork was difficult to read due to the serious state of deterioration of the paint layer, with a loss of significant portions of the painting, including pictorial parts that played a decisive role in the rendering of the image.

This had significant implications when it came to choosing the methodology for the pictorial reintegration of the painting. The aim was to reduce the negative effects caused by the state of deterioration as much as possible, to improve the readability of the work.

Following a conservative restoration of the panel and of the polychromy, and after submitting it to art historian officer for a careful and close evaluation, a differentiated pictorial reintegration of the work was planned, applying the Florentine “selezione cromatica" method for the main figure, Saint Sebastian, and for all lacuna treatments.

This intervention was carried out using tempera colours, overlapping by hatching three pure colours, chosen from the primary and secondary colours. I continued the “selezione cromatica” on the integrations, using varnish colours until achieving the desired tone, maintaining a tone of brilliancy and chromatic vivacity similar to the painting by Santi.

The other parts of the painting had been very seriously damaged due to irrecoverable losses and can no longer be reconstructed; these were treated by experimenting with the “chromatic abstraction” reintegration with tonal variations within the layers of abstraction. The method involves the application of a cross-hatching where no shape is reconstructed, in a four-colour scheme (yellow, red, green/blue, black), in tempera colours.

Keywords
Lacuna treatments; Pictorial reintegration; Hatching treatment; Cromatic abstraction; Martyrdom of Saint Sebastian; Giovanni Santi.

Figure 1 – The painting before restoration.

1. INTRODUCTION

The Martyrdom of Saint Sebastian, by Giovanni Santi, dated 1487-1488, is currently kept at the Museo Casa Natale di Raffaello, the birth house of Raffaello Sanzio, now a museum connected to the Galleria Nazionale delle Marche, in Urbino. The history of this work of art is inextricably linked to that of its conservation and to those places where it has been kept. Over the years, the painting has endured major environmental imbalances: its poor state of conservation was documented as early as 1695.

When the work reached our laboratory, it was difficult to read due to the serious state of deterioration of the pictorial layer, with a loss of significant portions of the painting, including pictorial parts that were essential to the rendering of the image. In particular, the figure of Saint Sebastian was vertically crossed, from the hair down to the knee, by a large lacuna portion that, luckily, had not affected his face. Figures were also missing like the emperor and the crowning angel above, the executioners and some of the faithful praying below, and there was also a disfiguring loss of colour concentrated in the sky, the tree behind the martyr, the grass, and the rocks in the foreground.

And then widespread artificial patinas and altered retouches from the last restoration in 1971 made the already compromised reading of the painting even more

Figure 2 – Details of the portion of the painting where an initial integrative proposal was made in view of the exhibition dedicated to Giovanni Santi in Urbino. Specifically: after cleaning with the lacunae already filled in with gesso and rabbit skin glue (left) and after the pictorial reconstruction (right).

Figure 3 – Detail of the *selezione cromatica*.

difficult as these were applied everywhere to hide the countless signs of wear and loss of colour.
As a result, the colour connections of the painting were completely distorted.
The situation was also aggravated by the constant formation of new detachments of the paint layers from the support, with new losses of colour. This element led to serious doubts on the efficiency of the wooden support control system of the last restoration with the crossbeams, strongly bound to the support, developing significant friction on the wood panel. So, one of the important objectives immediately set was to equip the work of art with a new crossbeam system. The first intention of our project, supervised by the official art historian, was the conservation of what had survived of the painting by Santi.
So, we intervened immediately to re-establish the adhesion between the lifted paint layers and the support. These first conservation interventions were also necessary to allow the work to be safely put on display at the exhibition dedicated to Giovanni Santi held at the Palazzo Ducale in Urbino in 2019 and named: *"DA POI…ME DETTE ALLA MIRABIL ARTE DE PICTURA"*.
Interesting archival documents have emerged showing how the work has undergone multiple restorations over four centuries with an alternation of generalised repainting over the entire surface, followed by their total removal. [1]
And it was only with the 1971 restoration, following the removal of the last previous repainting, that the neutral tone was applied to the lacuna portions of the painting. However, this operation was criticised by some art historians stating that, in recovering the painting by Santi, the overall view, still appreciable in the old photographic reproductions, had been lost, leaving the panel in a highly fragmentary state.
After four hundred years of documented history, with a succession of repeated aesthetic-conservative interventions, we had to, once again, reflect on what should be the most respectful critical choices to make,

especially to allow the painting to convey its expressive potential at best.
From a methodological point of view, it seemed fundamental to include all the operational phases within a single organic project, in particular keeping into account those linked to one another.
For example, the cleaning operation, aimed at restoring a correct balance in the painting's chromatic connections, made it necessary to consider the fact that major restorations of the painting would inevitably be necessary, and these had to be distinguishable.
It was precisely the serious conservation situation of the polychromy that gave rise to serious reflections on the methodological choice to undertake for the integration of the painting, aimed at reducing, as far as possible, the negative effects of the state of deterioration.
The final aim was to improve the understanding of the painting: to achieve this, the need surfaced to enhance and clarify the values and meanings that the work still managed to express, without, however, imitating it.

2. MATERIALS AND METHODS

The integrative proposal examined the Florentine *selezione cromatica* method, the chromatic selection to be carried out on all those lacunas that were understandable due to the continuity of the drawing. [2]
The three advantageous characteristics of this intervention, namely recognisability, differentiation, and reversibility, convinced us of the possibility of reconstructing the main figure of the representation in its entirety: Saint Sebastian. Luckily, although very fragmented, it still had sufficient evidence to support an integration in line with the original.
The painting was displayed with an initial reconstructive intervention for the exhibition dedicated to Giovanni Santi in Urbino. It was decided to integrate a part of the figure of the martyr, the bust, with a portion of the landscape and sky. All restoration work was completed on these areas up to the *selezione cromatica* reconstruction.
And it was precisely the need to directly evaluate the contribution of the pictorial restoration, placed next to the original colour, that prompted the first implementation of this integrative project that, although partial, has helped understand how the figure of Saint Sebastian was still rich in expressive force and able to live on its own.
With the same integrative technique have been reconstructed the remaining losses of the painting. My selection work did not begin directly on the white fills ground, but on the undertone colour bases, made in Winsor & Newton tempera colours. [3]

Figure 4 – Details of the *selezione cromatica* carried out with tempera, over tempera bases (left) and then with varnish colours (right).

This step is very important for two reasons: the first is to contain the processing time, all the more so in an extreme case like this one consisting in a very demanding and particularly long work of integration; the second reason, to create a useful film to attenuate the porosity of the gesso, in view of the absorption of the additions. I carried out an initial *selezione* integration on top of these chromatic bases using Winsor & Newton tempera colours, overlapping by hatching three pure colours, chosen from the primary and secondary colours. [4]

By overlapping several layers, I achieved a tone that was fairly close to the original. The use of tempera colours was preferred to watercolours, due to the need to obtain sharper and more defined lines that in the overlap remained clearly visible. [5]

I used these types of brushes: Winsor & Newton - Professional Watercolour Synthetic Sable Brush – Pointed Round, size 2, and Professional Watercolour Synthetic Sable Brush – Round, size 1 and 2. Taking care to keep the brush well pointed.

After the application of the restoration varnish, carried out with Laropal A-81 (dry), dissolved at 15% in White Spirit, I continued the *selezione cromatica* on the integrations, using Gamblin Conservation Varnish Colours until achieving the desired tone. For this retouching, I used a mixture of solvents consisting of 50% Ethyl-lactate and 50% Isopropyl Alcohol.

The choice of making two selections with different techniques, i.e.: first with tempera and then with varnish, has the advantage of making very vibrant integrations, where the tempera hatching underneath creates a first well-defined outline that helps the work to be made using varnish colours. Besides, the overlapping of these two hatchings that do not blend, enhances the chromatic vivacity of the actual integration.

We chose to intervene in the remaining part of the painting, where the loss of large and significant portions weighed on the formal value of the work, which could not be identified except through our invention, by lowering the tone of the visual disturbance by means of the *chromatic abstraction* method. [6]

This method consists, this time, in cross-hatching, where no form is reconstructed, according to a three-colour scheme of yellow, red, green, or blue, plus the addition of black. With the carefully graded components, overlaid in an intertwined way, the average chromatic value of the painting is obtained. The separation of the pure, unmixed colours allows that vibration and connection with the colours of the painting, where the result of the abstract composition is preferable to neutral. [7]

In the realization of the abstraction, I wanted to experiment with three tonal variations within the predominant and clearly distinguishable polychrome areas of the painting, where I chose to find the average chromatic value of the existing colours in each one. [8]

The first area concerns the executioners, the tree, the mountains in the distance and some faces of devotees on the right, then the meadow and, lastly, the crowning angel in the upper right. The second area is that of the mourners praying in the bottom right and the emperor in the top left part. Lastly, the third area is that of this sky.

Figure 5 – Samples chosen for the three matching chromatic abstractions

The idea to include these three abstractions in the vast colour losses in distinct areas is due to the need to reduce the incidence and weight of the actual lacunas. In was indeed the specific concentration of the vast and evident lacunas in the sky that led me to propose, among

other elements, a matching abstraction confined precisely to this specific part, where the predominance of the colour blue led to the consequent result of obtaining a very harmonised abstraction.

3. RESULTS AND DISCUSSION

When working on such complex paintings, any attempt at integration, whether made or not, always risks being deemed as arbitrary. We are faced with a painting severely damaged by irrecoverable losses, so much so that we can go so far as to say that the extent of the damage is, actually, aesthetically reprehensible, regardless of the painterly integration methods employed. The large losses of colour, with their irregular and closed shapes, delimited by an outline, are, indeed, perceived as real figures, which draw attention to themselves within the image, since they possess greater density. [9]
Trying to precisely limit this interference and intrusiveness of the gaps, to try moving them into the background, was the main objective of this integrative matching chromatic abstraction proposal. In this regard, the studies of the Gestaltpysichologie ("psychology of form") theorists, and the analysis of Cesare Brandi on the subject, have been of great help. [10][11]
They declare that to understand an image, our perceptual system must first be able to distinguish the figures from the background. During the perception of an image, the relationship between the figure and the background is not immutable, as it can be changed if the observer shifts the attention from one to the other. What we see as the background appears 'out of focus', vague and imprecise, while the figure is analysed in detail, until our attention shifts to the background, reversing the initial connection.[12]
This is a limitation of our perceptual system that is forced to make choices because it is unable to take all stimuli into account simultaneously. [13]

4. CONCLUSIONS

Our integrative proposal was based on this limitation that aimed at attenuating lacuna-figures in the background of the sky on which work was made trying to push them back to relegate them to a background

Figure 6 – The remaining part of the painting after cleaning and the material integration with gesso and rabbit skin glue.

Figure 7 – The painting at the end the restoration.

function only. According to my vision, granted by the art historian, if they had remained more in evidence, that is, of the same neutral tone of the abstraction of the first polychrome area (that of the executioners, of the tree, of the mountains in the distance and of some faces of devotees), they would have risked maintaining the "reversal of attention" on them, diverting the observer's concentration on the degradation, instead of on the surviving painting. In the same way, the large gaps in the areas of darker tone, those of the mourners praying and of the emperor, have been integrated in chromatic abstraction, where the average chromatic value of the existing colours was found again here.
Actually, what was done was trying to give this work of art by Santi a chance to clarify those values and meanings that, in my opinion, could still be recovered, understood and enjoyed.

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RETOUCHING A RETOUCHED PAINTING. EVALUATION AND RE-TREATMENT OF HISTORIC RETOUCHINGS IN THE CONSERVATION OF A PAINTING BY LAVINIA FONTANA

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ABSTRACT

A major conservation project on *The Visit of the Queen of Sheba to King Solomon* by Lavinia Fontana was completed at the National Gallery of Ireland in Dublin in 2021. The painting was previously restored in the 1960s by a team of conservators from the Istituto Centrale del Restauro in Rome, who came to Dublin during the establishment of the first Gallery conservation studio, shaping the Irish approach to conservation for decades to come. Consequently, the painting recorded material evidence of a particular moment in the development of conservation in Ireland.
Large areas of historic losses across the painting surface had been reintegrated with the application of retouchings in the *tratteggio* style, but during the most recent treatment, underlying instability required the removal of some of them. A decision-making model was developed to evaluate the quality and historic value of these retouchings to determine which to preserve, which to modify, and which to remove. A return to the *tratteggio* technique was chosen for the larger instances of loss compensation, albeit with a finer hatching so that the newer reintegration remains distinguishable from the historic one.
Furthermore, where heat damage in the paint layers resulted in uneven topography, Paraloid-based gels were applied to bring continuity the surface texture in these areas.
This paper will present the approach used to meet the conservation needs of the object, restore the legibility of the image and retain the evidence of the historic intervention of this founding team of Italian restorers at the National Gallery of Ireland.

Keywords
Lavinia Fontana; Tratteggio; Rigatino; Archival Documentation; Gamblin Conservation Colors; B72 Retouching Gels

1. INTRODUCTION

In 2021, a large-scale conservation project was concluded at the National Gallery of Ireland on *The Visit of the Queen of Sheba to King Solomon*, an oil on canvas by Lavinia Fontana, 1599. The vast canvas, which had been treated previously in the 1960s, carried many large areas of retouching and part of the treatment required decisions to be made regarding their removal or modification.
This paper will present the research and choices made during the project and how the approach to the retouching treatment was informed by the historical context and documentation of the previous restorations. It will also cover issues related to the appraisal and re-treatability of aged *tratteggio*-style retouchings and outline a complementary method for textured retouchings using Paraloid B72-based gels.

1.1 The painting

The Visit of the Queen of Sheba to King Solomon is a vast 16th century canvas, measuring 256 x 325 cm, and

was purchased by the National Gallery of Ireland in 1872. The painting was the first work knowingly acquired by a woman artist for the collection and it was to become a much-admired cornerstone of the Italian collection, hanging on display except for periods of loan, renovation or restoration for the ensuing 150 years.

The Bolognese artist, Lavinia Fontana, was an exceptional and significant figure in the Italian art history and was active from 1575 to 1614, working first in Bologna and then in Rome. She is generally known as the first professional female painter in Europe, outside of a court or convent, and the first woman artist to have her own independent workshop.

Fontana was primarily known for her portraiture, which was very much in demand during her lifetime, but she also produced varied and ambitious devotional paintings, altarpieces and mythological subjects.

The Visit of the Queen of Sheba to King Solomon is one of Fontana's largest and most prized extant works, painted at the turn of the 17th century in Bologna, ahead of the artist's move to Rome at the invitation of Pope Clement VIII. In it, Fontana asserts her mastery of the depiction of biblical allegory, portraiture fine costume and jewellery, landscape, and interiors.

By the 19th century the painting had made its way into the collection of Prince Napoleon, held at the Palais-Royal in Paris. The building was set alight in 1871, and after its rescue from the fire, the painting was shipped to London and sold at Christie's Auctioneers. It was then restored in England before transit to Ireland [1].

In 2019 the Gallery was awarded a generous grant by the "Bank of America Art Conservation Project" to enable a comprehensive research and treatment project for the painting.

The recent treatment sought to address structural instabilities that would require the removal of the varnish and at least some of the retouchings applied in the former restoration campaign.

1.2 The background

During the assessment of the painting, the quality and historical significance of the restoration materials were noted. The painting was treated in the late 1960s at the Gallery and the treatment itself is emblematic of conservation history in Ireland and in Italy.

The National Gallery of Ireland opened its doors in 1854, but with decades of political tumult and deprived public finances it wasn't until 1966 that the conservation department was opened, in collaboration with the Istituto Centrale del Restauro in Rome [2].

The Istituto Centrale acted as a consultant for the design and construction of the studio facilities and the initial survey of the collection, they also trained the first Irish conservators to staff the department. To initiate the operations of the department, a large team of professors and conservation students from the Istituto worked in Dublin for a period of five months over the summers of 1967 and 1968 to perform large-scale conservation treatments.

The Visit of the Queen of Sheba to King Solomon was one of the largest of the 118 artworks treated by the visiting team and a prime example of the use of novel materials and techniques associated with the Italian development of modern conservation methods.

The restorers left some images and documentation which informed and guided the project planning. Prior to the 1960s restoration, the painting, after over ninety years hanging in a gallery, once illuminated by candlelight, was coated in thick layers of grime and darkened varnish. Furthermore, Victorian-style retouchings were present across a large number of the damaged areas, probably applied using oil colours.

The 1960s treatment involved re-lining the painting using a modified version of the traditional Italian glue-paste lining, with the addition of a synthetic adhesive, novel at that time, called Gelvatol [3]. A new, heavy timber stretcher replaced the existing one and an open-weave lining canvas was used to support the original. Removal of dirt, varnish and retouchings was carried out with pure solvent and solvent mixtures, a system that would become common in the National Gallery of Ireland conservation department. Application of large swathes of gesso fillings were supported by a strawboard base, where the original canvas was missing. The campaign of retouching was applied in the relatively novel *tratteggio* style, using a Paraloid-based medium and a synthetic varnish was applied [4].

Tratteggio is an image reintegration method using a vertical hatching system that was invented and developed in the late 1940s in the Istituto Centrale del Restauro and was inspired by the theory of conservation-restoration of Cesare Brandi [5].

The treatment in the 1960s saw the application of *tratteggio* retouching along the entire lower edge and in vertical areas at the seams, the left and right edges and on the right side of the painting where large losses had occurred due to the fire. It was estimated the

retouchings were present at 15% of the painting surface.
These materials and techniques would become a signature set for the treatment of large paintings at the Gallery, as the department continued to operate after the Summer projects, staffed with Irish conservators, trained in Rome.
The use of techniques inspired by Brandi was not prevalent amongst English-speaking countries at this time, so this in itself distinguished the Gallery from its counterparts elsewhere in the Anglosphere.

2. MATERIALS AND METHODS

Due to the importance of the former restoration campaign, a minimal intervention approach that would preserve the evidence of previous restorations and allow for optimum re-treatability for the painting was applied. Examining the aged condition of these materials and the potential for removal, modification and re-treatability in this case would again see this painting set the standard for future interventions through the paintings collection.

2.1 Decision-making

The treatment plan was designed with the intention of leaving in place as much of the existing filling and retouching as possible, where it was deemed to be stable and in a 'good enough' condition to be adjusted.
Unfortunately, most of the large old canvas losses had not been individually repaired but only bridged using a strawboard base, which resulted in the cracking of the filling material, due to their contrasting responses to thermo-hygrometric fluctuations. The underpinning of the filled areas was surveyed and only removed where the structure was found to be unstable.
Aiming to maintain the most significant passages of retouching, a selective cleaning was planned, categorizing the retouchings to be removed, modified and maintained.
Lastly, a varnish system that would facilitate a greater degree of re-treatability with less invasive treatments in the future was evaluated.

2.2 Retouchings categorization

In order to consistently guide the cleaning and reintegration campaign, the existing retouchings were identified and grouped in three categories.
In the first category, the retouchings were of high quality and were finely laid down in *tratteggio* style but showed some discolouration. These areas often had a high level of reconstruction, at crucial and focal points in the composition. The removal of only the top layer of varnish was considered and the retouchings in this category were retained. Superficial adjustments were also planned to improve the colour match and slightly modify the reconstructed forms were required.
In the second category, the *tratteggio* was varying but of acceptable quality. In most cases, the retouching had been expedited by laying down base colour and applying lines over this, so the level of clarity and illumination in these areas was lower. The material was discoloured and the application was less skilful than the category 1 retouchings. The reconstructed forms in these areas required significant modifications so that the retouchings were retained but with comprehensive adjustments.
In the third category, a *tratteggio* of a much lower quality was identified. In these cases the vertical lines were applied in a less formal technique with varying thickness and at varying intervals. The boundaries of these retouchings were less well defined and would sometimes overlap original paint. The retouchings in this category were removed completely to be re-applied (figure 1).

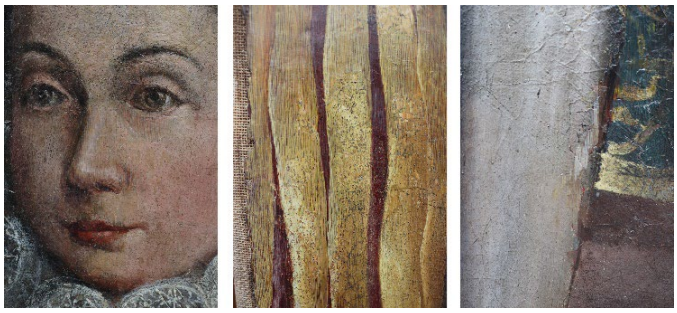

Figure 1 – Examples of the retouchings categorization. Category 1 (left), category 2 (centre), and category 3. Photos ©National Gallery of Ireland

2.3 Varnish removal and cleaning

The 1960s reports revealed the painting was varnished with 'Retoucher' varnish [4], which is generally composed of acrylic resins, and then was retouched with 'Paraloid' colours, which also consists of acrylic resin.
In a later document, dated 1982, written on the occasion of a loan, the conservator reported the

painting was varnished with a thin layer of dammar, natural triterpenoid resin [6].
Knowing the stratigraphy of the material to be removed (acrylic resin + terpenoid resin), with the aid of the Teas chart it was possible to estimate the solubility areas of each material and establish a solvent mixture able to selectively remove the top layer of yellowed natural resin without solubilising the Paraloid-based retouchings and acrylic varnish. Furthermore, other tests with pure solvents were carried out with the aim to remove both materials from the surface, without interfering with the original oil paint layer. The selective removal of layers of varnish and retouching was carried out, as the categories in section 2.2 dictated.
Based on the cleaning tests, two solutions were selected: an alcohol/hydrocarbon mixture that would remove only the top layers of natural varnish, leaving the retouchings intact, as for category 1 and 2; and an organic ester for the areas where removal of both varnishes and retouching was indicated. Application systems such as gels and absorbent tissue composites were tested but the most controllable and even results were achieved using cotton swab application.

2.4 Filling and intermediate varnishing

Where unstable fillings had been removed, they were reapplied with new gesso made with rabbit skin glue 10% in demineralised water and chalk (calcium sulphate), and their topography was finished according to the retouching method planned for each area. For the smaller losses a textured finish was applied, matched to the surrounding levels and modelling the gesso to imitate the irregularity of the paint layer. On the areas of large infilling designated for the new tratteggio, a flat filling was applied.
Prior to the retouching, an isolating layer of varnish, the aldehyde resin Laropal A81 in an aromatic/aliphatic solvent mixture was applied.

2.5 Fire Damage treatment

In addition, we sought out a texturing material to apply in the areas of wide aperture surface wrinkling and alligatoring resulting from the historic fire damage. B72 Retouching Gels, a medium developed to mimic the impasto found on modern paintings was particularly useful in this instance. The product is available in a selection of viscosities and evaporation rates and brings a depth of saturation and work-ability to textured retouchings that can be difficult to achieve using textured gesso and surface retouching.
A mock-up with the eight Gel formulations was created, by mixing the different gels with a selection of Paraloid B72 Retouching Colours (table 1), and the 'Fast – Heavy 20' formulation gave the best results due to its thickness and relatively quick evaporation time [7].
The fire damage affected large vertical areas on the canvas, and caused legibility issues over certain focal points of the composition. With the use of the B72 gel chosen, we were able to regularise the surface of the most extremely damaged areas to allow for a clarity in the image. Although we deliberately did not completely disguise the damage, which is characteristic evidence of a major incident in the history and provenance of the picture.
Due to the matte appearance of the acrylic resin contained in the gel, a top coating with Laropal A81 was applied, to even out the saturation of the area with the rest of the painting and the area was subsequently retouched (figure 2).

Figure 2 – An area showing fire damage before (left) and after treatment with B72 retouching gel (right). Photos ©National Gallery of Ireland

Table 1 – B72 Gels test

	RHEOLOGY/ TEXTURE	EVAPORATION TIME	SHRINKAGE/ CRACKING
Fast – Hard 25 Si	++	++	++
Fast – Heavy 20	++	++	++
Fast – Light 10	++	++	---
Fast – Light 10 Si	++	++	---
Fast – Very Light 7.5	---	++	+
Slow – Heavy 20	-	--	-
Slow – Light 10	--	--	--
Very Slow – Light 10	--	---	-

Quality:
--- very bad
-- bad
- poor
+ fair
++ good
+++ excellent

2.6 Retouching campaign

The new retouching campaign was carried out according to the categorization made during the cleaning.
For category 3, the new *tratteggio* was built-up systematically from the white gesso base using Gamblin Conservation Colors. Where reconstruction of forms was required this was done with reference to documentation and photography as well as a survey of Fontana's similar works. The application of colours was done in several steps and, compared to the pre-existing *tratteggio*, the new vertical brushstrokes are shorter and finer, and so remain distinguishable from the earlier campaign (figure3).
Where there 1960s *tratteggio* was retained (category 1 and 2) the modifications were limited to the adjustments required to reduce the discolouration and amend the edges of forms.
A typical example of this conservative restoration approach is the face of the man in the red coat, who is prominent in the foreground of the painting. In the centre of the most extreme area of fire damage, the entire face of the man, from the eyebrow to the chin has been lost. This focal point was given careful attention in the 1960s restorers and a fine tratteggio was applied. The previous Victorian reconstruction, from 1872, can be seen in an archival photo, where the man's features were romanticised and stylised and his hair was given a buoyant, curly crop. The Italian restorers, in the pursuit of neutrality, constructed a vague face for the man. The approach for this later intervention was to adjust the features near the boundary of the lacuna with reference to the traces of original paint and to modify the colour of the *tratteggio* slightly so it could be appreciated with its cleaned surroundings. The resulting image is less defined and more suggestive and the pentimenti on the ear of the man and in his hair were allowed to remain semi-visible (figure 4).

Figure 3 – Example of an extensive reintegration using *tratteggio* technique. Before treatment (top), after cleaning and filling (centre), after retouching (bottom). Photos ©National Gallery of Ireland

Furthermore, the increasing transparency of oil paint, due to the natural aging process and the abrasion brought by successive historic restoration campaigns, resulted in a high level of visibility for the many pentimenti throughout the painting. In many cases this confused the image and made distinguishing the final composition details very difficult. The perception of perspectival space and the solidity of depicted forms was also affected, encouraging a misinterpretation of the image. Therefore, a consistent level of retouching for these abraded areas was required. The intention was to re-establish the dominance of the artist's final image while allowing the pentimenti to be noted upon closer inspection. This was done with reference to the technical imaging, scientific analysis and art historical research that was carried out on the painting. Where abrasion had resulted in a fragmented surface, retouching was applied using a pointillism technique to reduce the impact of the abrasion and allow for the legibility of damaged forms. This was carried out with reference to technical imaging and archival imaging to ensure that pentimenti remained visible but the final composition maintained dominance. The pointillism retouching was also used to conceal the areas affected by the fire damage that were previously integrated with B72 Gel (figure 2).

2.7 Final Varnish

At the end of the treatment a final varnishing was necessary to protect the painting and the retouchings from discoloration and to achieve an even saturation of the surface. Due to the size of the painting, a satin varnish was chosen to saturate the painting surface while reducing light reflections. For this purpose, Regalrez 1094-based varnish was evaluated as the best option for its stability and its solubility in aliphatic solvents, without risk of solubilisation of the retouchings during brush varnishing.

Two proprietary formulations, Regal Varnish Gloss and Matt were chosen, which are developed for conservation purposes with the addition of UV stabiliser and an elastomer to facilitate the application by brush [9]. To best evaluate the adequate level of glossiness, a mock-up sample canvas was prepared with a selection of colours and finishes for evaluation, including Gamblin conservation colors. Half of the mock-up canvas was coated with two layers of the same Laropal A81 used as isolating varnish. Then the different mixtures of the two Regal Vanish were applied, in different proportions. The varnish composed by Regal Varnish Gloss 4:1 Regal Varnish Mat was chosen as final varnish, and a single layer was applied to the painting by brush. This final varnish has a satin appearance which is fundamental for the legibility of large-scale paintings as it reduces light reflections (figure 5).

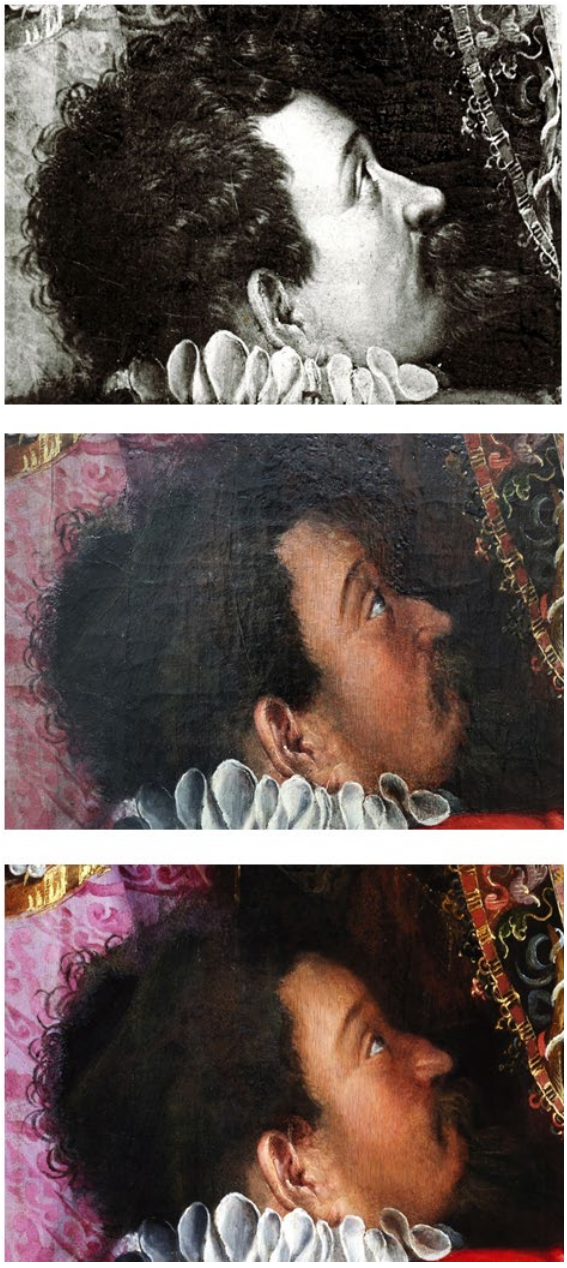

Figure 4 – Comparison of the man in red's facial retouching. 1872 reintegration from archival image (top), 1960s reintegration (centre), last treatment (bottom). Photos ©National Gallery of Ireland

3. RESULTS AND DISCUSSION

3.1 Archival Documentation

The comprehensive examination of documentation from the visiting restorers from the Istituto Centrale in the 1960s that was carried out during the course of this project will be of great value for future care and treatment plans for the collection at the National Gallery of Ireland. Almost 120 paintings were treated with this approach at the Gallery and many later treatments in the 1970s and 80s were heavily influenced by these methods and materials.
Each of the treatments carried out during the summer projects in 1967 and 1968 were accompanied by a report and photographic record and this corpus can be analysed to identify trends in the aging and deterioration of particular conservation materials, potentially informing preventative and interventive care plans for the collection. For this reason, further survey and assessment of archival documentation, including digitisation of the photographic archive, will be valuable.

3.2 Re-treatability of Paraloid B72 Retouchings

The assessment and selective removal of varnishes and retouchings where Paraloid B72 medium was used during this project will inform and guide the future approach to re-treatment of those paintings sharing similar materials and stratigraphy.
The levels of discolouration observed in these retouchings, the solubility for removal and the efficacy of superficial adjustments to the material are pertinent to any future treatment of this conservation material.

3.3 Paraloid Retouching Gels

Paraloid B72 resin has been used in conservation for numerous purposes for decades, with a growing body of evidence of the material's safety and reversibility after long periods of time. The use of Paraloid-based gels in this intervention was very beneficial to achieve a more even topography for those areas which could not be filled with traditional putties.
The evaluation of B72 Gels and their use as a surface modulator in areas of paint damage presents opportunities for further development and testing.

Figure 5 – Lavinia Fontana, *The Visit of the Queen of Sheba to King Solomon*, 1599, oil on canvas, 252 x 327 cm, National Gallery of Ireland, Dublin (NGI.76), after treatment in 2021. Photo ©National Gallery of Ireland

4. CONCLUSIONS

The results of the treatment allow for the painting to be enjoyed with a new clarity and legibility. Not only that, the evidence of its life experience, through pentimenti, fire damage or restoration, remains visible for those who would investigate. The treatment allows for increased re-treatability in the future and easy identification for each campaign of retouching present.

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[3] Gelvatol is the trademark of a poly vinyl alcohol, a water-soluble synthetic polymer developed in the early 1960s by Monsanto which was novel at that time.

[4] Archival reports mention the use of a *Retoucher*, which generally refers to a retouching varnish produced by Lefranc & Bourgeois, composed by an acrylic resin.

[5] CANAVAN, M., MARCATTILI, L. (2020). The Roman School at the National Gallery of Ireland: Connecting past and present conservation practices through the treatment of a painting by Lavinia Fontana. In *Young Professional Forum, Emerging Skills for Heritage Conservation: Proceedings.* Turin: Centro di Conservazione e Restauro di Venaria Reale. 164-170.

[6] Andrew O'Connor, National Gallery of Ireland NGI. 76 report: unpublished. 21 May 1982.

[7] B72 Retouching Gel, Fast- Heavy 20, produced by Artcare in the United Kingdom. It consists of a thick gel made by ethyl methacrylate and methyl acrylate copolymer in 1-methoxy-2-propanol.

[8] Kremer Retouching Chips Paraloid B72.

[9] Regal Varnish Gloss is a finishing varnish composed by Regalrez 1094 23,5% in aliphatic hydrocarbons, such as shellsol D40, with low toxicity and a boiling point f 140-160 °C. The formulation contains 1% by weight of plastifying agent called Kraton G-1650, a copolymer in blocks of styrene-ethylene-butylene-styrene, and 0.5% of UV stabiliser Tinuvin 292, a hindered amine light stabiliser (HALS).
Regal Varnish Matt is the same formulation as Regal Varnish Gloss, but with the addition of 3.5% of microcrystalline wax Cosmolloid 80.

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TOPIC 4

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ADAPTING AND EVOLVING THE TRADITIONAL TECHNIQUE OF EGG TEMPERA RETOUCHING AT THE HAMILTON KERR INSTITUTE

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ABSTRACT

This paper discusses the traditional retouching method of egg tempera, which, amongst other retouching techniques, remains a practised and taught method at the Hamilton Kerr Institute (HKI), University of Cambridge, UK. Since its introduction to Britain, the method has evolved and adapted, most recently owing to the absence of MS2A resin. Laropal A81 has been used as the replacement isolating varnish. However, the physical properties and handling differ from MS2A.

The typical diluent used at the HKI for Laropal A81 varnish is a 50:50 mixture of Shellsol A100 and Shellsol D40, however, when used as the isolating resin over an area of retouching this mixture could disrupt lower tempera layers. To remedy this, the diluent was changed to cyclococtane, an aliphatic hydrocarbon. Cyclooctane benefits from being less toxic compared to the aromatic hydrocarbon Shellsol A100 and can be manipulated more on the surface before the activation of lower Laropal A81 layers becomes problematic.

Laropal A81 solubilized in cyclooctane was successfully used as the isolating resin for egg tempera retouching and offers promise for a variety of varnishing scenarios and retouching. This paper demonstrates this adapted method of egg tempera retouching through a case study of a 16th-century panel painting with large losses perfectly suited to this method.

Keywords
Egg tempera retouching; Laropal A81; Cyclooctane; mimetic retouching

1. INTRODUCTION

The traditional retouching method of egg tempera remains a practised and taught retouching technique at the Hamilton Kerr Institute (HKI), University of Cambridge, UK. This paper will discuss the developments of egg tempera retouching from its origins in 19th-century Germany, through to the present day. While the method is largely unchanged, the materials used have evolved and have adapted through the generations of conservators using this method. One recent adaption of the materials for egg tempera retouching at the HKI involves substituting the diluent used for the isolating resin layer of Laropal A81, from a mixture of Shellsol A100 and Shellsol D40 to cyclooctane. To elaborate further on this adaption and to offer the reasoning behind it, a case study of a British 16th century panel painting is presented. This painting displayed large lacunae after cleaning and was perfectly suited to the egg tempera retouching system. A review of cyclooctane and its potential advantageous use within conservation is also considered. The aim of this study is to disseminate the recent adaptions into the wider conservation community.

1.1 The development of egg tempera retouching from Germany to the UK

Egg Tempera as a retouching medium originated in 19th-century Germany, where a number of painting restorers were known to work with the method. These include landscape painter and painting restorer Christian Philipp Köster (1784-1851) who worked at the Boisserée Collection, Heidelberg, the Solly Collection, Berlin, and later at the Königliches

Museum, Berlin; Köster's student and brother-in-law, Jacob Schlesinger (1792-1855), studied in Heidelberg, then later worked alongside Köster at the Boisserée Collection. Johann Christian Xeller (1784-1872) trained in Dusseldorf followed by an excursion to Italy, and from 1825 worked at the Gemäldegalerie, Berlin and the Boisserée Collection with Köster and Schlesinger [1]. Köster's 1827 volume *Ueber Restauration alter Oelgemälde* on the restoration of oil paintings [2], included a 30-page treatise written by Schlesinger on early Italian egg tempera paintings and their restoration. From 1929, Helmet Ruhemann (1891-1973) worked at the Kaiser Friedrich Museum, Berlin, where he was advised by the restorer and artist William Suhr (1896-1984), who is said to have taught Ruhemann the use of tempera. In 1933, during Hitler's rule over Germany, Ruhemann fled to England, and by the following year was working at the National Gallery, London. Ruhemann, whose preferred retouching method was tempera, trained numerous students and assistants. Herbert Lank (1925-2020) first worked privately with Ruhemann at his home before they worked together at the National Gallery. As skillful as Ruhemann was as a retoucher, his trolley was apparently somewhat chaotic and messy, initiating Lank to make some refinements to Ruhemann's tempera method with a more methodical approach [3]. Lank became the HKI's inaugural Director in 1976 and in 1980 initiated a sister-studio located at Ebury Street, London.

1.2 Egg tempera retouching methodology and the evolution of materials

Since its 19th-century origins, the materials used for tempera retouching have evolved. Schlesinger wrote in his 1827 treatise of retouching on white putty with egg tempera underlayers followed by lean oil colours. His egg tempera mix was composed of egg yolk mixed with a little vinegar as a preservative. He favoured egg tempera as it was fast drying and enabled the retouching to be done in thin layers, thereby achieving the appearance of an aged oil paint. Ruhemann modified Schlesinger's egg tempera method by using the whole of the egg (albumen and yolk) with a drop of wax-paste (beeswax and white spirit, 1:3), shaken together in a bottle of water (equal to the egg's volume), with a drop of acetic acid as a preservative. The egg tempera could then be ground on the palette with the desired dry pigments. Both Schlesinger and Ruhemann aimed to complete the majority, if not all, of a retouching using tempera, with a minimal mixture of pigments, burnishing each application with silk. If required, Ruhemann completed final glazing using oil or watercolour, and he then applied a brush varnish of mastic. Lank further refined Ruhemann's egg tempera approach; the number of pigments used was reduced to 23 (using only stable pigments). Like Ruhemann, Lank used the whole of the egg, but diluted it only with water (removing the wax paste Ruhemann had added for adhesion). Lank then used MS2A for isolating resin layers (aiding reversibility) and glazed with the same medium, instead of oil, or watercolour. With the development of spray guns, the final varnish application could now be sprayed enabling the same resin (MS2A) to be used without disrupting the glazing (also in MS2A). Ruhemann and Lank both advocated using a hair dryer to speed up the drying of the egg tempera application. This also has the added benefit of cross-linking the emulsion, ensuring stability [4]. Lank continued to teach egg tempera retouching to the students of the HKI, a practice which still occurs today, now alongside a variety of retouching systems, such as Paraloid B72 and Gamblin Conservation Colours.

1.3 Egg tempera as a retouching medium today

Today, one of the main draws of egg tempera retouching remains its versatility; it has the optical ability to achieve both opaqueness and transparency, but is especially suited to achieving large swatches of opaque colour. It is therefore well suited to paintings with large lacunae because when applied in multiple lean layers (and colour-matched accordingly), the optical interaction between the pigment and medium has the ability to flawlessly match aged oil paint. It is suitable for use on filled losses only, but when used in conjunction with a resin retouching medium (as is used for glazing the egg tempera), this is not problematic as retouching out paint abrasion is better achieved through resin retouching. As dried egg can become embrittled with age, there have been concerns over its reversibility, especially if painted directly onto areas of original paint [5]. However, used correctly, there should be no risk of irreversibility; first, the whole painting receives a full isolating varnish (using a reversible resin), in addition, the

tempera mixture uses the whole of the egg combined with water (not just the yolk which can become insoluble) and is then, ground with pigment and further diluted on the palette with water, and applied in thin, lean, layers to the painting's filled loss. An isolating reversible resin varnish is applied locally between the tempera layers (offering saturation and aiding reversibility). Reversibility concerns are based on egg tempera retouching in its 19th-century incarnation where the yolk only was used and where it was combined with glazing in oils. Lank's adaptations have now mitigated these concerns.

The technique of egg tempera retouching takes time to master. The layering system can limit efficiency to some degree, however, the optical appearance of a near-perfect retouching makes up for this [6]. Once familiar and experienced with the method it soon becomes second nature and is a very effective method for retouching large losses which require large swatches of body colour, before refining the upper layers to mimetically match the surrounding paint. Another draw of egg tempera is it requires only water as a diluent, and therefore limits solvent exposure for the conservator. That said, the isolating resin layers and glazing do require a solvent and historically MS2A was used, which requires an aliphatic hydrocarbon, such as Shellsol D40.

1.4 Demise of MS2A

Since production of MS2A stopped in around 2014 conservators have looked elsewhere for suitable reversible resin varnishes[i]. Like many institutions and private practices, the HKI turned to conservation-grade synthetics such as Laropal A81, Paraloid B72 and Regalrez 1094. For this process, Laropal A81, being a low molecular weight resin, is the best substitute for MS2A given its capacity to saturate well[ii].

Laropal A81 is an urea aldehyde resin, manufactured by BASF. It is resistant to yellowing and remains soluble in artificial aging tests [7]. Owing to its refractive index (RI) of 1.503 [8] the resin has excellent wetting properties and is soluble in a range of widely available solvents, making it a suitable candidate for varnishing and retouching [9]. In practice, it requires a solvent with high aromatic content for solubility (a 50:50 mixture of Shellsol A100 and Shellsol D40 is used at the HKI), making Laropal A81 less favourable for the health of the conservator[iii].

The inherent leanness of the egg tempera can result in a porous layer (even after burnishing), which then requires saturation. To remedy this, an isolating varnish layer is sandwiched between tempera layers which enables the conservator to 'fix' lower layers with sufficient saturation (and in turn aiding a correct colour match) prior to working on the subsequent layer[iv]. This resin layer also acts to ensure reversibility as the lean tempera layer is easily undercut with the resin's active solvent.

The scope of this paper is not to explore the practical methods of egg tempera retouching. Ample literature is available on the subject.

2. CASE STUDY

A complication was recently encountered when using Laropal A81 as an isolating varnish for the egg tempera retouching of a British Tudor portrait, which, after cleaning, displayed significant paint loss in large lacunae, and therefore was an ideal candidate for egg tempera retouching (Figures 1 and 2).

2.1 The problems encountered with Laropal A81

After cleaning *Unidentified Lady*, tests found the best varnishing result to be a composite layer structure composed of an initial application of Paraloid B72 (15% in Shellsol A100), followed by a further varnish application of Laropal A81 (17% in Shellsol A100 and Shellsol D40, 50:50). The painting received an initial brush varnish of Paraloid B72. For this varnish layering method, the Paraloid B72 layer needs to dry over a period of approximately one week prior to a further varnish application. To economize time, filling of the large lacunae was completed during this interval[v]. The fills were locally isolated using a weak solution of shellac (in Industrial Denatured Alcohol) and the first egg tempera application, pigmented to match the painting's ground colour, was applied (Figure 3). This egg tempera layer was burnished and the final brush varnish (covering the entirety of the painting) was applied using Laropal A81. This has the benefit of achieving good saturation whilst simultaneously isolating the initial lay-in of egg tempera. Application of subsequent egg tempera layers were when difficulties were encountered: These included a lack of achievable saturation to the egg

Figure 1 – Unidentified lady; 16th century, British; oil on oak panel; 65 cm ×58 cm; Emmanuel College, University of Cambridge, UK. Before treatment. Photograph © Chris Titmus Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

Figure 2 – Unidentified lady; after cleaning, filling and first full isolating varnish (Paraloid B72). Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

tempera and disruption of the retouching (redistribution and pick-up of pigment) because of re-activation/re-solubilization of the lower Laropal A81 layer.

Laropal A81 is easily reversible using a wide range of high and medium polar solvents. The porosity and lack of saturation of the egg tempera - especially some pigment mixes containing earths – necessitates the need for saturation from the localized isolating resin, however, to achieve a suitable level of saturation several passes with the brush were required. Frustratingly, this resulted in re-activating the lower Laropal A81 layer and therefore disruption of the egg tempera layers.

2.2 Testing

To remedy the problem encountered with the re-solubilisation of the Laropal A81, a reduction of the amount of brushing required to achieve saturation was the initial aim. Reducing the aromatic content of the solvent diluent mixture from 50:50 to a 60:40 mixture of Shellsol D40 and Shellsol A100 (which in practice is the lowest concentration to achieve solubility of the resin) and increasing the percentage of the resin up to 25%. This offered a limited improvement, but still resulted in disruption to the egg tempera.

Substituting the diluent to one with a lower aromatic content yet still with the ability to solubilise the resin was then investigated. A literature review of Laropal A81 located an article on the subject, written in 2015 by Alan Phenix and Agata Graczyk, discussing the use of aromatic-free hydrocarbons as a diluent for Laropal A81[10].

In the article, the authors discuss the RI of a hydrocarbon as a strong indicator of solvent power and connected with the polarizability of an organic substance; described by Phenix and Graczyk as, “the

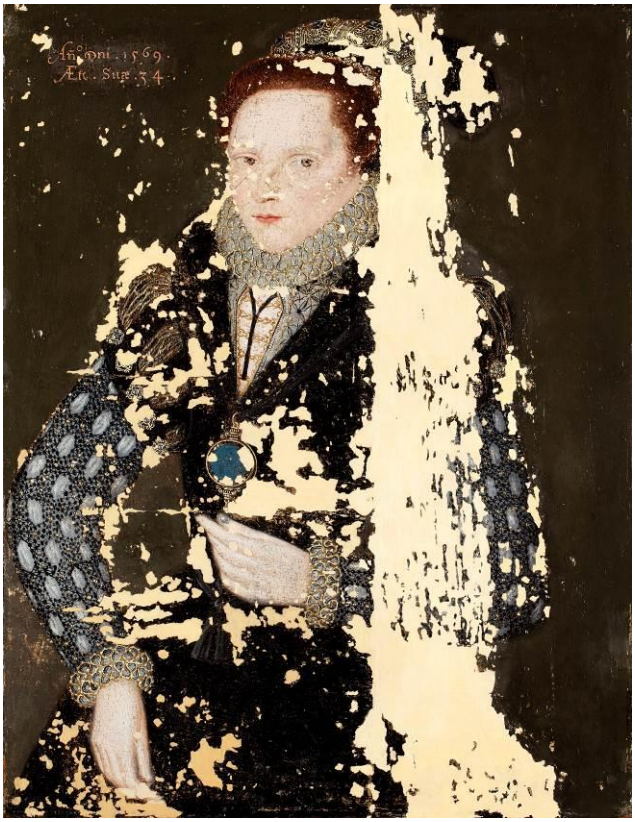

Figure 3 – Unidentified lady; During retouching, egg tempera applied to the filled losses to mimic the painting's ground colour. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

disposition for the electron cloud of the molecules to be distorted from normal shape by an external electric field" [11]. This could also be described as temporary dispersion forces. An aromatic hydrocarbon has a high RI and high polarizability, making them capable of strong dispersion force interactions [12]. Practically, this indicates that an aromatic hydrocarbon is capable of dissolving Laropal A81.

Phenix and Graczyk state cyclooctane's RI of 1.4557 is a higher value compared to a 70:30 mixture of Shellsol D38 and xylene which has a RI of 1.4380, suggesting its ability to solubilize Laropal A81 (requiring an RI of 1.430) [13].

3. CYCLOOCTANE

Cyclooctane is a monocyclic saturated hydrocarbon (Figure 4). A benefit to the use of cycloocane over Shellsol A100 is it poses no serious health risk to the user. Currently, it carries two Hazard Statements on its Safety Data Sheet: H226: Flammable liquids and vapour; and H304: Aspiration hazard, may be fatal if swallowed and enters airways. While perhaps far from ideal, this is significantly better than the current seven Hazard Statements for Xylene and five for Shellsol A100[vi]. Therefore, cyclooctane, when used appropriately, and in low quantities, is potentially suitable for use in the open studio (with adequate ventilation, local extraction, and PPE where required)[vii].

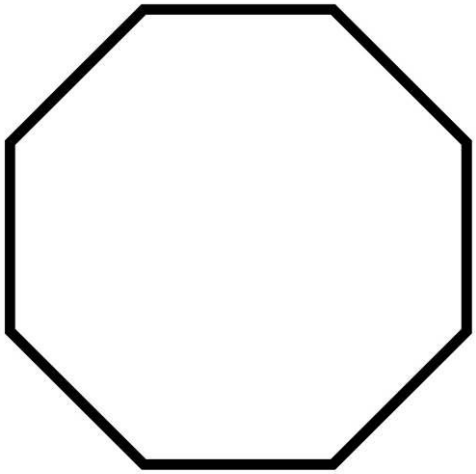

Figure 4 – Chemical structure of cyclooctane, C_8H_{16}

In practice, empirical testing found evaporation rates and drying time to be comparable between a 25% solution of Laropal A81 made with cyclooctane and the same concentration made with a 50:50 mixture of Shellsol A100 and Shellsol D40. The main disadvantage of cyclooctane is its cost. At the time of writing, it costs £45 for 100ml, or £450 for 2.5 litres. Whereas 1 litre of Xylene costs £27, and one litre of Shellsol D40 is £6.50. However, this compares favourably with the price of green solvents, which offer similar benefits[viii]. There is real potential for some solvents to be phased out of use and therefore a gradual switch to these solvents now may prove advantageous for the future.

For increased economy, Phenix and Graczyk discuss options for dilution, stating leeway in the non-polar solubility limitation of Laropal A81 [14]. A suggestion is given to a 50:50 mixture of cyclooctane and petroleum benzene, resulting in a RI of 1.4322, marginally higher than 1.430 (which is the required RI

Figures 5 and 6 – *Unidentified lady*; During the egg tempera retouching. The retouching's layer structure is built up to match that of the original painting. To enable accuracy, reference material was referred to throughout the memetic reconstruction process. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College-

to dissolve Laropal A81). In studio conditions, the author was unable to solubilise Laropal A81 with mixtures using cyclooctane and petroleum spirit[xix].
Cyclooctane was successfully employed as the diluent carrier for Laropal A81 for the isolating resin layers for the egg tempera retouching of *Unidentified Lady (Figures 5-10).* This enabled the isolating resin to be brushed on without reactivating previous resin layers or disrupting the egg tempera retouching. Glazing of the egg tempera and retouching of abraded paint were completed using Gamblin Conservation Colours (using propan-2-ol as the diluent), where necessary for additional gloss, Laropal A81 in cyclooctane was added to the paint mix.

4. CONCLUSION

Cyclooctane worked well as the diluent for Laropal A81 when used as a localised isolating varnish layer for egg tempera retouching. It achieved an acceptable saturation whilst enabling more brushing without reactivating lower Laropal A81 resin layers. This was a far better result than the use of the conventional solvent mixture of Shellsol D40 and Shellsol A100 (50:50) which had resulted in the redistribution of the egg tempera layer. Significant health benefits are also an advantage to the use of cyclooctane, which may outweigh any cost disadvantage.
Cyclooctane is now the preferred diluent at the HKI for localised isolating varnish layers with Laropal A81 when retouching with egg tempera. It has also been successfully employed as the diluent for Laropal A81 when ground with dry pigments for retouching, and tests suggest it could be a feasible option if a secondary brush varnish application is required over an initial Laropal A81 varnish layer. Tests are also promising for the application of a brush varnish in Laropal A81 (in cyclooctane) upon a varnish or retouching completed using Paraloid B72, without disruption to the Paraloid B72. It will also prove useful for activities away from the studio environment, such as varnishing *in situ*, where access to an extraction unit may be limited.

Figure 7 – Unidentified lady; after egg tempera retouching, before glazing with Gamblin Conservation Colours. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

Figure 8 – Undentified lady; After treatment. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

Figures 9 and 10 – Unidentified lady; details of completed egg tempera retouching. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

Figure 11– Unidentified lady; detail of completed egg tempera retouching. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

Figure 12– Unidentified lady; detail of completed egg tempera retouching. Photograph © Christine Braybrook, Hamilton Kerr Institute, University of Cambridge. By courtesy of The Master and Fellows of Emmanuel College, Cambridge

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[i] MS3, a substitute for MS2A is now in production, although the author has not had experience of this product it may offer promise for isolating varnish layers for egg tempera. https://www.boronmolecular.com/case-study/resin-for-old-masters/

[ii] Regalrez 1094, although a low molecular weight resin was not considered suitable for this application owing to its solubility parameters and inability to saturate the egg tempera application.
[iii] The author recommends referring to an up to date Safety Data Sheet provided by the supplier.

[iv] The frequency of the isolating resin layer is dependent on the preference of the individual conservator. The author suggests a resin layer is applied after every 2-3 tempera layers. In reality, this is commonly at the point of a colour change, as dictated by the artist's original technique.

[v] The filler was composed of calcium carbonate, gelatin (10% in deionized water), with a small addition of poly vinyl alcohol adhesive (Resin W) for flexibility.

[vi] Xylene: H226, flammable liquid and vapor; H304, may be fatal if swallowed and enters airways; H312 & H332, harmful in contact with skin or if inhaled; H315, causes skin irritation; H319, causes serious eye irritation; H335, may cause respiratory irritation; H373, may cause damage to organs through prolonged or repeated exposure; H412, harmful to aquatic life with long lasting effects
Shellsol A100: H226, flammable liquid and vapour; H304, may be fatal if swallowed and enters airways; H335, may cause respiratory irritation; H336, may cause drowsiness or dizziness; H411, toxic to aquatic life with long lasting effects.

[vii] Engagement in a substance's Safety Data Sheet and reading (or composing) the risk assessment prior to working with a new substance is essential to eliminate and reduce risks relating to exposure and working practices.

[viii] Two green solvents were looked at for their potential use to dissolve Laropal A81; Limonene and Ethyl lactate. Green solvents benefit from being less harmful to both the health of the conservator and for the environment. Although not tested practically for suitability as a varnish diluent, they have the ability to dissolve the resin. They offer a similar price comparison to cyclooctane, both are currently available from Sigma Aldrich.

[xix] The UK equivalent to petroleum benzene. It is thought the mixture was not able to solubilize the Laropal A81 resin due to disparities in the commercial hydrocarbon mix of petroleum spirit compared to the US petroleum benzene, resulting in a lower RI then what is stated. Tests were completed using a 30:70 mixture (petroleum spirit 100-120 and cyclooctane) which was also found to be unable to dissolve the resin.

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A NEW PIGMENTED WAX-RESIN FORMULATION FOR INFILLING AND REINTEGRATING LOSSES IN PAINTINGS: TESTING ITS WORKABILITY IN TWO CASE STUDIES

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ABSTRACT

A new pigmented wax-resin formulation introduced and tested for its suitability as a material to infill and reintegrate losses in paintings. This formulation contains Cosmoloid H80 microcrystalline wax and Regalrez® 1126 hydrogenated hydrocarbon resin, in a ratio of 1.5:1 (wax:resin, parts by weight), and is mixed with dry pigments and/or inert fillers (such as chalk, kaolin, or aluminium hydroxide).
After extensive research on the properties and the stability of various formulations, the most successful one was applied on two canvas paintings with very diverse characteristics: a 17th century oil painting, and a 21st century acrylic painting.
In this paper, the different application methods used are described step-by-step. These consisted of using the new formulations not only solely as infilling materials (by adding inert fillers to the wax-resin mixture), but also as materials capable of infilling and reintegrating a loss in one single step (by adding pigments to the wax-resin mixture). The possibility of imprinting and carving texture, as well as of sculpting the infills to recreate brushstrokes, was also tested and verified and is described in detail here.

Keywords: Pigmented wax-resin; Cosmoloid H80; Regalrez® 1126; infilling; reintegration; workability

1. INTRODUCTION

1.1 Pigmented wax-resin (PWR) formulations and their advantages as materials to infill and reintegrate losses in paintings

PWR formulations have been used to infill and reintegrate losses in paintings and other objects at least since the 18th century [1]. These formulations consist of mixtures of a wax and a resin, to which dry pigments and/or inert fillers are added.
The possibility of adding pigments directly to the wax-resin (WR) mixture is a significant advantage for it enables infilling and colour reintegration to be done in a single step, which can be especially useful for monochromatic surfaces. An accurate and quick colour match is possible since hues do not change as the mixture transitions from warm (fluid) to cool (solid) states. Where required, PWRs can also accept surface adjustments with glazes using different inpainting media. Additionally, a more traditional method of reintegrating losses is possible, as the WR mixture, with the addition of chalk or pigments, can be used as a neutral or toned base over which further layers of inpainting can be applied using an appropriate resin based retouching medium.
PWRs need to be melted prior or during application. They can, however, be applied in layers, allowing for an easy, controlled introduction into the loss. They will

also remain workable if warmed up, for example with a small heated spatula, facilitating sculpting of brushstrokes or other topographical features.
Another advantage of PWRs lies in their ability to receive texture (e.g., using silicone moulds to imprint craquelure or canvas weave patterns). They are easily removable mechanically or with low-aromatic solvents, such as white spirits, during and after application.
Where required, gloss can be adjusted: to achieve a high gloss, PWR infills can be polished with a soft cloth, while rendering them matte can be done with solvents or burnishing with matte, silicone or wax coated paper.

1.2. Finding a substitute for beeswax in PWR formulations

One of the most common materials present in traditional PWR formulations, produced either by conservators themselves or, more recently, by Gamblin Conservation Colors [2], is beeswax. Beeswax has, however, been reported to develop bloom (a thin whitish layer on the surface that changes its readability) [3] and to corrode copper supports used for oil paintings [4, 5].
Finding an appropriate replacement material for beeswax which could be combined with a stable synthetic resin, became the core of recent studies conducted at the NOVA School of Science and Technology (Lisbon, Portugal) [5, 6]. The most promising formulation that resulted from the two studies contained two synthetic materials: Cosmoloid H80 microcrystalline wax (as the replacement for beeswax) and Regalrez® 1126 hydrogenated hydrocarbon resin.
Extensive research on the workability and stability of a range of formulations containing these ingredients was conducted by the authors of this paper and is briefly summarised in the following section. Detailed information on this research is reported elsewhere [7, 8].

1.3. Summarised research on the stability and workability of the new PWR formulation

The main goal of the research was to find a new PWR formulation (referred to as NOVA-PWR) with working properties similar to that of Gamblin's Pigmented Wax/Resin Sticks, but that would not contain beeswax. The new formulation should be stable to different environmental conditions and be compatible with a range of varnishes and inpainting media. The research work was, therefore, divided into three main parts:
The first part focused on understanding how the materials (Cosmoloid H80, Regalrez® 1126, fillers and/or pigments), and their presence in different proportions, influenced not only the physical and optical properties of the formulations, but also their behaviour in terms of preparation and application. The most promising wax:resin and wax:resin:filler/pigment ratios were identified and studied further.
The second part entailed an evaluation of the stability of the selected NOVA-PWR formulations to fluctuating temperature (T) and fluctuating relative humidity (RH) – thought to be responsible for the development of bloom [3] – in an environmental chamber. The PWR formulations were also exposed to high temperatures in the environmental chamber (50 and 60ºC) and to radiant heat (up to 70ºC), to monitor any changes due to softening of the material. Results were assessed with macro photography, digital microscopy, hardness measurements and Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy (ATR-FTIR), and compared to those obtained for Gamblin's Pigmented Wax/Resin when subjected to the same environmental conditions.
Since PWR infills may require varnishing, adjustment with glazes or inpainting, the third part of the research consisted of testing a range of popular varnishes and inpainting materials for their compatibility with the NOVA-PWR infills.
This study showed that the best wax:resin ratio with Cosmoloid H80 and Regalrez® 1126 is 1.5 parts by weight of wax to 1 part by weight of resin. This ratio performed well across a wide range of RH and T.
Also demonstrated was that the amount of filler and pigment added can be significantly adjusted to meet the desired visual properties (e.g., in terms of opacity) and physical properties (such as hardness and flexibility) of the infill. The amount of inert filler and/or pigment could be successfully varied from 1.25 grams to 10 grams when added to 10 grams of the WR binder.
In terms of stability to high T, NOVA-PWR in the wax:resin ratio of 1.5:1 (parts by weight) was able to withstand T up to 70ºC without losing carved texture or three-dimensional surface features (e.g., recreations of brushstrokes). However, samples with 2 parts of wax or higher (to 1 part of resin, by weight) were not stable to the high T (60 - 70ºC) tested and developed blisters.
Results showed that the NOVA-PWR formulations do not develop bloom when subjected to fluctuations in RH and/or T. However, due to the presence of beeswax in

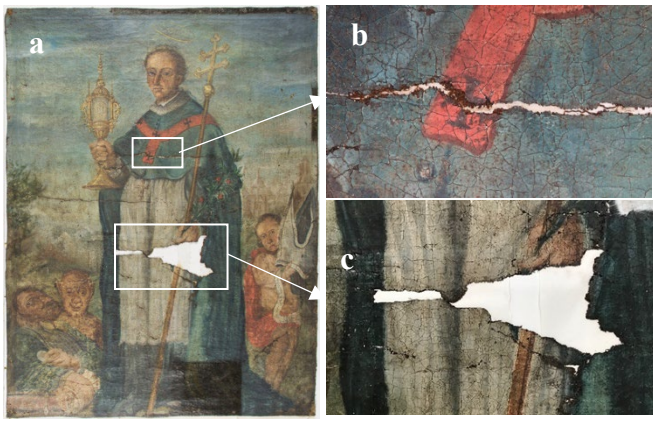

Figure 1 – a) Saint Norbert of Xanten before the application of the PWR infills; b) detail of one of the horizontal tears; c) detail of the large losses

their composition, the Gamblin Pigmented Wax/Resin formulations did develop bloom when subjected to the same environmental conditions.
Cracking was observed both in the NOVA-PWR and Gamblin formulations when applied to already severely cracked paintings with model paint made with a natural resin binder. The infills were applied to these paintings then subjected to fluctuations in RH and T[i].
On a molecular level, no visible differences in the ATR-FTIR spectra of the NOVA-PWR samples were detected before and after the environmental trials.
NOVA-PWR were found to be compatible with Paraloid B-72 isolation varnishes applied with 1-methoxy-2-propanol[ii], and with widely available inpainting media, such as Gamblin Conservation Colors (in Laropal® A81).

2. TESTING THE WORKABILITY OF THE NEW PWR FORMULATION ON TWO CASE STUDIES

To complement the research, it was considered crucial to test the workability and suitability of the NOVA-PWR in actual case studies.
Two deaccessioned canvas paintings from the Stichting Restauratie Atelier Limburg (SRAL), based in Maastricht, The Netherlands, were selected for this purpose. Although very different both in their materials and their age, as well as the subject depicted and the pathologies present, both paintings had a common problem that made them ideal candidates for testing PWR infills: each presented paint and ground losses that needed to be infilled, textured, and retouched. The fact that they differed radically – one being a four-century-old oil painting on a linen canvas and the other, executed only twenty years ago using acrylic paint on a commercially prepared cotton canvas – proved very useful for testing the versatility of the NOVA-PWR infill formulations.
In addition, the type and size of the losses present made it possible to test different application techniques and to prove the suitability of the formulation when used solely as an infill that works as a base for retouching, and as a material that achieves the infill and reintegration of a loss in one single step.

2.1. Case study 1: *Saint Norbert of Xanten*, ca. 17th century

The first case study consisted of an oil painting on linen canvas (99 x 78.5 cm), likely dating from the 17th century or slightly later (fig. 1a).
The painting presented severe structural and aesthetic problems associated with physical damage, water damage and exposure to high humidity. The most significant damage was a large triangular-shaped loss (17 cm long, up to 10 cm wide) in the centre of the canvas and a rectangular-shaped loss adjacent to it (7.3 cm long, 1.4 cm wide) (fig. 1c). Two horizontal tears (31 cm and 21.5 cm long) were also present (fig. 1b), as well as several smaller tears mostly associated with the

Figure 2 – a) *Untitled*, before the application of the PWR infills; detail of the gap before (b) and after (c) filling with an Arbocel® BC 200 mixture

triangular-shaped loss. The painting was mist-lined[iii] subsequent to applying PWR fills.

2.2. Case study 2: *Untitled*, signed JOZ, 2002

The second case study was an abstract acrylic painting on a commercially prepared cotton canvas, signed "JOZ '02", previously used in lining trials at SRAL.

At one point the painting had been cut off its stretcher around the edges close to the tacking margin, then after some time had been reunited with the tacking margins by lining. The cut line presented a gap (~ 0.3 cm wide) that required filling and retouching (fig. 2a-c). The painting was mist-lined prior to reintegration.

Due to the depth of the gap a mixture of Arbocel® BC 200, with Portafill® A40 (aluminium hydroxide), Klucel® G 4% in water (4 grams in 100 ml) and Evacon R was used and applied to the height of the canvas.

3. MATERIALS AND METHODS

3.1 Materials used for the NOVA-PWR applied in the case studies

- Wax: Cosmoloid H80
- Resin: Regalrez® 1126
- Fillers: Champagne chalk ($CaCO_3$), Kaolin, Portafill® A40 (aluminium hydroxide)
- Dry pigments: Burnt Umber, Terra di Sienna, Yellow Ochre, Brown Ochre, Titanium white and Cobalt blue

3.1.1. Cosmoloid H80

Cosmoloid is a brand name for a series of microcrystalline wax formulations, supplied by companies such as Kremer Pigmente GmbH & Co. KG, Talas, C.T.S and Zeus, and manufactured by Astor (now The International Group, Inc.). Cosmoloid waxes have been used in conservation for several purposes, for example as substitutes to beeswax.

Cosmoloid H80 has been recommended by Velson Horie as being an inert material with a suitable degree of hardness [11]. It has also been considered highly stable against chemical degradation [12].

Table 1 – Properties of Cosmoloid H80

	Melting point	Acid value	Density at 20ºC
Cosmoloid H80	83-94ºC [13]	0 [14]	0.85-1.05 g/cm^3 [14]

3.1.2. Regalrez® 1126

Regalrez® 1126 is a synthetic low molecular weight hydrogenated hydrocarbon resin that, along with Regalrez® 1094, has been widely used in conservation. Even though Regalrez® 1094 is more commonly used, especially as a picture varnish [15], Regalrez® 1126 was chosen for its higher molecular weight, higher glass transition temperature (T_g) and higher softening point (Table 2). For infilling, its higher softening point would provide more stability to T, such that impasto or a texture reproduction would be more likely to maintain their shape and sharpness when exposed to higher T. The higher T_g of Regalrez® 1126 also means that the resin is less "tacky" at room T, being less likely to attract dirt. Even if a higher T_g could lead to a more brittle material, the combination with wax (in PWR formulations) was expected overcome this problem.

Regalrez® resins have been reported to be photochemical stable [15], UV stable [16] and resistant to accelerated environmental conditions [17]. They have high compatibility with waxes, making them easily mixed with beeswax or microcrystalline waxes [18].

Table 2 – Properties of Regalrez® 1126

	Molecular weight	T_g	Softening point	Density at 21ºC
Regalrez® 1126	1250 g/mol [19]	67ºC [19]	124ºC [19]	0.97 g/cm^3 [19]

3.2. Preparation of the NOVA-PWR

The steps for preparing the NOVA-PWR "wafers" used in the case studies were as follows:

1) Weighing 6 grams of Cosmoloid H80 and placing it in a glass beaker.

2) Melting the wax by placing the glass beaker on a hot plate. The T required to melt the wax was approximately 70-75ºC.

3) Weighing 4 grams of Regalrez® 1126 and grinding it in a mortar with a pestle to achieve a very fine powder. This proved to be a crucial step that greatly helped in mixing the resin with the wax, accelerating both the melting and the mixing process.

4) Pouring the powdered resin, little by little, into the glass beaker after the wax was completely molten. To facilitate the melting of the resin, which has a higher melting point than that of the wax, the T was increased to 85-90ºC. To facilitate the mixing of both

components, a magnetic stirrer was used in the beaker at this stage.

5) After 20-25 minutes, the wax and resin were completely dissolved together. At this point:

a) For case study 1: the fillers were added while heating and stirring. The amount of filler added depended on the opacity and hardness desired for the infill, and on the filler itself.
   i) To make either chalk or kaolin infills, 10 grams of either filler were weighed and filtered through a fine mesh strainer before being slowly poured into the WR mixture. This was done to ensure that no large solid aggregates would be added to the mixture;
   ii) To make infills with aluminium hydroxide, 15 grams of Portafill® A40 were weighed and gradually poured in the WR mixture. It was not necessary to use the strainer for the Portafill® A40, since this material did not form aggregates.

   After the fillers were completely dispersed in the WR binder, the mixture was poured onto a silicone baking tray (see suppliers) in portions, forming small thin disks (wafers), to be later remelted if needed.

b) For case study 2: the WR mixture was poured directly onto the silicone baking tray to be later remelted and mixed with pigments prior to use.

3.3. Different application methods employed in the case studies

3.3.1. Application on a canvas insert (Case study 1)

Due to the large loss in the support for case study 1, a fabric insert was required to restore the physical stability of the painting. PWR infills were to be applied on the canvas insert. A previously sized (with sturgeon glue) linen canvas with a density close to that of the original canvas was selected. Cosmoloid H80 and Regalrez® 1126 combined in different ratios were mixed with different ratios of three fillers: chalk, kaolin and aluminium hydroxide (Portafill® A40) (see suppliers). The mixtures were tested for flexibility and pliability during the research [7]. Those with the best results contained chalk in a ratio of 50% of WR binder to 50% of filler (by weight). The ratio of wax:resin chosen for the insert was 1.75:1 (parts by weight). A higher amount of wax was chosen because of the large dimension of the insert and the concern that over such an expanse over a flexible support the relatively thin layer of PWR could crack. The same procedure was followed for the smaller loss adjacent to the large loss.

A heat press was used to achieve a uniform layer of the wax-resin-chalk mixture on the canvas inserts for both losses (fig. 3a, see suppliers). The thickness of the original painting (canvas + ground and paint layers) was measured using a calliper. The insert canvas had a similar thickness to the original. To match in overall thickness, the filling material needed to be, therefore, slightly thinner than the original ground and paint layers, to anticipate the added thickness from subsequent inpainting. To attain the desired thickness of the infill, thin metal plates were stacked on top of each other next to the inserts to allow for the thickness of the wax-resin-chalk mixture.

Thin disks of the infill material were laid out on the sized canvas with a sheet of baking paper on top. The heat press was set to a T of, approximately, 80ºC, and pressure was applied by turning the wheel on top until the press reached the height of the metal plates. The result for both inserts was a uniform layer of infilling material, with a thickness of 0.8 mm.

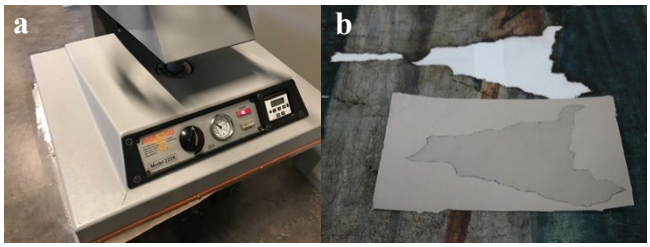

Figure 3 – a) Heat press; b) Piece of canvas for the insert after the application of the PWR in the heat press (below the loss with a Melinex® cut-out on top)

3.3.2. Imprinting texture with a silicone mould (Case study 1)

The next step was to apply texture to the surfaces of the infill material on the canvas inserts. Texturing the fills is a crucial part in loss reintegration for it will – if properly and accurately done – allow the reintegration to blend in with the original, becoming almost invisible to the eye of the viewer.

For this important step, and as recommended by authors such as Folkes and Reddington [20], the decision was to use a silicone mould to create a very accurate replication of the existing texture from a chosen area of the painting. As recommended by the authors, the

painting had already been cleaned but the intermediate coat of varnish prior to retouching had not yet been applied. The area of the paint surface selected for the texture was not adjacent to the losses but below them and included the same colours – therefore, the same cracking pattern – as would have been in the area that was lost. Before making the silicone mould, a thin coat of Regalrez® 1094 10% varnish (80 grams of resin in 200 ml of white spirit, 400 ml of iso-octane and 200 ml of Shellsol® D40) was brushed over the selected area of the painting to protect it from "direct contact with the silicone" [20]. The silicone mould – Silicone C 20 by Silicones and More – was prepared according to the instructions given by the manufacturer. The silicone solution was then brushed over the painting, creating a layer of approximately 0.2 cm. A sheet of 100µ thick Melinex® was placed on top for it "facilitates the mould's removal from the painting and provides a resistant-free surface during the process of ironing" [20]. The silicone mould was left to cure for approximately 24 hours, after which it was removed from the painting with the help of a spatula and a small cylinder. The cylinder was used to roll the mould and the Melinex® sheet, which proved to be very helpful when detaching them from the painting (fig. 4a). The layer of Regalrez® 1094 varnish applied to the paint surface was then removed with isooctane.

To imprint the paint texture onto the inserts, the silicone mould was place over top of them. Care was taken to avoid imperfections in the mould when positioning it over the inserts.

A heat spatula (see suppliers) set to a T of approximately 90ºC, was then used to iron over the surface of the mould (fig. 4b). The top surface of the filling became somewhat molten, accepting the texture from the mould. Folkes and Reddington [20] warn not to use Ts that are too high since that would "leave a slightly wavy and uneven surface as the wax begins to flow." The texture was transferred to the inserts before they were cut to their final shape, because this meant that it would be possible choose which part of the imprinted texture to include. To cut the inserts to correspond to the shape of the losses, outlines of the losses were first drawn on Melinex® sheets using a permanent marker, then the Melinex® sheet was cut out and placed over the filling material. Using a scalpel, the filling material was cut out along the outline. To aid the cutting process, a soft, malleable surface was placed under the insert, in this case, a thin lead plate (fig. 5).

Figure 4 – a) Using a roll to detach the silicone mould; b) heat spatula ironing the surface of the mould

Figure 5 – Insert after having been cut with a scalpel on top of a thin lead plate

The attachment of the edges of the inserts within the losses in the painting was done from the reverse with BEVA® 371 film. To ensure that the inserts would remain in place until the painting was lined, an interleaf of Parafil RT 20, a non-woven polyester fabric, covered with Plextol® D360 was attached to the reverse of the inserts. Although the application of the interleaf involved heat, the wax-resin-chalk infill layer did not show any changes in texture.

Once the inserts were successfully secured, the painting was turned face-up to allow for smoothening and flattening of the edges of the inserts. This step was done using a metal dental spatula (see suppliers) which was regularly heated on a small hot plate (in this case, a coffee-mug warmer was used - see suppliers) to soften the filling material locally (fig. 6). Small amounts of the wax-resin-chalk filler were melted directly into any gaps between the insert and the painting using a wax carving pencil (see suppliers). Raking light from different angles and directions was used during the entire process to ensure a seamless join between the inserts and the painting.

Figure 6 – Smoothing the edges of the insert and filling small gaps between the canvas and the insert

3.3.3. Infilling losses (Case study 1)

In addition to the large losses, other smaller losses, mainly associated with horizontal tears, required filling. For these fills, three NOVA-PWR mixtures containing chalk, kaolin, and aluminium hydroxide (Portafill® A40) were evaluated for their workability, ability to receive texture and visual appearance.

The application process was similar for all mixtures:

1. The wax-resin-filler mixtures were prepared according to the procedure described in Section 3.2 resulting in solid wafers;
2. Wax-resin-filler wafers were softened or melted with heat and applied to the tear area. This was done in two different ways:
   a. A small amount of solid wax-resin-filler wafer was placed on a sheet of aluminium on top of the small hot plate set to a T of approximately 70ºC. When it was only slightly molten and therefore paste-like, the dental spatula (which had been warmed on the same hot plate) was used to transfer the mixture to the tear area. Since the working time of the mixture was short, this was done quickly and repeatedly;
   b. A thin film of the solid wax-resin-filler mixture was placed directly into the loss and melted, little by little, with the tip of the wax-carving pencil (fig. 7).
3. After it had solidified in the loss, the wax-resin-filler mixture was smoothed and levelled. Smoothing was carried out in different ways:
   a. By using a metal spatula warmed on the hot plate to lightly pass over the surface; or
   b. By the application of a small amount of white spirit. The solvent could be delivered using a small cotton swab which was gently rubbed over the surface; or by using a smoothed wine cork (cut at an angle and sanded). The smoothed cork surface was dipped in white spirit and "rotated in a circular motion to remove surplus filler" [20].
4. Generally very little residue was left on the original paint using these methods, however where it did occur the paint surface was cleaned with a fresh cotton swab dipped in white spirit. All residue was

Figure 7 – PWR fill being melted directly on the loss with a wax-carving pencil (see suppliers)

Figure 8 – Replication of the surrounding texture on the PWR fill done by carving with a scalpel

easily removed without damaging the paint underneath and the infill in the tear was smoothed at the same time.

5. After smoothing and levelling the infill, the paint surface surrounding the loss was replicated using the silicone mould or simply by carving into the infill with a scalpel. For small infills, a scalpel was used to carve a continuation of crack lines, connecting the existing ones from the area above and below the tear (fig. 8). The use of raking light from different angles was very important while replicating texture, as it greatly enhanced the existing texture on the painting and the progress in achieving a match in the infill.

3.3.4. Infilling and colour integration (Case study 2)

One of the greatest advantages of PWR infills is that colour matching can be made directly by introducing the appropriate pigments to the WR mixture. Case study 2 was a good candidate for this method. The colour of the infill can be easily adjusted during pigment introduction. Figure 9 illustrates this method. To ensure an accurate match, colour options were applied on a commercially prepared canvas and placed near the gap for a visual evaluation (fig. 9a). Alternatively, solid samples of PWR mixture could have been placed directly on the surface of the original paint to evaluate what colour adjustments are needed.

Another option for colour matching, is to have PWR wafers ready-made in a range of, more or less, pure pigments. Individual wafers can be melted on the hot plate in greater or lesser amounts (as one does when mixing paints) to effect a colour match with the original paint. Both methods can be used, with powdered pigments introduced into the molten WR mixture, followed by melting pure colour from a pre-made wafer(s) beside it on the aluminium then mixing both together to adjust the colour.

For case study 2, the reintegration of the losses was done in several steps:

1. A wafer of the WR mixture was melted on a piece of thick aluminium (see suppliers) with the hot plate set to a T of approximately 75ºC (fig. 9b). The T could be increased as necessary and was used in a range between 75 and 85ºC.

2. Powdered pigments were introduced while the WR mixture was in a molten state on the hot plate (fig. 9c). In some cases, more than one pigment was added to achieve a match with the original paint surrounding the loss.

Figure 9 – a) Colour matching evaluation of fills with different pigments; b) WR mixture being melted on a small hot plate (coffee mug warmer); c) pigments added to the WR mixture while on the hot plate

3. The resulting PWR mixture was introduced into the loss using the dental spatula heated on the hot plate. To build thick impasto, the PWR was applied in layers, allowing the mixture below to solidify (it hardened quickly in approximately 7 seconds). It proved very easy to build the desired infill thickness (fig. 10). The dental spatula could also be heated using a hot air gun, and the wax carving pencil proved useful as well. In the case of the wax carving pencil, a T set to 75-78ºC was suitable for melting the PWR fill. When set to between 55 and 60ºC the PWR only softens which allows it to be shaped and sculpted in situ.

Figure 10 – Recreation of an area of impasto

4. For case study 2, the surface of the PWR needed to be somewhat matte. After application and texturing (which left a glossy surface), a piece of matte baking paper was placed over the infill, and light pressure applied with the dental spatula to achieve a matte surface. It was not necessary to apply a final coating layer to the PWR, as experimental results confirmed that the WR materials employed would not bloom in the future, and the surface T_g was unlikely to attract any more dust than the paint surface.

4. RESULTS AND DISCUSSION

4.1. Case study 1

In terms of the application of the NOVA-PWR over the significant surface area presented by the canvas insert (approximately 17 cm long and up to 10 cm wide) the results were very satisfactory. The biggest challenge consisted of finding a way to apply a homogeneous layer of infill with a specific thickness, given that the material is only workable when warm. This was successfully accomplished by using a commercial heat press which provided uniform heat and pressure.

Figure 11 – Insert in raking light after Mist-Lining

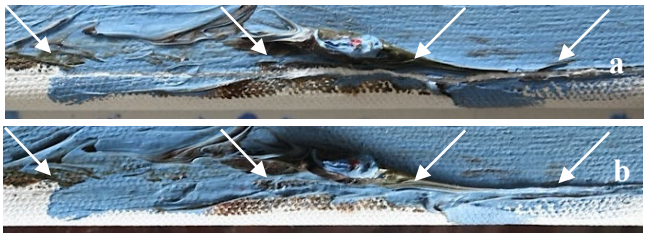

Figure 12 – Gap area before (a) and after (b) being filled with NOVA-PWR

The NOVA-PWR formulation with chalk could be easily imprinted with texture transferred from a silicone mould. Furthermore, no changes in the infill texture were observed after the painting was mist-lined (fig. 11).

Local applications of the NOVA-PWR in the horizontal tears were straightforward, with different application methods possible. In terms of the fillers tested, chalk, kaolin, and aluminium hydroxide (Portafill® A40), all gave easily workable formulations. The main difference was the colour of the final infill: chalk gave a light beige tone, kaolin a darker-yellowish tone, and aluminium hydroxide was the whitest.

The next step of the treatment would have been to inpaint on top of the PWR infills to achieve colour integration. Results for the compatibility of NOVA-PWR with varnishes and inpainting media showed that the following combinations could be successfully used [7]: Paraloid B-72 10 or 5% in 1-methoxy-2-propanol (as an isolation layer) followed by inpainting with Gamblin Conservation Colors (in Laropal® A81), with a top layer of Paraloid B-72 varnish[iv].

4.2. Case study 2

The second case study was especially useful for validating the advantage of the NOVA-PWR for infilling and reintegrating a loss in one single step, by adding pigments (or mixtures of pigments) to the WR binder. Because the colour of PWR infills does not change when passing from a fluid to a solid state, an accurate match to the uniform paint colour surrounding the losses could be made easily.

Colour matching was also facilitated since the solidified PWR could be placed directly on the paint surface for comparison.

5. CONCLUSIONS

NOVA-PWR infills composed of Cosmoloid H80 microcrystalline wax and Regalrez® 1126 (hydrogenated hydrocarbon resin) in a ratio of 1.5 to 1 parts by weight of wax to resin, in combination with fillers and/or pigments proved to be good alternatives to PWR infill formulations containing beeswax.

Extensive testing demonstrated that the NOVA-PWR formulation is stable in fluctuating RH and T, as well as to radiant heat. Case study 1 showed that the formulation is stable during Mist-lining.

NOVA-PWRs also proved to be highly versatile as they could be applied onto large canvas inserts, prior and post lining, as well as directly into small losses.

Although effective and suitable, PWRs can be challenging to apply on large losses, as the material hardens rather quickly (~7 seconds). This means that, in order achieve a large homogeneous layer of PWR, it may be necessary to resort to additional equipment, such as the hot press described above, that will maintain the PWR warm and soft and will create a homogeneous layer of the material, for example on top of an insert canvas.

Colour matching was easily achieved by mixing different pigments to the WR mixture, particularly because the hue remains unchangeable throughout the entire process. Although most advantageous in situations where a quick colour match is done, PWRs also proved useful materials for infilling losses that will receive inpainting on top. This is especially true due to the ability of the material to easily receive texture, both by carving with a scalpel or imprinting with a silicone mould, and be sculpted.

The possibility of manipulating the final gloss of the PWRs was also verified. This is an indication that, in some applications, colour matched NOVA-PWRs may not require further treatment with varnishes. Even if compatible with popular varnish and inpainting materials, since NOVA-PWRs are not prone to bloom or attract dust, it is not considered necessary to apply a protective coating over them.

Pre-prepared NOVA-PWRs, in the form of thin wafers or sticks, can be stored indefinitely and reactivated for use at any time. A selection of ready-made colours (which can be mixed together when molten) can be on hand for achieving colour mixtures for immediate infilling and colour matching.

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[i] This requires further research with more realistic samples of aged and cracked oil paintings on canvas. Note that traditional chalk/glue infills were not tested in the same conditions for comparison.

[ii] 1-methoxy-2-propanol was tested solely as a component of an isolation varnish applied on top of the PWR fills. It should not be used as dilutant in varnishes applied on oil paintings [9].

[iii] Mist-Lining is a cold, low-pressure lining technique developed at SRAL [10].

[iv] Because of its medium-high swelling effect on oil paint it is recommended that if a Paraloid B-72 varnish is to be applied over the entire surface of the original painting, the 1-methoxy-2-propanol solvent should be replaced with Shellsol A100 or other equivalent slow evaporating fully aromatic hydrocarbon solvents. The practitioner should wear appropriate PPE when applying such varnishes. Testing on the painted surface is always required prior to any varnish application.

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MATERIALS AND SUPPLIERS

Equipment:

- Gas Stove Burner Covers, Disposable Aluminum Square Foil [https://www.amazon.com/Aluminum-Square-Stove-Burner-Covers/dp/B07GFQLS3J]

- Coffee mug warmer, model CO294-CW, Cosori [www.cosori.com]

- Digital precision balance standard, Ohaus

- Hot plate with magnetic stirrer, model 34532, Snijders [www.geminibv.com/labware/snijders-hotplate-34532-stirrer/]

- Hydraulic Dry Mounting and Laminating Heat Press on Stand, Model 2226, Ademco

- Dental Modeling spatula, Model: Ceramic, Restaurar&Conservar [www.restaurarconservar.com]

- Silicone baking tray, MOUL'FLEX [www.debuyer.com/en/493-moulfex]

- Tacking Spatula Iron Thermocontrolled, Restaurar & Conservar [www.restaurarconservar.com]

- Whipmix Wax CarvingPencil: Wax carving pencil, commercialised by Gamblin Conservation Colors

Product	**Supplier**
Arbocel® BC 200	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Champagne chalk	
Cosmoloid H80	The International Group, Inc. https://igiwax.com/
Evacon R	Conservation By Design, Ltd. https://www.cxdinternational.com/
Kaolin (#58250)	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Melinex® 100µ	PEL Preservation Equipment www.preservationequipment.com/
Parafil RT 20	Deffner & Johann GmbH https://deffner-johann.de/en/
Burnt Umber, Terra di Sienna, Yellow Ochre	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Titanium white, Cobalt blue, Brown ochre	H. Schmincke & Co. GmbH & Co. KG www.schmincke.de/en.html
Plextol® D360	C.T.S. www.ctseurope.com/gb/
Portafill® A40	Laboratory Jan de Poorter www.ankerpoort.com
Regalrez® 1094 and 1126	Kremer Pigmente GmbH & Co. KG www.kremer-pigmente.de
Shellsol® D40	
Saga Baking Paper	Sligro - www.sligro.nl
Silicone C 20	Silicones and More www.siliconesandmore.com

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THE *HATCHING METER* AS A TOOL FOR COLLABORATIVE WORK IN THE CHROMATIC REINTEGRATION PROCESSES

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ABSTRACT

In order to achieve a reintegration that manifests a consonance and general homogeneity in all the losses present in a pictorial surface, it is important that the adjustment of the *vertical streaked lines* is made in an invariable way to achieve the procedural analogy. This is relatively simple when the work is carried out by a single operator, with a particular and uniform *modus operandi* that is defined by the quality of its stroke. However, the procedure is more complex when the interventions require the collaborative work of several restorers, especially in large-format artworks or where the size of the losses determines this circumstance.

For that purpose, it is proposed a work tool that we have named "hatching meter", which is useful to determine the calligraphy and measurement of the lines to be used in the discernible processes of chromatic reintegration by each one of the restorers involved in the intervention. This referential measurement tool is composed of a total of sixteen cells, ordered from left to right and from top to bottom, from lowest to highest tonal value or luminosity. This gradation is achieved with the modulation of what we have called LCTD variables, referring to the various parameters with which the line is constructed and which depend on its length, contour, translucency and dispersion.

Keywords
Chromatic reintegration; *Vertical streaks lines*; *Hatching meter*; Collaborative work; LCTD variables.

1. INTRODUCTION

The chromatic reintegration processes that are established under the criteria of discernment or recognition of the new integrative addition require analogy patterns that guarantee the uniformity of the patterns established in the chromatic losses. The disposition of an optical texture based on differentiating lines, together with the pointillism technique, are the most used methods in this type of action, which are aimed at recovering the legibility of the image. These techniques offer a certain scale of graphic contrast between the original painting and the addition that appears as a consequence of the restorative act.

The layout of a discernible pattern through a graphic-optical texture that offers homogeneity in the stroke is essential to achieve, under conditions based on regularity, homogeneity and equality in its execution, a balanced graphic arrangement. However, what may be relatively simple for the sensitivity of a single operator, always with a constant mode or character in the line, may involve greater complexity when the process of chromatic reintegration is carried out by a diverse group of restorers on a large-scale work (figure 1).

In these cases, it is necessary to establish guidelines for group action in accordance with a normalized graphic standard that helps to specify a reintegration process under an adjustment in the variables of proportion, size and eurhythmy.

Cooperation becomes necessary in order to agree on the characteristics that the reintegration stroke should have, according to a graphic reference tool. This element, which we present as a standardised instrument, will serve to attend to the process of chromatic reintegration, considering the variables of length, contour, translucency and dispersion of the graphic line.

At the same time, the decision-making that results from group work will enhance interpersonal development and socialisation at work [1]. In this way, an environment will be created in which restorers will assimilate values, competences and social and organisational norms that are very necessary in the business context.

2. THE *HATCHING METER* AS A REGULATORY TOOL

2.1 The use of norms and styles in group work

Teamwork in a pleasant and productive working environment encourages collaborative action planning, where individualism and competitive action are replaced by group participation. Therefore, the working team should aspire to reach convergent solutions that provide common ground or common positions on the problem of the treatment of the pictorial losses.

The working team goes beyond the sum of its parts; it is defined as a structure that functions as a single, integral organism, where its members work toward a common goal through interaction.

According to the definition of group sociology by the German sociologist Bernhard Schäfers [2], this collective purpose and motivation is achieved to the extent that constant communicative interaction takes place. In this process, other psychosocial realities are also developed, such as a deep sense of belonging to the group which, in the end, favours the manifestation of solidarity actions for the benefit of all, and which are sustained, especially, by a system of norms.
It is important to recognise the significance of positive interdependence in working groups and to implement consensus through constructive discussions of controversy. Acting as a group means, basically, establishing rules that, in addition to reinforcing this awareness of group identity and generating affective bonds [3], mark out the lines of action and trajectory that the team must follow as a modular unit.

Figure 1 – Group process of chromatic reintegration. Paintings by Gaspar de la Huerta in the Golden Gallery of the Ducal Palace of Gandia (Valencia).

2.2 The hatching meter as a referential and collaborative tool

Taking into consideration the psychosocial benefits of group work and justifying the need for a normative tool to unify criteria in the processes of chromatic reintegration, we propose at this point the design of a graphic reference standard which we have called the "*hatching meter*". In this way, individual practice is subordinated to the instructions derived from a standardised working model for behavioural homogenisation and group cohesion. This instrument will serve as a standardised canon of measurement to carry out group retouching work, where the

calligraphy and calibre of the vertical streaked lines must have a generic correspondence.

We believe that, in order for the meter to become a device intimately linked to the working group, it should not appear spontaneously, nor should it be imposed externally as a reference model. On the contrary, it would be more powerful if it were designed and created by the team members themselves, who would initially use it as a test bench to try out strokes, while at the same time this action would reinforce group cohesion.

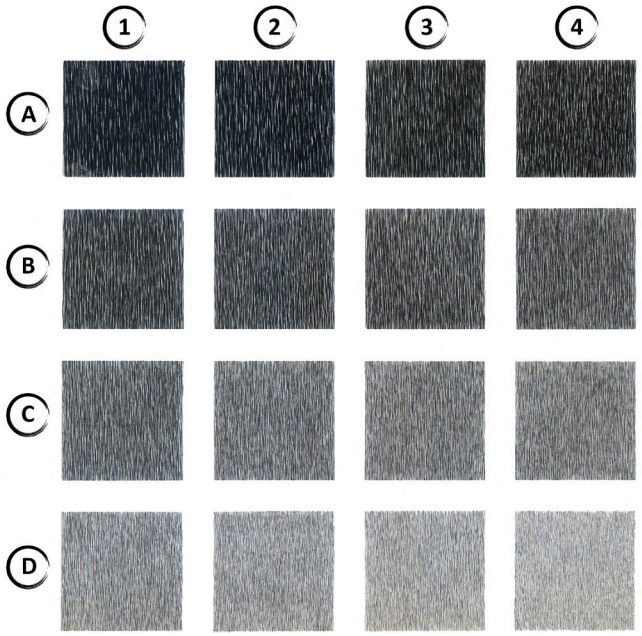

Figure 2 – The *Hatching meter*, consisting of sixteen cells arranged in order from the lowest to the highest brightness.

With the adoption of some basic initial rules, the group will create a graphic pattern that will serve to delimit the characteristics of the final graphic design to be adopted by the work team for the treatment of colour losses. It should be noted that, in this whole process, any kind of individualism and competitiveness is ruled out, so that each professional perceives that he or she can achieve his or her goals as long as his or her colleagues in the group do so as well [4][5]. However, this does not mean that the design and creation of the meter cannot be done through the distribution of roles, each of them related to the different peculiarities that will define the vertical hatching lines (length, contour, translucency and dispersion), or through the assignment of a team coordinator.

2.3 The LCTD variables in the design of the *hatching meter*

A series of simple instructions are established for the development of the *hatching meter*: the device, in the form of a graphic table (figure 2), will be a free representation of colour that exclusively follows a grey scale gradation; with a reading from left to right and from top to bottom, the different fields or cells will be ordered from the lowest to the highest tonal value or luminosity [6].

This gradation in tone will be achieved by modulating the main factors that make up a graphic pattern of lines for chromatic reintegration using the vertically streaked or hatched lines technique. In this way, the following graphical parameters will be considered, which we have called "LCTD variables" [7]:

- Length: indicates the longitudinal dimension of the line, preferably between 5 and 15 mm. Outside this dimensional range, too short or excessively long lines are generated, which are not very effective in creating a homogeneous texture.

- Contour: stipulates the thickness or width of the profile which, in any case, shall correspond to a fusiform and clearly defined line in relation to the established length.

- Translucency: this is the level of transparency or opacity of the graphics and is determined to a large extent by the amount of solvent contained in the painting technique used for the chromatic reintegration, usually watercolour, gouache or pigments agglutinated with varnish.

- Dispersion: refers to the density, concentration and spacing of graphic elements in the spatial support. The separation between the strokes will make it necessary to obtain more open or closed patterns and, consequently, with greater or lesser luminosity.

Within the working group, each individual or sub-group can be in charge of defining the characteristics that each of the cells of the *hatching meter* should have according to these LCTD variables, so that each

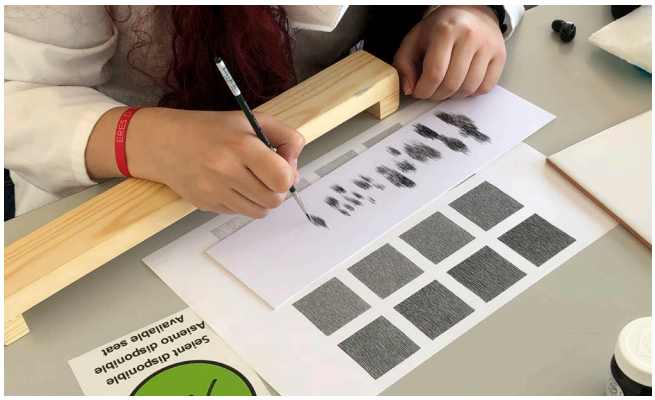

Figure 3 – Tests to determine the characteristics that each LCTD variable must have in each of the cells that make up the *hatching meter*.

member of the team will end up taking on a specific role. In other words, each member will take an LCTD variable and decide on the characteristics that this parameter should have in each of the cells that make up the meter, always bearing in mind that a downward progression of brightness is pursued (figure 3).

Ultimately, the procedural rules will end up being established internally by the members of the group themselves, although preferably, the final pattern of each of the cells should be agreed with the whole working team with the intention of detecting possible graphic inconsistencies. Similarly, this pooling will also adjust any anomalies in tonal values that may occur, since, according to the laws of visual perception, the gradation in the grey scale is conditioned by the visual acuity and sensitivity of each individual [8].

Participation, especially active participation, when generating a common mechanism, is also an integrating, cooperative and interdisciplinary act.
Once the meter has been generated, as an indicative graphic system for the group and cooperative processes of chromatic reintegration, it will be sufficient to jointly determine the cell that will serve as a reference, simply by using the Cartesian coordinate system that accompanies the tool.

3. OTHER GROUP MODALITIES TO REINFORCE FORMAL CO-OPERATIVE WORK

It is clear that, as opposed to competitive and individualistic work, in cooperative actions the achievements obtained by each member are interrelated with the objectives and performance achieved by the team as a unit. This reality ends up having repercussions on the productivity of the company, organisation or institution, as the human component, user of this action, ends up facing approaches that favour the development of reasoning at a high cognitive level that obliges the generation of creative and decisive proposals.

In addition, from the point of view of psychological health, teamwork increases self-esteem and the individual's confidence in his or her possibilities and those of the group [5]. It also favours the development of social skills and personal relationships, thus having a positive impact on socialisation at work and overcoming conflicts [9], while encouraging the acceptance of diversity and the inclusion of people who are the most vulnerable.

In order to enhance these benefits derived indirectly from the design and development of the *hatching meter*, it is proposed at this point to complement this task with other group modalities that favour positive interpersonal relationships and strengthen psychological adjustment in a supportive work environment.

For this reason, taking as a pretext the work meetings to attend to the elaboration of the meter and to determine the characteristics of the layout to be used in the chromatic reintegration processes, some moments of these conversations will be dedicated to strengthening interpersonal ties.

These moments of informal meeting will be used to discuss functional aspects of the group, with the intention of identifying possible risks that could destabilise the correct exercise of the restorative activity. By becoming a real basic group [5], issues relating to the professional progress of each member, unpunctuality, the different pace or involvement of each professional in their work, the resolution of interpersonal conflicts or individual situations that could influence the correct development of the collective activity would be dealt with.

Ultimately, the purpose of these meetings will be to achieve equal participation by all members of the team and to avoid general states of social laziness that could be very detrimental to collective progress.

4. CONCLUSIONS

As a result, in the processes of chromatic reintegration in works with significant gaps in form and colour, it is necessary to establish common working guidelines. The tool shown here, called the "*hatching meter*", is a standardisation tool for determining the characteristics of the vertically streaked lines to be agreed upon and adopted by all the technicians who jointly undertake this task. The graphic parameters considered correspond to the main factors that define the line pattern and which we have called LCTD variables, such as length, contour, translucency and dispersion.

The group elaboration of this calligraphy and calibre tool to reach a consensus on common graphic typologies, at the same time, aims to create cooperative work habits in the professional. This will suit working environments of conformity, acquiescence and unanimous consensus, where decisions and practical applications will be refined through integrative agreements, underpinned by an interpersonal vision of tolerance and mutual growth.

Social interconnections and positive interdependence will favour professional motivation and provide favourable stimuli for the achievement of a common good or goal, only attainable with the sum of individual achievements.

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PROBLEMS OF INTEGRATION IN POLYCHROME WOODEN SCULPTURE, EXAMPLES OF REPAIRING GAPS ON LARGE-SIZED, VERY INCOMPLETE ARTEFACTS

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ABSTRACT

In this paper I would like to focus the attention on the problems of integration in polychrome wooden sculptures, proposing some examples of repairing losses on large-sized, very incomplete artworks.
The artifacts that are illustrated were also complicated by the heavy tampering that occurred over time and by the cultural value, as they were not musealized and object of devotion by the communities to which they belonged.
The restoration of large gaps is one of the most complex themes of modern restoration.
To try to better understand this aspect I propose four examples of reconstruction of large size losses.
These extreme cases will be analysed in terms of severity of tampering, size and type of gaps, together with the solutions adopted in their formal recovery.
They are three large wooden Venetian crucifixes, which are dated between the second half of the fourteenth century and the second half of the fifteenth century, and two sculptures from the casket of an altar with doors.

Keywords: Chromatic reintegration; Wooden sculpture; Large losses; Watercolour reintegration

1. INTRODUCTION AND HISTORICAL NOTES ABOUT THREE CRUCIFIXES

1.1. The crucifix of Polverara

The first sculpture that I am going to present is the crucifix of San Fidenzio in Polverara (PD), dated towards the end of the fourteenth century, made by a Paduan carver and painted by a Venetian painter in the workshop of Paolo Veneziano. It is currently out of context as it is located in a mid-nineteenth century church [1]. The restoration was carried out with ministerial funding for an exhibition, which made it possible to recover the original *facies* of the crucifix.

1.1.1. Methodological approach:

The main challenge was represented by the material structure of the preparation, which in some way modified the skilful carving below. The decision to recompose all the gaps (depth and surface) was obviously aimed at re-proposing the aesthetic quality of the polychromy, but also at maintaining the very close relationship that existed between the carved and the pictorial parts. It was therefore not possible to leave the large gaps uncovered, because it would have resulted in a hybrid sculpture, halfway between carving and painting [2].
Only some gaps have not been reintegrated, because during previous restorations the mass of the carving was reduced, and if we had reinstated it, we would have risked compromising the aforementioned plastic and pictorial bond of the sculpture.
The integration was carried out with a chromatic selection of Windsor & Newton watercolours, on plaster and glue fillings, differentiating the line according to the size of the gap: the small gaps (mostly located on the arms and on the side) were almost camouflaged, while in the larger gaps (such as those on the head, face and loincloth the integration is dynamic and slightly subdued, in order to be able to make it easily identifiable, and this dynamic trait makes the perception pleasant to the eye (fig.1).

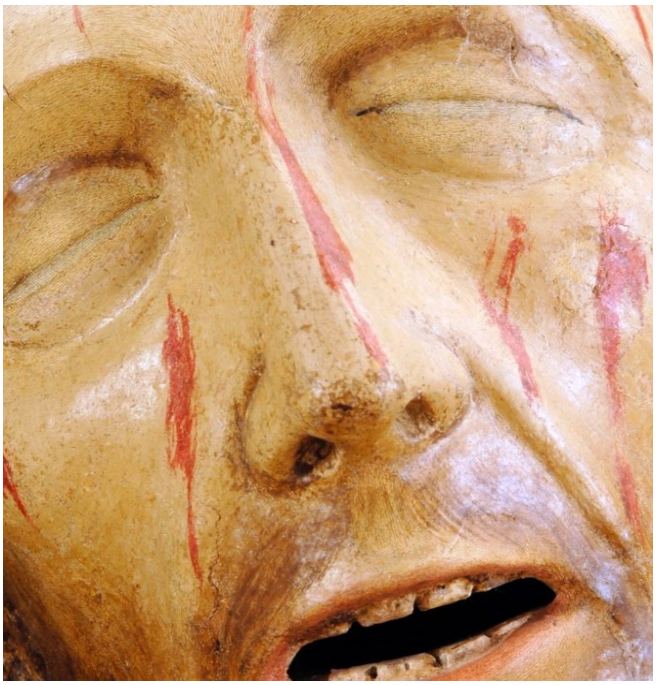

Figure 1 – Chromatic reintegration on the eyes and mouth.

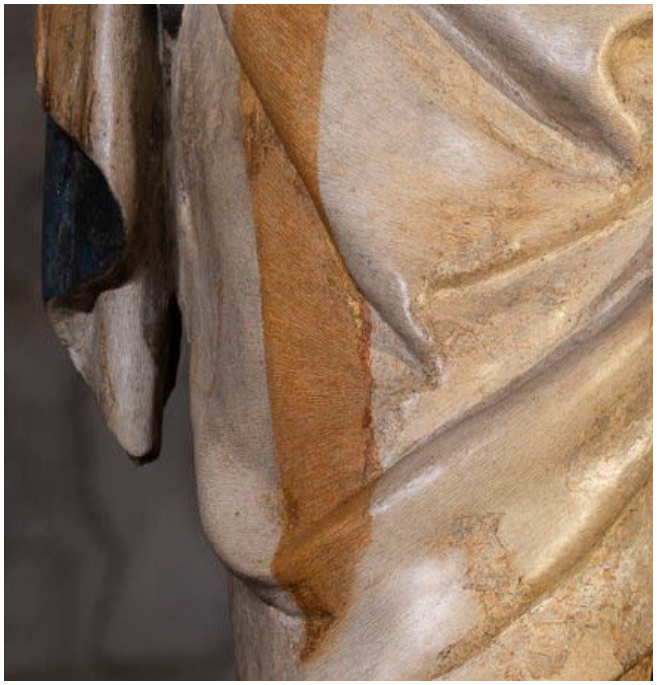

Figure 2 – Chromatic reintegration in undertone on the loincloth.

1.2. The crucifix of San Francesco della Vigna

This sculpture dates back to the first half of the 15th century, made by a Venetian sculptor and a painter near Michele Giambono's workshop.
On this crucifix we find the same problems found in the Polverara crucifix.
We have again a sculptor and a painter forming a kind of temporary business association. The carver, working a single trunk of maple chosen for the dimensions, able to create a sculpture of great quality, despite the difficult work conditions.
The painter, in addition to performing the polychromy, also made the pastille work (such as the nipples, the side and the veins).

1.2.1. Methodological approach:

The general carving was very powerful, but all in all rather summary in the general workmanship.
Therefore, it was not possible to leave the large gaps visible, because all the steps of the carving would have been seen and this might have prevented the work from being seen as a whole.
To overcome this problem, the construction management [3] opted to close the large gaps at the level, so that the plaster and glue state of the grouting would allow a correct reading of the sculpture.
Here, too, the pictorial integration was carried out with a chromatic selection, in Windsor & Newton watercolours, maintaining an undertone in the large gaps (fig.2) and camouflaging the abrasions and very small gaps.
The fingers were not reinstated because in this area the paint layer was very thin and the carver showed his excellent hand (he even managed to carve the nails).
The same procedure was chosen for the Polverara crucifix.
Once again, looking at the work in its entirety and the quality of the surfaces, this choice of pictorial reconstruction was chosen.

1.3. The crucifix of Porcia

The work, dated in the last quarter of the 15th century, is sculpted by a Venetian carver and painted by a painter, also of lagoon origin (they are thought to be part of the same workshop, so that for this sculpture there is a very close relationship between sculptor and painter as well).

1.3.1. Methodological approach:

We found the main problems in the polychromy (in addition to the common white layer of preparation with plaster and glue, it also presented a first

Figure 3 – Chromatic reintegration in undertone on the loincloth.

modelling preparation that was more greyish with the presence of some cords, although not present uniformly on the whole sculpture. This type of preparation is commonly found in German works) and in large gaps (located mainly on the arms, calves and all over the loincloth).
The gaps in the wood were few compared to the rest of the sculpture which mostly showed abrasions, but which covered about 70% of the complexion.
The loincloth appeared as an enormous mass of gaps with exposed wood, carved in a very dry, clean and linear way, which contrasted with the very soft if abraded complexion (fig.3).
The plaster and glue fillings that we made have restored the softness, now lost, to the drapery and thus the integration with a chromatic selection in undertone of Windsor & Newton watercolour has allowed to recover the volumes, with a long and dynamic line, following the trend of the folds of the loincloth.
The abrasions on the complexion have been reinstated in camouflage.
It was requested by the construction management [4] to restore the panel closure of the excavated rear. This infill was made with balsa wood, very light and easy to work with and possible to remove. The panel has been reinstated in watercolour in the same way as for the rest of the complexion, only here we have applied a tonal chromatic selection, deliberately made a little more rigid and geometric than the original polychromy, in order to make it recognizable (fig.4).
Even some missing fingers have been rebuilt with balsa wood and reintegrated in this way.

Figure 4 – Chromatic reintegration of the panel.

2. THE TWO WOODEN SCULPTURES OF THE SWINGING ALTAR OF PIEVE DI CADORE

These two wooden sculptures have a rather complicated conservation history. The works were originally inserted in the casket of a Flügelaltar in the church of Santa Maria Nascente in Pieve di Cadore (1499), the work of Ruprecht Potsch dismembered in the second half of the nineteenth century [5]. The two sculptures were found in 2007 in the parish church of Pozzale di Cadore. The two sculptures were sculpted by a master of Swabian origin, who participates as an independent in the workshop of the master from Brescia.

Figure 5 – Chromatic integration of the complexions.

2.1 methodological approach:

At the time of the restoration, the two sculptures had 11 previous interventions and were covered with 7 layers of paint.
The removal of the latter has highlighted the vast lack of gilding and complexion.
The areas of the fake brocade of the garments were plastered with plaster and glue and integrated with Windsor & Newton watercolour, creating a first draft in Payne's grey and then a sepia hatch (fig.5). The great shortcomings on the gilding required a neutral hatching, first applying the Indian yellow, the red lacquer, the bladder green and finally the sepia hatching (fig. 6).
The complexions of both sculptures were integrated on a level because the gaps were rather minute (Figure 5), using a small and tonal stroke, while the blues were integrated with a subdued glaze, because the gaps were a little larger.
On everything else the hatching is recognizable, long and dynamic and follows the trend of the carving.
This allowed to re-read the sculptures in a different way, eliminating the interruptions and allowing the light to flow again on the surfaces. This approach of recomposition of the chromatic structure was also aimed at the future relocation inside the swinging altar, which instead was all intact [6].

3. MATERIALS AND METHODS

In general, all four examples proposed in this article have been treated using the same method of intervention and the same materials for the realization of both the stucco and the pictorial integration. The

Figure 6 – Integration of faux brocade, gilding and blue.

grouting also represents a fundamental phase and a connection between the structural needs, not forgetting that the continuity of the surface also represents a guarantee of greater solidity for the edge of the gaps, and those of an aesthetic nature. This phase of processing the surface of the grouting is just as fundamental as that of the drafting of the pictorial restoration, since also a perfect execution of the latter, but on a not well done grouting, in the end gives an aesthetically unsatisfactory result [7].
For the grouting we used Bologna chalk and rabbit glue, while for the pictorial integrations Windsor & Newton watercolours in godet format.

4. RESULTS AND DISCUSSION

Wooden polychrome sculptures have the same methods of retouching because they had the same type of losses, and all had to regain the values of legibility and aesthetic pleasure. The practical decisions are the result of an exchange of ideas between the Restorer, the Client, the Chemist and the Superintendence for Cultural Heritage, whose aesthetic choices may result in the same solution. The phases concerning the

aesthetic proposal ended up being a compromise between artistic decisions and conservation requirements.
The integration with hatched chromatic selection can be modified in length and course according to the work, the cases and the final result to be achieved.
It is a technique that proves to be very adaptable to the gap, compared to the dotted, because it conforms to it (for example if I have a small gap, I use a small stroke, larger gap, longer hatch). The final aim is to close the gap, make it elegant and also noticeable.

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SKIN MATTERS. CONSERVATION-RESTORATION TREATMENT OF A SIXTEENTH-CENTURY POLYCHROME WOODEN SCULPTURE

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ABSTRACT

This paper presents results of the preliminary examination and conservation-restoration treatment of polychrome wooden sculpture, *Madonna and Child*, dated around 1520 from the National Gallery of Slovenia.
Extensive areas of paint loss, discoloration of old retouches and darkened coating on gildings disrupted the sculpture's visual unity and balance. Overpaints have progressively and significantly changed its appearance. Prior to the intervention we conducted detailed technical examination. Treatment included surface cleaning and partial removal of materials. Decisions, methods, and materials regarding aesthetic reintegration are pointed out: various approaches used on different surfaces, of which faces, and other parts of the skin, received a comprehensive "skin care".

Keywords
Sculpture; Wood; Polychromy; Overpaints removal; Aesthetic reintegration

1. INTRODUCTION

In 1979, the National Gallery of Slovenia acquired a polychrome wooden, life-size standing *Madonna and Child* (161 × 56 × 17 cm), dated around 1520 and attributed to the (unknown) Lower Styrian workshop at the auction in Munich, Germany. It was most likely placed in the central shrine of a late-Gothic altarpiece.
The sculpture represents Madonna holding her naked son and standing on a crescent moon. Her very long hair is surrounded by a veil and a crown. She is dressed in red and donned with a long, gilded mantle with punched trimmings and blue lining (Fig. 1).
The sculpture was not treated until 2015 when we reassessed its condition, conducted preliminary technical examination and planned a treatment.

1.1 Provenance /History

Madonna comes from the collection of Dr Richard Oertl (1865–1943), who was an art historian and a collector. He focused on German late-Gothic wooden sculptures (around 1480–1530) and developed a unique collection of art from Upper and Lower Bavaria, Tyrol, Swabia, and Upper Rhineland. For economic reasons he had to sell his collection at different auctions. One of the highlights of his set sold already in 1913 was *The Dangolsheim Madonna* by Nicolaus Gerhaert von Leiden (created around 1460), today in Bode Museum in Berlin. Other important works went to museums in Düsseldorf and Stuttgart, among others. In 1919, the Bavarian National Museum in Munich bought Michel Erhart's *Madonna from the Kaufbeurer altar* [1].
Dr Oertl lived and kept his valuable possessions in Miltach castle in Bavaria until his death in 1943. In 1979 the castle and the last quarter of his collection went on sale in *Neumeister Münchener* auction house where the work in question was purchased [2].
The owner suggested the provenance of *Madonna* at the mine church in Hallein near Salzburg. But the statue shows more stylistic similarities to sixteenth century sculptures from Lower Styria, which now belongs to Slovenia, and to a closely related figure of *Madonna and Child* from the Provincial Museum Ptuj Ormož. The attribution to the still-unknown Lower Styrian Workshop has not yet been discussed in scholarly literature [2][3][4].[i]

Figure 1 – *Madonna and Child*, (Anonymous) Lower Styrian Workshop, 1500 to 1520, National Gallery of Slovenia, polychromed wood. Sculpture before treatment. (Photo: National Gallery of Slovenia)

1.2 Study of artistic techniques

The statue is carved as a self-standing sculpture. The main volume is composed of two blocks of wood. The reverse of the statue is flat, but half of it has been additionally trimmed, probably with an axe. Besides gluing, no additional joining technique was used. The right block includes the hearth of the wood (the pith), whereas the left block is made of tangential timber with the outer surface facing forward. Traces/indentations of a flat clamp and a drill hole for attachment are visible on the underside.

From the presence of various holes and recesses, we conclude that smaller elements were carved separately and were then attached to the main volume: upper part of Madonna's crown, Jesus's crown, and a cross from the orb he is holding.

The wood has been gilded and painted. Small pieces of canvas that covered the wood prior to painting could be observed locally. The mantle, water gilded on a red bole has punched trimmings. The punch mark went through the polychromy into the wood.

On the ropery folds hidden from direct view we can observe typically darkened patches where so-called part-gold, *Zwischgold* (German), *oro di meta* (Italian) was used, material created by beating gold and silver together. This was quite popular in the Middle Ages in German sculptures. Its darkening could be attributed to aging mechanisms and insufficient protection of the silver in the double-layer material. At that time, apart from the economic reasons (as it allowed the gold layer to be thinner), it was often applied to hair with oil gilding technique and covered with coloured glazing [5], which we later discovered in our case as well.

1.3 State of conservation

The condition of the wooden support is generally very good. Next to the separately carved elements, only the smaller parts of Madonna's crown or spikes and fragments of the standing surface around the bottom edge are missing.

Paint layer was generally in good condition, too, but considerable loss occurred on Jesus' lap, thighs, and Madonna's right hand. Covering the nudity of the Christ probably led to this limited, but extensively damaged area where paint layers detached from the ground layer and fell off.

Old retouches on the faces turned to a warmer colour and became more visible. Except from the gilded mantle, several repaints covered all other surfaces. The dark brown colour of the crown strongly suggested repaints. Similarly, very dark colour of hair was unconvincing and also the colour seen locally underneath was much lighter. When examining the surfaces, on some areas (hair, mantle's lining) we have noticed irregularities, unevenness that indicated application of overpaints to previously uncleaned and/or damaged surfaces. The lining of the coat was very dark, almost black.

The high-quality original gilding of the mantle showed moderate wear damage and only fragment losses. Darkened, brown to grey coating obscured the gilding.

2. MATERIALS AND METHODS

We reassessed the sculpture's condition as generally stable but surfaces and the appearance have progressively and significantly changed.
Many mainly aesthetic problems disrupted sculpture's visual unity and balance. The most noticeable and disfiguring damage was the area of missing paint layer on Jesus's body.
Team of curators and conservators assessed the goals of the conservation-restoration treatment that would reveal at least some of the original colour scheme and would regain the artwork's artistic and esthetical values.

2.1 Preliminary technical examination

Prior to the treatment, polychromed *Madonna and Child*, a beginning of sixteenth-century production, was the subject of a study that aimed to reveal the artist's practice. We undertook radiography, ultraviolet examination and photography under UV radiation, stratigraphic and material analyses. Combining results contributed to a better understanding of the original technology, later interventions and helped us plan the treatment.
In UV radiation besides the missing paint layer and old retouches, extensive repaints on the Child's face became clearly visible (Fig. 2).
X-ray radiography showed no additional joining elements between constituent wooden blocks. Several layers of lead white pigment used on skin areas were noticeable as intense white areas.
We took samples from skin parts, hair, and garments to survey the stratigraphy and to characterize the material composition of the original and subsequent paint layers. These investigations would also help us to assess options for overpaint removal and to select appropriate methods and materials.
Sample analyses performed by the Natural Science Department of the Institute for the Protection of the Cultural Heritage of Slovenia included optical microscopy, Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy and scanning electron microscopy coupled with energy dispersive X-ray Spectroscopy (SEM-EDS).

Figure 2 – Photography under UV fluorescence. The darker areas show retouches, and extensive repaints on the Child's face. (Photo: National Gallery of Slovenia)

Results of the analyses revealed that original ground preparation (with distinguishable two layers) is composed of calcium carbonate filler with dolomite inclusions and proteinaceous binder with slight differences in a sample of a dress, where oil was possibly added.
Bole layer of similar reddish-brown colour on a mantle and a dress is applied in all the extension of the water gilded areas. It is composed of iron oxide, aluminium hydroxide, and litharge (probably from lead pigment degradation) mixed with protein and oil binder.
Sample taken from Madonna's hair (Fig.3) shows that at the time of its creation, the white ground (Fig. 3, layer 3) was covered with yellow paint first and then a translucent orange layer (Fig.3, layers 4, 5, 6) before the leaf was applied on oil binder (Fig. 3, layer 7). The alloy of the original metal layer identified by SEM-EDS (Fig.3 bottom left) shows the presence of silver and gold from the two-layered foil, *Zwischgold*. Metal leaf was then covered with a translucent brown glaze composed of natural earth pigment and oil (Fig.3, layer 8). The hair had been re-gilded once (Fig. 3, layer 9) and then repainted several times with protein/oil binder (*tempera grassa*) (Fig. 3, layers 10, 11, 12) [6].
The original polychromy of a dress applied on a red bole is made of (most probably burnished) silver leaf under translucent yellowish glaze. On the original lining of the mantle, the blue azurite pigment in oil binder was applied over a thin black underlayer, which was quite often in medieval times.
Flesh tones are originally composed of lead white matrix with cinnabar and minium (red lead, red oxide) in oil. The original polychromy was then repainted three

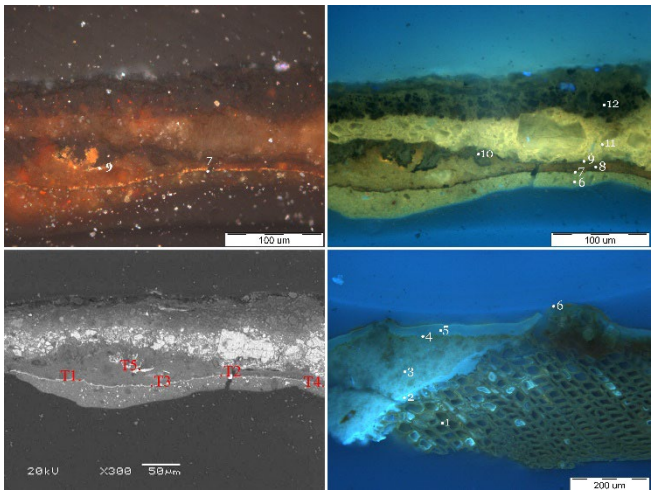

Figure 3 – Cross section from Madonna's hair (upper left) under UV light (upper and bottom right) and SEM-EDS analysis (bottom left). Photo: Institute for the Protection of the Cultural Heritage of Slovenia, Restoration Centre)

times. These layers are composed of lead white, cinnabar, occasionally with the addition of barium sulphate in oil binder [6].

2.2 Conservation-Restoration Treatment

2.2.1 Surface cleaning

Grime layers covered and obscured surfaces, which was especially perceivable and disturbing on lighter parts, like the skin. Surface cleaning was the first step of the treatment. Loose dust and dirt were firstly vacuumed off. After testing the solubility of the soiling material, we have chosen the most suitable buffer solution at pH value 5.5 in a liquid and/or gelled form. We utilized citric acid (with also mild chelating ability) buffered with sodium hydroxide. Where longer application time was needed, the same solution was gelled with hydroxypropyl cellulose Klucel G was used (Fig. 4).

2.2.2 Removal of film-forming materials

After surface cleaning, extensive repaints and fills from the previous treatment became clearly visible on the Child's face. Locally, the fills were not limited to the damaged area, but covered the paint layer around it, too. We removed the excess fill material around the edges mechanically with the use of a surgical scalpel. We smoothed the surface of the old fill and its edges with an abrasive paper with fine grit size and in this way we removed also the repaint of inappropriate colour.

2.2.2.1 Removal of water-soluble coating from the gilding

Medieval sculptures can have surface coatings on water gildings that could be original or subsequent. Authors suggest various materials that could be used: animal glue [7], egg white (glair) or water-soluble gums [8]. Due to the exposure to the UV light these coatings darken considerably.

Such an unevenly applied and discoloured greyish-brown coating covered only Madonna's gilded mantle. This coating was recognized as a later application which was utilized probably to consolidate damaged surface of the gilding. This conclusion stemmed from the accumulation of the material along the damaged edges. Subsequent application and aesthetically unacceptable changed appearance were the reasons that justified its removal.

A coating was not analysed, but tests showed its water solubility after slightly prolonged application of water in form of a rigid agar gel patch. As egg white coatings look bluish-white under UV light and they need a chelating agent to become soluble in water [8], we concluded that animal glue was most probably used in our case.

Rigid agar gel represents a targeted and controlled way of delivering water to the water-sensitive surface [9]. The moisture from agar patches laid on the gilding for very short time (less than a minute) dissolved and picked up most of the coating material and didn't damage the gilding. We avoided areas with exposed ground and bole layers.

Figure 4 – Partly removed surface dirt (left) and partly removed coating from the water gilded mantle (right). (Photo: National Gallery of Slovenia)

2.2.2.2 Overpaint removal

On the skin parts, overpaint layers show very similar composition (pigments and binders) and consequently colour very similar to the original one, while garments and hair were more comprehensively changed.

Although contemporary conservation theory generally turns away from overpaint removal to reveal the original [10], we decided, based on careful consideration, for a partial removal.

The decision to preserve overpaints on the skin was based on the composition, the quality, good adhesion, and the overall condition of these repaints. Removing overpaints from the very damaged Christ's body could further jeopardize the underlying layers.

In other instances, we decided to remove disfiguring and inauthentic layers and reveal some of the (more valuable) original layers. Unevenness of some surfaces (the hair and the mantle's lining) indicated that the condition of the underlaying layers is not very good, but we estimated that a large portion of the original polychromy was still preserved. On the dress the surface of the repaints was even, there was no hint/implication of underlying damages. The yellow glaze on a silver leaf could give considerably different impression from the top red repaint of the dress. Small stratigraphic windows, undertaken by solvents and scraping, indicated the original polychromy was still present, which also guided our choice to remove these repaints.

The sample analyses also helped us to decide and to select appropriate methods and materials for the cleaning and removal of materials. Recent development in the field has brought many new methods that enable the procedures of cleaning and removing of film-forming materials to be carried out more gradually, selectively, efficiently and, above all, more safely for both the work of art and the conservator-restorer [11].

We changed the cleaning protocols for various problems and selected materials and methods for specific layers to be removed. The work was undertaken very carefully, also under the stereomicroscope *Leica M80* for certain tasks.

Aged oil repaints were softened by several applications of highly viscous solvent surfactant gels, where the penetration of the solvent is limited. The solvent action is held on the surface and the evaporation rate of the solvent is slowed.

After testing solubility of the repaints, we firstly prepared nonpolar solvent surfactant gel with ligroin, *Carbopol* and *Ethomeen C12* and water. Then we added 20-30 % of benzyl alcohol. Applications of the gel covered with *Melinex* foil lasted between a couple of minutes to more than an hour and softened the layers that we then removed mechanically with the use of a disposable surgical scalpel. We used this method to remove repaints from the crown, the veil, the dress, and the mantle's lining. Knowing the azurite layers (on the lining) are very susceptible to solvent cleaning, we removed the top (dark blueish black) layer using nonpolar solvent surfactant gel, but the last whitish overpaint layer was removed from it with a surgical scalpel and under the stereomicroscope for more precise work.

For the removal of greasy tempera repaints from the hair we used gelled emulsions in which we combined solution of diethylenetriaminepenta acetic acid (DTPA) buffered with sodium hydroxide to (an alkaline) pH value 9 and a nonpolar mixture of solvents (isooctane and benzyl alcohol). As a gelling agent for the water solution in O/W emulsion we used *Carbopol*. In W/O gelled emulsion, the outer phase represented nonpolar solvent surfactant gel. Layers were taken off gradually and with the help of the microscope to clearly see what needed to be removed.

Repaints on the hair and the crown significantly changed the original appearance. Removing them brought to light a veil of a warmer white colour, a gilded headband, and a narrow area of hair just above it, both previously overpainted white. Gilded and punched crown became visible again. We revealed remains of the original polychromy on the hair: gilding with an orange-brown glaze which lay on the (exposed) priming ground of a very similar orange colour. (Fig. 6).

Removal of the repaints from the mantel's blue lining revealed damaged original polychromy made of azurite layer applied over a black underlayer which still gives the overall impression of a blue velvety surface. On the dress, the silver leaf with a yellow glaze was heavily worn out, probably sanded, and the extensive area of exposed bole gave a reddish-brown colour impression to the dress.

2.2.3 Aesthetic Reintegration

After the surface cleaning, some damages became even more evident, for example exposed priming ground where paint layer fell off became lighter white and more contrasting. Removal of repaints also revealed some areas of heavily damaged original polychromy.

Figure 5 – Removing overpaints revealed a gilded headband and a crown with punched decoration and lightly-coloured hair. (Photo: National Gallery of Slovenia)

When observing a work of art, damage to it is the most eye-catching element - where the continuity of a surface is interrupted, the unity is invalidated. An area of damage creates a strong visual disturbance and greatly influences the perception of the work.

But it is not just the damaged area that attract our attention, and not all in the same way.

A study by Massaro et al. from 2012 analysed the human gaze. Methods developed in medicine, psychology and neuroscience were used to analyse the viewers' responses to works of art. One of the outcomes of this study was that when observing a coloured static human image, the gaze is mostly focused on the facial area, followed by the hands. The face is the first to attract attention; it contributes to an aesthetic experience of the artwork and can also elicit the simulation of emotions and sensations [12].

These aspects guided our choices regarding the range/ extensiveness of the aesthetic reintegration. We decided to select a protocol not very common in conservation-restoration (of polychrome wooden sculpture) and to address various parts of the sculpture with three different approaches: filling and retouching, retouching only or no intervention.

We limited the aesthetic reintegration to damages on the faces, hands, and the surrounding skin parts. The treatment would restore the unity of the work by respecting the theoretical principles of recognition and the reversibility of the intervention. We sought to find a balance between aesthetics and the work's role as a historical document.

We differentiated between two areas with losses: the faces and the rest of the skin. Since they receive the maximum of the attention, losses on the faces would most disturb the perception of the artwork.

Where both the original and the subsequent layers peeled of the ground, slightly recessed lacunae with sharply defined edges were created. On these edges the effect of catching the light unevenly was more evident and disturbing. We determined that on the faces this could not be solved only by retouching. Retouches should be quite thick to level the damaged with the surrounding area. We decided to eliminate the interference of the lacunae with a fill first. We used a mixture of chalk *Bologna light*, acrylic dispersion *Ares33* (Samson Kamnik) and *Gesso* primer (Lascaux) to fill the gaps on the faces. We smoothed the surface of the new repairs.

The whitish islands of the exposed ground on Madonna's right hand and the Child's body were also very contrasting, eye-catching elements, that could be perceived as placed in front and would also impair the perception of the work. It was difficult to leave them non-retouched. But as they are not so much in focus, we decided not to fill them, but to retouch directly to the exposed ground.

In the final phase, the technique of recognizable retouching was chosen. We connected the filled parts and/or exposed ground with the surroundings using *puntinato* (Italian), a technique introduced in the restoration of polychrome wooden sculpture by *Istituto Centrale per il Restauro* (Rome, Italy). With *puntinato* or pointillist technique, the desirable effect is realized by dots in the colours that unite the gaps with the encompassing surface. The technique accommodates perceiving from a distance, when dots visually merge and reconstruct the optical continuity of the surface, but on close inspection remain clearly visible. We agree

that when applied to 3D objects, the dots are in advantage as they do not compete with the form, which sometimes happens with parallel hatching [13]. Retouching was carried out with *Gamblin Conservation Colours* (Gamblin) that ensured simple removability (Fig. 6).

We decided not to reintegrate lacunae that reveal the ground layer, bole, or the bare wood on the rest of the surfaces, but to leave them visible. The gilding of the mantle and the crown was, apart from being worn out, in a remarkably good condition. The original polychromy on the hair, the orb Jesus is holding, the dress and the blue lining, although fragmentary in places, was left to make its impact. We adopted the solution used in Belgium at the KIK IRPA[ii], which presumes that viewers can mentally reconstruct certain missing parts from (past) experiences [13] that is why the wear and losses on these surfaces could be accepted without filling and retouching. In rare instances, the visibility of these damages was just toned down. We varnished only a dress with *Soluvar Gloss Varnish* (Liquitex)[iii] where worn-out and locally exposed silver needed to be protected. The varnish has excellent stability and is removable in nonpolar solvents [14].

Figure 6 – Detail of *Madonna and Child* after treatment. Pointillist retouching applied to filled lacunas on the faces and to the exposed ground on the rest of the skin parts visually merges the damaged areas with its surroundings when viewed from a distance but maintains discernibility. (Photo: National Gallery of Slovenia)

3. RESULTS AND DISCUSSION

On the statue of *Madonna with Child*, where aesthetic problems confront historical reality, we decided to preserve the remains of different periods.

Removing overpaints had a great impact on the appearance. On certain surfaces we revealed just fragments of the original polychromy. In the case of the hair, similar colours of fragments and the groud layer reduce the visibility of damage and (without additional treatment) we achieved the visual impression of the original, fair-haired Madonna.

However, the polychromy of the dress is (unexpectedly) damaged with the red bole layer exposed over a large part of the surface. It is possible that the surface was smoothed, sanded before applying the paint. Locally preserved patches show the original polychromy, but the overall final impression of the dress is dominated by the exposed red bole, which deviates from the original appearance of golden glaze on silver and to some extent affects the color balance.

With the aesthetic reintegration limited to skin parts, we succeeded to re-establish the optical continuity of the surface and achieved oneness of the work. We maintained the discernability and reversibility of the retouching. We estimate/believe that the decision not to reintegrate damages on the other parts has proven to be successful and that the appearance of these surfaces does not significantly impact the perception of the whole.

4. CONCLUSIONS

The appearance of this medieval sculpture is a patchwork of the original and the subsequent materials, damages, and old repaints. When dealing with the aesthetic reintegration of these surfaces, we used an approach that was slightly different from the established theories and practices, since we treated surfaces individually.

The time required for such a treatment could represent a well-founded concern about the justification of the intervention, which is pointed out by the modern

approach to the restoration of polychrome wooden sculpture.

While some decisions may have been different, we truly believe that this long-lasting process and the selected approach in esthetic reintegration regained and highlighted the work's artistic, historical, and aesthetic values and that the observer can once again enjoy the beauty of *Madonna and Child*, which entered the Permanent Collection of the National Gallery of Slovenia in February 2020.

The author is constantly accompanied by self-questioning about the appropriateness of past decisions. Especially when thinking about them from a distance, these issues become particularly challenging. Sharing decisions with fellow professionals is like putting yourself in front of the strictest jury, which could become especially burdensome. Nevertheless, with this contribution we would like to share our solutions and the results of the intervention, which are available for further evaluation/ assessment.

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NOTES

[i] Personal communication with prof. dr. Samo Štefanac (University of Ljubljana, The Faculty of Arts), dr. Branko Vnuk (curator from Provincial Museum Ptuj Ormož), Marie-Theres Haslböck (Neumeister Münchener Kunstauktionshaus)

[ii] *KIK-IRPA*, Royal Institute for Cultural Heritage-Koninklijk Instituut voor het Kunstpatrimonium - Institut Royal du Patrimoine Artistique); Bruxelles Belgium

[iii] Soluvar Varnish is composed of 40% solids (Paraloid B-67, piBMA and Paraloid F-10, piBMA) in slow drying petroleum destilate.

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INNOVATIVE APPROACHES FOR THE RE-INTEGRATION OF FIFTEENTH-CENTURY SPANISH PANEL PAINTINGS

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ABSTRACT

The Suermondt-Ludwig Museum (Aachen) holds five Spanish fifteenth-century panel paintings in their collection. The five panels are all fragments, likely removed from their original settings at the turn of the nineteenth century during the upheaval of the Napoleonic Wars and sold on the art market after extensive restoration.
Three of these five panels have been already treated at SRAL. The additional two will undergo a full conservation campaign in the coming year carried out in collaboration with conservation students from the University of Amsterdam and conservation training programmes in Spain.
A treatment protocol was devised to ensure a systematic and sympathetic treatment, including reintegration. This provided key skill development for the trainee conservators. The removal of non-original surface materials revealed overcleaned and severely damaged surfaces. The integration of these surfaces required an innovative approach to return a sense of authenticity to the artworks, individually and as a disparate group. The subtle shift in gloss and texture between areas of paint and gilding, between different pigments bound in animal glue, egg tempera, and oleo-resinous glazes had been lost. The selection of conservation materials for infilling and retouching aimed to return this ephemeral play on light to the surfaces.

This paper will discuss this innovative approach using the reintegration of one of the set of five panel paintings: the "Adoration of the Kings" (Inventory number: GK 243) as a case study. The materials were carefully chosen so as not to be mistaken for original materials in the future. The approach entailed thinking out of the box and approaching the filling and retouching stages simultaneously rather than as independent actions. This allowed a more holistic strategy to reintegration than if all losses were filled first prior to retouching.

The filling materials utilised are based on a studio formulation consisting of a novel combination: Arbocel 500 (cellulose fibres) bound in a mixture of Aquazol 500 (poly(2-ethyl-2-oxazoline)) and Methocel A4M (methylcellulose) bound in water. This mixture was used to fill deeper losses and modified with aluminium hydroxide powder to create a surface fill. The protocol used began with testing of the materials to find the right formulation; adaptations for the typology of fill were incorporated into this design. The filler formulation is modified to best adapt to the specific losses in each area of each panel. The decision not to re-varnish the panels allowed filling and retouching to be carried out simultaneously and the different gloss surfaces of individual paint areas to be imitated by modifying the amount of retouching binding media (Aquazol 200 dissolved in ethanol/water). The resulting appearance allows different colour and surface finishes to retain their independent characteristics and returns a more authentic surface finish to the fifteenth-century artworks.

Keywords: Chromatic reintegration; Retouching; Filling; Arbocel;Aquazol; QOR.

1. INTRODUCTION

The Suermondt-Ludwig Museum (Aachen) holds five Spanish fifteenth-century panel paintings in their collection. The panels are undated. A confirmed provenance can only be traced as far back as the late nineteenth century when the group was accessioned. Stylistically they can be attributed to the eastern region of Spain corresponding to the Kingdom of Aragon - a region encompassing Zaragoza, Barcelona and Valencia. The five panels are all fragments, likely removed from their original settings at the turn of the nineteenth century during the upheaval of the Napoleonic Wars and sold on the art market after extensive restoration.

The five paintings come from three altarpieces constructed in three separate workshops. Each workshop has different working practices and materials usages, but all are steeped in the traditional artistic practice of the period. On the stylistically dated later panels, there is a clear innovative use of new Hispano- Flemish painting technologies.

Archival documents held at the museum provide some insight into the provenance of the panels prior to accession. Two panels (GK532 and GK533), originating from one altarpiece, were donated by Dr. Franz Johann Joseph Bock in the late 1880s.

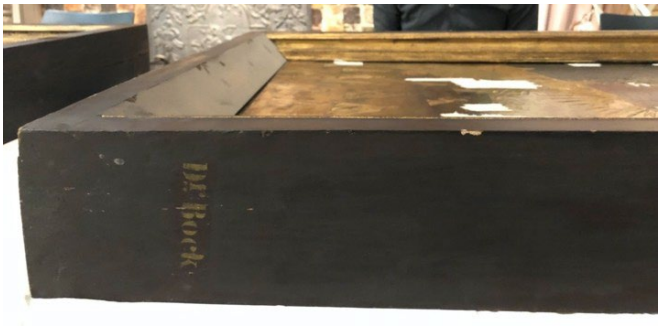
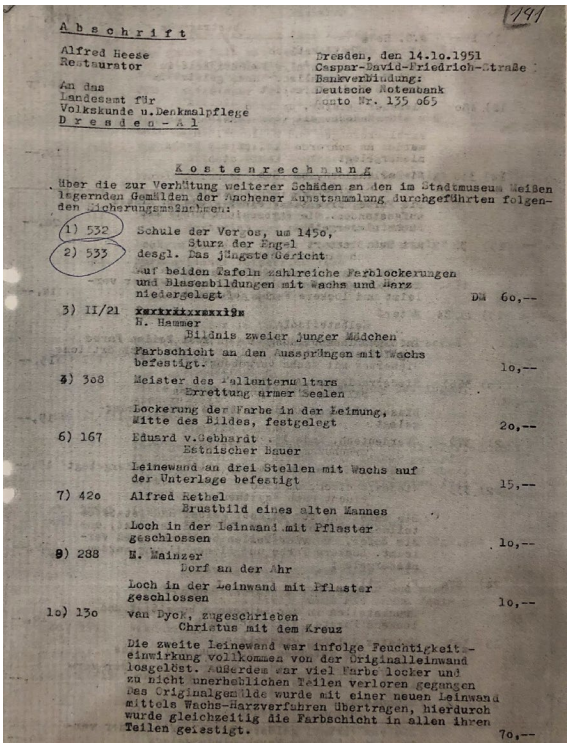


Figure 1 – Side of the frame with the stenciled name of Bock (donor).

The three other panels were donated to the museum in 1914 by Geh. Kommerzienrat Louis (Ludwig) Beissel (1842– 1914), an entrepreneur, cloth manufacturer and friend of Robert Frederick Suermondt (1844–1919), son of the founder of the museum [1].


Abschrift

Alfred Heese
Restaurator

Dresden, den 14.10.1951
Caspar-David-Friedrich-Straße
Bankverbindung:
Deutsche Notenbank
Konto Nr. 135 065

An das
Landesamt für
Volkskunde u.Denkmalpflege
Dresden-A1

Kostenrechnung

Über die zur Verhütung weiterer Schäden an den im Stadtmuseum Meißen lagernden Gemälden der Aachener Kunstsammlung durchgeführten folgenden Sicherungsmaßnahmen:

1) 532 Schule der Vervos, um 1450,
2) 533 Sturz der Engel
desgl. Das jüngste Gericht
Auf beiden Tafeln zahlreiche Farblockerungen und Blasenbildungen mit Wachs und Harz niedergelegt ... DM 60,--

3) II/21 [redacted]
N. Hammer
Bildnis zweier junger Mädchen
Farbschicht an den Aussprüngen mit Wachs befestigt. 10,--

4) 308 Meister des Fallmeramtars
Errettung armer Seelen
Lockerung der Farbe in der Leimung, Mitte des Bildes, festgelegt 20,--

6) 167 Eduard v.Gebhardt
Ethischer Bauer
Leinewand an drei Stellen mit Wachs auf der Unterlage befestigt 15,--

7) 420 Alfred Rethel
Brustbild eines alten Mannes
Loch in der Leinwand mit Pflaster geschlossen 10,--

8) 288 H. Mainzer
Dorf an der Ahr
Loch in der Leinwand mit Pflaster geschlossen 10,--

10) 130 van Dyck, zugeschrieben
Christus mit dem Kreuz
Die zweite Leinewand war infolge Feuchtigkeitseinwirkung vollkommen von der Originalleinwand losgelöst. Außerdem war viel Farbe locker und zu nicht unerheblichen Teilen verloren gegangen. Das Originalgemälde wurde mit einer neuen Leinwand mittels Wachs-Harzverfahren übertragen, hierdurch wurde gleichzeitig die Farbschicht in allen ihren Teilen gefestigt. 70,--

Figure 2 – Archival document describing the treatment carried out in 1951

All the panels have been cut down in size to a 'unit' that could be sold independently from the rest of the altarpiece. Structural damages originating from the removal from their original setting had been addressed prior to arrival in the collection (presumably much earlier), and one panel (GK84b) was transferred from its original support in the 1970s. The five panels were evacuated to Dresden during the second world war and were treated there before returning to Aachen in the early 1950s.

Most of them presented non-original varnishes, extensive overpainting and overfilling covering overcleaned and damaged paint areas, as well as

Figure 3 – GK84A, GK84B, GK532 & GK533 (before treatment, visible light)

structural issues. Three of these five panels have been treated at SRAL over the past decade. The additional two will undergo a full conservation campaign in the coming year. The conservation treatment is carried out in collaboration with conservation students from the University of Amsterdam and conservation training programmes in Spain.

With this in mind, a treatment protocol and procedure was devised to ensure a systematic and sympathetic treatment for the five masterworks, including reintegration. The reintegration aimed to stay true, not only to the colour and condition of the original paint layers, but also to the differences in surface gloss and texture that the panels would originally have presented. This provided key skill-development -for the trainee conservators, especially when considering the recovery of the surface characteristics - a very subjective goal that required a non-standard approach to the aesthetic phase of treatment.

The removal of non-original surface materials revealed overcleaned and severely damaged surfaces. These damages could be clustered into different loss typologies ranging from narrow scratches, abrasions, thinning, small to large, shallow to deep. In addition, many original paints were discoloured or faded. The reintegration of these surfaces required an innovative approach to return a sense of authenticity to the artworks, individually and as a group. The subtle shift in gloss and texture between areas of paint and gilding, between different pigments bound in animal glue, egg tempera, and oleo-resinous glazes had been lost. The selection of conservation materials for infilling and retouching aimed to return this ephemeral play on light to the surfaces, as well as reintegrating the colourful images depicted.

This paper will discuss the innovative approach developed at SRAL using the reintegration of the 'Adoration of the Three Kings' (Inventory number: GK 243) as a case study. It was important that the technique developed could be used for all five panels. The materials were carefully chosen so as not to be mistaken for original materials in the future, but able to fulfil the desired aesthetic effect. The approach entailed thinking out-of-the-box, approaching the filling and retouching stages simultaneously rather than as independent actions. This shift in well-established order of execution allowed a more holistic strategy to the reintegration than if all losses were filled first prior to retouching. Furthermore, as a teaching exercise, this project provided a thought-provoking challenge allowing conservation students to augment their retouching skills.

1.1 The Adoration of the Kings

Besides the Bode-Museum (Staatliche Museum zu Berlin), this is one of the few centres in Germany to have Spanish late Gothic period artworks in their collections. This makes the five panels within the Suermondt-Ludwig collection a unique set.

The Adoration of the Three Kings is a fragment. It is likely to be one of the *sotto banco* (or predella) sections of a much larger altarpiece. The artist is unknown but stylistically it is attributed to the School of Ramon Sola II (c. 1445-1502), Catalonia. The panel was donated to the Museum in 1914 by Louis (Ludwig) Beissel (1842–1914). The manufacturing technique is consistent with contemporary traditional Spanish practice, though the painting technique shows the influence of the Hispano-Flemish style that became popular in the latter part of the fifteenth century in Spain. The other four paintings within the Suermondt-Ludwig Collection all indicate aspects of these novel painting techniques.

The support consists of one thick (c. 3 cm), horizontal, pinewood board encompassing the pith. The upper framing decoration, composed of quatrefoil shapes in both corners separated by ten parabolic arches, is constructed by attaching smaller, independent sections of wood directly to the support before the preparatory layers are overlaid.

Figure 4 – GK243: Adoration of the Three Kings (recto) (before treatment, visible light)

Figure 5 – GK243: Adoration of the Three Kings (verso)(before treatment, visible light)

The twisted column placed on the left side is original. It is constructed of a single piece of carved, gilded pinewood (of a different species than the primary support) attached after the painting process. Additional nails now hold this in place. Clearly visible saw marks, observed on the right edge of the panel, indicate that the support originally extended to the right. It is possible that the panel also extended to the left, though the presence of the column suggests that this edge could have been flush with the (missing) *guardapolvo*. The structural integrity of the panel was disrupted by the large horizontal split transecting of both painted surfaces (recto and verso) which required stabilisation treatment.

The front of the panel shows traditional stratigraphy for a fifteenth-century panel painting, conforming to the techniques described by Francisco Pacheco [2]. The support was prepared using a fine woven lined cloth. applied below the layers of *gesso grosso* and *gesso mate*, directly to the wooden surface. The paint application is carried out according to a carefully delineated black ink underdrawing. Areas of gilding were then prepared by applying a layer of light-red coloured bole. The halos, crowns and star are pounced and a different tool is used to texture the brocade drapery of the kneeling King.

The paint medium was egg tempera, except for Madonna's robe which, if traditional workshop practice was followed, must have been executed with the azurite

pigment bound in animal glue. The three Kings are dressed elaborately with gilded brocade cloaks and richly decorated crowns. The effect is created by applying the pattern of the textile using an oleo-resinous medium applied over tooled, gilded areas. It is not likely that this paint surface would have been originally varnished. Evidence of dirt layers beneath superficial varnish coatings lays evidence to this. There is also evidence of extensive retouching applied to hide damages in the surface, especially in the blue robe of the Virgin. The extent is visible in the False Colour Infrared image.

Figure 6 – GK243: Adoration of the Three Kings (recto) (before treatment, false-color infrared image)

A later addition, also in pinewood, has been attached to the lower border, supporting the lower gilded framing edge and enclosing two original hand-forged nails. A textile overlap has been applied to the reverse of this section and later applied restoration wooden fixtures serve to reinforce the join. This addition is testimony to the removal of the panel from its original setting and preparation for sale at auction.

The reverse of the panel is also painted, though this is not likely to be original to the construction period. The painting shows the saintly figure of Melquisedec holding bread and a jug. The applied ground and paint on the reverse extends over the later applied piece of textile bridging the gap between the original support and the later addition. The ground layer was applied to the surface prior to painting but not sufficiently to smooth out the traces of woodworking tools used to prepare the reverse of the panel. The paint layers are matt and are unvarnished, though areas of ultraviolet-induced fluorescence are present. We date these additions to the beginning of the nineteenth century when many churches were looted during the Napoleonic wars. There is evidence of later applied fills and retouches indicating that the reverse of the panel has also undergone a restoration campaign in the past. While not contemporary to the obverse, this depiction has become part of the object and was treated with the same respect as the obverse.

The condition of the obverse decorative surface is intermediate - some areas are well preserved while others have suffered considerable damage. Damage typologies vary from superficial scratches and abrasions to deeper structural issues relating to cracks and splits in the primary support. One larger section of the (upper) framing elements have been badly damaged by insect infestation and was missing. Other damages relate to past treatments. The painting has been cleaned in the past and as a result paint layers, glazes, and gilding have been overcleaned. The reverse showed similar typologies of damage and thus the same methodology could be applied to reintegrate this surface.

The challenge was to mask areas of loss using a filling system that could imitate different surface textures and return a subtle and specific use of opaque colours and glosses to emulate the original artistic technique. The variety of damage types required a filling system that could easily be adapted to the differing depths of the losses and textures of the surrounding areas. Respecting the original aesthetic appearance and artistic practice involved the decision not to varnish the artwork. This decision added a facet of difficulty to the retouching phase as differences in gloss could not be reduced or adapted with the application of a final varnish layer. This meant that a retouching medium that could be applied to match surfaces of shifting gloss and texture was desired. A novel methodological approach was devised which allowed filling and retouching to take place non-consecutively. Materials were selected for their ability to produce a wide range of surface textures and used in adaptive formulations to make the most of subtle differences in application.

2. MATERIALS AND METHODS

2.1 First steps of the conservation treatment

Initial treatment consisted of the structural repair of the severe longitudinal split running with the woodgrain and multiple minor splits in the end grain. The circa 3 cm thick support made this a challenging operation, but it was necessary to return structural stability to the painting. This operation was further complicated by the necessity to retain the painted reverse. The curvature of the panel was enhanced by the natural warping of the thick wooden support. This prevented a full closure of the split partially on the front and the complete reverse of the panel, although the resulting 'v' shaped opening was minor. A gap-filler adhesive consisting of fish glue extended with 1:1 (w:w) ground coconut shell powder and phenolic micro balloons [3] was used to accommodate the lack of closure in the panel structure. Posterior surface cleaning, overpaint and varnish reduction were carried out.

2.2 Reintegration: filling

The decision not to re-varnish the 'Adoration of the Three Kings' panel allowed filling and retouching to be carried out simultaneously. The different gloss surfaces of individual paint areas could therefore be imitated by modifying the texture of the underlying fill and the amount of retouching binding media utilised. The resulting appearance allows different colour and surface finishes to retain their independent characteristics and returns a more authentic surface finish to the fifteenth-century artwork.

Our approach aimed to bring the level of any loss, whether shallow or deep, to the same plane as the original surrounding surface and mimic the surface texture. The viewer's eye would, therefore, not be caught by any differences in topography. A range of infill formulations based on combinations of Arbocel 500 (cellulose fibres), bound in a mixture of Evacon R (ethylene vinyl acetate dispersion) and Methocel A4M (methylcellulose), and further bulked with Portafil A40 (aluminum hydroxide pigment) were tested[3]. Formulations could be modified for use in deep fills or for areas where higher gloss was needed. Therefore, a variety of formulations was developed that dealt with more structural or surface requirements. A combination of layers could be used in deeper fills, with the first application consisting of higher proportions of Arbocel 500. Higher gloss areas used a greater proportion of the binding media to bulking agents.

The ingredients for the filler were selected because they could not be confused (analytically) with materials used in the original manufacture of the panel, and more importantly, because their mechanical properties would not generate new tensions in the artwork. The selected filler is, thus, a studio formulation that to the authors' knowledge is not reported elsewhere. The firsts uses of some of this materials for this purpose in spare institutions such as the Opificio delle Pietre Dure [4], which inspired the further improvement of the filling mixture in order to refine itsformer known properties.

The protocol used began with testing the formulation to find the right proportions for the variety of damage types and establish the variants required to emulate the different typologies.

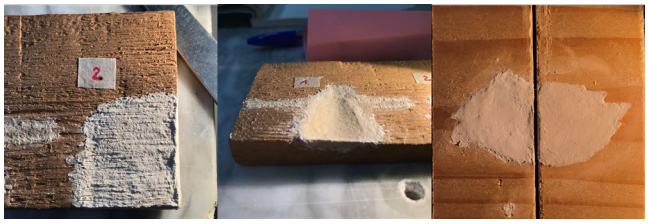


Figure 7 – Tests made it over wood to try the differentvariants of the filling proportions

The experience gained during testing encouraged our methodology to be refined. The filler is easy to apply and presents little shrinkage on curing. This seemingly soft and fluffy filler dries to a flexible but stiff, airy structure. The structure and mechanical properties of the fill have similar consistencies to *papier mâche*.

As the proportions of the filler mixture vary considerably, it is not possible to provide a single recipe, however 'standard' formulations that had consistent working properties were developed. We will discuss next the individual ingredients and underlying reasons for their selection. We have clustered the materials into their function: bulking agents and binding media.

Binding Media

Methocel A4M: methylcellulose with a viscosity of 3000-5500 mPa.s, 3% in H_2O (20 °C). The chemical nature of this binding medium is like that of the main bulking agent Arbocel cellulose fibres. This promotes affinity and stability. Methocel A4M was selected due to its ease of swelling in water and availability. The viscosity of the 3% solution in water is relatively low. This allows good wetting of both bulking agents used in the formulation. The inclusion of this material, and the high-water content, dictate the rheology of the formulation and are, thus, the key to the fluidity and flow of the formulated filler. The working properties of the fill are therefore directly related to the proportion of this component. However, the cellulose ether and viscosity could be modified if looking for alternative variants.

Evacon R: this is an ethylene-vinyl acetate dispersion. This material is formulated for the conservation sector [Ref 5: CXD (2021)]. It contains no plasticisers and a small percentage (0.05%) of calcium carbonate. Research has shown that it mixes well with cellulose ethers [6]. This material was added to our formulation to increase the cohesive properties and provide a higher flexibility to the cured filler. Its presence also ensures good adhesive bonding to the loss edges and makes it easier to load pigments and colour the mixture. The combination of Evacon R and a cellulose ether have been used at SRAL for over a decade as a combination binder for aqueous fillers.

The proportion of the two binding agents was modified depending on the depth and location of the losses. A putty-like consistency was used for the deeper losses, whereas a smoother more fluid variant was required for the shallower losses. A mixture of 60% - 40% Methocel A4M (3% in water) and Evacon R respectively gave the best results for the deeper losses as this allowed our bulked filler to bond well to the wooden support. However, deep losses were not filled in one application. The first, bottom layer contained a higher proportion of Arbocel fibres, whilst for the second, upper layer the percentage of this component was reduced. The higher binder content provided increased adhesive strength which guaranteed the perfect base to build up our filler structure. The mixtures containing less Evacon R gave improved handling for the final skimmed surface application of the filler and reduced any possible tensions within the underlying and surrounding areas of the artwork piece as the filler cured. To work the surface of our layered structure a wet cotton swab was used to enhance the mechanical adhesion between layers. The final surface could be also worked the same way with help of other tools to flatter the filler.

Bulking agents

Arbocel fibres: these come in different lengths from 700 µm to 200 µm. We used Arbocel 500. This bulking agent can absorb compressive, bending and torsional stresses, which turns it into the perfect matrix for fulfilling the gaps in our current wooden support. The cellulose, in addition to lignin, conforms to the major forming material of the panel and would continue and adapt in the best way the rheological forces the filler will be exposed to. Therefore, the Arbocel cellulose fibres met the requirements and alike the nature of the wooden painting support. The chemical structure of the fibres allows them to expand and contract, adjusting the filler to the gap without applying tension to the wooden support nor the ground layers. Furthermore, these short-staple fibres with high elasticity will prevent the formation of shrinkage and joint cracks on curing and over time.

Aluminium hydroxide: this was added as a bulking material to our formulations designed for surface fills. This addition allowed us to modify and smooth the final surface of the filler after curing. The ratio of the bulking agents have a direct effect on shrinkage and ease of removal. The binding media remains water-soluble, which assists in the removal of excess material aiding the successful levelling of the surface. The refractive index of aluminium hydroxide (RI 1.57) is such that it produces little 'haloing effect' when removing excess from the surrounding original surface. The inclusion of aluminium hydroxide also facilitates the future identification of this intervention as it cannot be chemically confused with the original material used for the ground - calcium sulphate.

Results: Testing Filling Formulations

The first tests exploring the working properties of the Arbocel fillers formulated for the deeper losses revealed the sensitivity of this material to water-based environments. Tests showed that the natural shrinkage of these fibres, as water content is lost, needs to be compensated with a higher proportion of bulking agent in the upper applications. Yet the specificity of our filler

working properties shifted the approach from a bulk filler to a stratigraphic one. Here the layers of the filler were applied in sequential steps, allowing the previous layers to dry prior application of the next one. Thus, a two-step process for filling was employed, with the formulation modified accordingly. Additional aluminum hydroxide was added to create smoother fills. These retained a porosity similar to that of gesso and created a surface on which the retouching media could be applied.

2.3 Reintegration: retouching

The surface texture of the obverse and reverse panel differed subtly. Additionally, neither surface was uniform in gloss. The dominant shifts in gloss on the obverse can be associated with the different typologies of materials used to construct the panel: gilding, tempera paint and oleo-resinous glazes. The differences in gloss on the reverse were less. The decision not to apply varnish after cleaning meant that the surface gloss differences were maintained. A retouching system was required that could be easily adjusted to the gloss of the surrounding area. We required a medium that could be either matt or glossy and did not alter considerably on drying or change colour on ageing. The medium should retain solubility in water or alcohol.

We selected QOR watercolours for initial [7]. These are readily available in a wide range of colours as artistic materials for painters and can be easily modified with the addition of a supplementary binding medium. More importantly, studio formulations can easily be made by dissolving the binding medium in water or water/ethanol solutions to produce a wide range of coloured paints with slightly different drying characteristics. The luminosity and brilliance of the pigments bound in this medium are maintained on drying and matches closely with that of egg tempera. The binding medium of the QOR coloursis Aquazol®.

Aquazol®: this is a synthetic resin, poly(2-ethyl-2-oxazoline), which is available in different molecular weights first produced by Dow® Chemical in the late 1970s. It has a broad solubility in water and polar organic solvents, and retains its solubility over time. It has been used in conservation since the 1990s as a consolidant, adhesive and binder for inpainting [8]. The properties that make it ideal for use as a watercolour binder also make it an excellent medium for retouching. QOR colours (of which there is a range of 83) have been developed by Golden Paints. Aquazol® (variants 50, 200 and 500) is available from most conservation suppliers.

Figure 8 – Retouching tests made it over the previously arbocel tests

The self-formulated binding medium can be easily mixed with dry pigments. Formulations based on water and water/ethanol mixtures can deliver a wide range of paints that produce surfaces with differing degrees of mattness or glossiness. A variety of studio formulations were trialled and in combination with the different typologies of fillers as described above. Results were promising as higher gloss surfaces could be achieved with a higher proportion of binding medium, which matched the surface glance of the oleo-resinous glazes originally applied over gilding, and matter surfaces could be attained by decreasing the amount of binding medium, matching the matter tempera paints. Colour matching could be achieved by selecting and mixing modern pigments with spectral appearances close to those of the fifteenth century.

The visual perception of the painting was deteriorated by several white blanched areas that appeared as halos across the pictorial surface. We tested to improve those aesthetic damages with our in-painting and recover through it the original painting perception while respecting the artwork patina.

3. RESULTS AND DISCUSSION. METHODOLGY: FROM TESTING TO PRACTICE

The same approach was utilised for both the recto and verso of the panel. Treatment was carried out consecutively by three trainee conservators, Christa

Molenaar, Betlem Alapont and María Vicente, as part of their training at SRAL. The three students (all authors in this paper) came from three different University degree programmes, respectively the University of Amsterdam (Amsterdam), Universidad Politécnica de Valencia (Valencia), and Escuela Superior de Conservación y Restauración de Bienes Culturales (Madrid). The three students' time at SRAL studios did not overlap with each other. Test boards and formulations were left for the subsequent student and repetitions of the experiments allowed each student to become familiar and comfortable with the innovative system. Tips and tricks were passed on providing a good base for developing skills and prowess in filling and retouching. The methodology utilised differed from that taught previously to each student in that no varnish was employed that unified the surface gloss and saturation of the paint, nor was filling completed prior to retouching. The lack of varnish proved the most novel challenge as 'mistakes', such as overfills or mismatched colour, had to be removed directly from the original surface. These mishaps could be removed or modified easily with water, which applied in a controlled manner was not dangerous for the original surface. The flexibility of the system allowed different zones to be completed before moving on to other areas. This deviates from traditional filling and retouching techniques where first the former is completed prior to the latter. Dividing the tasks in such a manner allowed for a more holistic approach to the reintegration of the pictorial surface.

4. CONCLUSIONS

This case-designed, new methodology aimed to develop a reintegration system that would be suitable for all five panels. This was considered important as all five panels are part of the same collection and could be exhibited together, as a set or individually, amongst artworks from other times and regions. The fills and inpainting needed to be consistent in appearance, but variable in application, to achieve slightly different surface textures and glosses as a unifying varnish would not be utilised. Each of the five panels presents different aesthetic challenges, and thus creating a single, set formulation was not possible. The formulations were designed to be easily adjusted to achieve as wider range of surface characteristics as possible. The variables considered were stiffness v fluidity, matte v glossy, smooth v rough and dense v porous. These differences were achieved through experimentation and slight modification of the constituent components of the fill (Arbocel, Evacon R, cellulose ether and aluminium hydroxide) and of the retouching system (QOR v dry pigments+medium, dilutent). The study through practical testing and material research managed the successful treatment result visible while contemplating the all five panels back on display. For further testing and research we would like to suggest studying the applicability and stability of the method in larger areas.

The highly skilled retouching technique forced us to master the balance between the dry pigments and colours. This method besides the matteness of the non-varnished painted surface was one of the most challenging matters from the retouching stage, but a perfect case of study for our own personal and professional future references.

This training has been of great value for the students, not only regarding their retouching skills but improving their etiological vision and conservation approach for their further professional careers. The flexibility of the method allowed the trainees to resume cleaning treatments in some areas as a result of a further understanding of the complexity of the composition and the required improvement on those selected sections. Thus, regaining the more likely original appearance of the artwork.

Finally, the unusual workflow and knowledge sharing exercise this innovative project presented should be highlighted. The sharing and active collaborations of all parties involved in the study strengthened the importance and indispensability of practise and skill acquisition, as well as knowledge transmission and communication within the conservation field.

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NOTES

[i] Titles *St. John the Evangelist Drinking from the Poisoned Chalice* (GK84a) and *The Beheading of St. John the Baptist and the Feast of Herod* (GK243), *The Fall of the Rebel Angels* (GK532) and *The Last Judgement* (GK533), Suermondt-Ludwig-Museum, Aachen.

[ii] The severely abraded and damaged condition of this paintlayer supports this assumption.

[iii] The recipe of this combination varied substantially depending onthe needs of each area requiring filling.

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DYES, PAINTS, AND INKS: AN OVERVIEW OF VISUAL COMPENSATION TECHNIQUES IN TEXTILE CONSERVATION

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ABSTRACT

Currently there is no single resource summarizing the different visual compensation methods used in textile conservation. Many techniques are shared through spoken communication, and there is a lack of literature documenting accepted options. The goal of this paper is to introduce common techniques, such as the use of dyes and paints, as well as a less common method, digital printing. The authors discuss when each option is appropriate, addressing their respective color-matching capabilities, workability, appearance when dry, and time and material requirements. Numerous case studies illustrating the use of these methods, with an emphasis on painted fills, are presented. The case studies represent a range of textile types, such as costume, needlework, historic and modern printed textiles, as well as a range of materials, including silk, cotton, and wool. Case studies include examples of visual compensation in areas of stains, patterns, and non-woven structures. The successes and limitations of each method are discussed.

Keywords
Visual compensation; textile paints; dyes; digital printing

1. INTRODUCTION

The use of custom-dyed fills for visual compensation in textile conservation is a widely accepted practice. However, a range of non-dye related materials are available to achieve different levels of integration, while working with a variety of collection types and treatment parameters. These materials range from printer ink to fabric paints and dyes, on substrates ranging from plain weave textiles to paper. The methods employed by textile conservators are primarily communicated orally. There is no literature source explaining the options, when each is appropriate, and their pros and cons. The lack of resources can create a discrepancy in the knowledge of acceptable practices of visual compensation methods. This text seeks to fill that need by introducing a range of methods, exploring when they might be used and why, and illustrating their use through a series of case studies. The authors are located in the United States and acknowledge the materials presented may not be available in other parts of the world.

2. VISUAL COMPENSATION TECHNIQUES IN TEXTILE CONSERVATION

The following is an overview of materials the authors have encountered as visual compensation methods in North American textile conservation labs.

2.1 Dyes

The use of custom-dyed fabrics is the most common form of visual compensation in textile conservation. Dyeing is performed when a specific color fabric is required as either an underlay for visual compensation or a sheer overlay for stabilization, and an Oddy-test-approved commercially dyed fabric (e.g. Kona® Cotton) cannot be found. It is also commonly used on conservation threads, such as hair silk. The dyes used are known and trusted for their colorfast, lightfast, washfast, wetfast, and crockfast natures. The dyes available to the authors are acid dyes such as Lanaset and PRO Sabraset, which are used for silk, nylon, and wool; fiber reactive dyes, such as Procion MX, used for cotton and linen; and Jacquard's Silk Colors, a modified fiber reactive dye.

2.2 Paints

Painted fabrics are a relatively new form of visual compensation in textile conservation. The authors are most familiar with PROfab Textile Paints, fluid acrylic paints [1], such as those sold by Golden, and Pébéo Setasilk Paints.

PROfab Textile Paint (PROfab) is a water-based pigment paint that can be used on all fiber types. It comes in both transparent and opaque varieties. The authors have primarily worked with the transparent paints, finding earth tones (e.g. "camel," "terracotta," "buttercream," and "earth brown") the most successful for matching aged, undyed cellulosic textiles. The consistency of the paint is thick and can be difficult to use for replicating patterns or detail. However, it can be diluted to create a watercolor-like paint that is easier to layer and minimally affects the textile hand. PROfab requires heat-setting with an iron for five minutes to make the paint washfast and colorfast. PROfab Opaque Fabric Paints have passed Oddy-testing. [2] Slight variations in color have also been observed after heat setting.

Golden Fluid Acrylic Paints (acrylic) are lightfast, low-viscosity paints with a high pigment load. They are used widely by conservators in many specialties in the United States. They are water-based and can be used on all fiber types. They dry quickly and do not require heat-setting to make them washfast and colorfast. They are easy to work with, come in a wide range of colors, and can be layered. However, they can produce a sheen, especially when trying to obtain a saturated color, and will result in the textile having a stiffer hand.

Pébéo Setasilk Paint (Setasilk) is a water-based paint manufactured for use on silk and intended to mimic the appearance of dyeing. The paint needs to be heat-set with an iron for four minutes to obtain washfastness and colorfastness (with a 48-hour rest after heat-setting). [3] In the authors' experience, Setasilk paints yield bright colors with little to no effect on the textile's hand. They are not suitable for recreating details.

2.3 Digital Printing

Digital printing is the most recent development in visual compensation for textiles, having been successfully used in textile conservation since at least 2000. [4] Some institutions have contracted out the digital reproduction of fabric within their collection, such as the Metropolitan Museum of Art. [5] It is also possible to perform in-house digital reproductions. In-house printing can be performed using an inkjet printer and a prepared fabric, such as Crafter's Images PhotoFabric (PhotoFabric) or a fabric pre-treated with a resin or coating, such as C. Jenkin's Company Bubble Jet Set 2000 (Bubble Jet Set). The long-term suitability of digitally printed reproduction fabrics is unknown. One of the authors, Kris Cnossen, is in the process of testing the washfast, colorfast, and chemical stability of digitally printed reproduction fabrics.

2.4 Comparing the Options

Each of these options poses unique challenges and advantages. Often the use of more than one technique may be necessary to achieve successful visual compensation. Factors to consider when choosing a compensation method include material compatibility, workability, time and budget constraints, health and safety, and final appearance and hand.

Dyeing fabric for loss compensation is most useful when a medium-to-large amount of fabric is needed, when a specific color of thread is needed, or for toning a sheer overlay fabric, such as nylon net. Some negatives of dyeing are that is takes substantial time (1-2 days), color matching can be difficult and time consuming, and there are health hazards associated with the dyes. Dyeing also requires specific equipment, such as a scale, heat source, and pipettes.

Paints are most useful when creating small fills or when trying to replicate non-repeating patterns or mottled surfaces. Painting is significantly faster than the other compensation methods presented, but it is most likely to affect a textile's drape, making it unsuitable for larger amounts of fabric. Paints are also useful when recreating a pattern, layering designs, or matching wear, stains, or general signs of degradation. The paints presented in this article additionally pose little to no health hazards, and the material requirements are minimal (a variety of brushes and a palette; an iron for PROfab and Setasilk).

Digital printing, if available, is the best option for reproducing complicated designs that cannot be realistically or easily recreated through other means. The amount of fabric printed is limited by the size of the printer, however. While the health hazards of this technique are minimal, there are significant and costly material needs. In order to create a digitally printed reproduction of a historic fabric, high quality photographic and a photo editing software such as Photoshop is necessary, in addition to an inkjet printer. A pre-treated fabric (e.g. PhotoFabric) or a fabric treated with a coating (e.g. Bubble Jet Set) is also recommended. While some commercial printers will perform certain steps in the process, such as photo processing, this can be expensive.

When to use or combine any of these three visual compensation options—dyeing, painting, and printing— must be decided on a case-by-case basis, depending on the parameters of each treatment. It is also important to note that other media and substrates may be appropriate for replicating unique surfaces or patterns, as will be demonstrated in the following case studies.

3. CASE STUDIES

The following six case studies have been chosen to illustrate the range of results one can achieve using painted and printed fills. All of the conservation treatments were completed under the supervision of Laura Mina and Kate Sahmel at the Winterthur Museum, Garden and Library between 2019 and 2021. The case studies involving painted fills were carried out by Annabelle Camp as both an undergraduate and graduate student in conservation. They represent a diversity of not only compensation techniques, but also material and collection types. The case studies presented here include the successful use of acrylic and PROfab paints, watercolor pencil, and archival ink pen on substrates including plain weave cotton, silk habotai, Asian paper, silk net, and needle felted wool.

The digitally printed case study was carried out by Kris Cnossen as part of their graduate studies in conservation and demonstrates success in an understudied area of textile compensation techniques.

3.1 Painted Fills: Pair of Handkerchiefs

Compensation materials used: PROfab on plain weave cotton; Acrylic on plain weave cotton

During the 2020-2021 academic year, an uncut pair of handkerchiefs commemorating the death of George Washington from the collection of Historical Society of Haddonfield, New Jersey served as a student treatment project at the Winterthur/University of Delaware Program in Art Conservation.

The rectangular textile (19 ⅛"H × 42 ¼"W) is a plain weave cotton, copperplate printed using an iron-mordanted dye; it dates to 1800, the year following Washington's death. The proper right print is titled "THE DEATH of GENERAL WASHINGTON," while that on the proper left is titled "THE TEARS of AMERICA." On each print, there is a central circular scene surrounded by boxes of text. The two prints are separated by a ¼" unprinted area where they were likely meant to be cut.

Few extant examples of both prints represented on this piece can be located, and no other example of the two together have been found. This piece provides an important insight into how copperplate-printed handkerchiefs were produced in the 1800s and are key examples of American mourning art in its inception. However, the textile was in poor structural condition due to acidic degradation caused by poor housing and dye degradation. This had led to significant tears and losses, overall weakening of the fibers, and discoloration. The conservation treatment aimed to improve the physical and chemical stability of the object while also improving its aesthetic condition by reducing the overall discoloration and stains, stabilizing all existing tears, and compensating for losses.

The textile underwent a phytate treatment [6], an accepted antioxidant treatment used by paper conservators to slow the autocatalytic degradation of iron-based inks and dyes, which in this textile had resulted in significant "fall-out" of the print areas [7]. The textile was then lined with silk crepeline precoated with a 4% solution of Klucel G. While these steps stabilized the textile, the significant losses were distracting, so it was deemed appropriate to fill the majority of them using plain weave cotton of a similar weave and thread count to the original textile.

This textile required over 50 individual fills, and because the majority of losses were in areas of the printed design, they each needed to be hand painted. Initial test fills were made using PROfab, but the need to customize each fill required multiple modifications, and the repeated heat-setting of the PROfab took significant time.

Following testing of different tracing, stenciling, and painting methods, the following protocol was deemed to have the best and fastest results:

1. Plain weave cotton was toned with PROfab to achieve the appropriate background color and heat set.
2. The fill was cut to shape based on a Mylar tracing of the loss.
3. It was placed in position with a Mylar barrier between the fill and textile, and acrylic paints were then used to paint the design in situ.
4. Once dry, the fill was adhered to the crepeline lining by reactivating the 4% Klucel G with ethanol vapors.

The use of acrylic paints for areas of the printed design allowed for more immediate verification of color matching (as PROfab can slightly shift in color upon drying), faster production (as no heat setting is required), and finer line quality.

However, the hesitancy among textile conservators to use acrylics is their tendency to be plasticky and shiny. This was a problem in two areas of loss where a saturated purple black was required. Achieving such a saturated color with acrylic did result in the fill having a distracting, plasticky sheen. Therefore, in these areas, PROfab alone was used.

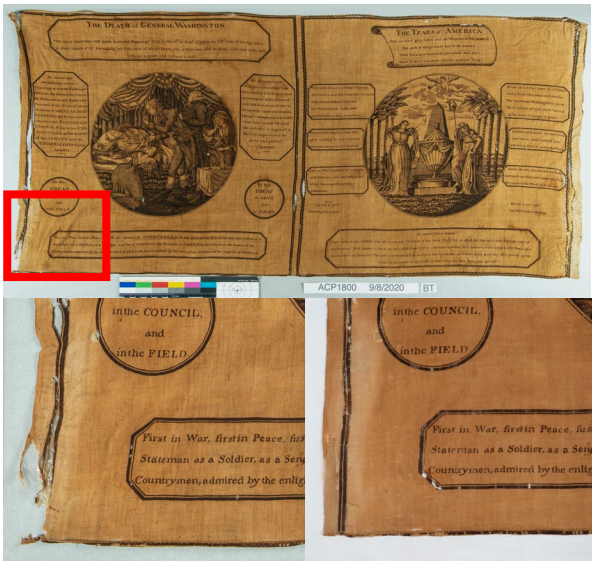

Figure 1 – The textile before treatment (top) with a detail of the bottom left corner before (lower left) and after (lower right) treatment. The Historical Society of Haddonfield, New Jersey 1921-104.

The textile is now visually cohesive with the printed text and imagery legible (Fig. 1).

3.2 Painted Fills: Miniature Pillow Sham

Compensation materials used: PROfab on plain weave cotton; Acrylic on silk net; Liquitex Matte Medium

Similar to the pair of mourning handkerchiefs, the 2019 treatment of a miniature pillow sham from the collection of Winterthur Museum, Garden and Library required the use of both acrylic and PROfab for visual compensation. The miniature cotton pillow sham (4 ⅜" H × 6 ⅜" W) and associated insert were likely made in the museum's former sewing rooms in the 20th century for display on a miniature bed in the Attic Corner period room of the house museum.

The pillow and sham came to the textile conservation lab for treatment due to damages caused by silverfish, which were likely attracted to a stain previously documented on the sham. Grazing had resulted in a loss measuring 11/16" × 3/16" on the front of the sham. Additional losses were present in the cotton bobbin lace edging around the perimeter, although the cause of these losses is unknown.

To compensate for the central loss in the sham body, the following procedure was conducted:

1. A plain weave cotton of similar thread count and weight was chosen and cut to shape using a scalpel following a Mylar tracing of the loss.
2. The fill was painted to match the original textile using PROfab "Buttercream" color and heat set.
3. The fill was stitched in place using hair silk and supported with a nylon net underlay.

While this procedure was successful in visually compensating for the loss in the body of the sham, it made losses in the lace edging more prominent and distracting. To compensate for these:

1. A lace silk net with similar mesh size and shape to the lace was found, painted using "Buttercream" color PROfab fabric paint and heat set.
2. The net was stitched in place as an underlay using hair silk.
3. In the largest area of loss in the lace, the repeating circular pattern was built up on the fill using Golden Fluid Acrylic paint bulked with Liquitex Matte Medium. Once dried, the pattern was made further matte by stippling the acrylic surface with a pin.

The combined result of these two compensation techniques is a visually cohesive sham (Fig. 2).

Figure 2 – The pillowcase before and after treatment. Winterthur Museum, Garden and Library 1964. 2197.001. Image courtesy of Jim Schneck.

3.3 Painted Fills: Patchwork Dog

Compensation materials used: Acrylic and Pigma Micron Archival Pen on plain weave cotton; PROfab on felted wool; Lanaset dyes; Kona® Cotton

During the 2020-2021 academic year, a stuffed animal dog with patchwork covering owned by a private individual served as a student treatment project for the Winterthur/University of Delaware Program in Art Conservation. The

plush hound (11.5”H × 12.0”W × 22.5”L), named “Leonardo,” was purchased at a craft fair in 1973. It is made of printed cotton patchwork over cotton muslin and stuffed with green synthetic filling, estimated to be modacrylic. Additionally, it has felted wool eyes and a copper alloy leash.

The dog had been well-loved. In addition to severe structural damage, such as tears in the tail and back left leg and the loss of interior stuffing, the patchwork exterior had significant losses, with nearly complete losses in patches on the tail and feet. 14 different floral prints were used to create the patchwork pattern, and 38 of the 59 patches required aesthetic compensation.

While the large tears required structural stabilization, the majority of this treatment focused on the restoration of the printed patchwork. The owner preferred a full aesthetic restoration, which allowing for significant experimentation with acrylic-painted fills.

Due to the three-dimensionality of the dog, image capture for digitally printed reproduction fabric would be difficult. Different patches also were unevenly faded. However, it was deemed appropriate to restore the fully printed appearance. Thus, the only option was to hand paint each fill. Acrylic paint was selected due to the wide range of colors available, the ability to layer colors, and their rapid drying time.

The plain weave cotton fills were prepared using the following procedure:

1. An overall background color or tone was achieved using washes or direct applications of Fluid Golden Acrylic paint. For patterns with a black background, the pattern was painted onto black Kona® Cotton, as achieving a saturated black with acrylic alone resulted in a highly stiff textile.
2. Once dry, the patterns were painted on top using acrylic. As necessary, these patterns were replicated using Mylar tracings of the original.
3. Additional patterning was added where necessary using a Pigma Micron Archival black pen and heat set using an iron for five minutes, preferably before acrylic was applied to prevent melting or altering the surface of the paint layer.
4. All fills were stitched in place using hair silk dyed with Lanaset dyes.

Additionally, losses in the dog’s left felted wool eye were aesthetically compensated for using needle felted wool fills toned with PROfab fabric paint, heat set using an iron for five minutes, and stitched in place with cotton thread.

Figure 3 – The patchwork dog “Leonardo” before and after treatment.

While incredibly time consuming, the fill painting process was highly successful in visually integrating the many losses (Fig. 3). Such a level of integration could not have been achieved with other methods available.

3.4 Dyed, Painted, and Penciled Fills: Silkwork Picture

Compensation materials used: Lanaset dye and PROfab on silk habotai; Aquarelle pencil on Gampi tissue

Unlike the other treatments presented, which primarily include cotton fills, the 2020 treatment

of a painted silkwork picture from the collection of the Winterthur Museum, Garden and Library required fills of both silk and Asian paper.

This rectangular silkwork picture (19.5”H × 23.5”W) consists of a plain weave silk ground with cotton support. It depicts a reclining woman beneath trees and a bower in the foreground with a house in the background. The imagery is depicted using silk embroidery, the majority of which is enhanced with paint. Both the sky and the woman’s head and arms are executed completely in paint. The artist used both dry brush and wet techniques. There is an embroidered inscription along the bottom which attributes the piece to Natchez, Mississippi, 1811.

It is a significant piece within the Winterthur collection, as it is a beautifully executed early American embroidery. However, due to its many condition concerns, the piece could not be exhibited. Overall, it was in poor structural condition due to the highly fragile and damaged silk and associated losses and tears, as well as the stained and brittle lining. It was in poor aesthetic condition with distracting staining on the bottom edge and proper left.

Much of this treatment focused on stabilizing structural damages and reducing tidelines and staining. Tear repair was completed using silk crepeline underlays coated with 15% 1:1 Lascaux 360HV:498HV, and tidelines and staining were reduced using a variety of gels and chelator solutions. Once stabilized, the compensation of large areas of loss was deemed necessary for the legibility of the picture.

Losses around the perimeter of the silk were filled in the following way:

1. The losses were traced using Mylar and cut to shape using a scalpel.
2. Fills were cut from silk habotai pre-dyed with Lanaset and further altered or mottled using PROfab to match the remaining stains. The paint also helped diminish the natural sheen of the silk habotai so that it more closely matched the light reflecting properties of the silkwork. All painted fills were ironed following the PROfab guidelines.
3. Fills were adhered to the crepeline underlays already in position from tear repair, and the adhesive was reactivated with an ethanol vapor chamber.

There were also losses in the painted woman’s arm and forehead, which were inaccessible from the back due to the surrounding embroidery. These were filled in the following way:

1. The losses were traced using Mylar and cut to shape using a scalpel.
2. Fills were cut from Gampi tissue and colored with Museum Aquarelle Watercolour Pencils.
3. Where crepeline underlays were possible, the tissue fills were adhered directly to them.
4. Where crepeline underlays were not possible due to the surrounding embroidery, the tissue fills were applied as overlays. Once the appropriate color was achieved with Aquarelle, they were coated with 30% 1:1 Lascaux 360HV:498HV, and once in position, the adhesive was reactivated using an ethanol vapor chamber.

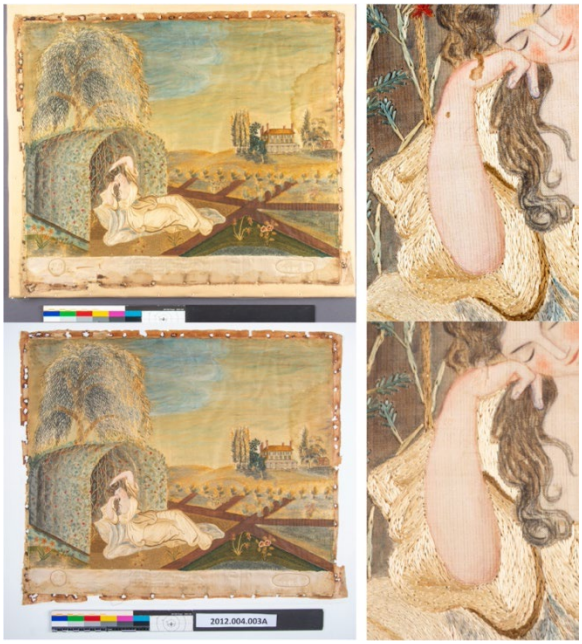

Figure 4 – The silkwork before and after treatment (left) and a detail of the woman’s arm before and after the Gampi tissue fill (right). Winterthur Museum, Garden and Library 2012.0004.003A.

The use of these two different fill materials was necessary to match both the structural and aesthetic needs of this complex textile (Fig. 4). The use of Aquarelle was found to be the most appropriate texture to match the painted face of the figure, while paints and dyes were necessary to compensate for the other areas of the work. This demonstrates the successful marriage of numerous compensation methods in one conservation treatment.

3.5 Digitally Printed Fills: Green Dress

Compensation materials used: Crafter's Images PhotoFabric, C. Jenkin's Company Bubble Jet Set 2000, Epson Sure Color P600 UltraChrome HD pigment ink printer and inks

During the 2020-2021 academic year, an early 19th-century green dress (52" collar to hem; 27" waist circumference; 32" chest circumference; 98.5" hem circumference) with a blue feather print in the collection of Winterthur Museum, Garden and Library served as a graduate student treatment project. The dress had some tears and multiple campaigns of previous repairs. A large and visually distracting repair patch on the proper right sleeve of the dress prompted an investigation into digitally printed reproduction fabric.

The fabric was woven in an alternating opaque and sheer stripe pattern that was dyed with a compound green and printed with a blue feather pattern (Fig. 5). The intricately dyed and woven nature of this fabric made it nearly impossible to replicate due to time, money, and skill constraints.

Due to other cost and time constraints— as well as a belief that developing an in-house printing methodology was needed for conservators— it was decided to digitally print the reproduction fabric in-house. After performing a literature review of in-house digitally printed textiles used in conservation, it was unclear if digital printing would be able to capture the complex nature of the original print, especially the opaque-and-sheer stripes. The saturation and clarity of line were also a concern [8].

Figure 5 – The dress before treatment and with printed fill options for sleeve. Winterthur Museum, Garden and Library 1965.2368. Lower image courtesy of Evan Krape.

The investigation into digital printing began by taking a high-quality image of a pattern repeat and using Photoshop to color correct and ensure the image was to size. Next, two pre-treated textile options were identified: PhotoFabric from a local fabric store and cotton coated with Bubble Jet Set. The Bubble Jet Set allows for more fabric options than the PhotoFabric, so long as the fabric is cotton. The downside to Bubble Jet Set-coated fabric is that it must be attached to a rigid surface in order to go through a printer. The instructions suggest that the coated fabric be ironed to freezer paper, but this repeatedly jammed the printer.

Instead, it was discovered that the Bubble Jet Set-coated fabric could be ironed to the used backing paper from the PhotoFabric. This makes the Bubble Jet Set option less easy to use than PhotoFabric. The primary downside to the PhotoFabric is that it only comes in one fabric choice: cotton poplin.

Using the PhotoFabric and Bubble Jet Set-coated fabric, 4" × 4" samples of the reproduction fabric, or strike-offs, were printed to test the color, drape, and hand. It was found that the PhotoFabric was easier to use than the Bubble Jet Set-coated fabrics and created a successful visual match to the original fabric, even though the PhotoFabric is cotton poplin, a thicker, more opaque fabric than the original sheer and opaque striped fabric.

Based on this success of finding a visually appropriate fabric digitally printed in-house, Kris Cnossen is currently researching the suitability of four different digitally printed fabric options: two contract (Spoonflower and Dyenamix) and two in-house (PhotoFabric and Bubble Jet Set-coated). The suitability is being assessed via washfast, crockfast, and Oddy tests, as well as solid-phase microextraction followed by gas chromatography-mass spectrometry method (SPME-GCMS). The results of this research will be published in collaboration with Miriam Murphy, Textile Conservator at the St. Louis Art Museum, in an upcoming issue of the Journal of the American Institute of Conservation.

4. CONCLUSION

This article presents a handful of successful cases using painted and printed fills in textile conservation. These techniques have been proven to yield a wider variety of results, often in less time than accepted custom dyeing practices, especially when used in combination with other techniques, such as paper, archival ink, and pencil. They are materials and methods that should be added to every textile conservator's toolkit.

However, this area is ripe for further testing and experimentation. Although current research suggests textile paints are safe, [9] [10] further aging tests of textile paints and printing inks should be conducted to confirm these findings and better understand their long-term compatibility with objects.

Additionally, many of the materials used in these case studies are taken from other conservation specialties, such as Golden Fluid Acrylics, Gampi tissue, and Aquarelle pencils. It is possible that there are other materials suitable for the aesthetic compensation of textiles utilized by other specialties that are yet to be explored by textile conservators.

Moving forward, the authors will continue to expand on the materials and methods presented here to properly meet the visual compensation needs of each textile treatment as they arise.

MATERIALS LIST

C. Jenkin's Company Bubble Jet Set 2000: Proprietary fabric coating applied to silk and cotton to make them suitable for inkjet printing.

Crafter's Images PhotoFabric Cotton poplin fabric with paper backing for at-home inkjet printing.

Epson Sure Color P600 UltraChrome HD pigment ink printer and inks: Professional-quality photographic printer and associated pigment-based printing inks.

Golden Fluid Acrylic Paints: Lightfast, low-viscosity acrylic paints with a high pigment load. Manufactured by Golden Artist Colors.

Hair Silk: Fine silk thread.

Klucel G: Non-ionic thermoplastic adhesive (hydroxypropylcellulose), soluble in ethanol and water.

Kona® Cotton: Plain weave, solid color cotton. Manufactured by Robert Kaufman.

Lascaux 360HV: Thermoplastic acrylic resin composed of water-based dispersion of butyl acrylate and methylmethacrylate thickened with acrylic butylester. Dry film is slightly tacky and can be used as a weak pressure-sensitive adhesive or reactivated with acetone, ethanol, glycol esters, toluene, or heat (50–55°C). This is no longer available and has been replaced by Lascaux 303HV. Manufactured by Alois K. Diethelm, Switzerland.

Lascaux 498HV: Thermoplastic acrylic resin composed of water-based emulsion containing butyl acrylate thickened with methacrylic acid (40% solids). It can be thinned with water; the dry film is insoluble in water but soluble in acetone, ethanol, glycol esters, toluene. Manufactured by Alois K. Diethelm, Switzerland.

Liquitex Matte Medium: Acrylic paint additive. Manufactured by Liquitex

Mylar: Clear, colorless thermoplastic film of polyethylene terephthalate. Produced by DuPont.

Nylon Net: Lightweight nylon netting with hexagonal meshes.

Pébéo Setasilk Paint: Thin, flowable, water-based paint designed for use on silk. Manufactured by Pébéo.

PROfab Textile Paint: Water-based pigment paint manufactured for use on textiles.
Manufactured by PRO Chemical and Dye.

Silk Crepeline: Sheer, lightweight, plain weave silk
Silk Net: Lightweight silk netting with diamond meshes.

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RETOUHING MURAL PAINTINGS IN HYPOGEUM: PRELIMINARY STUDY AND FIRST RESULTS

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ABSTRACT

This study was carried out during the ICR conservation project involving two of the mural paintings of the Saint Peter and Paul's hypogeum in Matera. Retouching mural paintings preserved in such a peculiar environment as hypogea is not an ordinary operation. In these contexts, relative humidity approximating to 100% makes hygroscopic materials less durable, favouring biological growth on them. In addition, severe climatic conditions can lead to a fast degradation of retouching materials. Watercolours, extensively employed for retouching mural paintings, are not completely recommendable in such humid environments, so a research was planned to find a compatible and alternative binding media. A study was carried out on laboratory samples to select the most suitable binding media among the following: two synthetic resins, Laropal A81 and Regalrez 1094, and two natural products, Funori and arabic gum. Each binder was blended with two different pigments. For each binder four different dilutions were tested, in order to find out how these factors could have affected the analysed properties. These products have been investigated in relation to their optical properties, wettability, vapour and water permeability, resistance to salt crystallisation and bioreceptivity. Some tests were repeated after an artificial ageing process, based on cyclical alternation of humid-cold and dry-hot exposure conditions. In addition to the laboratory tests, some in situ applications were performed. Amongst four binders, Regalrez 1094 showed the best results. Nevertheless, its bioreceptivity and applicability issues make necessary to continue and develop further research.

Keywords
Hypogeum, reintegration, Laropal A81, Regalrez 1094, Arabic gum, Funori.

1. INTRODUCTION

The Saint Peter and Paul mediaeval church is one of the most ancient hypogeum in Matera (Southern Italy). On

this site, completely carved into the local calcarenite, the XIII century church was erected and named after San Francesco d'Assisi. The church and the hypogeum are connected only by a narrow manhole, placed in one of the chapels of the upper church. A series of stairways allow visitors to reach the underground rooms where some noticeable frescoes, dating back between the XIII and XIV century A.D. [1] are preserved.
These frescoes were made according to the traditional mediaeval technique of rupestrian paintings.
The constitutive materials have been studied through analytical investigations [2]. The paint layer was applied on a single lime-based plaster (average thickness of 1 cm). The artist used a poor palette of colours, mainly based on earth-pigments.
This paper describes the 2021 preliminary study of retouching materials for intervention on two of these fresco paintings, during a thesis work at Istituto Centrale per il Restauro (ICR). Both paintings showed a severe lack of image integrity, due to the extensive loss of paint and plaster layers, to such an extent that a reintegration treatment had to be carefully planned.

Hypogea are characterised by peculiar environmental conditions which strongly affect restoration treatments; they are generally dark places, with high humidity levels and often subjected to water condensation phenomena. These conditions are favourable for the growth of certain types of microorganisms, such as streptomyces [3]. In some cases, karstic phenomena may occur and determine the formation of calcitic encrustations [4]. Other damages can be caused by the alteration of the microclimatic stability, due to air circulation or to visitors' presence. The permanence of visitors increases carbon dioxide concentration and consequently that of carbonic acid [5]. In addition, visitors can be vehicles of spores and microbiological contaminants that can colonise rocky and painted surfaces [6]. Hence, before the intervention in Ss. Peter and Paul hypogeum, microclimatic and biological surveys have been performed. The one-year monitoring survey revealed that the hypogeum has 97-99% relative humidity and a minimal seasonal temperature variation due to a considerable thermal inertia (14-20 °C). Finally, the microbiological survey demonstrated the lack of a vital microorganisms colonisation.
These stable conditions can be easily altered by the introduction of new materials so the selection of the intervention products should be properly done. When choosing the suitable binder for colour reintegration in hypogea some important factors have to be considered:
1) high humidity level requires a binder with both good permeability and water resistance;
2) the humid environment, favourable for microorganism growth, requires products scarcely sensitive to biological attack;
3) health issues for operators: toxic solvents and products should be avoided in environments with low air exchange;
4) short chain alcohols can activate a microorganisms colonisation [7,8,9].
A bibliographic survey demonstrated that there is no tested and traditionally used material for retouching in hypogea and that the most commonly used binders belong to two different categories: natural polysaccharides polymers and synthetic ones. Several documented treatments (from 1976 to 2020) show that watercolours have been widely used, despite their high sensitivity to humidity and biodegradability. As they tend to fade or turn colour [10] in a short time because of severe climatic conditions of hypogea, from the 90s onwards, restorers have experimented with alternative solutions. More recently, the use of pigments dispersed in pure water, in biocide products or in water lime have been documented, as well as the use of synthetic resins, like urea-aldehyde polymer contained in Gamblin Conservation Colors.
Furthermore, the bibliographic survey did not reveal any scientific study about the long-term behaviour of retouching products in the peculiar climatic conditions of hypogea.
Therefore, an experimental study was carried out to test four binders, selected among the others for their properties or for their tested use even in retouching mural paintings: two natural polysaccharide polymers (Arabic gum, Funori) and two synthetic resins (Laropal A81, Regalrez 1094).

2. MATERIALS AND METHODS

2.1 Materials

As generally known, natural organic binders commonly used for reintegration and based on polysaccharides are less resistant to water effects and biodegradability than synthetic resins solutions. The latter, on the other hand, could form an impermeable film and are often dissolved in solvents that should be avoided in a hypogeum environment, both for healthy and conservative issues.
The binders tested during this experimental study were selected taking into account issues related to the

described environmental conditions and the bibliographic data concerning the most used binding media in past interventions.
It has been established not to investigate commercial formulations because some of them can contain additives. In addition, self-made colours obtained from raw binding materials, made it possible to dissolve them in the proper solvent and to choose the suitable concentration for each binder.

Laropal A81 is an urea aldehyde resin, recently used in the field of retouching of mural paintings. Its water insolubility [11] makes this product suitable in contexts with high humidity levels. The temperature of glass transition (Tg= 57°C) is higher than that commonly detected in hypogea [12]. Moreover, the adjusted mixture of powder colours and Laropal A81 gives back a matt surface [13], comparable with the optical features of frescos. A wide range of solvents can be used to dissolve this resin [14], allowing the selection of the less toxic for the restorers and to avoid the alcoholic ones, able to stimulate the formation of microbial colonization.

Regalrez 1094 is an aliphatic resin mainly used as varnish for easel painting. There is not a wide bibliography concerning its use as binding material [15], but its scarce sensitivity to water made it a potential binder to be used in environments with high presence of moisture. Its Tg value (33°C) is lower than that of Laropal A81, but still higher than temperature values commonly detected in hypogea. Its refraction index is higher than that of Laropal A81 [16], producing a transparent veil similar to watercolours. Regalrez 1094 ensures stability and reversibility with the solvent in which it has been dissolved, as proved in previous studies [17,18].

Funori is a polysaccharide obtained from a natural seaweed, mostly used in the consolidation treatment of mural paintings [19,20,21] and as a binding material [22] due to its gluing properties. As it produces matt films [23] and resists to yellowing [24], it is also suitable for the reintegration of matt surfaces. On the basis of its proven good resistance to biodegradability, this product was selected for the experimental study [25]. This polysaccharide was extracted by raw seaweed and purified according to the method developed at Tuscia University [26].

Arabic gum is a natural polysaccharide used in the formulation of watercolours. It is the most widely used product for retouching mural paintings. Hence it was tested to work as experimental reference for the evaluation of the behaviour of the other binders.

Each binder was mixed with two different pigments: Ultramarine blue and Burnt Sienna. These two pigments are included amongst the twelve selected by the ICR for retouching wall paintings [27]. In addition, this choice makes the reading of comparative colorimetric measurements easier: the blue facilitates any yellowing and bleaching detection, while the red earth makes any colour changes more evident.

The binder/solvent ratio, as shown in table 1, was established considering the lowest amount of product necessary to obtain a sufficient cohesive strength of the paint film and suitable optical and handling properties.

Table 1 – Binders/solvent ratio of the tested binders.

Binder	Proportion %	Solvent
Laropal A81	**30**	**White Spirit D40/ Ethyl-lactate (1:1)**
Regalrez 1094	**30**	**White Spirit D40**
Funori	**2**	**Water**
Arabic Gum	**10**	**Water**

Each binder solution was blended with pigments in four different volume ratios: 1:1, 1:2, 1:3, 1:4.
All the binders were applied on a lime mortar layer which had a similar composition to that of the original plasters previously determined by analytical investigations.

The supporting plasters of the analysed wall paintings are made of air hardening lime and calcareous sand and therefore they are very similar to each other. The petrographic study with a polarising light microscope on thin sections revealed the size of the clasts (ranging from 150 to 400 μm) and the binder/aggregate ratio which show an abundant use of lime rather than aggregates. According to this result, the mortar of the experimental samples was realized with lime and calcareous sand, in a 1:2 mixing volume ratio.

2.2 Methods

The scientific research was aimed at testing the behaviour of each binder when put in environmental conditions simulating the ones present in hypogea.
The following properties were investigated:

- optical properties by colorimetric measurements
- hydric behaviour by contact angle measurement and wet sponge test
- salt damage resistance by salt crystallisation test
- bioreceptivity

All measurements and tests were performed in a controlled laboratory environment (20°C and 55% RH). Unless the salt crystallisation test, they were carried out before and after artificial ageing in a climatic chamber (CH250 CLIMATEST ARGOLAB). Alternated 6 hour cycles of cold/humid (T=13°C and R.H.=90%) and hot/dry (T=26°C and R.H.=60%) simulated and intensified the real environmental condition. UV light ageing was not performed, because photochemical degradation was considered negligible in a hypogeum environment.
Each sample underwent 900 hours of T/RH artificial ageing.

2.2.1 Colorimetric measurement

Measurements were carried out by means of a Minolta® CM700d spectrophotometer. A template was prepared to be applied on the sample before the measurement, in order to repeat the test at the same point before and after the ageing. Measurements were also performed on films made of pure binders without pigments, applying them on a transparent slide of glass.
The modifications that occurred on the surface were taken as an indicator of the microscopic alteration.

2.2.2 Contact angle

Wettability is a necessary information when selecting a binder to be used in an environment with relative humidity values close to saturation. The interaction between a drop of water and a material reveals a hydrophilic or hydrophobic surface. The wettability of the painted films was investigated by contact angle measurements, according to NORMAL-33/89. The acquired images were processed with Angle Metre 2.0 software.

2.2.3 Wet sponge test

Wet sponge test was performed according to the UNI 11432 standard to evaluate if the selected binders applied on a sample allow the transfer of liquid water. Some test procedures were modified:
- the dimension of the sponge was reduced to better match the samples (2,7 cm diameter and 0.85 cm in thickness).
- Samples were not conditioned at 60 ± 2 ° C, as recommended by the standard because the integrity of the films could have been compromised at that temperature. Therefore the imposed conditions in the climatic chamber were: 23 °C of temperature, 50% of relative humidity.
According to the results of some preliminary tests, 1 ml of water was introduced in the sponge and the contact pressure was applied for 1 minute. The sponge was changed after approximately 40 measurements.

2.2.4 Vapour permeability test

Vapour permeability test was performed following the UNI EN15803 2010 standard to evaluate if the selected binders allow the transfer of water vapour.
The test cup vessel was filled with a 30% potassium nitrate (KNO_3) solution, leaving a 1.5 cm gap between the sample and the surface of this solution. The potassium nitrate, dissolved in demineralized water, keeps constant the relative humidity value at 93.2%. Before the test, samples were conditioned in a climatic chamber at T 23 ± 1° C and R.H. 50 ± 3%. The water vapour amount flowing through the sample was evaluated by measuring the weight differences of the sample-holder system over time. The stationary condition was reached when the curve in the weight/time diagram assumed a constant slope passing through the last five points of measurement.
Two batches of samples were consecutively analysed: firstly, NOT COATED samples (NC), i.e. the plaster itself, and then COATED samples (C), i.e. the same plaster coated with a paint layer applied by brush.

2.2.5 Salt resistance test

Salt resistance test evaluated the pictorial films resistance to salts disintegration. This test did not follow specific standards, but it was designed by mixing procedures from different standards: capillarity absorption (UNI EN15801), vapour permeability (UNI-

EN 15803) and salt ageing resistance (TC Rilem 127-MS).
Samples were prepared as follows: a 1 cm thick layer of mortar was spread on a 5 × 5 × 4 cm stone block; the different selected binders were applied over the dried mortar.
Each sample of mortar, after being sealed on the four side faces with an impermeable strip, was placed in a container, with the film facing upwards and the underlying stone immersed for 3 cm in a solution of sodium sulphate (3% of conc.). The surface of the saline solution was sealed with oil, in order to force the evaporation of the solution only through the sample surface, where the crystallisation of the sodium sulphate necessarily occurred (Fig. 1).

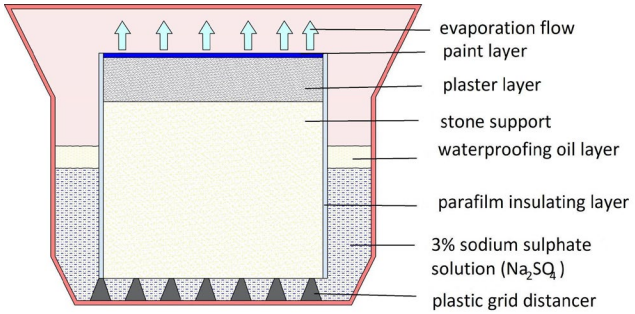


Figure 1 – Scheme of the sample-holder used for the salt resistance test.

The described system was placed in a climatic chamber at controlled humidity and temperature conditions (20 ° C and 50% RH). Throughout 2 weeks, the weight variation of the system was measured at 24 h intervals, in order to obtain an indirect measure of the solution evaporation rate. After each weighing, the surface of the sample was dusted, removing the crystallised salts on the surface and part of the disintegrated film. After this operation, the system was weighed in order to determine the loss of material due to the salt damage.

2.2.6 Bioreceptivity

The bioreceptivity test evaluated if the pictorial films favour the microorganisms growth. This test consists in exposing the samples to the airborne contaminants present in the crypt, placing each sample horizontally on the floor. *S*amples were monitored every week for four months. During this period, any biological growth was detected and photographed.
At the end, all samples were carefully observed under a stereomicroscope equipped with a digital acquisition system.

3. RESULTS AND DISCUSSION

3.1 Colorimetric measurement

Colorimetric measurements performed on pure binders showed that Arabic gum, Laropal A81 and Regalrez 1094 have similar colorimetric coordinates (Tab. 2). Funori is less bright than the other binders and tends to have a yellow tone.

Table 2 – Colorimetric coordinates of pure binders applied on glass slides.

Binder	L*(D65)	a*(D65)	b*(D65)
Laropal A81	**88,60**	**1,59**	**-3,50**
Regalrez 1094	**88,92**	**1,60**	**-3,49**
Funori	**84,98**	**0,76**	**0,10**
Arabic Gum	**88,42**	**1,43**	**-2,65**
glass slide	**90,08**	**0,77**	**-3,57**

Table 2 – Colorimetric coordinates of pure binders applied on glass slides

When Funori is mixed with pigments and applied on mortar samples, its chromatic coordinates are comparable to those of Regalrez 1094 and Arabic gum binders' pigmented films. Laropal A81 films are darker than others, confirming technical literature results [16] (Tab. 3).

Table 3 – L*a*b* coordinates of the four selected binders registered for 1:1 mixing ratios blue films.

Binder	L*(D65)	a*(D65)	b*(D65)
Laropal A81	**34,91**	**22,16**	**-63,46**
Regalrez 1094	**41,15**	**16,34**	**-63,01**
Funori	**44,23**	**15,10**	**-63,35**
Arabic Gum	**41,78**	**16,92**	**-63,42**

After artificial ageing in the climatic chamber, no visible chromatic changes were detected on any of the binder films, since ΔE values were always below the human eye limit (ΔE<3). The accelerated ageing

process did not chromatically affect the pigmented binder films applied on mortars.
Anyway, natural binder films have suffered considerable morphologic alterations: Arabic gum films cracked and detached from the underlying glass slide, while Funori films folded.

3.2 Contact angle

This analysis highlighted the hydrophilic behaviour of films obtained from natural binders (Arabic gum and Funori). On these films, no contact angle values were registered as every water drop was immediately absorbed. On the contrary, the synthetic binders showed an opposite trend due to their chemical nature. In fact the acquisitions carried out before ageing gave back an evident hydrophobic behaviour for both Laropal A81 and Regalrez 1094 resins, although limited to the samples with a binder/pigment mixing ratio of 1:1. The water drops on the surface produced contact angle between 75° and 105° for the former and between 86° and 100° for the latter resin. After ageing, there was an increase in the water repellence of both synthetic resins (Fig. 2a). Specifically, it was noted an increase in the Laropal A81 hydrophobicity: in particular, in 1:1 dilution, contact angle increased considerably, up to 120°. Regalrez 1094 also showed a general increase in water repellence after ageing (Fig. 2b). While in the 1:1 samples the drop persisted on its surface with a contact angle between 100° and 120°, the higher dilutions were characterised by less hydrophobic behaviour and every water drop was immediately absorbed.

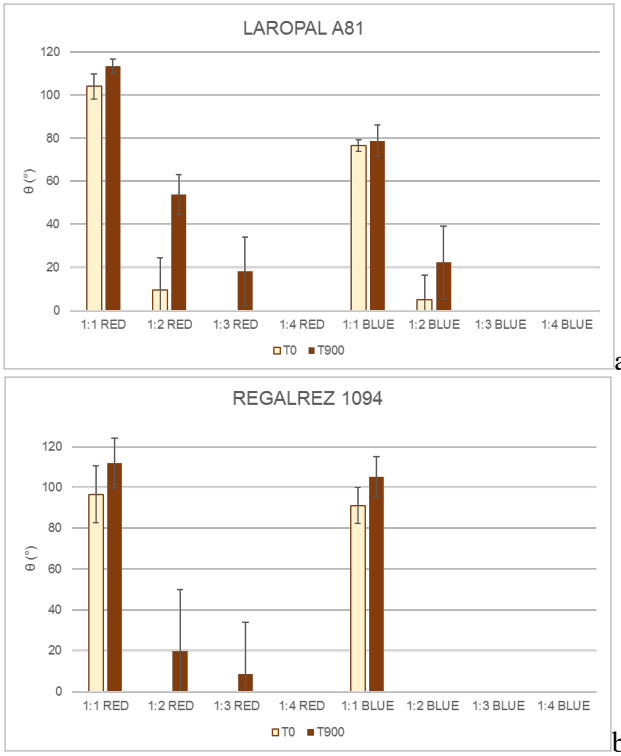


Figure 2 a,b – Laropal A81 (a) and Regalrez 1094 (b) contact angle (θ) before (T0) and after the artificial ageing (T900).

3.3 Wet sponge test

The wet sponge test demonstrated that all films are permeable to liquid water, especially in higher dilutions (Tab. 4). Regalrez 1094 produced the most permeable film. UR-T ageing caused a general increase of the absorption coefficient (Wa).

Table 4 – G*- Arabic Gum, F*- Funori, R*-Regalrez 1094 L*-Laropal A81 –Absorption coefficient Wa (g/cm^2 x s) before (T0) and after the artificial ageing (T900).

	T0		T900	
Binder	**Burnt Sienna**	**Blue**	**Burnt Sienna**	**Blue**
G*_1:1	**0.83**	**2.03**	**4.01**	**11.48**
G_1:2	**0.98**	**2.47**	**5.67**	**2.47**
G_1:3	**0.95**	**1.81**	**5.86**	**8.01**
G_1:4	**1.96**	**1.69**	**7.86**	**11.83**
F*_1:1	**1.61**	**2.81**	**4.05**	**2.72**
F_1:2	**3.32**	**2.58**	**5.65**	**5.57**
F_1:3	**3.36**	**3.80**	**7.13**	**7.16**
F_1:4	**12.54**	**1.39**	**7.68**	**4.55**
R*_1:1	**1.14**	**0.46**	**12.43**	**12.45**
R_1:2	**1.15**	**4.78**	**22.74**	**12.96**
R_1:3	**1.10**	**6.28**	**16.81**	**26.73**
R_1:4	**1.13**	**10.73**	**19.29**	**22.84**
L*_1:1	**0.69**	**0.82**	**0.83**	**1.78**
L_1:2	**0.51**	**1.89**	**2.65**	**1.97**
L_1:3	**0.60**	**1.25**	**3.35**	**3.90**
L_1:4	**0.58**	**4.73**	**7.86**	**4.54**

3.4 Vapour permeability test

Permeability test detected no significant differences in permeability values between natural and synthetic binders (Fig. 3). Coated samples (C) showed permeability values similar or slightly lower than those of not coated (NC) ones.

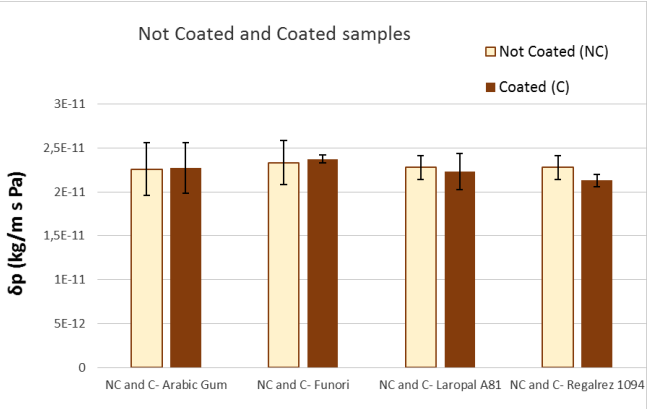
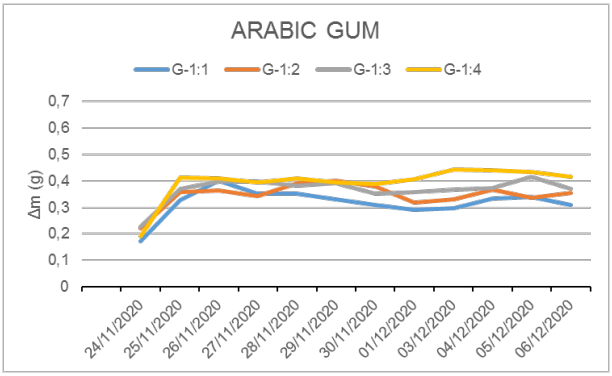


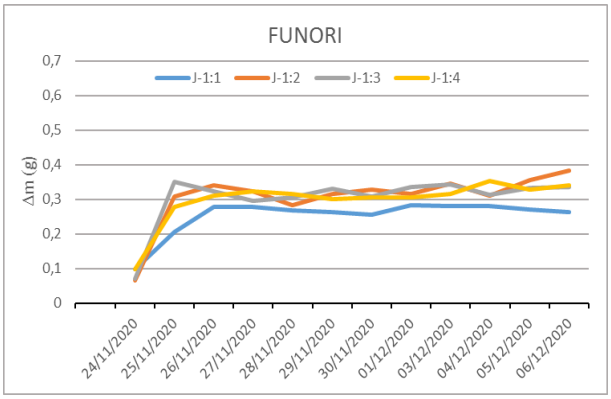
Figure 3 – Permeability (δp) of NC and C samples.

3.5 Salt resistance test

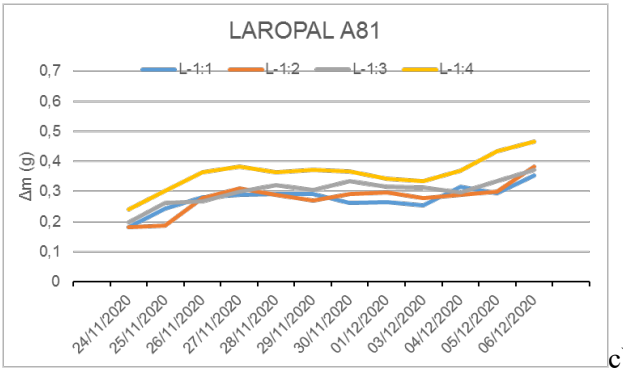
All films in all the tested dilutions allowed the transfer of the salt solution through the samples and, as a consequence of its evaporation, salt crystallisation on the surface. The higher the dilution the higher the amount of material disintegrated by salt: 1:4 lose more weight than 1:1 dilution films. Anyway, synthetic resins showed an overall material loss which was higher compared to natural binders. (Fig. 4 a, b, c, d)



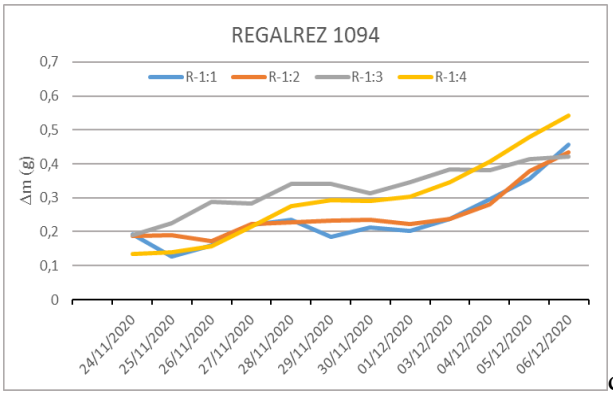
a)



b)



c)



d)

Figure 4 a, b, c, d – Weight loss (Δm) over time of Arabic gum(a), Funori (b), Laropal A81 (c) and Regalrez 1094 (d) samples due to sulphates disintegration.

3.6 Bioreceptivity

The growth of microorganisms was observed and documented on natural binder film surfaces already after 1-month exposure in the hypogeum. After two months, microorganisms also appeared on Laropal A81 and Regalrez 1094 films. Dilutions directly affected the extent of microorganisms presence, as a higher quantity of binder corresponded to a higher microbial growth on the surface (Fig. 5). Among all the selected binders, Regalrez 1094 showed the lowest microorganisms spread on the samples surface.

4. CONCLUSIONS

In conclusion, the above-mentioned experimental results showed that all the tested binders (Arabic gum, Funori, Laropal A81 and Regalrez 1094):

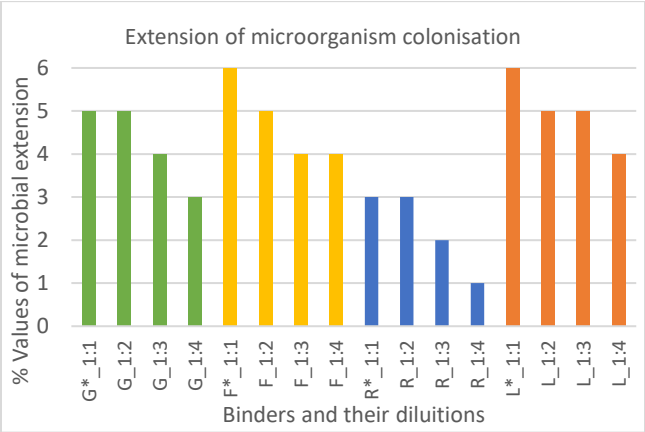


Figure 5 – Extension of microorganism growth on the films surface, expressed as percentage of colonized area: (1 = <10%; 2= 20-30% =2; 3 = 30-40% = 3; 4 = 40-50% = 4; 5= 50-60%; 6 = 50-60%); G*- Arabic Gum, F*- Funori, R*- Regalrez 1094, L*-Laropal A81 – (%).

- have good chromatic stability;

- do not interfere with the transfer of liquid and vapour water;

but:

- are bioreceptive, although at different degrees.

Regalrez 1094 showed the best performance, both when blended with Ultramarine blue and Burnt Sienna. However its bioreceptivity (the lowest compared to the other binders) makes it unsuitable for applications in hypogea. In addition, Regalrez 1094 presented some technical problems when applied on the humid mortar of the crypt: it created a not uniform painted surface and tended to form translucent stains all around the film borders.

Concluding, none of the tested binders is suitable to retouch mural paintings in hypogea. However, further research is needed to improve Regalrez 1094, which showed the best experimental results. Specific biological inhibitors and rheological modifiers that could overcome the handling issues of this product can be designed in future research. For instance, a new formulation should be identified combining Regalrez 1094 with the advantages of a biological growth inhibitor product (i.e. silver nanoparticles or Biotin R1+R2), that does not significantly alter the binder properties.

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ASSESSMENT OF CHROMATIC REINTEGRATION TECHNIQUES AND MATERIALS WITH SIMULATIONS ON MOCK-UPS: THE EXAMPLE OF A POLYCHROME GLAZED CERAMIC PITCHER FROM THE COLLECTION OF THE NATIONAL MUSEUM OF SLOVENIA

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ABSTRACT

The glazed ceramic pitcher no. N11519 from the National Museum of Slovenia collection presents empirical research and approaches to conserving damaged paintings by testing conservation materials and various reintegration techniques. Studies of specific pigmented retouching paints describe the retouching practice of glaze-like retouching paints. They have been a part of the diploma thesis entitled *Ways of reintegration the missing polychrome painting on ceramic pitcher* at the Academy of Fine Arts and Design, University of Ljubljana, majoring in Conservation and Restoration of Fine Arts. The reintegration assessment intends to present multilayered paint effects on chromatic reintegration of a large area of reconstructed painting on a ceramic pitcher. A silicone mold was made in the selected area of an extensive paint loss for reintegration samples, from which gypsum casting mock-ups were formed. The practical determination of the chromatic reintegration was to simulate the stratigraphy of the paint layer and the in-glaze method of decorating the pitcher: a white underglaze over which a polychrome painting with overglaze was applied.
The practical goal was to get close to the original painting's color, structure, and texture with differing application modes in lines, dots, liquid strokes, and surface smoothing. The chromatic reintegration tests of a glaze painting were perceived with varied and comminated approaches to applying retouching paint media to gypsum mock-ups. This can be achieved by meticulous scrutiny to review and evaluation a medium in the appropriate solvent. The mock-up assessments showed that the most suitable for the glazed pitcher is chromatic reintegration with dotted hatched, using the retouching colors with urea-aldehyde resin Laropal® A 81. The researched methods and the technique of chromatic reintegration on a ceramic pitcher were presented in the exhibition *In Good Hands: 60 Years of the Department of Conservation and Restoration of the National Museum of Slovenia* (Fig. 7).

Keywords
Restoration; Chromatic reintegration; Materials and techniques; Mock-up testing; Glazed ceramics; Aldehyde resin Laropal® A 81.

1. INTRODUCTION

1.1 The issues of chromatic reintegration

Reintegration might be considered an intervention in the painting concept of a work of art in the color, content, and compositional or spatial conception. Through this research, the National Museum of Slovenia searched for recent materials for the most suitable methodology of

chromatic reintegration on polychrome glazed ceramics. We focus on principles and ethical aspects to find suitable materials and techniques for chromatic reintegration. The development of chromatic reintegration in various retouching media and types of modeling techniques and brush strokes depend on the extensive paint losses. The way of trade with damaged paintings is based on the current understanding of the profession's recommendations, awareness, experience, and technical capabilities that improve the visual impact of the work of art on the general viewer. Despite the greater choice of different retouching paint media to use in conservation-restoration, in some instances, it is difficult to choose the suitable medium and method that would also suit aesthetically. Through practical research about how we retouch paintings, was treated questions on how to preserve the artistic value, aesthetic and historical value in combining material and immaterial aspects with subject-specific and non-subject-specific information. [1]

Due to the technical and technological complexity of the original painting, insufficient material analyses, problems of compatibility of materials and mixtures ratios used, or the very purpose of reintegration, we are often forced to prefer an alternative solution for chromatic reintegration.

1.2 Condition description of the ceramic pitcher no. N11519 before the procedure

The pitcher is decorated in Florentine high renaissance style. The central scene on the pitcher shows the biblical story of Sodom and Gomorrah. It could be classified from the first half of the 18th century until the beginning of the Neo renaissance period in the second half of the 19th century after copying this style was typical. In the faience painting technique, it is usual to build polychromy on a white underglaze, usually in a tin glaze. Microscopic analysis of the paint layer stratigraphy confirmed that the original painting technique was based on the technology of making faience. Before the intervention, several areas of the pottery had paint losses. The most damaged part of the pitcher was the glazed painting, which had cracks over the entire surface and deviated slightly from the ceramic base (Fig. 1). The cracking of a glaze on a fired pot is called crazing—the result of the glaze shrinking more than the clay body in the cooling process. Due to the damage position, a mechanical crack-up through the thump is an assumption on the most convex area of the belly. The pitcher has been conserved and restored in the past, but that has not been documented. Especially noticeable is the larger reintegration on the foot of the pitcher and the traces of gypsum plaster on the contact between the foot and the belly.

Figure 1 – Photo documentation of the ceramic pitcher with inv. No. N11519 before the procedure - the front side with the central painting scene (left) and the side with the paint loss (right).

2. MATERIALS AND METHODS

2.1 The aim of the research with preliminary reintegration mock-ups

Empirical tests of conservation-restoration materials and techniques on the glazed ceramic might be harmful and ethically inappropriate. Therefore, gypsum was used, casting mock-ups for this purpose. To ceramic objects, mock-ups could be copies of a lost part in their entirety or only one element for educational purposes. In our case, mock-ups were made as a reproduction of a segment with a quite significant loss of paint layer on the ceramic pitcher. It allowed technical and methodological approaches, in addition, to reconstructing paints of great optical complexity with a subtle color range. These examples involved the optical gamut from transparent to semi-opaque resin paint media; they require some form of hatched or stippled

application. Rigger brushes with narrower and longer bristles are mandatory to paint fine lines, dots, and detail to reintegrate the lined and dotted hatching techniques. On this wise, was analyzed the visual effects of reintegration and thus selected the most appropriate solutions.

The gypsum mock-ups were made by casting silicone rubber on the pitcher's surface with extensive paint loss. This procedure was decided due to the successful consolidation of the surrounding paint layer of ceramics, as otherwise, the surface could be further damaged. This required comprehensive consideration because of the lead and tin-glazed earthenware production craze. A solution of Paraloid™ B 72 in ethyl acetate has effective penetrating properties and gives an accurate refractive index.[2] Due to the matte appearance of the dried consolidate, the procedure didn't change the brightness and color depth of the glaze painting[i].

Figure 2 – Casting the silicone rubber on the field of the selected surface's damage for making gypsum casting mock-ups.

Before the silicone rubber casting process, the selected field of the damaged painting was further coated with microcrystalline wax, which served as a barrier between the object and the casting materials. The wax was dry superficially removed from the surface after a few minutes. With the help of restorative plasticine positioned on the pitcher's surface as containment walls around the damaged part, the shape of the sample mock-ups was determined when casting the silicone rubber (Fig. 2). After the silicone negative had dried, gypsum was poured even so with the help of plasticine containment walls around the negative to imprint the imitation of the pitcher's damaged painting.
For probationary tests, was made ten gypsum castings. The silicone mold could be helpful in further trials, but the flexibility and elasticity of silicone rubber are questionable in the long run[ii].

The gypsum casting process enabled an accurate low relief imprint of the damaged painting for surface reconstruction. The latter allowed the transfer of repetitive motif patterns in a 1: 1 ratio to the original painting. The contour reconstruction of the painted motif was made by mirroring the decoration from the preserved part of the ceramic body. For this purpose, the thermoplastic foil was heated with a heat gun and placed on the surface of the gypsum mock-ups to achieve the desired concave shape. The contour of the loss motif was drawn on thermoplastic molding foil directly from the pitcher and then transferred through perforation to the damaged area of mock-ups. (Fig. 3).

Figure 3 – Reconstruction of loss motif on a thermoplastic foil to transfer the motif on gypsum mock-ups and the ceramic pitcher.

2.1. Selection of retouching paints and solvents

To imitate the glaze appearance of a painting, a greater color depth of retouching paints is required on ceramics.

Synthetic resins with adequate pigments seem to be the most suitable inorganic materials, as they are resistant to degradation over a more extended period and are more durable. [3][4]. We had several concerns when choosing the suitable material. The product's main ingredients are usually given, while smaller components (stabilizers, plasticizers, emulsifiers, etc.) that perhaps significantly impact long-term stability are rarely mentioned. It is more difficult to obtain complete data on a typical polymer's formulation and properties. Products composed of polymers of the same class can change their properties with the production processes depending on the polymerization used (with additives, solvents, etc.).[5] As a rule, the selection follows those approved and published in professional, scientific papers as suitable for conservation-restoration purposes, which we took into account when choosing materials for the reintegration process. The used materials were compatible with the original and the input materials of the previous conservation-restoration intervention.

The Kremer® Retouching Colors palette, which was tested in the chromatic reintegration of the ceramic pitcher, is similar to the Gamblin® Conservation Colors. They differ in that they give the surface a glossier appearance in the final look. Kremer® Retouching Colors are industrially prepared paints based on photochemically stable urea-aldehyde resins with the trade name Laropal® A81[iii]. Laropal® A 81, produced by BASF, is a synthetic resin dissolved in a mixture of petroleum distillates. Laropal® A 81 belongs to a group of low molecular weight resins whose optical properties are similar to a refractive index to glaze and color depth of the painting. It is often well enough to relate the properties of dispersed pigments and retouching media. The solution selection and ratios of resin determine the color and transparency matching. The retouching paints have good covering power and are easily removable. They are suitable for all types of reintegration techniques. Lower or medium polar solvents are used for diluting such paints. Solvents such as xylene, ethyl lactate, and isopropyl alcohol have assessed this approach to find the appropriate gloss for the color. We used them to evaluate the solubility of such solvents (alternatives are available).

The process solves a restoration treatment of the re-solubility of underlying layers by applying a new layer when building up retouching. Therefore, it has had to develop that lightness of touch needed for successful working with such media. To describe the retouching practice of hatched or stippled application differing layering modes, was assess preparations with the Laropal® A81. Suggested working properties are associated with different solvent-resin-pigment formulations. However, they involve a procedure without the final varnish of the retouching. The appropriate finishing layer was obtained with the chromatic reintegration itself.

The solvent xylene (a common solvent as a paint thinner), ethyl lactate, and isopropyl alcohol (fewer toxic alternatives) were used, showing that the xylene was used to compare and assess the visual difference between the surface gloss and light reflectance. The resin solutions have been established by using (e.g., turquoise fluid color), and thereby the aesthetic consequences for dried films have been finally analyzed.

To perform the procedure of chromatic reintegration, it's essential to have adequate and stable lighting for the reintegration to match the polychrome glaze of the enameling pottery. It adapts to the optical properties and color temperature of the light at which the object is exhibited (i.e., exhibition light). We used photographic light to set color temperature values since various light temperatures in restoration workshops appear visually different from exhibition spaces. This was important when retouching in a turquoise glaze colorant, where the effect of metamerism with variations between a more warm or cold hue is more pronounced[iv].

The transparency of the paint application to dry paint depends on the refractive index of pigments and binder, granulation, and pigment concentration. These parameters also depend on the amount of light reflected from the surface. When searching for suitable pigments for chromatic reintegration on the pitcher in question, was used pigments similar to those used in the original painting. Most pigments correspond to historical ones, both in pigment granulation and composition. We started from traditional pigments, which corresponded to the initial period and are useful for painting ceramic products.[6] (Table 1)

The hue, color strength, and opacity or transparency are noticeably dependent on our ability to disperse the paint medium. In doing so, some pigments may be coarser-grained or lack the required degree of transparency. They

often need a larger amount of sorption capacity of binder, which can cause premature usually yellowing. Their transparent ability varied between concentrations from pigment to pigment—the stratigraphy of the original layers conditions the use of translucent or covering paints. The paint may be covering the substrate while being translucent in the last layer. The smaller the pigment grains, the greater the degree of transparency and closer to each pigment's optimal size. Inorganic pigments with larger prime particles and a higher reflective index give more opaque paints. Since each pigment has a different binder requirement, depending on the amount of pigment or its specific weight, we see advantages in using such retouching paints. [7] [8] The choice of material has been determined, considering hue, saturation, brightness, texture, smoothness, thickness, and refractive index.

Table 1 – The Kremer® Retouching Colors in Laropal® A 81 were used for:

Brown paint:	**1st layer** it. natural hay (4040092);	**2nd layer** it. natural umbra (4061292)	**3rd layer** manganese black (4750092)
Turquoise paint	**1st layer** malachite (1034592), titanium white (4620092);	**2nd layer** cobalt turquoise (4576092), spinel black (4570092);	**3rd layer** green earth from Verona (4082192), burnt umbra (4070092).

Yellow paint	**1st layer** titanium white (4620092), it. gold ocher (4022092)	**2nd layer** Neapolitan yellow (4312292)

2.2. Chromatic reintegration techniques

The variable chromatic reintegration on the trial area of mock-ups followed the stratigraphy of the pitcher's polychrome paint layers. On the in-glaze, the underglaze-painting with the overglaze finish was built on the lead-enameled glaze, which requires a third firing[v]. [9] This was intended to mimic a layer of translucent glaze, which is essential for the traditional technique of making faience pottery. Therefore, for the chromatic reintegration assessment, all mock-up fields were first painted brown, also in hatched or stippled technique, to imitate the ceramic base. Then followed the imitation of white tin-enameled underpainting, painted in three layers with calcium carbonate (no. 5849092) and cream white (no. 4600092) of Kremer® Retouching Colors in 20% (w/w) solution of Laropal® A81 [10] with a combined technique of lined and dotted hatching technique.

Due to the optically specific turquoise tone, the basic color, especially in the upper layer of the painting, was mixed on the palette concerning the age signs in the glaze and cracks on the surface. Firstly, we look for the appropriate tone for damages to the painting, while in the second, we look for light and tonal differences of the parts of the painting from the surroundings for each damage separately. The preparation of the samples was followed by the central part of the assessment, which included the application of glaze turquoise and yellow tones for the background technique on mock-ups in a liquid application, dashing, dotting, and combinations used as a base or undertone to mimic the motif.[11] Depending on the artwork, this reintegration assessment might be used in different paint application techniques to suit finishing coats. In the case of a minor loss field alone, this methodology pushes the damage into the background of the painting.

To achieve a glossier surface was tried to smooth the reintegrated surface with the heating spatula over the siliconized foil. The shades were applied to the trial area of gypsum mock-ups in short strokes with minimal color input. We perform tests of gliding the resin paint media accurately leveling with the original level of the painting (Fig.4, 4th row). With which it merged as it would if the surface were sealed. Alon, this technique noticeably reduces the visibility of the damage (Fig.4, 4th row).

3. RESULTS AND DISCUSSION

3.1 Results

The assay of chromatic reintegration in lines, dots, fluid strokes, and combinations was assessed with gypsum mock-ups. In chromatic reintegration of the surface damage on several mock-ups (Fig. 4), the stain painting technique in an appropriate transparent tone, we tried to imitate the painted motif and improve the readability of the original painting. The reintegration mimics the glazed appearance of the painting by increasing the medium concentration and completely imitating the motif. By imitating repetitive decorative grotesque motifs with stylized birds and plants, we faced an issue

of the re-solubility of underlying layers on applying a new layer when building up retouching and have had, therefore, to develop that lightness of touch needed for successful working with such media. This has been considered to the surface properties of a layered motif have been painstakingly modeled, especially as they relate to reflection direction and strength. The reconstruction of the motif was performed with fine modeling strokes, which gradually restored the appearance of the whole with the original surface. In the line hatching technique on probation mock-ups, the overlying paint layer follows the method of applying the technique in the direction of the brush strokes of the painting. In the dotted hatching technique probations, the construction of the reintegrated paint layer is shown with minimal color input in lighter and slightly cooler color tones.

The retouching paint was applied with fine short strokes without unwanted melting of the lower coats despite using the same solvent. Full coverage or different levels of transparency to a fluid color was achieved by adding the appropriate viscosity of the medium. Slightly more time for investigation and assay is required to find the suitable gloss that matches the appearance of the overglaze on the original painting.

With the addition of diluent solvent Laropal® A81, we could maneuver the final appearance of the gloss of the retouching paint. This considers the evaporation of the solvent and the drying time, which vary from color to color. When using a faster-evaporating solvent with higher polarity, in our case, isopropyl alcohol, the application usually is faster. The strokes of the brush are sharp while being the final appearance of dried paint semi-glossy or matte. With lower or medium polar solvents, solvent evaporation is slower, allowing greater flexibility of use. The latter allows us a longer time interval from preparation to applying paint. The brush strokes are softer, and the paint dries longer and gives a higher sheen to the surface. Ethyl lactate has proven to be a suitable solvent for diluting aldehyde resin-based paints, as it allows uniform application of paint and retouching of colors on the palette. The sufficient concentration chosen to achieve the appropriate gloss of the paint was already at a ratio of 20% (w/w) solution of Laropal® A81 in ethyl lactate.

Figure 4 – The results of chromatic reintegration testing on mock-ups: (1st row) transparent and glaze appearance of the color and motif in a stain painting technique. (2nd row) Color and motif reconstruction in line strokes to a hatched or stripped approach and (3rd row) in a dotted hatching technique. The smoothed surface of the color reconstruction (4th row) the achieved with a heating spatula and siliconized foil.

In the hatched or stippled technique, the pointillistic effect of the color reflection and final gloss can be adapted by applying resin paint due to diffuse reflection.

When searching for an appropriate solvent, it was visually assessed that xylene didn't significantly increase the gloss surface intensity compared to ethyl lactate. In addition, it has the advantage of being an organic solvent that is biodegradable and non-toxic. [12] It has low surface tension, which allows even application of paint and preparation of retouching color on the palette[vi].

The practical experience proved that isopropanol is suitable for less sheen glazed surfaces.

The mock-up probation appears that the most suitable for the glazed ceramic is chromatic reintegration with dotted hatching. By arranging the dotted structure in warm-cool and dark-light contrast color tones and increasing the medium concentration, it was possible to achieve the multi-layered paint effects of the glazed painting. The chromatic reintegration was in such a manner successfully carried out on the ceramic pitcher (Fig. 5).

3.2 Discussion

The use of the Kremer® Retouching Colors combined with, e.g., urea aldehyde resin Laropal® A81 seems practical in museum work and handling. The study encourages the preparation of paints according to the ceramics period in advance. It makes sense to treat objects systematically, observe them in the longer term, and reduce measures to reach quality approaches with minimal interventions. We often encounter aesthetically disturbing color and tonal changes in the museum practice of previous reintegration of ceramic objects. The dot or line hatching technique supports the ability to correct a retouch and improve the tone-altered reintegrated fields that aren't removed. In the appropriate color groups, their appearance might be improved and unified with the original surface of the paint layer with a repetitive stroke. The reintegration approach with the lined and dotted hatching technique seems to be the most appropriate process, as it is perceived as the optical effect of warm and cold and lighter and darker color strokes. The completed part of the chromatic reintegration should look slightly cooler and lighter than the surrounding color of the original. As a rule, first, a cool and then a warm tone of paint is applied. With application by superposition, the paint layers are placed one on top of the other until their right color effect is achieved. The wise of additive application, the appropriate color tone according to the glaze colorants is mixed on a palette and then applied as one layer. This procedure is not solely about the original structure but also about the temporal appearance corresponding to the original surface. Ideally, the reintegration matches the construction of the surrounding paint layer [13].

The surface appearance, texture, transparency, and gloss are essential in matching the paint layer's glaze colorants on the artwork. Using a hatched or stripped technique, the surface differs slightly from the original smooth and gloss of the glaze in structure and texture. Especially the nature of the painting of the pitcher requires a high sheen of a reintegrated surface. Therefore, the resin's refractive index is critical in the final appearance of the chromatic reintegration. The characteristic of the film was determined by the glass transition temperature (Tg), which is essential when choosing a binder that acts as a final varnish of the chromatic reintegration.

During our initial testing of different paints and varnishes based on acrylic, alkyd, and aldehyde resins, which were further diluted, if necessary, they proved the weakest fitting in integrating the loss polychrome painting of glazed ceramics. To adjust these according to the National museum's requirements. We research commonly used materials for pigmented retouching paints of glazed ceramics and adapt them. Included in the reintegration assessment was Epoxy resin Araldite® CY 220-1 served primarily as a reintegration varnish for Liquitex acrylic color, as it was intended to mimic the final transparent lead overglaze. This method cannot melt the lower layers or be removed separately from reintegration. There is a change in the color brightness and visual effect after applying a final varnish on the retouch. It changes the turquoise tone to a warmer and brighter hue, making it hard to predict. Despite numerous trials of the turquoise hue, we were unsatisfied with the results. The same development of the turquoise tue we had from fluid to dry paint with Amsterdam's water-based glaze color. Still, according to the experience of experts in the museum, they are photochemical instability (not light-fast and consequently turn yellow quickly).

For reintegration of turquoise fluid color, the dotted hatching technique was also used in the low layering to mimic the in-glaze of decorating pottery, instead of perhaps a visually more appropriate fluid application to execute. For a liquid appearance of the applied paint, retouching color from the bottle with the tip of the needle was added and mixed with enough resin to correspond to a lubricating and enough transparent solution. Before the paint at the palette dries, a minimal addition of a diluent is sufficient. Thus, simultaneously reducing the possibility of premature yellowing or discolorations of reintegration. Still, concerns about the long-term behavior of modern retouching are reduced if they are sandwiched between isolating, and the long-

Figure 5 – Chromatic reintegration of the large reconstructed area with multilayered paint effects of the painting on a ceramic pitcher.

Figure 6 – The-reintegrated missing painting on the ceramic pitcher.

term properties of those varnish layers are known. The physical function of such retouching is to form a temporary resin film, while the content identity of the retouching media may change through interaction with pigments. The reintegrated painting on the ceramic pitcher is mainly based on additive mixing of pigments in the finishing layer (excl., varnish layer.).

In reintegration with glaze appearance in a stain painting technique, we are usually forced to paint the motif in one go, which means we don't have many chances for corrections. Unlike the dot or line hatching technique, upgrading the painted motif is possible. The latter allows for current and subsequent modifications or revisions to complete reintegration and imitates the overglaze decoration of the pottery more accurately. We had more time planning the application method and scrutinizing the applied paint's visual effect during the work.

Figure 7 – The researched methods and techniques of chromatic reintegration on a ceramic pitcher presented as a part of the exhibition *In Good Hands*.

4. CONCLUSIONS

Conservators-restorers have slightly different retouching techniques and application modes, even within a single institution such as the National Museum of Slovenia. The conservation-restoration practice in

the museum; by using retouching paints, the mimetic reintegration or tratteggio is the most often used on ceramic. Therefore, we were attentive to an intervention of chromatic reintegration, which would differ only to a small extent from the original painting of the ceramic pitcher. In the preliminary research on mock-ups, we decided on the most suitable method of chromatic reintegration on the museum's pitcher. Through the dotted hatching technique and urea-aldehyde resin paints, we agreed on the approach to the motif of the original painting accurately (Fig. 6).

Preliminary tests on mock-ups significantly reduce the possibility of reintegrations misapprehending the original. Although conservators-restorers often haven't enough time for such comprehensive and systematic mock-up assessments, it makes sense in the case of important artifacts when introducing new materials and techniques or improving conservation skills. However, it is essential to point out that retouching additions to the missing parts of the subject are intended to recreate the artist's work. Still, simultaneously they might perceive them as the individual conservator-restorer's interpretations. In connection with deciding what to exhibit and how an exhibition should affect us, the theme of reintegration reflects the current prevailing museum exhibition policy, which may change over time.

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NOTES

[i] In general, we would, in the process, obtain a slightly higher stickiness with a lower Tg of the consolidation.

[ii] K31 silicone rubber, which hardens with the additives of 2.5% C88 catalyst or Tixo-Quick.

[iii] Laropal® A81 is a condensation product of urea and aliphatic aldehydes. Based on the surface appearance properties, a possible alternative also might be Laropal A ® 101 or Laropal® A-8L.

[iv] The light on the transparent reintegration penetrates to the depths (i.e., deep light) where it is partially absorbed.

[v] Lead glaze becomes opaque by the addition of tin oxide.

[vi] The industry pigment preparations are combined with the medium by grinding with a small palette knife or ground glass muller on the ground glass surface.

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THE VOLUMETRIC AND CHROMATIC REINTEGRATION OF HYDRAULIC MOSAICS: COMPARISON BETWEEN FOUR DIFFERENT TECHNIQUES

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ABSTRACT

The mosaic made of hydraulic tiles, is an architectural coating with a significant decorative importance, characteristic of both modernist and Art Deco architectures.

This technique appeared in France in the decade of the 1860s, spreading all over Europe with great rapidity, and with a remarkable impact until the beginning of World War II.

The decoration with hydraulic mosaic is based on the use of tiles made of compressed cement, adorned with intense colours and a glossy appearance.

After been used for more than a century, many of these decorations are in need of an immediate intervention. As they are serialized and mass-produced elements, their volumetric and chromatic reintegration becomes easier. Non-interventional procedures are not usually acceptable, as they often have pavement function.

In this work, four different restoration techniques have been compared. Starting from inorganic binders, we have proposed 1) white cement / silicate mineral paint; 2) acrylic resin / paint and 3) epoxy resin / paint. Last, reintegration tests were made on marble stucco using a combination of plaster, pigments and animal glue.

The results of these four systems were compared with the ones obtained from the traditional hydraulic mosaic, paying special attention to gloss, hardness, and porosity. As the goal is to choose the most appropriate technique applied to Cultural Heritage, its behaviour was tested through two accelerated aging tests. On one hand, a group of test samples have been exposed to the penetration of salts by capillarity, very common in pavements. On the other hand, the samples were placed in a climatic chamber with the aim of accelerating its aging, exposing them to humidity, heat and UV radiation.

These tests have made possible to know the potential of each of these materials and their suitability for volumetric and chromatic reintegration.

Keywords
Hydraulic mosaic; Hydraulic tile; Mortar; Conservation and restoration; Architecture.

1. INTRODUCTION

Hydraulic mosaic refers to a decorative technique based on compressed mortars, used for covering floors in the second half of the 19th century and the first half of the 20th [1]. Its main characteristic is a top face with a very fine texture, showing a glossy finish [2].

This decorative technique associated with architecture was chosen, and sometimes even designed, by the architects, since they usually have an important aesthetic impact. For all these reasons, its conservation and restoration requires a careful examination.

1.1 Beginnings and evolution of the hydraulic mosaic

In an aesthetic sense, the hydraulic mosaic is heir to the Roman geometric mosaic [3] but, in its technical aspect, the first predecessor of the system that concerns us are the tiles made 'al banchetto'. It is a traditional technique that appeared in Italy in the 18th century, in which a portion of natural cement was compressed into a wooden mould with the help of a mallet, to subsequently apply a coloured paste with a spatula and then burnish it. This technique produced irregular and relatively fragile pieces, not being used regularly in noble spaces [1, 2]

The hydraulic tile as such, emerged in France around 1860-1870 [4], spreading rapidly to Spain and Belgium. This decorative technique jumped from Europe to the old colonies, rooting strongly in Latin America and North Africa [5].

This type of floor expanded greatly until the early 30s, due to its low manufacturing cost, the simplicity of the production process, the possibility of making almost unlimited motifs and its ease of laying. After the Spanish Civil War, and World War II, its use was limited to an industrial level, but with a loss in aesthetics, seeking much simpler functional designs [5].

At the end of the 1950s, this system was gradually replaced by granite mosaic and terrazzo. In the 1960s, the production of hydraulic mosaic in Europe had practically disappeared, being only preserved in North Africa and Latin America [5]. At the beginning of the 21st century, traditional hydraulic pavement began to be valued by interior decorators.

1.2 Manufacturing process

As has been said before, this decorative technique is based on the manufacture of tiles through the compaction, in a press, of a series of sand and Portland cement mortars

The hydraulic mosaic is composed of three layers: the "pastina" (also called colour or finish) that forms the decoration, an intermediate layer called "seca" ("brasague" or fine), and the main structure of the tile formed by the "baña" (also named "gros", mix or backing) (figure 1). The mentioned "pastina", is the most superficial layer that forms the drawings and provides a glossy finish [1, 6].

First, the artist prepares the design in shape and colour of the pieces. Afterwards, the industrial artist chooses

Figure 1 – Surface and stratigraphy of a hydraulic mosaic

the most suitable quantity of pigments and prepares a trepa, an instrument that allows the different colours to be separated within the mould.

For the preparation of the colour or pastina, the pigment and cement are mixed dry in the desired quantity. Although the mixing can be done manually, it is recommended to mix it in a ball mill. González-Novelles [3] indicates proportions of between 5-12.5% of pigment in the cement. Gray cement is usually added, but for light colours it is necessary to use white cement.

Once the cement is coloured, fine sand is added to it in a proportion of 2,5 parts of coloured cement and 1 part of sand. The proportion of water must allow the mixture to be fluid enough to fill all the spaces of the trepa, but not exceed the absorption capacity of the seca. Excessive moisture in this layer causes problems both in manufacturing (blurred lines and difficulties in demoulding) and in aging (less hardness and greater ease of exfoliation) [1].

The seca is a mixture of fine sand and cement in a proportion of 20-30% sand in 70-80% cement. If a thicker sand is used, it can be applied at 50:50. The baña is also prepared dry, with 1 part of Portland and 4 or 5 parts of sand [1].

Once all the components have been prepared, the base of the mould is placed on the press.

Then, the frame is placed and a release agent is also added. Inside, the trepa is fixed and each space is filled with the corresponding colour pastina. Next, the trepa is removed and the seca is sprinkled on top [2]. This aims to absorb the water from the pastinas, preventing the lines from becoming blurred and sticking to the sides of the mould, although an excess of it can generate exfoliation problems already mentioned [1]. Subsequently, the baña is added and it is levelled, to put the cover on the mould and insert it into the press.

Once compacted, the piece is carefully removed and stored while the components harden (figure 2).

Many manufacturers air harden the pieces, although for a high-quality mosaic, it should be aired for a couple of hours, then left submerged in water for three or four days. The pieces are then removed from the water and moistened, often for another three or four days. Finally, they harden for the necessary time, around 20 to 30 days [1].

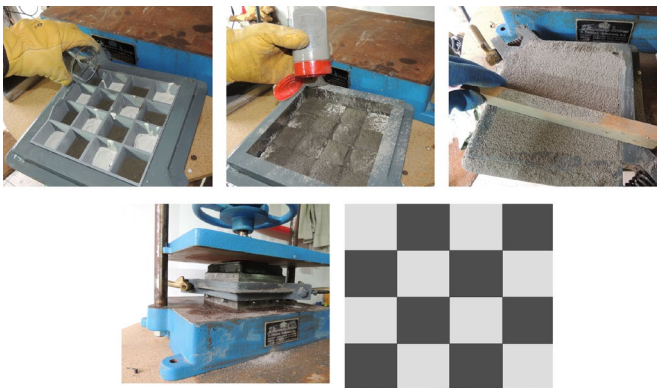

Figure 2 – Hydraulic mosaic manufacturing process

The simplicity of its production and its versatility led to the appearance of a large number of manufacturers, which generated variations both in its production method and in the final quality of the product. This especially affected the selection of pigments, which were not always suitable, as well as the process of pressing and curing of the pieces [1].

In the field of conservation and restoration, these materials have been intervened following methodologies designed for the recovery of ceramic tiles, which is not always the most appropriate.

2. MATERIALS AND METHODS

This research analyzes the use of four different techniques for the reintegration of hydraulic mosaics, these techniques have been chosen so that the volumetric and chromatic reintegration contain the same binder in order to improve the compatibility of both processes.

The following materials have been tested: white cement mortar and sol-silicate paint mixed with inorganic pigments, stucco and polychrome based epoxy resin with inorganic pigments, resin and acrylic paint, and inlaid marble stucco. For the tests, hydraulic mosaic fragments from the Mosaic Factory brand have been chromatically reintegrated.

For reintegration with white cement mortar and sol-silicate paint, firstly, it was reintegrated volumetrically with a Valderrivas CEM II/A-L 42.5 R. white cement mortar and Arija GRS05 sand, in a 1:3 ratio. For the chromatic reintegration, white sol-silicate paint from the Losung commercial brand was used, mixed with inorganic pigments.

For the epoxy-based reintegration, in the first place, it has been volumetrically reintegrated with a saturation mixture of matte plaster and Epofer EX401 resin, with its E432 catalyst in a 100:32 ratio, both from the Feroca commercial brand. Once hardened, the chromatic reintegration has been carried out with inorganic pigments agglutinated with this same resin.

For the acrylic-based reintegration, the volumetric part has been executed with Jesmonite AC100 resin with a powder-to-liquid ratio of 2.5:1. The chromatic reintegration was executed with acrylic paint from the Amsterdam range of the Royal Talens brand.

In the intervention with marble stucco, the volumetric and chromatic reintegration is done at the same time, since the pigment is applied “en masse”. First, the mixture of plaster (Iberyola E33) and Zurich bone glue (CTS) with the predominant colour of the tile is prepared. The polishing process begins, in which this phase is alternated with the application of an increasingly finer grout. 120, 200, 400 and 600 granulometry sandpapers are gradually replaced. At this point, the areas to be coloured are reduced and filled with the appropriate mass. Then the polishing process continues with granulometries of 800, 1000 and 1200. Once completely dry, the samples have been protected with a coat of 8% beeswax in turpentine essence.

2.1 Gloss and colour measurement

To quantitatively control the colour and its possible changes, a 3NH brand NR10QC colorimeter was used, with the observer at 10º and Illuminant D65. The colour measurements have been carried out under the UNE-EN 15886 standard [7]. As indicated, the measurements are expressed through three values (L*, a* and b*) marking coordinates in the CIELAB space. To evaluate the colour changes, the following formula has been applied:

$$\Delta E_{ab}=[(L^*_a-L^*_b)^2+(a^*_a-a^*_b)^2+(b^*_a-b^*_b)^2]^{1/2}$$

Concerning to Cultural Heritage interventions, a perceptible change is considered by the human eye when ΔE>3 [8].
To control the gloss level, a 3NH model YG60S gloss meter was used, with a measurement angle of 60º.

2.2 Accelerated aging

For this investigation, a controlled environment chamber has been used that pretends to approach the conditions described in the UNE-EN ISO 11341:2005 standard [9]. As a base, a 40x25x20 cm glass terrarium has been employ, which has been protected on its sides with insulating foam and, on its lower and upper part, with a ceramic tile. The heat sources applied are: an 8W Heat Mat heater and two 100W Ceramic Heaters, all from the commercial company Exoterra. For the incorporation of humidity, the Reptile Fogger from the Inkbird company, an ultrasound-based humidifier, was used. The chosen radiation is of a 25 W Reptile UBV 200 bulb, also from the Exoterra commercial house, which has been chosen due to its high level in UV between 390 and 440 nm. To control the different values, the digital thermostat/hygrostat controller of the Reptiland commercial house was utilized, which activated or deactivated the different elements according to the values inside the chamber. This construction has provided an UV-visible type light, a temperature of 50ºC with a fluctuation of ±5ºC and a relative humidity of 80% with a fluctuation of ±10%.

Four 10x10 cm hydraulic mosaic samples have been prepared, which were reintegrated chromatically and volumetrically with the different techniques to be tested, to expose them to 300 hour cycles inside this device.

2.3. Salts absorption by capillarity.

Another set of 10x10 cm samples has been prepared to which a 5cm cement mortar base has been added. These, have been subjected to a salt absorption test by capillarity based on the works of Zornoza [10], and Rodríguez-Navarro and Doehne [10]. To do so, the lower part of each sample has been introduced into a container with a capacity of 500 mL, and a 25% p/p solution of NaCl poured in distilled water. The container was sealed using a molten paraffin, forming a layer of approximately 2 cm.

Figure 3 – Comparison of the behaviour of the reintegration in acrylic and silicate base

Once sealed, the water has no choice but to pass through the porous system of the sample, dragging its high salt content with it. The evolution was observed in a period of 15 days.

3. RESULTS AND DISCUSSION

The reintegration with white cement and silicate paint, turned out to be the most compatible technique, as it is based on a silicate matrix, just like hydraulic mosaic. However, aesthetically the finish is completely matt.
The reintegration with epoxy resin presents high hardness but shows an excessively glossy result and it is difficult to adjust the colours, especially the light ones, since the resin provides a base colour.
The reintegration with resin and acrylic paint is simple to execute. The resin provides a suitable colour and texture for the chromatic reintegration and the paint has a satin finish.

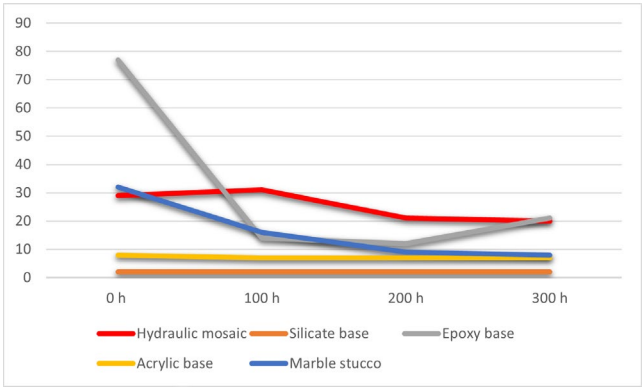

Figure 4 – Changes in brightness during accelerated aging. Gloss Units (GU) versus time (h).

Inlaid marble stucco is the slowest execution technique but provides the hydraulic mosaic a characteristic shine and allows an adequate colour palette.

After the test of salt absorption by capillarity, we found two differentiated behaviours, the most porous materials (marble stucco and cement mortar) allow transpiration similar to the original part, appearing saline efflorescences on the entire surface of the sample. On the other hand, the most impermeable materials (Epoxy and acrylic) concentrate all the efflorescence in the original areas, leaving these intact (figure 3).

Through accelerated aging, the future behaviour of different materials can be estimated. The gloss measurements (figure 4) indicate that the marble stucco presents the most similar behaviour to the hydraulic mosaic, both in gloss level and in aging. The epoxy resin has a very irregular finish, with measurements varying greatly from one point to another. The acrylic base is the most stable material in terms of gloss but shows much lower values than the hydraulic mosaic.

Contrary to the brightness, considering the colour, the behaviour of the different techniques has been very similar between them. The reintegration with cement mortar and silicate paint has suffered a slight alteration ($\Delta E>3$). The other techniques have had an adequate behaviour, highlighting the acrylic base as the most stable one. Next, the measurements corresponding to the red colour in the different techniques are shown (table 1).

Table 1 – Colour alterations after the accelerated aging process (red colour)

		Silicate base	Epoxy base	Acrylic base	Marble stucco
0 h	L*	42,66	36,62	30,1	39,86
	a*	27,66	22,2	12,25	25,5
	b*	16,66	13,59	5,43	18,51
100 h	L*	41,9	38,46	29,82	38,83
	a*	27,32	23,72	11,7	25,91
	b*	17,19	15,3	4,59	19,01
200 h	L*	43,45	37,66	29,41	40,25
	a*	26,92	24,04	11,78	26,46
	b*	16,33	15,96	4,38	19,93
300 h	L*	44,71	38,15	29,83	40,8
	a*	25,61	23,31	11,57	26,61
	b*	15,27	15,18	4,18	19,81
ΔE 0-300 h		3.21	2.47	1.44	1.95

4. CONCLUSIONS

Once analyzed the results of the tests, inlaid marble stucco is the one that provides the most satisfactory result, especially due to its level of gloss, very similar to that of hydraulic mosaic. It also has the advantage of mass producing and resisting future polishing. The disadvantage of this technique is its slow execution, which can hinder large surfaces restoration projects.

If a volumetric and chromatic reintegration cannot be applied with marble stucco, a second option would be reintegration with resin and acrylic paint. The obtained results are of a lower quality, but it is a more affordable alternative.

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MOISTURE SENSITIVE EASEL PAINTINGS: A PRACTICAL APPLICATION OF FILLING AND TEXTURING OF LOSSES WITH AQUAZOL® BASED FILLER

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ABSTRACT

The filling of losses in easel paintings must provide the level and texture of the original pictorial layers. Synthetic poly-2-ethyl-2-oxazoline based stucco (Aquazol®) has been one of the latest additions with good results in the filling of paintings on canvas. The main objective of this research is to determine the properties of Aquazol® 200 based filler as a texturing filling with respect to its workability and its mechanical behaviour in relation to the structural stability of different textile substrates. To this end, two case studies have been used as a starting point, both of which share the need to find a stucco that does not add moisture to the canvas and that can reproduce the texture of the painting layer. In the experimental part, 18 mock-ups were made reproducing the pictorial surface of each work, as well as the restoration treatments of their supports. These were subjected to accelerated ageing to qualitatively analyse the stability of the filling before and after. After testing, it was found that Aquazol® 200 has excellent qualities for levelling and texturing gaps on moisture-sensitive substrates. The good ability to reproduce brush grooves, small impasti and smooth surfaces is noteworthy. On the other hand, a satisfactory result was not achieved on very pronounced impasto, requiring further study.

Keywords
Aquazol ®; Canvas; Filler; Impasto; Texture.

1. INTRODUCTION

A conservation-restoration intervention, according to the current criteria and methodologies, does not have a standardized and generalizing character. This requires the specific adaptation of each treatment and its materials according to the needs of each particular work of art. Thereby, the conservator approaches each intervention as a unique and singular case of study. Thus, a methodical approach is developed, consisting of studies and experimental tests whose possible application to the painting in question is made after interpretation of the results [1].

It is along this lines that the present investigation was conceived, which arose from the need to tackle the process of filling the losses in the pictorial surfaces of two easel paintings that share a common problem: high sensitivity to humidity. In addition, the topographical characteristics of the paintings must be reproduced at this stage. One of the paintings shows a surface marked by the furrow of the bristles of the brush, while the second combines a smooth finish with fine brushstrokes and different impasti applied with a palette knife.

Over the years, different fillers of natural and synthetic origin have been studied, both self-made and commercially available, with the aim of minimising or supressing the contribution of moisturising during the filling process. However, all of them have a series of

advantages and disadvantages according to the particularities of each case of study, such as the number, size and morphology of the losses, or the type of texture of the surface to be levelled, among others [2].

1.1 Filling texturization

From the beginning of the restoration discipline itself, and according to the treatises of the time, the texturing of the filling material was carried out to improve the integration with the pictorial fabric during the retouching phase. Vincente Poleró describes how to reproduce the weft of the support by means of an incision system [3]. However, the imprint of the weft is not the only aspect to be reproduced, but many others specific to the artist´s pictorial technique. In addition to the effects of the degradation of the work, such as cracking due to age or premature cracking.

For the texturing of the filler, the type of surface to be reproduced, the constituent materials and their compatibility with the different filling options, the subsequent retouching, the finish varnish, and the environmental conditions in which the piece is to be exhibited, must be considered.

Generally, without having to resort to flexible moulds, making different fillings involves working with soft or biting fillers. Within this category, and among the binders that do not provide excess moisture to the painting during their application, are acrylic based fillings, polyvinyl acetate based fillings, polyvinyl alcohol based fillings and polyethylene glycols. However, according to the studies carried out, the first three become irreversible over time, while the latter present a certain incompatibility with the constituent materials of traditional paintings. The thermoplastic fillers are another alternative but are difficult to work with when it comes to imitating textures such as brush strokes [2] [4]. On the other hand, commercial fillers have optimal properties for texturing, but in most cases part of their chemical composition is unknown [5].

1.2 Aquazol® based filling

One of the latest additions has been a synthetic filling made from a thermoplastic polymer of poly-2ethylene-2oxazolin (trade name Aquazol®). This material has a solid application in the field of conservation-restoration, especially as a consolidant of matte surfaces and, recently, as a pigment binder for pictorial retouching [6] [7]. Within this last application, it has also been tested in the preparation of painting pastes in order to carry out the illusionist chromatic reintegration in a single step, eliminating the filling phase. However, the results obtained with fillers bound with Aquazol® 200 20% in water, Aquazol® 500 20% in water and Aquazol® 500 20% in water emulsified with 50% egg yolk were not satisfactory. These pastes, prepared in a 1:1 binder/pigment ratio, crack after drying [8].

There are different types of Aquazol® in the market depending on their molecular weight, from 5,000 a.m.u. to 500,000 a.m.u.. In the restoration field, the most commonly used are 50, 200 and 500, especially the last two. The main difference between the two lies in their adhesive power, which is closely and proportionally related to their molecular weight. Thus, Aquazol® 500 is more adhesive than Aquazol® 200, although both products are weak adhesives [9]. This aspect also influences the purpose of their use, as they are ideal materials for the adhesion and consolidation of coloured layers with a high elongation capacity. The use of one or the other will depend on the morphology and pore size of the surface to be treated, as well as the degree of penetration required [10].

Thanks to previous studies, the stability of the filling based on Aquazol® 500 and Aquazol® 200 against different degradation agents is known, obtaining as conclusions their optimal physico-chemical and mechanical behaviour. In addition, they are inert to biological attack. One of the most relevant aspects of these analyses was the great similarity between the filling studied and the animal glue filling, known as traditional [11] [12].

This poly-2ethylene-2oxazoline based filler is unstable against ultraviolet radiation. Under this degradation factor the binder gives rise to the formation of amides due to the breakage of its main chain [5]. Therefore, the filling must be protected by an insulating layer, either an intermediate retouching varnish or a final varnish [12].

Given the qualities of this binder the coating process is safer, as there is no contraction phenomenon during drying [11]. It can also, among other things, reduce or

eliminate the contribution of humidity to the item as it is soluble in polar solvents.

Another of the alleged qualities of Aquazol® based fillers is that they allow coloring to facilitate the subsequent retouching process. This aspect has been analyzed in fillers prepared with Aquazol® 500 at 10% in ethanol plus one part of calcium carbonate and one part of pigment. The conclusions drawn in the study consider this product to be a poor binder due to its high viscosity and difficult workability [13].

The objectives of the following research are to determine the proprieties of Aquazol® 200 based filling as a texturing filler and to determine its behaviour in relation to the mechanical stability on textile substrates that are sensitive to humidity.

2. MATERIALS AND METHODS

2.1 Painting under study

Case 1: Anonymous (XVII century). *Petronia Vitelli Uxor*. [oil on canvas]. Madrid: Private collection. (Figure 1). This painting has the following stratigraphic structure: linen canvas (support), animal glue (insulation layer), earth colour oil (primer), oil size (paint) and natural resin varnish (protection layer). The sensitivity to moisture of this painting is caused by the remaning animal glue of an old flour paste canvas lining. Following the methodology proposed by Enrica Boschetti, the adhesive was removed leaving a small amount to consolidate the fibres of the original fabric [14]. After this process, tension bands with a polyester fabric (Trevira Ispra®) were applied and textile intarsia was made with the same synthetic fabric, with a silk crepeline reinforcement and thread bridges, all bonded with Beva 371®. After cleaning the pictorial surface and filling, which will have to reproduce the grooves of the brush bristles, a retouching varnish (Regal retouching varnish®) will be applied, and the retouching will be carried out according to the criteria of the *selezione cromatica,* using QoR® watercolours. Finally, a layer of varnish (Regal varnish gloss®) will be applied.

Figure 1 – Front of the painting *Petronia Vitelli Uxor* before filling.

Case 2: Anonymous. (XX century). *Landscape* [Oil on cotton]. Granada: Private collection. (Figure 2). This painting has the following stratigraphic structure: cotton canvas (support), synthetic ground (ground) and oil size (paint). In this case the sensitivity to humidity is caused by the nature of the pictorial support itself. The treatment of this item consisted of textile intarsia with polyester fabric (Trevira Ispra®) and a reinforcement of silk crepeline and thread bridges adhered with Beva 371®. After surface cleaning, the losses will be filled. Their surface texture, which has brush grooves, touches and spatula impasto, should be reproduced. Afterwards, an insulating layer of 5% Paraloid B72® in Dowanol™ PM spray will be applied over the fillings. The retouching will be carried out according to the mimetic retouching method, with QoR® watercolours. To conclude, a final protective layer of 10% Paraloid B72® in Dowanol™ PM spray will be applied.

Figure 2 – Front of the painting *Landscape* before filling.

2.2 Making of the mocks-ups

The creation of the models was subjected to four main criteria: 1) the type of impasto to imitate, 2) the type of loss, 3) the treatments already carried out on the works and 4) the future treatments that will be carried out on the works once this study has been completed. A total of 16 20x18 cm mock-ups were made, the properties of which are shown in table 1.

Mocks-ups case 1:
Reproducing the characteristics and treatments of the support involved carrying out the following sequence: lining (using 'gacha', traditional flour and animal paste), removing the lining, removing the adhesive, and applying tension bands. In the models where the lack of the original fabric was simulated, reinforced textile intarsia was made. In the intervention phases, the steps and materials used on the real paintings were followed. A 100% natural fatigued linen was used as original canvas. In accordance with the stratigraphic study, a layer of animal glue, a layer of an earth colour primer and a layer of hand-prepared black oil paint (carbon black pigment bound with linseed oil) were applied to the canvas.

The losses filling was done using a 10% Aquazol® 200 based filler in a hydroalcoholic solution (25% water/ 75% ethanol) and calcium sulphate until saturation. This preparation process is the same as for the traditional stucco. However, given the viscosity of the binder concentration, the settling time of the solid material is much longer. In this way, the preparation of the filler is slower, since the calcium carbonate is added, the glass bottle is covered to prevent the evaporation of the solvents and it is left to decant. This process is repeated until the liquid is saturated. In both types of losses, the filling was applied by drip and then levelled with a spatula. The surface was textured with a stiff-bristled brush following the directions of the brushstroke. At some points, to reinforce the texture or correct imperfections, the filling binder was activated with an aqueous solution and textured again.

Mocks-ups case 2:
An industrially prepared (synthetic ground) open weave cotton canvas (Phoenix®) was used as original support. For the pictorial layer, an industrially produced green oil paint (Titan® 65) was selected. It was applied with a palette knife to generate more pronounced impasto and with a brush for the touches and the smooth surface areas. The intervention on the mocks-ups where the loss of the pictorial support was simulated was carried out according to the methodology and materials used in the real painting.

The losses filling was done using a 10% Aquazol® 200 based filler in a hydroalcoholic solution (25% water/ 75% ethanol) and calcium sulphate until saturation. In the losses where to imitate the brush groove, the same procedure was followed as in the mocks-ups of the case 1. In the samples with impasto, the losses were first filled and then levelled. Once dry, more filling was applied with a spatula according to the topography surrounding the missing surface. For the mocks-ups where the pictorial surface is composed of touches, the same procedure was followed. At some points, to reinforce the texture or correct imperfections, the filler binder was reactivated with an aqueous solution and textured again.

Table 1 – List of models made for the experimental study

Mock-up	Real case	Type of loss	Type of impasto	Varnish
1	Case 1	Pictorial layer	Brush groove	Yes
2	Case 1	Pictorial layer	Brush groove	No
3	Case 1	Textile	Brush groove	Yes
4	Case 1	Textile	Brush groove	No
5	Case 2	Pictorial layer	Brush groove	Yes
6	Case 2	Pictorial layer	Brush groove	No
7	Case 2	Textile	Brush groove	Yes
8	Case 2	Textile	Brush groove	No
9	Case 2	Pictorial layer	Knife palette	Yes
10	Case 2	Pictorial layer	Knife palette	No
11	Case 2	Textile	Knife palette	Yes
12	Case 2	Textile	Knife palette	No
13	Case 2	Pictorial layer	Touch	Yes
14	Case 2	Pictorial layer	Touch	No
15	Case 2	Textile	Touch	Yes
16	Case 2	Textile	Touch	No

2.3 Experimental trial

The models were subjected to accelerated ageing in a climatic chamber where they were exposed to variations in relative humidity (cycles of 30% and 90% RH) for 168 hours. The parameters have been selected according to De Luca, Borgioli, Orsini, and Buratt´s study, but the minimum value of relative humidity was adapted to the climate of Madrid (exhibition place) [12]. Before and after this treatment, the stability of the filling in relation to the mechanical behaviour of the pictorial ensemble was qualitatively studied with grazing light and on a macro and microscopic scale (Dino-lite® AD4113T-I2V).

3. RESULTS AND DISCUSSION

3.1 Application properties

The elaborated filling has plastic properties very similar to those of a traditional stucco, which allows for drip filling. In terms of its texturization, it allows its surface to be modelled both when fresh and when dry and can be easily reactivated with an aqueous or alcoholic solution.

During the drying of the filler, no shrinkage of the material was detected. At 50x magnification, no fissures or cracking were observed at the contact edge between the filling and the paint. Likewise, the fillings were not altered and/or modified after solidification.

As far as the reproduction of the textures is concerned, the best result was obtained in the models where the aim was to imitate the grooves of the brush. However, the filling of the impasto with a palette knife was not completely satisfactory, as they were not faithful to the original surface, producing an impasto with sightly soft edges. Despite this difference, the loss integrates with the original topography, closing the figurative fabric of the painting. In the reproduction of the impasto by touches, the result obtained was the same as in the previous case.

3.2 Mechanical behaviour of the filling after accelerated ageing

Paintings that have been lined with flour paste undergo a change in their biaxial mechanical behaviour after the lining is removed. According to studies carried out by Alain Roche, in the case of relative humidity fluctuations, the stresses in a painting whose lining has been removed (unlined) are different to those of the painting before being lined. However, the behaviour curves of the painting in both situations are similar, unlike the curve for the lined painting which is more fluctuating. The tension values of the unlined painting are higher than those of the original painting, but lower than in the lined painting.

The tension of both the original and the unlined painting remains constant up to 30% RH. From this point on, it starts to decrease slightly up to 70% RH, where the tension quickly reaches its minimum value. This remains stable up to 95% RH. Therefore, the lining removal process involves a change in the mechanical stability of the work, which results in higher tension values [15].

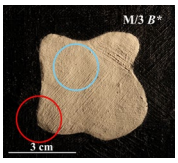
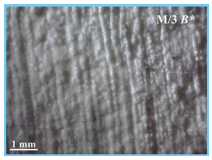
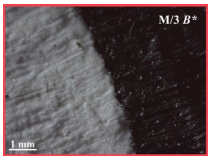
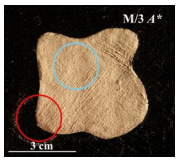
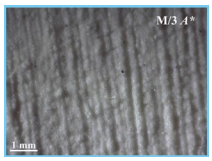
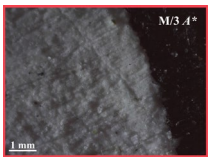
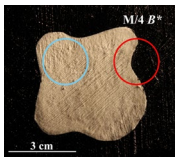
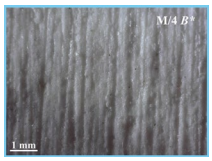
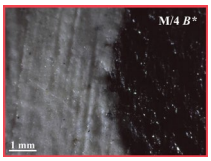
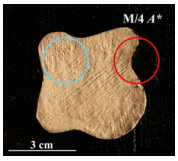
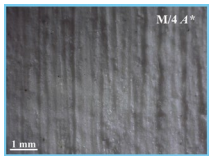
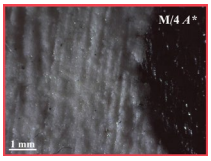
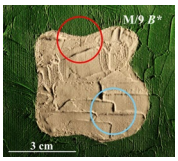
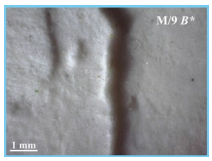
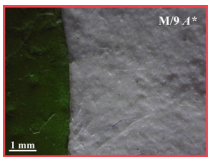
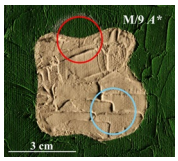
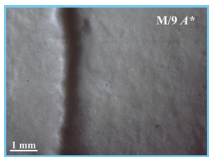
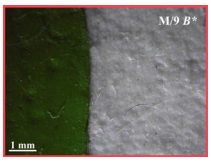
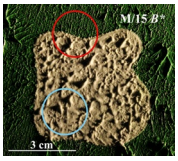
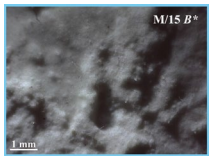
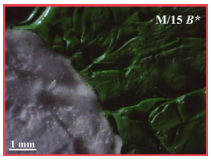
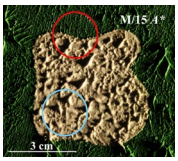
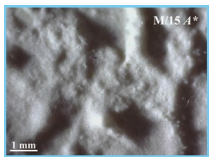
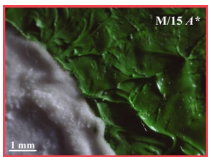
As for cotton supports, and in relation to a contemporary pictorial structure, they show the following behaviour in relation to variations in RH: the initial tension of the work nailed to a stretcher frame begins to decline slightly from 30% RH until it gradually reaches a lower tension at 95% RH [16].

According to the observations made during the course of the experimental test in the climatic chamber, the textile intarsia treatment and its reinforcement did not intervene in the movement of the support for the following reasons: the polyester fabric used for the reintegration of the missing support is inert to changes in humidity [17]; the reinforcement system used does not significantly interfere with the tension/relaxation movements of the canvases as it is a point method adhered with a flexible adhesive [18].

After exposure to relative humidity cycles, it was possible to see how the 10% Aquazol® 200 based filler adapted to the different movements of the textile supports in both cases. There are no differences between the models where textile intarsia has been applied and those where it has not. At 50x magnification, no separation, cracking or craquelure can be detected in the filled loss or around the contact edge with the original paint (table 2). Likewise, no stresses have been produced to the support that could lead to distortions.

The good mechanical stability of the stucco is due to the physical properties of poly-2-ethyl-2oxazoline.

Table 2 – Results of filling and texturization of losses in the mocks-ups 3, 4, 9 and 15 before and after accelerated aging in climatic chamber.

Raking light photography	50X micrography with grazing light of the texture	50X micrography with grazing light to the edge of loss
		
		
		
		
		
		
		
		

B: Before accelerated aging
A: After accelerated aging

This morbid material has a Tg 69°C which makes it behave like a plasticising substance. Furthermore, this amorphous polymer with a modulus of elasticity equal to 104.2 MPa is considered a flexible substance as this parameter is lower than 400 MPa. After thermohygrometric ageing, it remains flexible and loses stiffness during ageing due to a process of polymerisation rather than cross-linking [10].

3.3 Application to real cases

The application of the results obtained in the experimental part to the corresponding case studies has made it possible to bring said results closer to reality. In this last research process, the same materials and methods tested on the models have been used.

In the first case study, it was possible to reproduce the texture of the original surface without difficulty. No movement of the textile support was observed during the stuccoing of the large losses. After intermediate varnishing and retouching with QoR® watercolors, a phenomenon known as the *lotus effect* occurred occasionally in the losses where the brushstroke texture was most intertwined. This is caused by the hydrophobicity of a surface due to a two-level microstructure. When liquids with a high surface tension are deposited on it, drops can form with a contact angle of more than 90º [19]. The effect manifested visually as a division of the strokes into small drops of color. The medium used to dilute the watercolors was water (surface tension 72.8 dynes/cm). After this, water was replaced by 2-propanol (21.7 dynes/cm) to reduce the surface tension. With this solvent, the retouching lines could be drawn correctly.

In the experimental part of the second case study, the results were not fully satisfactory in the reproduction of spatula impasto. However, this type of relief was only to be achieved in small areas and, therefore, it was finally decided to use the same materials and methods used in the tests for the filling of the painting *Landscape*. After this phase, where it was mainly necessary to reproduce a smooth surface combined with small impasto touches, a fully satisfactory finish was obtained. Given the experience in color reintegration in case 1, in this second phase, 2-propanol was used directly to dilute the QoR® watercolors.

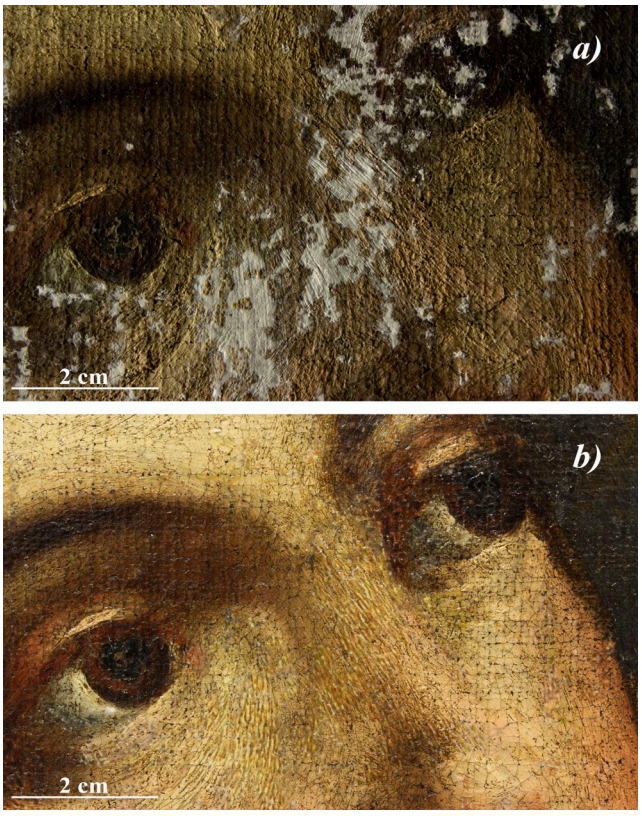


Figure 3 – a) Detail of the filling in case 1 with raking light b) Detail of the retouching of the case 1 with visible light.

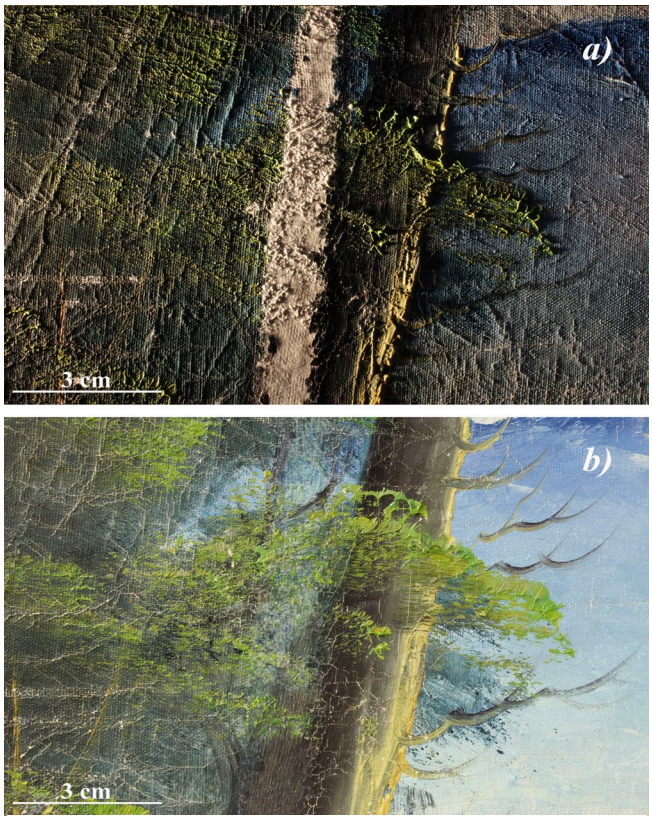


Figure 4 – a) Detail of the filling in case 2 with raking light 2. b) Detail of the retouching of the case 2 with visible light.

4. CONCLUSIONS

Tests have determined the optimum qualities of this filler for levelling gaps in substrates sensitive to humidity. In terms of its texturing properties, the ability to reproduce brush grooves, small impasti and smooth surfaces is noteworthy. On the other hand, a fully satisfactory result has not been achieved on samples of very pronounced impasto, requiring further study.

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CONTACT LENSES ON THE CHROMATIC REINTEGRATION PROCESS OF THE EYEBALLS OF A WOOD SCULPTURE

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ABSTRACT

Chromatic reintegration aims to decrease deterioration evidences in the artwork and retrieve the visual interpretation of its iconographic shapes and contents.
This case study will focus on the chromatic reintegration process of the eyeballs of a wood sculpture representing Saint Teotónio. Instead of applying colour over the eyeballs, it was decided to make thin lenses that could be placed directly on the surface.
Experiments were carried out with different resins, on one centimetre in diameter moulds. The resins tested were Paraloid B72; PVA Inpainting Medium (Gustav Berger's Berger's O.F.); Mowilith DS 5/2; Aquazol 200; Plextol B500 and the monomer 2-ethyl hexyl acrylate (2 EHA).
The selected resin was the monomer 2 EHA, which was then tested in a mixture with acrylic paint to achieve an accurate colour representation of the iris and pupil of the eye.

Keywords: Conservation of wood sculpture; eyeballs; lenses; chromatic reintegration; monomer 2-ethyl hexyl acrylate.

1. INTRODUCTION

One of the essential features of the chromatic reintegration of wooden sculpture and other artworks is to be discrete. The main goal of this intervention was to recover the “sight" of the sculpture without interfering with the interpretation of the original, maintaining its devotional function.

One of the most challenging restoration processes is reconstructing the eyes of a sculpture. Some changes in the Saint Teotónio expression can occur when no previous visual information exists. The reconstruction poses several ethical and practical questions. Since this sculpture is a holy object, the discussion on overcoming these challenges was widely debated. It was decided to create something that could be easily removed, functioning as a contact-lens, and avoiding the direct application of the colour in the reconstructed eyeball. This decision would also fulfil other criteria such as some properties of the original material- since the original eyeballs would have been made of glass.The current ones were created, in a prior intervention, using an epoxy resin; the application of an opaque layer of paint could lead to a much different optical result from

Figure 1 – The front side of Saint Teotónio sculpture and head with epoxy resin reconstruction of the eyeball in a prior intervention.

Figure 2 – Detail of the backside of the 18th century sculpture, made of chestnut wood wearing episcopal robes.

the original, caused by a distinct interaction between the light and this new material (Figure 1).

There are artificial acrylic eyes for sculptures for sale in sizes 18 mm to 75 mm. The retina is sold in many colours such as Black, Brown, Light Blue, Dark Blue and Green. But no publications on the production of artificial eyes in conservation and restoration were found.

As context, it is important to mention that the object is a full-size 18th century chestnut wood sculpture, depicting Saint Teotónio, wearing episcopal robes (Figure 2). Two polychrome techniques had been used: oil for the flesh tones and tempera for the clothes and the pedestal.

The edgings of the clothes are decorated with gold leaf and the lower part of the robe with vegetal and geometrical shapes, made with an estofado technique. The base is decorated with a marble effect (Figure 3).

The sculpture had already been subject to volumetric reconstructions when we started the project. The eyeballs were reconstructed with an epoxy resin, white and opaque. It was decided to preserve the previous intervention in order to avoid damages to the original material, particularly in the eyelid, and to think of a solution to finish the treatment. So, we aimed to reintegrate the small losses and to accomplish a truthful

Figure 3 – Detail of the pedestal. It is possible to see the estofado technique and the marble effect of the base.

colour representation of the iris and pupil of the eye (Figure 4).

2. VALUE QUESTIONS

Analyzing an object in the 21st century does not necessarily depend on predetermined values. It cannot be confined to historical-artistic characterizations only, since each case varies substantially. Also, the sense of conservation and restoration, or preservation, has been

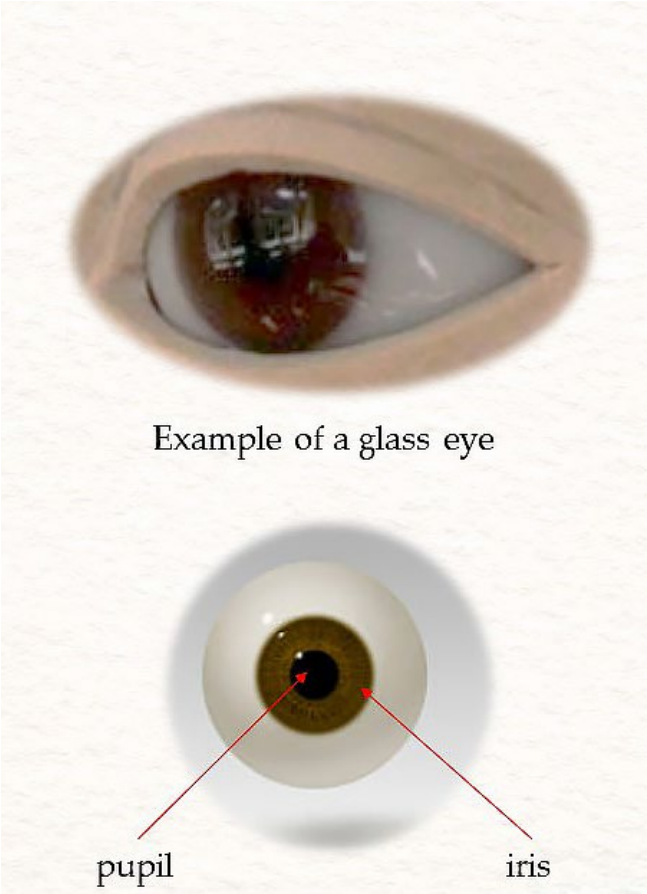


Figure 4 – Example of a glass eye. Identification of the pupil and iris.

extended, considering the material and immaterial features of the object.
For the process of chromatic reintegration, the history and the marks of time are two things to have in mind.

The main goal is to return the object to a state close to its creation. The mentioned objectives are contradictory since to bring the work closer to what it would be in creation, it is necessary to eliminate certain marks of time. For this reason, it is essential to reflect on the need for reintegration and where and how an aesthetic procedure should be done. It is necessary at this stage to choose the most appropriate intervention for the object and take responsibility for this decision. As indicated by Ashley-Smith «the restoration treatments can produce (...) changes in their value [of the objects] » [1].

Considering the different values that an artwork can assume, it is considered that two of them, related to each other, can help in the decision-making process: the patrimonial function and the symbolic character of the object at the time of the intervention. The function can be subdivided into two categories: spiritual contemplation, associated with rite, symbolism, and iconography, and the material function, related to the creation of the work, *techné*.

In the first situation, when the losses interfere with the iconographic reading and the spirituality or the ritual of a community, the reconstruction of the work is considered so that it can fulfil its function. Reintegration is performed with formal and chromatic references and/or photographic or graphic documentation. In the second case, the decision depends on several actors and therefore may vary between non-intervention, minimal intervention, or integral reintegration (mimetic or differentiated).

The Saint Teotónio sculpture is a holy object. So, the aesthetic component of the artwork was taken into consideration. Devotion to an eyeless image is a difficult thing to do.

To accomplish both the criteria of recognition and retractability of the intervention, without changing the appearance of the face of the sculpture, the main idea was to create something that could be easily removed, and that could reassemble to a pupil and iris made of glass.

A contact lens seems to be the solution to achieve these criteria, avoiding the direct application of the colour in the reconstructed eyeball and providing similarity with the original material.

3. MATERIALS AND METHODS

a. Mould Making

As A. Riley [2] wrote, "mould design is an important part of the development process when considering the production of a new moulding". To select the material for the mould, some considerations were taken:

- Successful removal of the casting from the mould is a critical factor to have in mind. The selected material for the mould should be flexible, and the side walls must ensure that the casting can be removed. The moulding must also be flexible enough and the undercut

sufficiently small to pop or blow it off without damaging the casting material.

- The mould should have a circular shape with 1 cm in diameter to fit in the centre of the eyeball of Saint Teotónio;

- The mould should have approx. 1,3 mm of thickness. The lenses will be put in the eyeball through a magnet with 0,1 mm thick and with an area of 4,0 mm^2.

- The shape of the mould should be easy to replicate countless times without imperfections, in order to help with the experiment.

After taking these accounts into consideration, the siliconized paper from the silicone furniture crash pads seemed a good solution (Figure 5). More explanations will be given in the results topic.

Figure 5 – Silicone furniture crash pads

b. Synthetic Resins

As mentioned, the application of an opaque layer of paint over the epoxy resin eyeballs would conduct to a much different optical result from the original glass eyeballs, caused by a distinct interaction between the light and this new material.

It was decided to compensate this lost of gloss using a material that could imitate the pupil and iris and reduce the impact of the changes in the light reflection.

The first experiments were carried out with five different resins available in the Conservation and Restoration Laboratory at the Instituto Politécnico de Tomar:

1. Paraloid B72 + Isopropanol (20% w/v);
2. PVA Inpainting Medium (Gustav Berger's O.F.) + ethyl alcohol (20% v/v);
3. Aquazol 200 + water (20% w/v);
4. Mowilith DS 5/2 (pure);
5. Plextol B500 (pure).

Paraloid B72 (Rohm and Haas) is a well-known and studied acrylic resin which has been and still is extensively used in the conservation field. It is a copolymer of ethyl methacrylate and methyl acrylate in a ratio of 70:30 [3], and it has a high molecular weight. According to Koob [4], its earliest use on glass is unknown but probably dates to the late 1970s and has been tested as a filling material for losses in ceramics and glass since then [4, 5]. For this case study, Paraloid B72 was prepared with 20% weight/volume of B72 dissolved in 2-propanol (i.e. 20g of B72 to 100ml 2-propanol) and allowed to dry up to l5 minutes.

PVA Inpainting Medium (Gustav Berger'sBerger's O.F.), is a concentrated retouching medium based on polyvinyl acetate (PVA), which can produce a very solid and transparent film [6]. The medium was diluted in ethyl alcohol (i.e. 20ml of PVA to 80ml ethyl alcohol) and allowed to dry up to 15 minutes.

Aquazol 200 (AQ 200) is formed by poly(2-ethyl-2-oxazoline) which have good resistance to ageing and high reversibility. It can be used both as an adhesive and consolidant of paint layers. It's completely soluble in water, as well as polar solvents. It can replace water-based adhesives like animal gelatin, acrylic and polyvinyl acetate emulsions [7]. The resin was prepared with 20% weight/volume of Aquazol dissolved in demineralized water (i.e. 20g of AQ200 to 100ml water) and allowed to dry up to l5 minutes.

Mowilith DS 5/2 is a copolymer of vinyl acetate dibutyl maleate, which can be used as paint binders, coatings, and adhesives in conservation. As Mowilith DMC2 and Mowilith SDM5, the Mowilith DS 5/2 also ended up

being discontinued. Like the manufacturing company Hoechst in 2009, Celanese (which included Hoechst) also decided to end the production of this soft polymer, widely used in conservation and restoration. CTS replaced Mowilith with a different polymer from a chemical point of view (ethylene vinyl acetate instead of a dibutyl maleate-vinyl acetate copolymer) called Eva Art [8]. But for this experience, it was used Mowilith DS 5/2, available in the lab, not diluted and allowed to dry up to l5 minutes.

Plextol B500 is an aqueous dispersion of a non-ionic stabilized thermoplastic acrylic polymer. It has excellent resistance against frost and high chemical stability. It is free from solvents and plasticizers and forms a clear, slightly tacky film. Plextol B500 has a density of 1.07 g/cm3 and an average particle size of 0.15 microns [9]. Plextol B 500 is most used in film-forming applications and as an adhesive for canvas lining and consolidation treatment of special plasters and was used not diluted.

The unsatisfying results, especially with elasticity, made the team search for another option. The chosen material for continuing the experiment was the monomer 2-ethyl hexyl acrylate (2-EHA), available on the market by Liquitex as a pouring medium for acrylics. At the time, this monomer was being used by one of the authors to get a solid and flawless body of very elastic paint.

The 2-ethyl hexyl acrylate (Dow) is not a well-known monomer in the conservation field. It's an acrylate monomer with the molecular formula of $CH_2 = CHCOOC_8H_{17}$, in the form of a transparent liquid.

2-EHA is one of the most used soft monomers/plasticizer materials for surface coatings, pouring medium, film, tapes, and for Pressure-Sensitive Adhesives (PSAs) [10] because of the low Tg (-54 and -70 ºC, respectively) [11] and low water solubility (0.15 g/100 cm^3 and 0.04 g/100 cm3 at 25ºC) [12]. It has good resistance to visible light and UV light.

The monomer 2-EHA is not soluble in water but is readily miscible with other organic solvents, such as alcohols and ethers. It has a characteristic acrylic odour and is readily polymerized with monomer molecules to create polymer chains. Reacts with oxidizing agents such as alkalis and polymerizes with heat application. It can be dosed through drops, has good dispersion, a higher tendency to generate gel [13] and low toxicity.

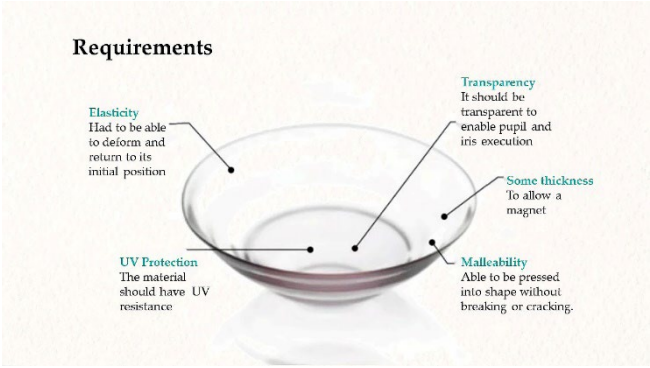


Figure 6 – Requirements for the "lenses".

In conclusion, this monomer respects the requirements of elasticity, transparency, thickness, malleability, and UV resistance designed for the "lenses" (Figure 6).

c. Paints

Experiments with paints were performed to reach the intended hues for the iris and the pupil representation. Black was the selected hue. The intention was to attain a dark saturated pupil and an unsaturated, dark iris.

Were selected three brands of acrylic paints available in the lab:

- Vallejo Acrylic Artist Colour
- Winsor & Newton Galeria
- Liquitex Heavy Body

Vallejo Acrylic Artist Colour pigments are dispersed in a 100% acrylic polymer dispersion, with no addition of fillers or matting agents. The colours have a thick and pasty consistency, drying with a minimal colour alteration. The film is flexible and resistant. According to manufacturers [14], the colour is water-resistant, non-yellowing, and UV resistant.

The paints Liquitex Heavy Body have a minimal wet-to-dry shift. According to the information disclosure by manufacturers [15] forms a flexible, durable, non-yellowing, UV-resistant and water-resistant film when dry.

Winsor & Newton Galeria are fluid colours with a lower concentration of pigments, but, according to the manufacturers [16], with good coverage, opacity, and permanence with a smooth, satin finish.

d. Application with magnets

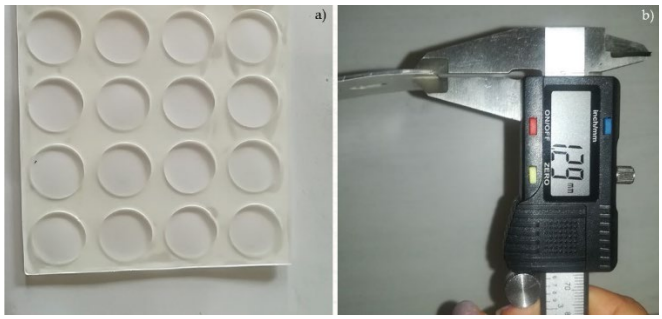
Along with the main goal of finding a solution that could reassemble the vitreous quality of the original eyes, it was also an aim to create a system that could be easily removed, if necessary. To achieve this, two 0,1 mm thick magnets, with an area of 4,0 mm^2, were applied in each eyeball and in the back of each lens (back of the pupil).

4. RESULTS

a. Mould Making

The 3M siliconized paper was used as a mould without the silicone crash pads. With these "moulds" we could accomplish the requirements:

- circular shape with 10 mm of diameter;
- 1,29 mm of thickness (Figure 7);
- Flexible;
- side walls that will minimize the damage of the material of the casting;
- can be replicated countless times.



Figures 7 – a) The siliconized paper without the silicone crash pads; b) measurement of the siliconized paper with a pachymeter.

b. Synthetic Resins

The first experiments were taken with the five different resins: Paraloid B72, PVA Inpainting Medium (Gustav Berger'sBerger's O.F.), Aquazol 200 Plextol B500 and Mowilith DS 5/2 at room temperature (approx. 18º C).

The evaluation of the behaviour of the resins was performed through observation and visual comparisons of optical, mechanical, and physical properties. One sample of each resin was prepared. Five factors were evaluated: drying time, elasticity, malleability, transparency, and thickness. Some of these parameters are related to each other in terms of thickness, elasticity, and plasticity. The result was intended to be a thin material, 1,3 mm thick, with enough flexibility to be shaped as a lens, and with enough elasticity to be safely removed from the mould, without risk of deformation.

The resin with the best results was Paraloid B72 (Table 1) because PB72 dried fast, had good elasticity, very good malleability, became utterly transparent and was possible to achieve a thin thickness.

Table 1 – Results of the visual comparisons between the five resins.

	DRY TIME	ELASTICITY	MALLEABILITY	TRANSPARENCY	THIN THICKNESS
Paraloid B72 + Isopropanol	+++ Dries fast	++ Good	+++ Very good	+++ Completely transparent	++ Good
PVA + Gustav Berger	++ Average	++ Good	++ Good	+++ Completely transparent	++ Good
Mowilith Ds 5/2	+ Very slow	++ Good	+++ Very good	++ Transparent slightly yellow	+ Bad
Aquazol 200 + H_2O	++ Average	+ Bad	+ Gets stuck in the mold	+ Yellow opaque	+ Bad
Plexol B500	+ Very slow	++ Good	++ Good	++ Transparent slightly bluish	+ Bad

But the good results of PB72 were not enough. Some problems were experienced related to: bubbles; adjustment of the resin to the mould and deformation of the lenses when taking them out of the mould.

The elasticity was good but not excellent. The resin did not return precisely to its initial position.

The search for better results led to a second experiment with the monomer 2-ethyl hexyl acrylate (2EHA). It was then possible to overcome the bubbles' shape and deformation problems.

After selecting 2 EHA, it was necessary to define the accurate thickness of the lens. The first tests were made by applying one drop into the mould directly from the package. This material was very fluid and had a good dispersion. For these reasons, it was possible to use a tool such as a wooden stick or a small spatula to help

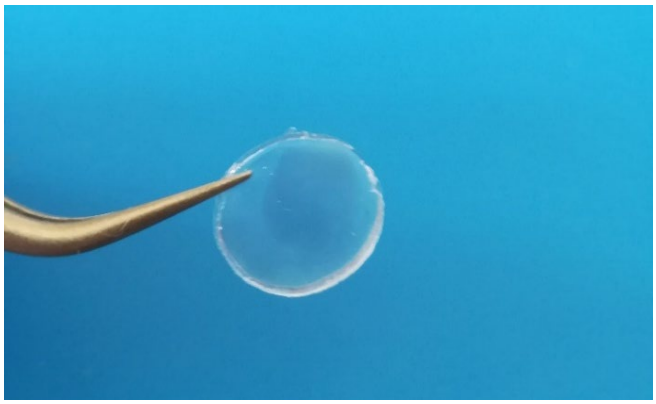


Figure 8 – First 2-ethyl hexyl acrylate lens.

the monomer flow into the mould. Due to the remarkable capacity of fluidity, 2 EHA adjusted precisely to the shape of the mould. To achieve the right thickness with some curve, were necessary six drops, c. 0,3 ml (Figure 8).

The lenses could be easily removed, but some minor deformation occurred when removing the lens from its mould, but the elasticity and malleability allows some corrections.

c. Paints

The monomer 2 EHA was tested with the three previous mentioned brands of acrylic paint:

- Vallejo Acrylic Artist Colour
- Winsor & Newton Galeria
- Liquitex Heavy Body

Before starting the mixing, a question was imposed? How to achieve a pupil and an iris? Mixing the acrylic paint with the monomer did not seem to be the right way. The result would be a black "lens", without differentiation between pupil and iris. For this reason, it was attempted to apply the acrylic paint in the centre of the 2 EHA monomer after the beginning of the drying process to control the pupil's colour slightly and distinguish it from the iris.

As the tones of black vary, the undertones of three blacks were also compared before starting (Table 2):

Table 2 – Comparison of undertones of three blacks.

Colour	Undertone
Lamp Black (PBk7)	A black with a bluish tint, producing a variety of cool blue-greys
Ivory Black (PBk9)	Black colour with brown undertones
Mars Black (PBk11)	A dense black colour with a brown undertone

Lamp Black (PBK 7) is a semi-opaque to opaque, intense black with a high tinting strength. It often has a cool undertone, bluish-grey when mixed with white. It is an amorphous carbon from soot.

Ivory black (PBk 9) tends to be semi-opaque to semi-transparent, and it is usually lower in tinting strength. Often has a yellow or brown undertone, which can be seen in glazes and tints with white. Ivory Black was originally made by carbonizing ivory. Now, any black paint containing the pigment number PBk 9 is produced from animal bones, which is to bear in mind if the purpose is to avoid animal products.

Mars black or iron oxide black is different to all the previously mentioned black pigments because it is not carbon-based. This characteristic was one of the motives to choose this pigment. The two others were:

- warm in undertone, which gives a more realistic appearance for the pupil and iris;
- high tinting strength could help the achievement of a strong colour for the pupil.

The Mars family of pigments were developed in the 20th century as alternatives to natural earth pigments. This family includes Mars Yellow and Mars Violet, all synthetic iron oxides. Mars Black (PBk 11), along with Lamp Black (PBK 7) and Carbon Black (PBk 6), is one of the opaquest of the black pigments. It is often warm in an undertone, ordinarily brown, with high tinting strength and has good coverage.

After several tests, the resin that allowed better results was Vallejo, for not dispersing/emulsifying instantaneously in the monomer. It was possible to better control the distinction between pupil and iris,

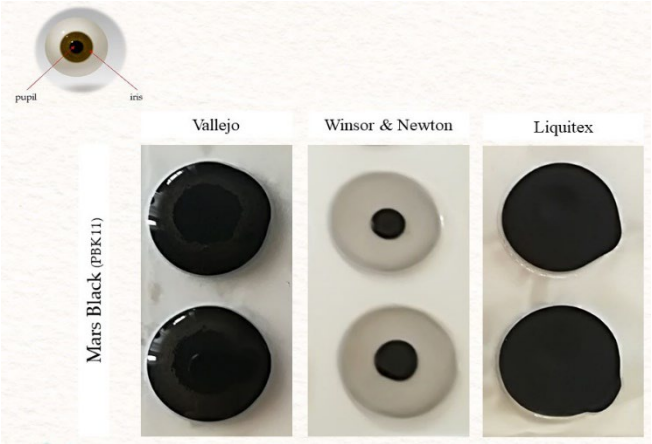


Figure 9 – Testing three brands of acrylic paints: Vallejo, Winsor & Newton and Liquitex.

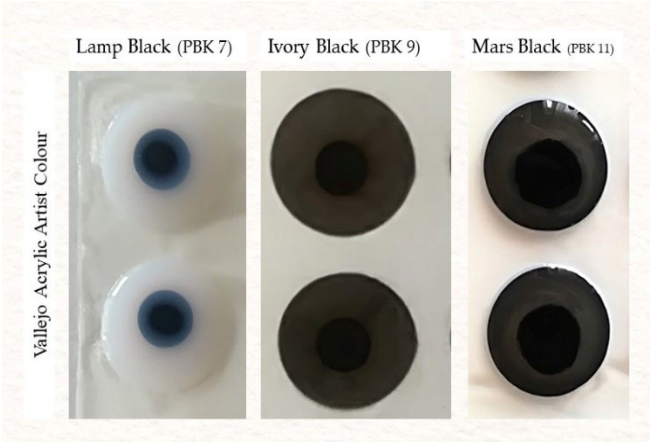


Figure 10 – Testing the three blacks of Vallejo Acrylic Artist Colour. The best result was achieved with Mars Black.

although it was necessary to accomplish several samples to have a similar pair. One in each group of five samples was chosen.

The acrylic paint from Liquitex, because it was of the same brand as the monomer in use, was instantly mixed with it, and for that reason, the pupil diameter could not be controlled. Winsor & newton's acrylic paint wasn't appropriately dispersed (Figure 9).

After the decision making about Vallejo Acrylic Artist Colour, the different blacks were tested, and the undertone was established (Figure 10).

After selecting the suitable materials and proportions, the main challenge was obtaining at least one pair of lenses with a similar paint distribution in the iris and a similar pupil diameter. After several tests, it was defined that the best way to get these results was to start by placing the 2 EHA in the mould cavity, followed by the paint applied with a wooden stick while the monomer is liquid. Are necessary six drops of 2 EHA (approx. 0,3 ml) and just a small quantity of paint (Figure 11). To put the colour right over the centre of the monomer is essential to use the stick perfectly perpendicular to the surface. The inclination of the wood stick promotes deformation of the pupil diameter that may become irregular.

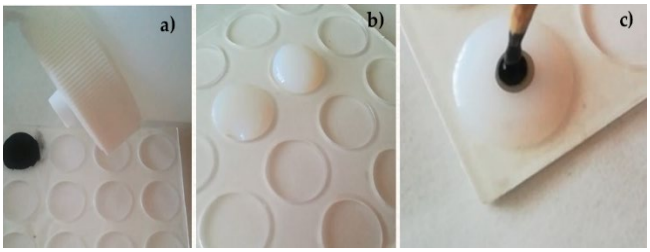


Figure 11 – Methodology: a) placing the 2 EHA directed from the package; b) appearance of the monomer; c) applying the colour with a wood stick.

d. Chromatic Reintegration and application of the lenses on the eyeball

Chromatic Reintegration of the losses in the face

The treatment started with the chromatic reintegration of the filling materials in the face of the sculpture. Professional Watercolours of Winsor & Newton brand were applied layer over layer until they imitated the appearance of the original colour of the face as closely as possible. The technical name for this method is referred to as "imitative" or "mimetic" retouching because it aims to reconstruct the missing parts of the image and resemble the original colour. The colours

applied were: Ultramarine Blue (PB 29); Yellow Ochre (PY 42); Indian Red (PR 101); Burnt Umber (PBr7); Raw Umber (PBR 7), and Titanium White (PW 6).

- It was used a pinkish tone, made with titanium white (PW 6), earth colours and Indian red (PR 101) for the flesh colour. In some areas it was also added a small portion of the blue colour (PB 29);
- For the hair, a mix of yellow ochre (PY 42), ultramarine blue (PB 29) and Indian red (PR 101), plus burnt umber (PBR 7).
- About the application: first, overpaint and then glazes.

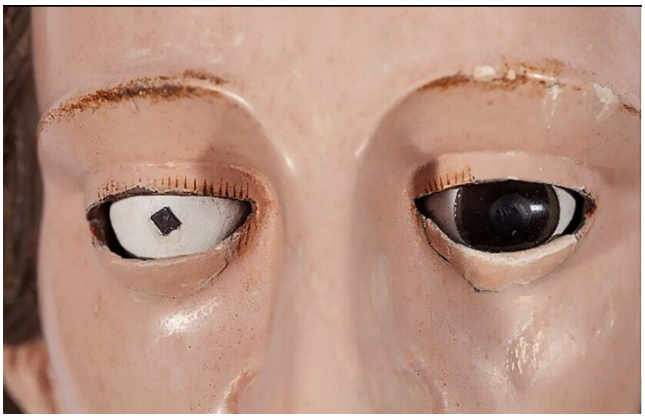


Figure 12 – Application of the lenses using a magnet.

Application of the lenses

Along with the primary goal of finding a solution that could reassemble the vitreous quality of the original eyes, it was also an aim to create a system that could be easily removed, if necessary. To achieve this, two 1,0 mm thick magnets, with an area of 4,0 mm^2, were applied in each eyeball and in the back of each lens (back of the pupil). For the lenses not to be separated from the surface of the eyeball, due to the increase of thickness from the magnets, it was necessary to carve the surface. In this way, it was possible to keep the correct conformation of the lenses, with no gaps between the surfaces. The magnets were glued using a polyvinyl acetate adhesive (Figure 12, 13).

Figure 13 – Final result.

5. CONCLUSION

Of the six tested materials, the one that gave the best results was the monomer 2-ethyl hexyl acrylate. With 2 EHA and a two-layer application system made of pure monomer and acrylic paint, it was possible to reach the three important properties initially defined, such as a flexibility, elasticity, and transparency. Although distinguishable from a glass eyeball, the result shows similarities in terms of the optical features and light interaction, mainly due to the depth achieved using a transparent and glossy material.

It is essential to point out that the evaluation of the behaviour of the resins was only qualitative, performed by visual comparisons of optical, mechanical, and physical properties. Other methodology can be applied to achieve other results.

These “lenses” obtained with 2 EHA can also be moulded into the desired shape and easily removed from the mould with minimal deformation.

This study is an ongoing project; many other tests are necessary to improve the surface, which can be more convex (bulging outwards from the lens), concave (depressed into the lens), or planar (flat) depending on the primary goal.

The result is a wood sculpture with a removable iris and pupil. The method applied can accomplish the ground principles of conservation and restoration, such as recognition, removability, and minimal intervention.

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INDICATIONS FOR THE SELECTION OF RETOUCHING MATERIALS USED IN CONTEMPORARY PRACTICE

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ABSTRACT

The materials used by restorers have to fulfil the criteria of stability and reversibility. For retouching we use artistic materials adopted for this purpose (for example watercolors) and paints specially produced or handmade with selected pigments and resins - acrylic, polyvinyl acetate, until recently also ketone replaced by urea-aldehyde. Producers' positive assessment of the pigment or paint lightfastness and the estimation of the removability based on binder data and even on paint layers ageing test may not provide enough information for an infallible selection of materials to use. Sometimes unintended changes of appearance occur relatively shortly after the completion of the retouching process. Furthermore, in practice, we create the retouching layer-varnish system, more consistent than we assume, which has consequences not only for visual effect but for the removability of the retouchings themselves. It matters especially in the case of varnished retouching layers exposed to light.
Selected results of the research on contemporarily used retouching materials and the examination of some changed retouchings are presented to illustrate the indicated issues and facilitate the choice. They come from wider research conducted since the end of the 1990s, which had been continued up to now within the framework of partial projects
The investigation was based on accelerated light ageing accompanied by instrumental colour assessment and of structural changes imaging by SEM. The conclusions and hypotheses resulting from the removability tests and surface examination by OCT realized on varnished and unvarnished aged paint layers are included in this paper as well.

Keywords
Retouching materials; Paint layer lightfastness; Pigment photoactivity; Removability; Varnished retouchings

1. INTRODUCTION

The disturbance of the aesthetics and reception of the work caused by changes in the appearance of past additions or reconstructed parts of the paint layers of paintings or polychrome sculptures should never be the main reason for their re-treatment, but sometimes it just is. Each subsequent conservation treatment with the use of solvents, but also by mechanical means carries a risk for the original matter and, regardless of what we are inclined to believe - its depletion. Hence, in order to reduce the risk of interventions undertaken solely due to appearing defects of earlier reintegration we should act in accordance with the principles of modern conservation. It means that not only the separate materials used for retouching, but also the retouches themselves, should meet the requirements of high optical stability and reversibility (or more precisely - safe removability).

We have a wide range of materials at our disposal. [1] [2] [3]. Ready-made paints, currently specially produced for restorers, contain acrylic binders, polyvinyl acetate and urea-aldehyde resin, which has been replacing the ketone resin for some time. We also have hand-made paints made of mixtures of pigments with various water- or solvent-borne binders, or artistic

paints adapted for retouching - e.g. professional watercolors - or artistic crayons. We reach for various varnishes. The choice is not always obvious. This may be due to both - the lack of sufficient manufacturer information about the product, as well as occasional awareness or knowledge of users about the applied materials.

1.1. Choice of pigment palette

In any case, it is necessary to choose the paint / pigment palette that will ensure the desired visual stability of the retouching. The producer's promise of the 'highest lightfastness' of professional materials that we use may not be its guarantee.

We are not always aware that the materials we use are not characterized enough, mistakenly assuming that the lightfastness of a pigment given in the ASTM scale gives us a full range of information as to the behavior of the paint layer containing it under the influence of light. [4:141] [5]. Meanwhile, this is not enough knowledge and the lightfastness may not be the final selection criterion in some cases~~..~~ The conviction of expected chemical inertia of the contemporarily used lightfast pigments must be reviewed. The visible effect of changes caused by pigments are the color shifts of retouching, whitening being one of the most striking manifestations They were reported as early as 70 years ago as isolated cases [6] [7]. They were also signaled in later conservation literature [8], in reference to a simplified interpretation [9], which - presumably- did not act as a warning. My own observations of both changed retouching [10] and the cases of whitening reported in the studies of some paints [4] were an incentive to undertake detailed investigations aimed at explaining the causes and thus enabling conscious avoidance of the problem.

1.2. Final varnish choice and retouchings removability

The varnish applied to the surface of the painting, apart from the aesthetic functions and mechanical protection, hardly minimizes the negative effects of external factors.

Although it does not really protect the lower layer from UV and visible light, we know that the properties of the final varnish are important for the durability of the retouching features. It is not only about the immediate changes in the appearance that can be introduced by its application [4: 146-154] [5], nor is it about its influence on the color stability in the ageing process.

We are inclined to assume that the varnish creates a separate distinct layer. However, the question arises whether this is the case with solvent-borne retouch layers varnished shortly after their completion. In this context, an important factor that a varnish may compromise is the removability of retouching. It could be crucial when they are made in the volume of the original layers (for example on abrasions up to underpainting or on damaged glazes).

. However obvious it might be, my experience to date has prompted me to illustrate the issues that are important for the conscious choice of materials with the results of the research below.

2. MATERIALS AND METHODS

2.1. Choice of pigment palette

As was stated in the introduction, the described issues are discussed in this text in relation to the currently used paints - ready-made or hand-made - used to the reintegration of lacunas in ~~the paint layers of~~ paintings and other polychrome surfaces. Nevertheless, the general guidelines for selecting pigments presented below apply to all colored retouching materials. Examples that illustrate them are taken from the investigation of several retouching case studies and from the research on retouching paint layers (mostly made with solvent-borne paints) performed over many years.

2.1.1. Preliminary choice

The method of pre-selecting pigments or retouching paints is to look at the standard-based evaluations of their lightfastness, taking into account different binders and pigment concentrations. If the assessment of the pigment producer and the paint producer do not coincide, and whenever the ready-made paint contains a mixture of pigments, it is advisable to familiarize yourself with the lightfastness of these components [11] [12]. This preliminary information will allow us to predict the possible behavior of the retouch layers when exposed to light.

2.1.2. Visual stability of the paint layers – selected examples

The results of the previous investigations [3], [4], on different retouching paints and a case study from

subsequent research [13] served to demonstrate the influence of the type of binder and the concentration of the chromatic pigment in the paint on the lightfastness of the obtained paint layer. An illustration of these issues was provided by the accelerated light ageing of the paint layers and their colorimetric assessment.
At the same time, the research provided data allowing to consider what rating of lightfastness can be satisfactory in painting conservation.

- The choice and preparation of the paint layer

The above-mentioned issues were illustrated with the use of paint layers with various binders, including the red imitating madder lake, (necessary on the palette), , and Prussian blue. Antraquinone red pigment - synthetic alizarin crimson (PR 83:1) was used, as well as its monoazo substitute (PR187) called 'Azo Alizarin' and layers based on ready–made paints imitating its hue, containing quinacridone rose (PV19) in mixture with perylene red (PR 149) and ultramarine (PB29). They were tested in full strength and reduced with titanium white rutile PW6 (Kremer Pigmente or titanium white from ready-made paint sets). White was mixed into red in the same proportion by weight in the first series of tests and in the following series of tests [9],[2] until the reflectance (R) of the layer of 30-40% in a minimum reflection (see Figure. 1 in section 3).
Prussian Blue (PB 27) – its ammonium variety Ferric Ammonium Ferrocyanide (Kremer Pigmente, DE) was chosen to be examine in two different binders [13]. Layers were applied in full strength and reduced with rutile type titanium white as above. For Prussian Blue the layers extended with 'Chalk of Bologna' (Kremer Pigmente, DE) - natural inert mixture of gypsum and calcium carbonate (chalk) were made as well.
Examples of conservation paint layers have been selected to illustrate their lightfastness.
For the support of paint layers the glass plates were chosen – to exclude the influence of any absorbing material on the results of the ageing process. Half of the surface of paint layers was covered with varnish (see 2.3.21).

- Accelerated light ageing

Accelerated ageing of the series of paint layers, after their seasoning, was carried out in a xenon arc lamp ageing apparatus. Xenon lamps provided light true to the CIE D_{65} illuminant and light filters blocking UV and IR radiation were used to simulate indoor daylight. Together with the samples, blue-wool standards (ISO R105) were aged – up to discolouration of 7 standard of the 4th degree of the grey scale (ISO 105 A02). The radiation dose absorbed by the samples was 'converted' into exposure time under normal museum conditions, that is about 60-100 years (depending on the 200 lx/h or 150lx/h illuminance) [4] [14]. The Relative humidity in the ageing chamber was maintained at 60%.

- Colour and colour change assessment

Colorimetric measurements before and after ageing of paint layer samples were performed using spheric reflectance spectrophotometer using d/8º geometry, CIE illuminant D65, 10º standard observer, and with specular component included and excluded. Color changes was assessed visually and mathematically expressed using color difference dE CMC equation (one of the modification of dE* CIELAB formula, introduced by the Color Measurement Committee of the Society of Dyers and Colorists, better correlated to visual assessment).

2.2. Changes of appearance – whitening

A survey conducted among conservators and then a review of the condition of retouchings carried out in the galleries of the main Belgian and Polish museums and several ateliers as early as in the 1990s, supplemented in later years each time when visiting permanent museum exhibitions, allowed to register, among other things, changes in retouching consisting in whitening.

2.2.1. Case studies of whitened retouchings

In the case of whitened retouching observed during the review, efforts were made to determine the time, technique and composition of the altered retouching. At the beginning, a query was conducted - a review of annotations and conservation reports as well as an interview in museum studios. The next step was to make macroscopic observations in VIS and UV followed by microscopic examination. The composition of whitened retouches in the selected cases was analysed [15] [16]. The elemental composition was determined spectroscopically (XRF) and the crystal structure of the pigments present in the sample was defined by X-ray diffraction (XRD). In individual cases, it was possible to perform GC-MS analyzes in order to determine the kind of binder.

2.2.2. Mock-up paint layers examination

The results of the whitened retouchings analyses were an incentive to conduct further tests on specially made

samples. All the more in view of the already noticed whitening of the aged layers of paints factory-modified with white, considered as screening and being the same ones as those found in the whitened retouchings [4: 158, 167]. Mock-ups were made to confirm the possibility of similar changes and to investigate them.

- Paint layers preparation

Pigments and paints were selected for testing and their pigment content was instrumentally determined by XRF and XRD analyzes.

The samples were made in such a way that it was possible to make observations at the fractured cross-sections. Light blue paint layers containing white pigments selected on the basis of the content of the whitened retouchings and mixed with cobalt blue (PB 35, Kremer Pigmente) in predetermined proportions, were applied to the substrate made of a chalk-containing ground, applied to a thick polyester foil and insulated with varnish The painting layers were made with solutions of Paraloid B-72, dammar and ready-made paints - acrylic dispersion (Cryla Flow Artists') and gouache (Designers' Colour Extra Fine, Talens). Some sample surfaces were insulated with acrylic varnish made of poly isobutyl methacrylate (Acrylic Varnish Glossy, 114, Royal Talens, NE) and dammar varnish of own production. After three months of seasoning, the samples were subjected to accelerated ageing.

2.2.2.2. Artificial light ageing

Accelerated ageing was carried out in the manner and under the conditions described above in the ALPHA High Energy Xenotest (see 2.1.2)

2.2.2.3. Assessment of changes of appearance

Changes in the samples due to ageing were observed under microscope. and instrumental colorimetric assessment was made as previously described (see 2.3.).

2.2.2.4. An attempt to determine the nature of changes

In order to initially recognize the type of changes in the structure of binders contained in the whitened layers tested, comparative tests of several samples were performed. The FTIR spectra obtained from the batch of aged and non-aged identical resin film samples and paint layers were compared. Due to the small amount of research material and the content of various polymers in the samples simultaneously, the research was merely indicative.

- Imageing of structural changes in whitened paint layers

Due to the limited possibilities of chemical analysis, it was decided that the changes observed visually, recorded by colorimetry and initially analytically confirmed, were to be visualized by means of a scanning microscope. Fractures were made of selected samples of the paint layers, not covered with varnish and varnished, both in original and aged areas.

2.3. Final varnish choice and retouchings removability

The stability and removability of conservation paints is generally tested without any varnish insulation layer to know the response to light ageing of the paints themselves [17] However, to finish retouching work we generally cover them with varnish. It was decided to compare the solubility of aged layers containing different pigments in masstone and reduced to tint, both unvarnished and varnished and to attempt an interpretation in order to draw practical conclusions.

2.3.1. Samples preparation

Paint layers obtained from various hand- and ready-made solvent-borne paints currently used for retouching were selected for the tests. Both layers covered by varnish and without unvarnished were tested. The selection of materials - paints and varnishes - was made on the basis of the available assortment and the popularity of use.

Paint layers obtained from pigment mixtures (Kremer Pigmente) were represented with acrylic copolimer solution Paraloid B-72, poly-vinyl acetate solution (type Mowilith 20), both in proportions based on previous experiences and the calculations of pigment volume concentration. The ready-made paints were ketone-based containing poly-cyclohexane (RestaurArte, Bresciani and Maimeri), acrylic-based poly-n-butyl methacrylate with poly-isobutyl methacrylate addition (MSA Golden), mastic-based paints (Restoration Extrafine Varnish Colors, Maimeri) and urea-aldehyde resin Laropal A81-based paints (Conservation Paints, Gamblin). Charbonell acrylic-ketone paints, long discontinued, were omitted in the text. The layers were tested in sets consisting of titanium white and nine different chromatic hues mixed with it and applied in masstone. The aim was to

create sets with identical hues and pigment composition, however, in ready-made paints, a given color was not always created by the same pigment [3] [4, 200-201]. (Tested hues are indicated on Figures 4. and 5.). Unpigmented films of binders and varnishes were also created. All samples were applied with a clean brush to glass plates in separate bands made one after the other had solidified. No attempt was made to reproduce the actual layout present in retouching [18] (mastic - isolation varnish - retouching / with isolated underlayer or without / - final varnish) but only the top layers to avoid additional factors influencing the interpretation. The varnish was applied on half of the surface of dry paint layers. For most samples poly-isobutyl methacrylate (Acrylic Varnish Glossy, 114, Royal Talens) was used. For PVAc layers polycyclohexanone varnish (G. Berger's OF BEVA Finishing Varnish, CTS, formerly constituting a set with this binder) and for samples with Laropal A-81 (Gamblin) varnish of hydrogenated hydrocarbon resin RegalRez 1094 (Eastman) self-made, stabilized with Tinuvin 292 were applied. They were diluted in white spirit. After varnishing, the samples were ~~re-~~seasoned.

2.3.2 Accelerated light ageing

After seasoning, the samples were subjected to accelerated ageing - in the manner and under the conditions described in section. 2.1.2.2

2.3.3. Removability tests

The determination of removability was supported by solubility tests performed initially on selected paint layers, briefly reported earlier [3] [4], and then on all aged ones, repeated twenty years later, after being stored non exposed to light. The tests were made in a comparative manner on the same aged layers without varnish and varnished. A set of solvents and their two-component mixtures was used for testing, creating a scale of increasing polarity (and 'solvent power'). It was inspired by the famous proposal of Robert Feller [19].

To bring the test results closer to the common conservation practice, white spirit was used instead of cyclohexane (a mixture of aliphatic and aromatic solvents with experimentally determined proportion; it obviously had an impact on the solubility parameters of the first steps of the scale).

Table 1 – Solvents and mixtures for removability tests

White spirit	toluene	acetone	Nr
100	-	-	1
75	25	-	2
50	50	-	3
25	75	-	4
-	100	-	5
-	75	25	6
-	50	50	7
-	25	75	8
-	-	100	9

Solvents were applied to the paint layers in the form of drops and the result was observed after 45s by applying a blotting paper. The time slot finally used in the protocol was determined after performing the preliminary tests as sufficient to make observations for tested layers with different solubilities. The tests were repeated many times, taking into account local differences in the thickness of the layers applied with a brush, which may affect the results obtained. Whenever it was necessary to extend the operation time, the application was repeated. It was assumed that - due to, among other factors, the non-absorbency of the sample substrate - the test results is not a direct determinant of the solubility of the actual retouch layers - especially its speed - but an indicator of removability limitations of the systems such as the tested ones.

In order to complement the observations and tests, the varnished / unvarnished boundary surfaces of the selected samples were analyzed by the optical coherent tomography (OCT) method.

3. RESULTS AND DISCUSSION

3.1. Choice of pigment palette

3.1.1 Preliminary choice and assessment of lightfastness of paint layers – chosen examples

The ASTM assessment for a given pigment in various binders provides preliminary data [20] - if available. ASTM rate for natural alizarin Crimson (PR 83) and its synthetic imitation (PR83:1) is III (i.e. fair) in oil and acrylic binder and IV (poor) in watercolors. The monoazo substitute (PR187) of those antraquinone

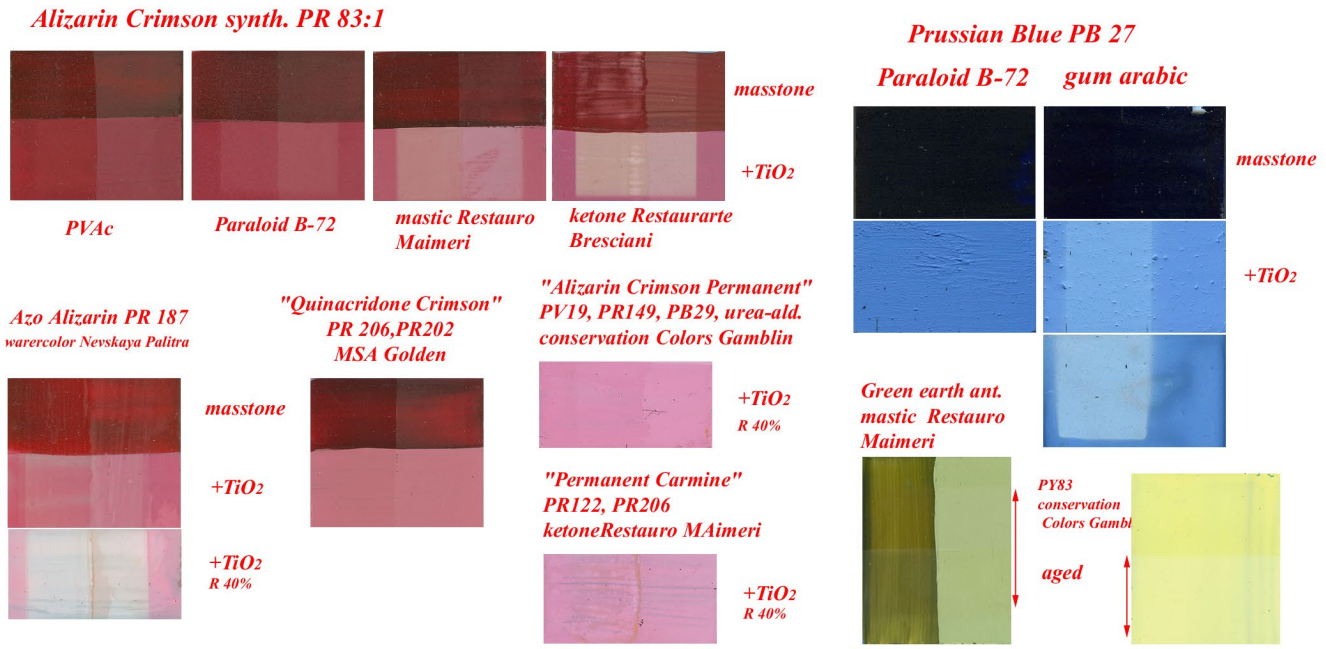

Figure 1 – Lightfastness of pigments in paint layers

pigments is assessed as II, but in some suppliers' websites it can achiveve lower marks. Quinacridone pigment (PV19), is rated as I for oil and acrylic binder, II for watercolours, its rate can also depend on its hue (rose tints are less stable). What is signaled is the dependence of pigment lightfastness in the paint layer on the type of binder and its protective properties. The next step in the preliminary selection is to search for the data marked according to the Blue Wool Standard (BWS) eight-point step, taking into account the pigment concentration. And so, alizarin crimson achieves 7 in full tone, and only 5 in tint, while its synthetic counterpart PR 83: 1 - 7-8, 7-8, 6. For PV 19 it is differentiated - depending on the binder, from 8;8;8 to 6;6 [20]. In the case of mixtures of pigments contained in the ready-made paint, the comparison of their lightfastness allows us to assume how the color of the layer obtained from it may evolve when exposed to light. For a mixture of PV 19 and PR149 (perylene red), as long as PV 19 is used in a more durable purple variant, its shade may become dominant over time. In the case of Prussian blue, it is even clearer that stopping at the ASTM assessment, high (I) for various binders is insufficient, its instability at a lower concentration (in tints) is indicated by the BWS assessment [20].

The truth of these indications was confirmed experimentally [Figure 1]. As is demonstrated by the results of the ageing of paint layers containing synthetic alizarin, in full tone its durability in various binders used for retouching does not visually raise any objections, and the changes registered by colourimetry are very insignificant. When slightly reduced by the addition of the same amount of titanium white, the differences in lightfastness between layers with different resins become clear. [Figure 1] The layers with ketone and mastic binders turn out to be very unstable. Nevertheless, what is significant, there are also visible differences in lightfastness of layers with stable polymers - Paraloid B-72 and polyvinyl acetate – surprisingly to the disadvantage of the first, more stable resin. It is likely that the inconsistency results from a different interaction of the anthraquinone pigment itself with these polymers [21]. The comparison of watercolor layers containing PR 187 in various concentrations reveals its clear instability in light tint (reduced to R ~ 40%). The example of paint layers of Prussian blue with gum arabic and Paraloid B-72 confirms its high rating in full tone. However, reduction with titanium white makes the differences in the layers with different binders easily legible. [Fig. 1].

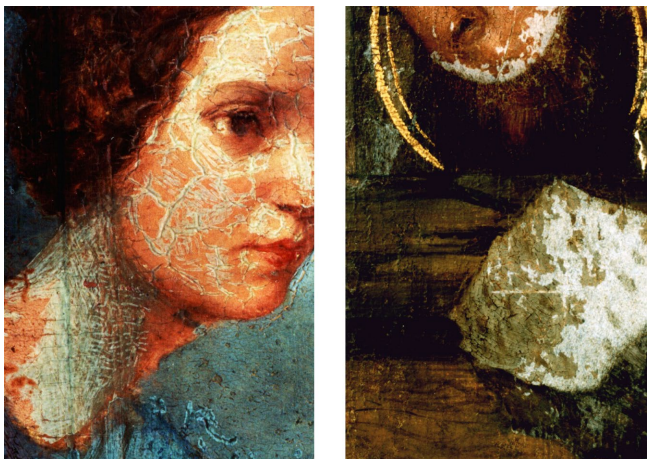

Figure 2 – Examples of whitened retouchings- fragments of paintings: W.K Stattler, Portrait of Potocki, National Museum Warsaw, phot. W Górski, A, Skowroński; Legend of St. Victor, n 13, Mechelen St Rombault Cathedral, phot. E.Szmit-Naud

When reduced with the 'chalk of Bologna' extender, it becomes explicit due to changes in the color properties of the pigment and possibly also of the binder. [13] The comparison of those two layers containing gum arabic confirms that titanium white, although strongly scattering light in the layer, nevertheless plays a screening role.

The conducted research also provokes reflection on the ratings of lightfastness presented by paint manufacturers. Among the presented examples, both professional artistic watercolor (Madder Lake Light Red) and conservation paints: Indian Yellow Permanent urea-aldehyde and Antique Green Earth mastic were rated the highest by the manufacturer. Meanwhile, the changes resulting from ageing are clearly legible, which in the case of red and yellow (PY83, diarylide yellow HR70) should be associated with their lightfastness. In the case of green earth, which is a mixture of lightfast iron earth pigments, the changes are greater in the layer without white. They probably result from the interaction of light on the paint components and from the interaction of iron pigments with the mastic binder [4: 116, 161].

Most likely the paint producer's rating simply corresponds to the assumptions according to which the highest lightfastness, i.e. I degree ASTM and 7-8 BWS, is given when changes reach dE = 4, and the rate II and BWS 6, i.e. 'very good', is accepted, [7] although it even means changes between dE 4 and 8. However, do we accept such a level of changes? Will they actually not occur before the predicted time? Already in the classification proposed years ago (the first time in 1975) by Robert Feller [19], materials obtaining the 6th BWS degree were considered 'intermediate'.

My research and observations confirmed that changes in the color of the samples in the vicinity of dE CMC = 2 are clearly visually noticeable (which corresponds to dE* ab formula from ~ 2 to 4.5 depending on the color parameters of a given pigment). They appeared on aged samples when the change of the BWS 7 standard became noticeable.

The current year will see the end of the research presently conducted by the ASTM Subcommittee with Golden Artist Colors, Gamblin Artist Paints and Natural Pigments with the aim of developing a new testing method for artist's materials [22]. Let us hope that they will bring new opportunities in this matter.

3.1.2. Changes of appearance induced by the lightfast pigments - case studies of whitened retouchings and mock-up paint layers examination.

Ultimately, the results of the overview revealed that whitened retouching accounts for almost 1/5 of all cases where unwanted changes in the appearance of retouching are noticeable. Conservation records and documentation allowed to establish that the whitening may occur very quickly after retouching is completed - after 2-3 years or even a year. The data on the technique of whitened retouching was more difficult to pin down, especially since corrections were made in some cases - sometimes to whitened retouchings themselves! Nevertheless, it was possible to conclude, based on the information about the materials used in the studios at a given time, that whitened retouching could be made with very different techniques, homogeneously or in combinations: with oil and oil paints combined with dammar or mastic, ready-made oil-resin paints, pigments with natural resins, later also synthetic ones, mastic paints, gouache and watercolor [15][16]. Observations made in situ occasionally allowed to notice the detachment of the varnish and chalking under it, but also whitening in the subsurface layer or in the entire thickness of the retouching without the loss in its cohesion. None of the whitened retouching was subject to permanent 'regeneration' with solvents or resin solutions. The gloss of the altered areas was varied. Unlike other retouching, the whitened ones showed in UV radiation gray, bluish

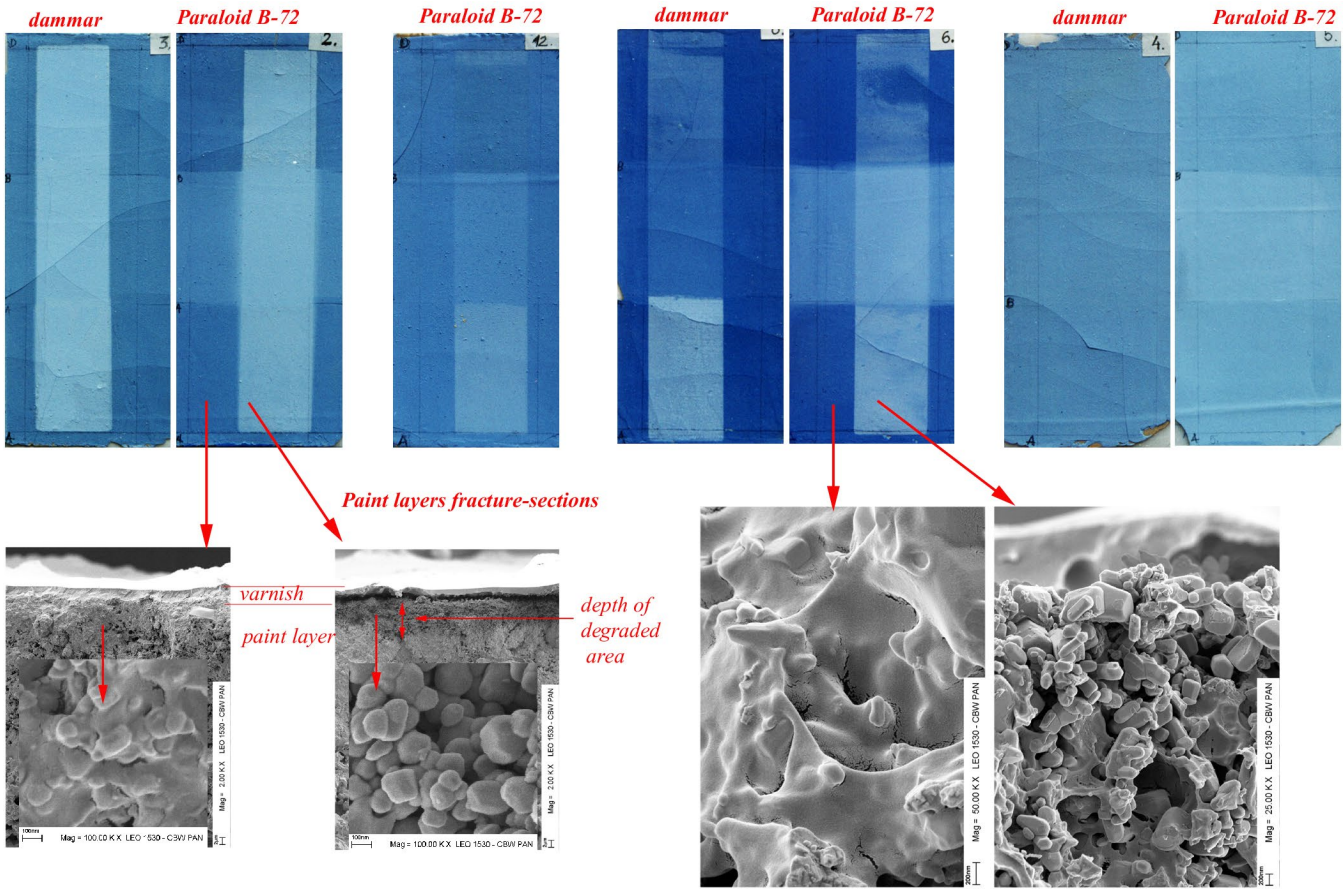

Figure 3 – Whitening of mock-up paint layers containing zinc white (PW4, and titanium white (PW6) rutile and anatase

gray or gray-violet appearance. Whitening occurred in the retouched parts of skin, sky, light robes and other light ones. Their pigment composition was examined in fifteen paintings. Apart from a small amount of color pigments adapted to the part of the retouched image, the analysis identified predominantly white pigments. The common feature in the composition of the whitened retouchings was the presence of zinc white (zinc oxide) and titanium white - titanium dioxide in the anatase crystalline form, sometimes both at the same time. They were sometimes supplemented with lead white and fillers - barite or chalk.

In the case of a retouchings containing zinc white (whitened after a year!), made with watercolors saturated with dammar varnish and another unchanged one from a dark part of the same image, it was possible to compare their spectrum in the infrared, which allowed to observe a difference suggesting the occurrence of acid decarboxylation, indicative of the binder degradation.

The results of mock-up analyses revealed an intense whitening of the initially blue paint layers , containing titanium dioxide anatase and those containing zinc oxide in both binders, i.e. in Paraloid B-72 and in the dammar, both with and without varnish. In the varnished parts, the chalking at their contact with the paint layer was so strong that it caused the varnish to detach. In the samples with anatase, the dammar varnish was even flaking. However, it was generally noted that all whitenings are not exclusively superficial. Samples in which anatase was present in equal proportions with barite or with rutile titanium dioxide whitened less, regardless of the type of paint (acrylic or gouache). Barely visible but instrumentally recorded changes occurred where anatase was only an admixture to rutile. Colorimetrically assessed slight color changes in the sample with rutile only did not

consist in whitening. The comparison of the reflection spectra of the samples before and after ageing confirmed that the whitening is not a discoloration. The indicative results of comparative instrumental analyzes (FTIR) of both unaged and aged film of the resins themselves and of whitened paint layers containing them, exposed differences suggesting the occurrence of structural changes in the resins present in the whitened samples. The SEM scans of the fractures of several whitened samples clearly showed a loss of resin volume in the varnish layer at the contact with the paint layer, visible as an empty slit and the exposure of pigment grains below to a depth of several micrometers [Figure. 3]

The changes observed as whitening of the retouching in the bright parts of paintings, described already in the 1960s, were associated with the presence of zinc oxide in them and were explained by the chalking of oil binder and dammar and / or the fading of organic pigments in its presence [6] [7]. The studies described above distinctly illustrate the fact that also titanium white can cause them with greater intensity, and these changes are also subject to resins other than dammar, e.g. acrylic, also those with proven chemical stability, such as Paraloid B-72, which was confirmed by subsequent studies [23] [24]. It was not until relatively recently that the specific interest in the problem of whitening has been renewed in publications addressed to conservators [25], [26], however, already more than 70 years ago researchers working in the field of polymer chemistry dealt more widely with the properties of zinc white, then titanium white and their interactions with the environment causing or enhancing chalking of binders in their presence. The bibliography for this topic and extensive explanation were cited earlier [4:121-126; 166-171]). They can be summed up by the statement that both zinc oxide and titanium dioxide exhibit photocatalytic activity, inducing radical reactions leading to the degradation of binders. The reason for such properties of zinc white, not recognized by all, are the imperfections of the crystal lattice of this oxide and their degree, closely related to the production method. As a result, some varieties may not display them. [27: 42,44] [28] The fluorescence color of the pigment in UV may be an indication, but my own observations did not confirm the possibility of differentiating on this basis [4: 122-123]. In the case of titanium dioxide, both of its crystalline varieties (anatase and rutile) used as pigments show photocatalytic properties resulting from the semiconductor nature of this oxide and can induce oxidative degradation. This activity is limited in various ways, including by treating the surface of the pigment. The rutile variety is modified in this way, and in the case of anatase, which is more photochemically active, the ability to cause chalking is even used in external 'self-cleaning' white paints. The effects of the above-mentioned mechanisms, perforce only briefly signaled, are confirmed by the results of the presented research. One may wonder about the fact that zinc oxide, considered to be less photochemically active than titanium dioxide and, similarly to it, strongly absorbing UV, is still used as a screening pigment and added to other paints. However, whitened retouching and mock-up layers could contradict the thesis about its protective effect, especially when it is present in a significant proportion. In addition, in the case of zinc oxide, due to its alkaline nature (pH 7.1-7.5), whitening can also be seen as an outcome of its reaction with the environment, i.e. with the components of binders and air pollutants. The result will be salts (including soaps), also white. Identifying the possible products of such reactions in the course of the described research was not feasible due to the insufficient amount of research material. Therefore, although the registered changes indicate the degradation of binders, the other mechanism cannot be excluded, either.

It should be noted that, although in the described cases, the changes in the appearance of the paint layers are striking, titanium and zinc whites are not the only reactive pigments or those showing photocatalytic properties present on our palettes, [4: 126][29][30], The possibilities for further research into the noticeable changes caused by these properties of the pigments in use have not been exhausted.

3.3. Removability of varnished retouchings paint layers

When varnishing the paint layers of individual sets of retouch paints, clear differences in absorption were visible. In order to insulate the surface, the layers of ketone paints required multiple varnish applications, while acrylic and mastic layers only two, and polyacetate and urea-aldehyde paints – a single one.

Already during the research on the effect of varnish application on the appearance of the painted layers of these sets, the dependence of luster on the type of pigment and the addition of white, as well as the type of paint binder [4: 150-154] [5] was clearly visible in each of them. Varnishing and ageing did not blur those

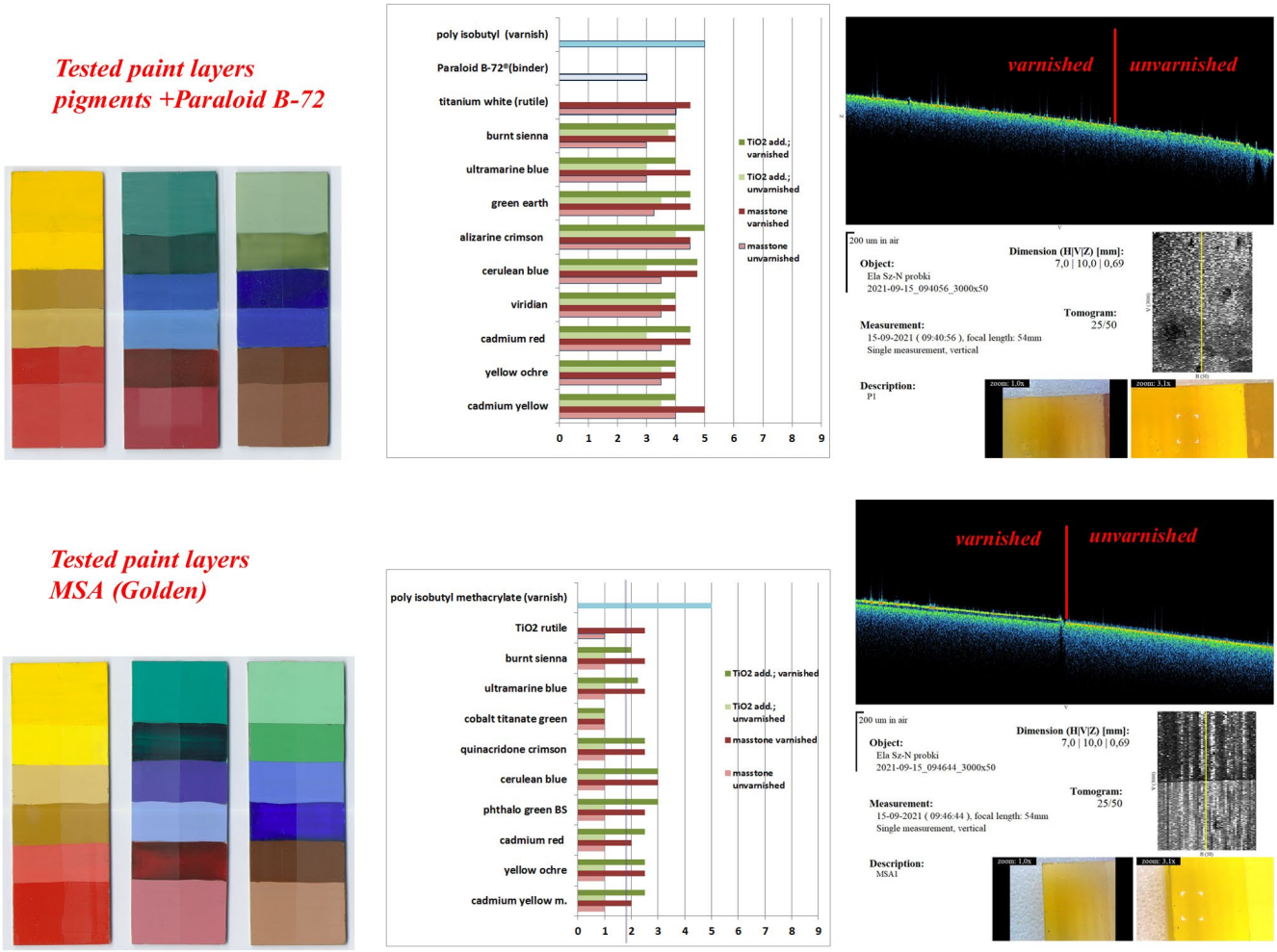

Figure 4 – Removability and surface OCT imaging of varnished and unvarnished paint layers - aged acrylic paints example

differences. It is not surprising that the unvarnished paint layers containing only titanium white (rutile), regardless of the binder resin, were less soluble in general, or even showed worse solubility than other layers in masstone.

From the point of view of the type of paint binders considered as a whole set, the most easily soluble of the discussed are the layers of MSA acrylic paints, then Gamblin urea aldehyde, layers with Paraloid B-72, slightly worse polyvinylacetate, then ketone and definitely the hardest - mastic. However, the removability of the layers not covered with varnish and varnished was not identical. The analysis of the test results showed that the application of the varnish may make it easier or more difficult to remove after ageing, as will be illustrated by a number of examples.

In the case of layers with Paraloid B-72 and MSA paint layers, the binder of which is poly butyl methacrylate, covering them with a ready-made varnish containing another acrylate – poly isobutyl methacrylate, resulted in a reduction of their removability compared to non-insulated layers. The initial solubility of both acrylic binders of these paints is different. Initially, dissolving poly butyl methacrylate does not require a high content of aromatic solvents. It was not required after ageing to dissolve the layers of unvarnished MSA paints, still soluble in white spirit, but it was necessary to add toluene to completely solubilize the varnished layers. In the case of Paraloid B-72 paints, a larger proportion of it was necessary to remove the varnished layers.

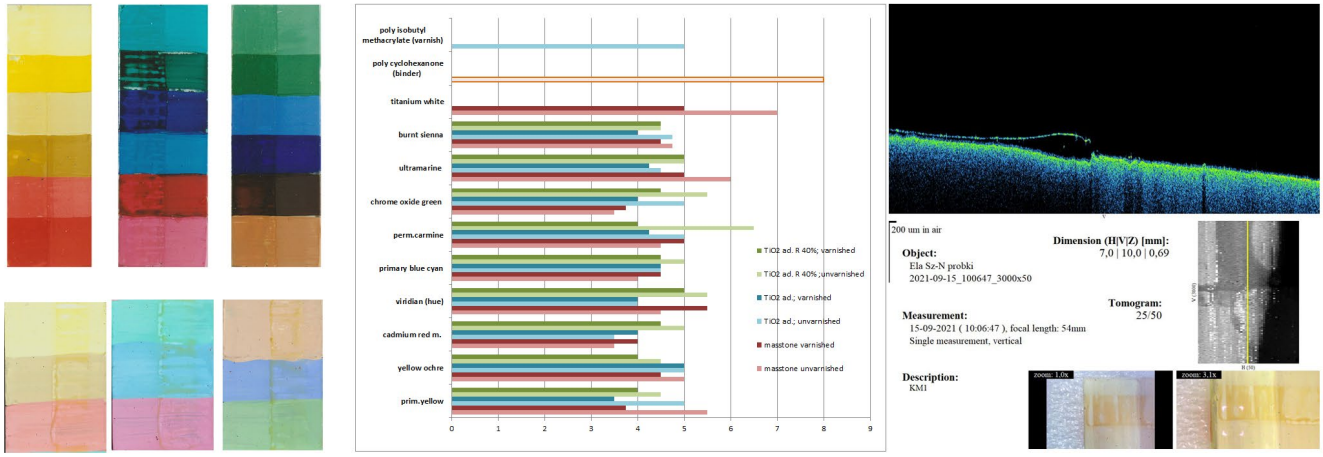

Figure 5 – Removability and surface OCT imaging of varnished and unvarnished paint layers – aged ketone paints example

According to the surface image obtained in the OCT, these are two different situations – the varnish seems to penetrate into the paint layer with Paraloid B-72 and to create distinct layer on MSA. However, it cannot be ruled out that its parts may penetrate into the paint layers, which visibly soften during the application of the varnish. The solubility of unvarnished layers of MSA paints in white spirit and the need to add toluene in the case of varnished layers, could indirectly indicate the use of stabilized resin in paints (which, however, is not confirmed in the manufacturer's information) and unstabilized poly isobutyl Oversaturation of ketone paints layers with varnish containing isobutyl methacrylate resulted in the easier removal of varnished layers compared to non-varnished ones (i.e. lower toluene content). In the layers that have absorbed varnish to a smaller extent, the ageing effects of the ketone resin paint binder seem to have a dominant effect on solubility, resulting in its greater reduction.

A similar effect was achieved by applying a ketone varnish onto PVAc paint layers, although their absorbency was lower (they required double varnishing in individual cases). The OCT image suggests that the varnish, penetrating into the near-surface area, formed a thinner and less distinctive layer on top. All the varnished layers required slightly more toluene to remove than the unvarnished ones, and in one case the addition of acetone. It seems that the effects of ageing of the varnish ketone resin were dominated by changes in solubility due to aging by exposition to light (i.e. the prevalence of methacrylate in the varnish. It is its solubility that has been reduced, although both resins are subject to cross-linking. Perhaps this condition was also influenced by the addition of turpentine oil in the ready-made varnish [31: 120, 128].

The opposite situation, i.e. paint layers with a binder resin less chemically stable than the one in the varnish, is illustrated by the example of ketone paint layers covered with an identical acrylic varnish. The layers of these paints were saturated with it before it finally formed a film on their surface, more regular on smoother tints (those with more white). polyclohexanone oxidation over polyvinyl acetate degradation)

In the case of mastic paint layers, covering them with a layer of acrylic varnish (as above) gave in OCT a surface image similar to the one described above, suggesting penetration into the surface of the paint layer. This resulted in often only slight differences in removability requiring, unfortunately, similarly to unvarnished layers, very polar mixtures (content from 50 to 100% acetone). It is possible that these differences would be more advantageous if the ready-made acrylic varnish (Acrylic Varnish Glossy, 114, Royal Talens, NE) did not contain turpentine oil, which could additionally catalyze the oxidation of the mastic.

And finally - in the case of some paints of the set, coating the layers of paints with Laropal A-81 stabilized varnish from RegalRez 1094 allowed to dissolve them in a mixture of white spirit with toluene (50:50), while unvarnished layers required a larger

proportion of toluene (and in the case of the aforementioned Indian yellow permanent even with acetone).

The performed study lead to conclude that if we apply a varnish that is less chemically stable in the ageing process (including additives in it) onto layers containing more stable resins, the limitation of the removability applies to this whole. It is illustrated by the examples of layers made of acrylic paints and PVAc. On the other hand, covering the retouching with a varnish containing a resin that is more stable than the binder resin improved its removability compared to an unvarnished layer. It was illustrated by the example of ketone paint layers, and was noticeable for the layers with Laropal A-81 conservation paints as well as those with mastic.

The described test results demonstrate that the characteristics of the resin (and possible additives) in the varnish applied to a dried, but recently made retouching layer, will visibly affect its removability in the long term. This cannot be interpreted as a simple dependence on ageing changes in the varnish itself as the final protective layer, because in the applied system used it does not form a completely separate layer.

In order to determine the nature and degree of changes and to confirm its interpretation resulting from this study, more extensive research and instrumental analyzes are required

4. CONCLUSIONS

When choosing materials for retouching, we obviously pay attention to their application features and the compliance of the obtained effect with the original painting. However, the properties that guarantee the long-term durability of the achieved visual results are equally important.

The first, obvious step in selecting materials is checking the lightfastness of the pigment or the ready-made paint. The examples of color changes in the paint layers recorded and illustrated here in confrontation with the normative assessments (ASTM, BWS) provoke reflection. I assume that in the case of all paints produced for conservators the lightfastness rates does not only rely on the table in the appendix of the ASTM standard but are the effect of the research. It may seem that the manufacturer's ‘higest’ lightfastness rating does not match the independent experimental results because the changes presented here were noticeable and confirmed by colorimetry The remaining question is what is the rate of changes that are willing to accept. Let us hope that the aforementioned research aimed at developing a new testing method for artist’s materials will bring a reliable assessment of the materials proposed to us.While waiting for the results, I would postulate that when selecting pigments and paints for the conservator palette, one should give up those whose components of the BWS ratings in both masstone and tints are below 7, and in the case of available lightfastness tests for specific paints, consider those whose dE^*_{ab} does not exceed 4 (or calculated with improved dE formula is close to 2).

Excellent lightfastness turns out to be in some cases an insufficient selection criterion. White paints containing ‘Chinese white’ and anatase titanium white are a clear example of this. Recently more numerous publications on these particular properties of theirs may result in greater care in avoiding them in conservation applications.

It should be noted that the exposure to light and the level of air humidity necessary for the reactions in which both discussed white pigments take part, do not have to be extreme, as evidenced by whitened retouching in museum galleries. At the same time, the zinc white and titanium anatase themselves do not deteriorate. Although zinc oxide may not always have a photocatalytic effect, it is difficult to recognize what kind of pigment we are dealing with, and it can also cause changes due to salt formation. For the durability of the retouching, it is a safe solution to exclude from the palette of paints the ones containing zinc white (PW4) and titanium white (PW6) of an unknown type and to use a treated – and thus ‘safe’ - rutile variety that limits its photoactivity.

In addition to the properly selected components of the retouching paint itself, its properties are also determined by the varnish, usually applied very quickly after painting reintegration is completed. As a rule, we are inclined to treat the varnish as a separate film. Observations on unvarnished and varnished aged layers of retouching paints convincingly indicate that the retouch covered with the varnish is a system that should be treated inseparably. It is mistaken to assume that the changes in the solubility of the varnish and the retouch layer underneath can be considered independently. The varnish applied does not (only) work as a "filter". From the point of view of the safety of removing the retouching from the area where they

were applied within the thinned original layers, the above statements are utterly significant.
The examples discussed in this text, taken from many years of research on retouching materials, were not intended so much to present their assessment (which was done in separate earlier publications) but to focus using them on the aspects important for the conscious choice of retouching materials and their handling. I hope that the presented conclusions will provide the guidelines supporting optimal selection and use of retouching materials.

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NOTES

Artificial ageing: Xenotest 150S (Heraeus, Hanau – Germany) in Instituut Collectie Nederland, Amsterdam and in Institute of Dyestuffs of Łódź Polytechnic; Xenotest ALPHA High Energy (Atlas, USA), Department of Conservation and Restoration of Paintings and Polychrome Sculpture of Fine Arts Faculty, Nicolaus Copernicus University (NCU), Torun

Colorimetric assessment: Minolta CM 2002, Instituut Collectie Nederland in Amsterdam, Macbeth 2020 Color Eye, Labortory of Colorimetry, Institute of Dyes and Organic Materials, Łódź; SP-64 XRite, Nicolaus Copernicus University, Department of Conservation and Restoration of Paintings and Polychrome Sculpture of Fine Arts Faculty at NCU, Torun

XRF: Energy dispersive X-ray spectrometer MiniPal PW 4025 (Philips Analytical) analysis: Adam Cupa, Department of Paint Technique and Technology of Fine Arts Faculty, NCU, Torun

XRD: Tractor Xray Du Bois 404 Object Analyser. analysis: L. Maes, Département des Laboratoires, Institut royal du Patrimoine artistique (IRPA/KIK) Brussels; diffractometer Siemens D500, analysis: Stanisław Gierlotka PhD, Diffraction X Laboratory, Institute of High Pressure Physics Polish Academy of Science, Warsaw; diffractometer X HZG4/A, analysis:Jerzy Rauchfleisz, Laboratory of Instrumental Analysis, Faculty of Chemistry, NCU Toruń

FTIR : dr Marina van Bos, Département des Laboratoires, IRPA/KIK, Brussels ; Perkin – Elmer, analysis: dr hab Irmina Zadrożna, Faculty of Chemistry Warsaw University of Technology

GC-MS : GC: Varian 3400, capillary column DB-5. MS: Finningan ITS 40, analysis: Marina van Bos PhD: IRPA/KIK, Brussels ; GC- Hewlett-Packard HP-5890II, capillary column Ultra 2, MS: HP-5971A. dr hab Irmina Zadrożna, Faculty of Chemistry Warsaw University of Technology
SEM- Leo1530, column Gemini, analysis dr Adam Presz, Institute of High Pressure Physics Polish Academy of Science, Warsaw

OCT – optical coherence high resolution tomography, analysis: dr hab. Magdalena Iwanicka, Laboratory of Nondestructive Analysis, Center of Modern Interdisciplinary Technologies, NCU, Toruń

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MOCK-UP RECONSTRUCTIONS OF GOLDEN TEXTILES DEPICTED IN THREE RENAISSANCE PAINTINGS FROM CROATIA: THE PURSUIT OF EMBELLISHMENT TECHNIQUES

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ABSTRACT

This research will focus on three small-scale mock-up reconstructions of several embellishment motifs used by renaissance painter Nikola Bozidarevic from Dubrovnik (Croatia). The reconstructions were carried out as a part of the practical portion of the *Technical analyses and historical reconstructions* course at the Arts Academy of the University of Split during the academic year 2020/2021. During the reconstruction process a number of questions concerning the painter's working properties aroused. The attempt was made to answer which methods of transferring the pattern on the gilded surface could have been used. Further questions concerned the subsequent steps of decoration, for example did the pouncing of the surface occurred before or after delineation of the motifs in thick paint. In spite the fact that most of these questions remind ambiguous, the experience gained from the reconstruction process emphasized the importance of understanding the practical aspects of decorative techniques as well as the high level of knowledge about the painter's materials required for this kind of process.

Keywords
Renaissance paintings, Golden textiles, Embellishment techniques, Small-scale mock-up reconstruction.

1. INTRODUCTION

During the 15th and 16th century, in the Dubrovnik Republic, artist developed specific techniques to emulate the gold brocaded silk velvets worn by the religious characters in their paintings. This paper will focus on three small-scale mock-up reconstructions of several embellishment patterns used by Nikola Bozidarevic (1460.-1517.), one of the most important painters within the entire Dalmatian painting of that time. All reconstructions were carried out by conservation-restoration students during a practical portion of the course Technical analyses and historical reconstructions II. taught at the Arts Academy of the University of Split (AY 2020/2021). This research is inspired by an ongoing project of the Croatian Conservation Institute (HRZ) related to the conservation and technical investigation of the panel painting The Virgin and Child from the church of Our Lady of the Snows in Cavtat[i], whose authorship is associated with Bozidarevic and his father Bozidar Vlatkovic. [1]

1.1 Objectives

In accordance with the typical motif selection of the 15th century European masters [2], Bozidarevic often

Table 1 – Analyses of the blue and red coloured motifs of the gilded Virgin's dress from the painting The Virgin and Child, The Church of Our Lady of the Snows, Cavtat. Column III. and IV. are based primarily on XRFresults performed by Domagoj Mudronja, PhD from the Natural Science Laboratory of the HRZ, Zagreb. [5]

ANALYSES OF THE BLUE AND RED COLOURED MOTIFS OF THE VIRGIN'S DRESS				
Technical studies	**Location**	**Registered elements**	**Possible materials / pigments**	**Materials used in reconstructions**
Visual observation Cross section analyses X-Ray Fluorescence Energy-dispersive X-ray spectroscopy	Blue motifs	Ca, Fe, Cu, Au, Pb (S, K, Co, Ba)	4th blue layer - azurite, lead white	Prussian Blue LUX 45202 Cl : PB 27. 77510, Kremer; Titanium white (Art. 46200) - Kremer
	Red motifs	S, Ca, Fe, Sr, Hg, Pb (K, Cu)	4th transparent red layer – (?) 3rd red layer - vermilion	Cadmium red Nr. 1 hell hochst lichtecht, deckend 211200 ce: PR 77208, 77196, SiO2; Alizarin Krapplack dkl. Conc. C, 23611

painted vegetable motifs in red and blue with undulating repeats of flowers, pomegranates, leaves, or seed like forms over the gilded surface. The motifs were also methodically ornamented with punch marks, in contrast with the flat background. [3, 4]

This research was guided by the idea that motifs were not made freehand by the master from the very beginning, but rather that the patterns were used to achieve simple motif replication, after which the lines of the imprint are thickened freely by hand. The idea was based on the cross-section analysis of the red motifs from one of his paintings (see chapter 2) as well as on the usefulness of using such design patterns, in particular for accelerating the decoration process and saving time.

Further aims were to discover how the painter conveyed the subsequent steps of decoration. For example, did the ornamentation with punch marks occur before or after the pattern was delineated onto the surface. The goal was also to imitate the effect of the textured lines i.e., the thick paint used for delineation of the motifs.

Finally, this research includes the reconstruction of *sgraffito* technique, also used by Bozidarevic to depict minute details of the embellishments on the edges of garments. Due to the toxicity of the required traditional pigments and their price on the market, contemporary equivalents were used in the process as shown in Table 1.

2. MATERIALS AND METHODS

The technical studies of the painting from Cavtat, performed by the Natural Science Laboratory of the HRZ, contributed to better understanding of Bozidarevic's embellishment techniques.

The results concerning the motifs were used as a guiding tool in the reconstruction process (Table 1). [5] However, since the painting from Cavtat is badly damaged and altered with several campaigns of overpaint, the motifs for the mock-up reconstructions were selected from three other paintings made by Božidarević during the 16th century: polyptych depicting The Virgin and Child with Saints from the Church of St Mary's (Our Lady of Dance) in Dubrovnik, altarpiece for the family Đorđić - *Sacra conversazione* and triptych of the Bundic family, both from the Dominican Monastery in Dubrovnik.

All reconstructions were performed in six principal steps: (1) preparation of the gesso, (2) preparation of the red clay – bole, (3) gilding, (4) preparatory drawing of the motifs, i.e. motif replication, (5, 6) paint delineation of the motifs (Figure 3, 5, 7).

The idea of introducing the preparatory drawing of the motifs (step 4) or more precisely - the lines of the imprint, in reconstructions No. 1 and No. 2, was inspired by the insight into the stratigraphy of the red motif (Figure 2) on the painting from Cavtat, i.e. the presence of a thin opaque red layer (vermilion) situated

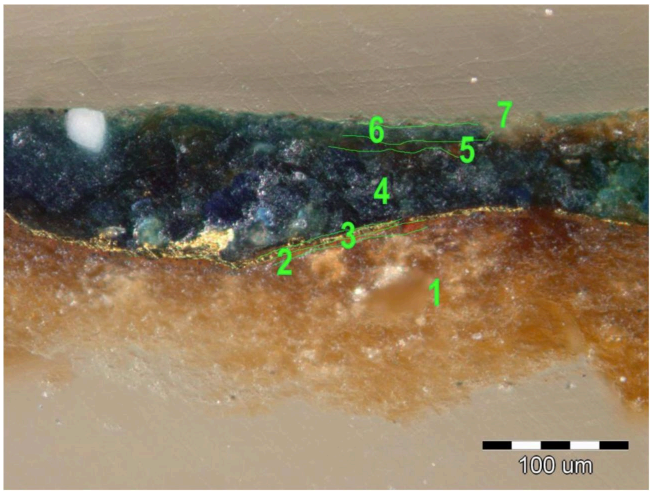

Figure 1 – Photomicrograph of the cross section of the blue motif (sample no. 26031). Photo: M. Jelincic. (7) yellow-brown layer; (6) blue-green layer - azurite, malachite, barium white, (5) brown layer - iron oxide, (4) blue layer - azurite, lead white, (3) gilding – gold, (2) red layer - iron oxide, (1) yellow-brown layer – plaster. [5] Note that the sixth and seventh layers are part of the overpaint.

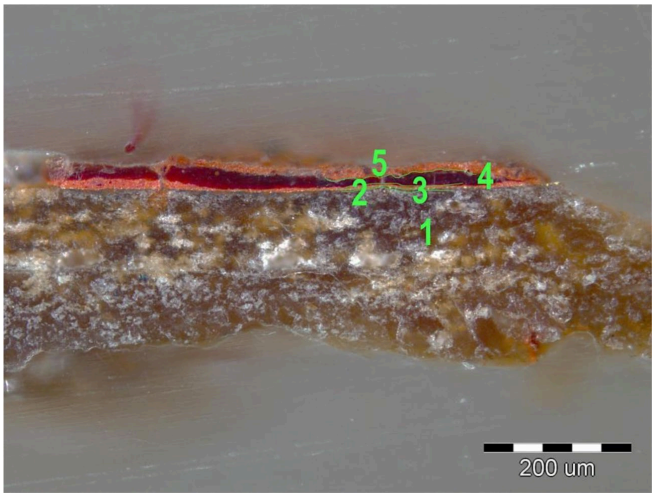

Figure 2 – Photomicrograph of the cross section of the red motif (sample no. 26032). Photo: M. Jelincic. (5) red layer with grains of red and blue pigment - vermilion, azurite; (4) transparent red layer – (?), (3) red layer – vermilion, (2) gilding – gold, (1) yellow-brown layer - gypsum, lead white, iron oxide. [5] Note that the fifth layer is part of the overpaint

between the gold leaf and the thick transparent red paint of most likely organic origin.

2.1 Reconstruction No. 1 - blue motifs

Reconstruction No. 1 – depicting blue motifs – was based on the photography of the Polyptych the Virgin and Child with Saints (detail of Virgin's dress), 16th c., Church of St Mary's (Our Lady of Dance), Dubrovnik.

For the reconstruction No. 1. the cardboard tiles were used as a support (dim. 5 x 5 cm).

With the respect to the drying time between each application, the surface was covered with six layers of gesso. When the final gesso layer was dry completely, the surface was evenly smoothened with sandpaper. The red clay – bole, mixed with glue, was applied in several transparent layers. After drying, it was gently burnished with smooth bristle brushes. The surface

Figure 3 – Detail of the polyptych The Virgin and Child with Saints (detail of Virgin's dress), 16th c., Church of St Mary's (Our Lady of Dance), Dubrovnik.

was then wetted with water containing small amount of ethanol, and the gold leaf was placed and gently pressed down. Shortly after, it was burnished with agate tools to make it more reflective.

The method of transferring the motif onto the gilded surface was inspired by *spolvero* technique. Instead of cartoon and charcoal dust, tracing paper and wet paint were used in the process (blue Miloriblau pigment in gum arabic as a binding medium). Namely, the tracing paper was pricked with a needle, and the paint was pushed through the holes with a pointed brush to mark the surface below. (Figure 4)

The initial drawing of the motif was formed by connecting the dots using the mixture of Miloriblau and Titanium white in gum arabic. The decision about choosing this particular medium is addressed in final discussion.

Next, the ornamentation of the spaces within the motifs was performed by gently hitting the punching tool of required size and shape with a hammer. [3, 6]

Finally, the lines of the imprint, i.e. preparatory drawing of the motif, were covered with two additional applications of the paint (same as for the preparatory drawing), but with the exception of Titanium white. The goal was to achieve the required thickness of the motif lines (Figure 3).

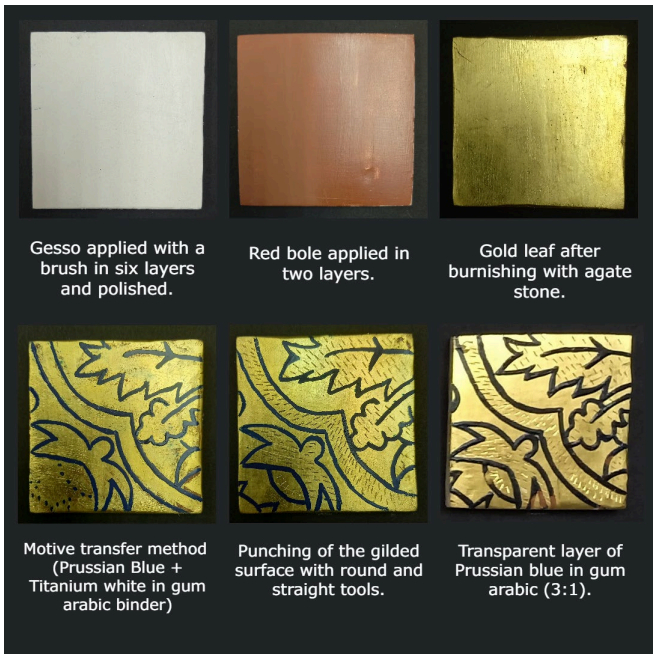

Figure 4 – Chronological process of making the mock-ups for the reconstruction No. 1

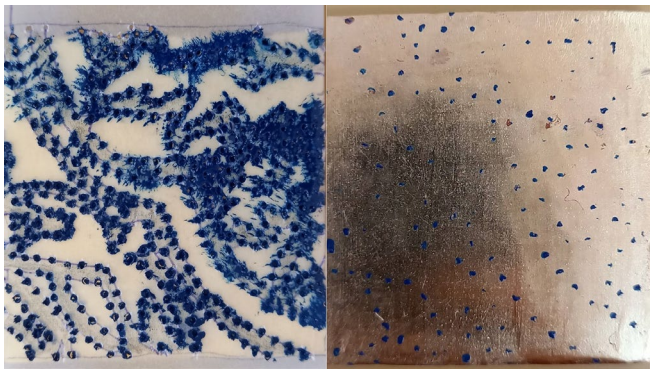

Figure 5 – Motif transfer technique performed on the reconstruction No. 1

2.2 Reconstruction No. 2 - red motifs

Reconstruction No. 2, depicting red motifs, was based on the photography of the altarpiece for the family Đorđić - *Sacra conversazione*, (detail of St. Blaise cloak), from the Dominican Monastery in Dubrovnik.

Figure 6 – Detail of the altarpiece for the family Đorđić - *Sacra conversazione*, (detail of St. Blaise cloak), 16th c., Dominican Monastery in Dubrovnik.

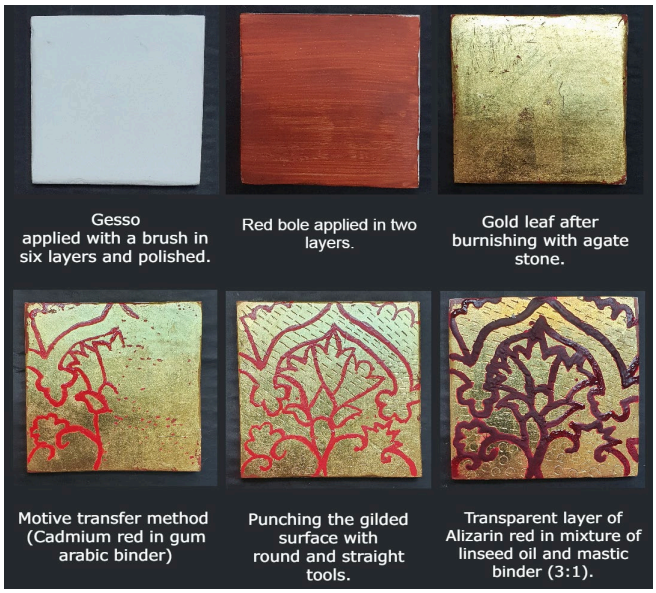

Figure 7 – Chronological process of making the mock-ups for reconstruction No. 2

Figure 8 – Application of the final transparent layer over the opaque preparatory drawing of the red **motif.**

The preparation of the surface, the gilding, as well as the motif transferring method, was performed in the same manner as in the reconstruction No. 1.
Besides the pigments and the pouncing tools, the main difference regarding reconstruction No. 2 was the selection of the paint medium for the final delineation of motifs.
Namely, the preparatory drawing of the motif was made by the mixture of Cadmium red, Titanium white and Cadmium yellow bonded with gum arabic.
After drying, the spaces within the motifs were patterned with the combination of straight and rounded metal punches, similar to the ones in the original painting (Figure 5). [3, 6] Finally, the motif lines were thickened with two coats of Alizarin pigment bound with the oil-resin medium (cooked linseed oil with the addition of mastic) (Figure 6).

2.3 Reconstruction No. 3 – *sgraffito*

Reconstruction No. 3, depicting blue and red motifs in *sgraffito* technique, was based on the photography of the Triptych of the Bundic family (detail of Virgin's dress), from the Dominican Monastery in Dubrovnik.
The cardboard tiles (dim. 5 x 5 cm) were prepared with gesso in the same manner as for the reconstruction No. 1 and No. 2.

The sketch of the chosen motif was transferred with the help of translucent tracing paper and carbon transfer paper. The sketch was then carved into the gesso with a pointed metal tool.
Again, the application of the bole, as well as the gilding process, was made in the same manner as for the reconstruction No. 1 and No. 2.
However, tempera was prepared from the mixture of egg yolk and water in 1:1 ratio, and used as the medium for the pigments (Figure 8). Two colours were made; first one using Prussian blue and Titanium white, and second using Cadmium red and small addition of Venetian red earth to match the required hue. The prepared paint was applied on gilded surface while matching the lines of the incised motif. When dried, the paint was carefully scrapped with the bamboo stick following the forms of the motif and revealing the gold underneath. This was done with minimal pressure onto the surface (Figure 7).

3. RESULTS AND DISCUSSION

During the reconstruction process, a number of questions concerning the painter's working methods aroused. Regarding the initial transfer of the motifs, the reconstructions No. 1 and No. 2, made evident that

Figure 9 – Detail of the Triptych of the Bundic family (detail of Virgin's dress), 16th c., Dominican Monastery

the method we have used to transfer the pattern (similar to *spolvero* technique), is rather questionable method even for a small mock-up format, let alone a large painting. One can easily loose the shape of the motifs while linking the dots, even if the initial pattern is constantly observed during the process (Figure 4).

Although gum arabic was primarily used for the art on parchment at the time [3], the decision was made to explore its behavior and adhesion onto the gilded surface and to compare it with other mediums (such as egg tempera and oil-based binding media) at the next stage of this project.

Interesting problem occurred when trying to emulate the thickens of the lines of original motifs. Namely, it was immediately evident, that the initial drawing of the motifs needed to be followed by an additional layer of paint in order to get the required thickness. However, regardless of the different selection of the mediums, both reconstruction No. 1 and No. 2 displayed the same problem of the coat flattening after it had dried. This indicated that our attempt in selecting the medium for emulating Bozidarevic's motifs was rather poor. It is unlikely that he would repeat the same action on a large surface until he achieved the preferred thickness. The question is how would egg tempera and oil-based binding media behave in this regard?

Furthermore, the paint used in the reconstructions No. 1 and No. 2 turned out to be very brittle with low adhesion to the gold leaf, resulting in fine network of craquelures several weeks after the application.

Regarding the reconstruction No. 3, it was evident that the bamboo stick used for *sgraffito*, was not sufficiently precise tool in defining miniature shapes of Bozidarevic's motifs. The paint separated from the surface in lumps, making the scratching hard to control. This phenomenon led to the suspicion that the

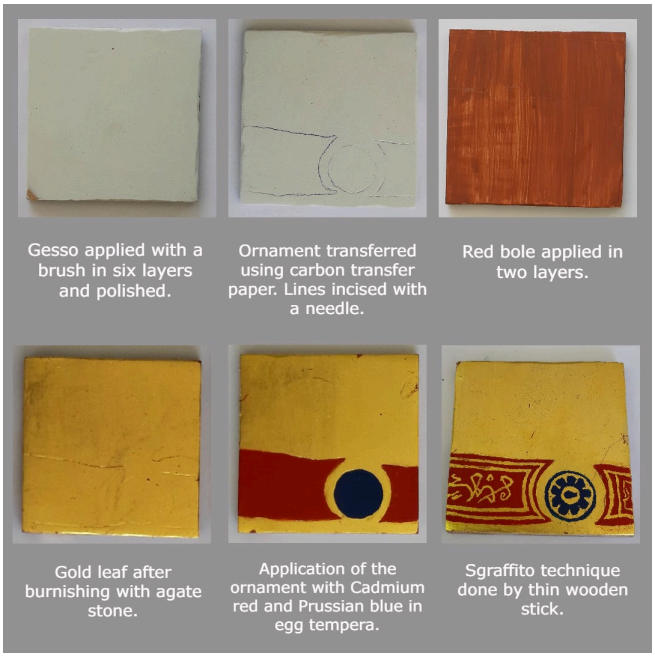

Figure 10 – Chronological process of making the mock-ups for the reconstruction No. 3

time passed for the paint to dry was rather too long, or the pigment concentration was not suitable.

4. CONCLUSIONS

Although the exact method of depicting golden textiles in Bozidarevic's paintings remind ambiguous, this research has helped in understanding certain practical aspects useful for further discussions in this area. Namely, the inadequacy of the method we have used to transfer the pattern onto the gilded surface, was clearly demonstrated.

Owing to the insight into the practicality of the process, the ornamentation with punch marks most likely occurred between two sessions of motif delineation – the first one, concerning simple motif replication, and the second one, made by thickening of the imprint lines freely by hand.

In addition to further investigate other possibilities of transferring the pattern, future research should be aimed at discovering Bozidarevi's paint binder, capable of achieving the required thickness in a single

application. Besides the need of selecting a more precise tool for *sgraffito*, working on reconstruction No. 3 reviled the necessity to consider the drying time of the paint as well as to test the different ratios of water and egg yolk in order to make the paint more workable for depicting minute details of Bozidarevic embellishments.
In spite the fact that most of these questions remind enigmatic, the experience gained from the reconstruction process emphasized the importance of understanding the practical aspects of decorative techniques as well as the high level of knowledge about the painter's materials required for this kind of process.

5. SUPPLIERS

Mini cardboard for painting (5 x 5 cm), Hobby Art Centar Chemaco, Grada Vukovara 226, 10 000 Zagreb, Hrvatska

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).

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

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

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

Bologna chalk (Art. 58100). KREMER, Kremer Pigments Inc. 247 West 29th Street New York, NY 10001

Blue pigment (Miloriblau LUX 45202 Cl : PB 27. 77510, Kremer Pigmente, Ersatzproduct fur 45200) KREMER, Kremer Pigments Inc. 247 West 29th Street New York, NY 10001

Titanium white (Art. 46200) - KREMER, Kremer Pigments Inc. 247 West 29th Street New York, NY 10001

Cadmium pigment (Cadmiumrot Nr. 1 nell hochst lichtecht, deckend 211200 ce: PR 77208, 77196) SiO2 – haltigen Fullstoff Zusten, KREMER, Kremer Pigments Inc. 247 West 29th Street New York, NY 10001

Cadmium yellow (2135 Mitel. F) KREMER, Kremer Pigments Inc. 247 West 29th Street New York, NY 10001
Venetian red (40510e), KREMER, Kremer Pigments Inc. 247 West 29th Street New York, NY 10001

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NOTES

[i] Conservation-restoration of the panel painting The Virgin and Child from the Church of Our Lady of the Snows in Cavtat was initiated in 2012 by the Dubrovnik Department for Conservation of HRZ. Leader of the conservation-restoration project were: Katarina Alamat Kusijanovic (from 2012 to 2019); Mara Kolić Pustić (in 2020), and Sandra Sustic Cvetkovic (from 2020 to present).

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THE USE OF 3D SCANNING AND PRINTING IN THE RESTORATION PROCESS OF THE EXPOSED CERAMIC PANELS OF JORGE BARRADAS (PALÁCIO DA JUSTIÇA DE LISBOA)

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ABSTRACT

The techniques applied to restore and conserve the 16 ceramic panels which are an integral part the façade of the Palácio da Justiça's South Building, in Lisbon (authored by Jorge Barradas, Querubim Lapa and Júlio Resende), was marked by the adoption of disruptive technology as one of the main methods of approaching the pieces in need of intervention. Different materials and techniques, both digital and manual, either from physical or aesthetic perspectives, guaranteed their future preservation. Following principles of restoration ethics, photographic references of the compositions served as a goal to assimilate the original work as much as possible.

Recurring missing parts were then to be reconstructed by means of 3D scanning and current object printing technology. Such technique allows a preview and manipulation through specific computer software. Once the file has been completed with all the information necessary to produce the object, it can be sent directly to a 3D printer.

The main objective of intervening Jorge Barradas' panels with 3D printed objects, was to replace large key pieces in a non-intrusive way and without damaging the original work. Simultaneously, in addition to the durability of such printed materials, a "life insurance" is created in case of any damage or theft, since it can be replicated quickly from the thorough scan, stored in a digital file format.

Keywords
Conservation and restoration; 3D scanning and printing; Exposed ceramic plates; Replicas.

1. INTRODUCTION

The present work focuses on the restoration and conservation methods carried out on 16 panels of ceramic slabs in relief, with an area of 12 m^2 each, arranged along the exterior gallery of the Palácio da Justiça's South Building, in Lisbon, built in 1970.

This intervention took place in 2020 and was carried out in partnership between the Câmara Municipal de Lisboa (CML) and 3Dlife Tridimensional Print. A multidisciplinary team

was then formed, consisting of two conservators-restorers, a technical assistant in conservation and restoration and a designer, an engineer, and an historian.
The panels which underwent said intervention, had their missing areas rebuilt. Based on fragments of the original pieces and the more recent photographic documents available from the building's construction period, several distinct methods were applied to be well succeeded.

For instances: Jorge Barradas' compositions, with large sized pieces, presented the greatest damage, even the total loss of some elements. This meant adding the option of a viable way of replacing damaged elements - which happened to be in a consistent routine of being exposed to less proper (or involuntary) accidents.

Still in our recent collective memory, one can recall the reconstruction of 28 Pompeii statues through 3D printing. Hiltrud Schinzel had already set the tone, by means of reflecting upon the need to be open to the immense possibilities of technological driven modern times (Schinzel & Huisgen, p. 27, 2003). Mentioning that restorations and conservation techniques are narrowed to the same techniques of the remote times in which they were conceived, contemporary art has presented itself with new challenges which open way to embrace the technological bursts of our century. But does this imply that digital technology is anachronical and therefore should be avoided, when used to restore pieces prior to its existence? We argue it should be embraced with all the responsibility it encompasses. Therefore, seeking to contribute and reflect upon the use of new technologies and materials, we will provide theory and evidence towards its validity as a new conserving and restoring approach to the preservation of cultural heritage.

1.1 Historical Context

Institutional functions at the Palácio da Justiça de Lisboa as a Judicial Court began on September 30,

1970. This coincided with the final cycle of the Estado Novo (New State) before Portugal's transition into representative democracy. Long-time symbolic authoritarian leader, Oliveira Salazar, had passed away earlier the same year of the building's completion.

The first negotiations for the buildings' projection date back to the late 50s, although, only in 1965 would the project be firmly taken into fruition. Going back to 1958, when Architects João de Melo Bryner Andersen and Januário Godinho were hired by the Ministry of Obras Públicas (public infrastructures development), through its Directorate-General for Edifícios e Monumentos Nacionais (national monuments and buildings), Architect Carlos Chambers Ramos, then director of the Escola de Belas Artes do Porto, was also included in the project, as a coordinator between said designers and the CML (Santana & Sucena, p. 942, 1994).

When it began being conceived, four buildings were to be built at Rua Marquês de Fronteira: Superior Courts, Civil Court, Criminal Court and Police and Penal Execution Courts. Despite this, only two buildings were seen through completion: the Civil Court and the Police and Execution Court.

The South Building remains an imposing modernist construction of judicial-driven architecture, with a rectangular layout and straight, heavy lines (a characteristic of the Estado Novo's architecture). It consists of four bodies, separated by transverse joints, and structured by a grid, framed in reinforced concrete.

The responsible architects who participated in the project were: Januário Godinho de Almeida (1962); João Henrique de Melo Breyner Andresen (1962); Raul Lino (artistic coordinator) and José Luís da Cruz Amorim (furniture).

In 1967, Architect Raul Lino became responsible for coordinating the artistic commission of the project. The vision was to incorporate artwork into the building. Such task was distributed among three ceramic Artists: Jorge Barradas (1894-1971), Querubim Lapa (1925-2016) and Júlio Resende (1917-2011).

1.2 The Ceramic Panels

At the invitation of Architect Raul Lino (responsible for the artistic program at the Palácio da Justiça, three of the most important Portuguese ceramic Artists designed and produced 16 large-scale panels to decorate the gallery of the mentioned south building.
The commissioned works were as follows: Querubim Lapa contributed six panels, entitled "Adão e Eva expulsos do Paraíso", "O Direito que possibilita a Paz entre os Homens e a suas glórias", "Criação de um Código", "A prática da Justiça apoiada no Direito", "Espírito da Ordem" and "Temperança"; to Júlio Resende, six panels were also commissioned, entitled "Sapiência", "Verdade", "Fortaleza", "Serenidade", "Temperança" and "Prudência"; lastly, Jorge Barradas completed, in 1969, four panels, entitled "A Justiça", "O Juíz de Fora", "O Código" and "A Balança".

Concerning the relief tile panels, researcher José Meco refers, in his book "Azulejaria Portuguesa" (José Meco, 1992, p. 87), that Jorge Barradas began a more serious shift into the ceramic art tile medium in 1944. Meco considers his early work to be too ambiguous and inconsistent in his attempt to merge modern traits with a more traditional approach to the *Azulejo* (Portuguese art tiles). Later, although, the Palácio de Justiça de Ovar (with its altar patterns), the relief panels from the Church of Parede, or the panels from the Palácio da Justiça de Lisboa, saw a more mature Artist emerge in respect to his chosen ceramic medium, albeit perhaps, not being as influential, through the years, as his more direct peers.

Figure 1 – "O Juíz de Fora" (before and after): the main missing elements were the spike at the top left of the composition, and the judge's scepter.

2. ADOPTED METHODS & PRACTICES FOR THE CONSERVATION AND RESTORATION PROCESS

Following Buys & Oakley's statement - "Science can help conservators to understand the properties of materials and possible ways to modify them, but only conservators can invent recipes for combinations of

materials adapted for specific treatment problems. new application methods are often required as well" (Buys & Oakley, 2007, p. 333-334) - the referred 16 compositions were intervened through various conservation and restoration techniques - manual and digital - with various materials serving as resource. The aim was to reconstruct missing areas and elements, based on original fragments and available photographic documents to be used as a reliable source. Therefore, from Appelbaum - "A fundamental issue facing conservators is whether to use treatment materials that are the same as original materials or different. The decision is often made *a priori* rather than on a case-by-case basis and seems, in fact, to be characteristic of certain schools or styles of conservation" (Appelbaum, 2010, p. 329-330) – our team consensually opted for the adoption of recent disruptive technologies to aid a more traditional methodology, based on the scenario that was put before us. Further below, we will address possible ethical concerns.

In the essence of our choice, the Jorge Barradas panels presented greater damage when compared to the other ones. This reason, above all, is the centre of our decision to embrace newer methods of restoration. Barradas' compositions, due to unfortunate and unpredictable events, were more exposed to either involuntary risk, negligent actions or even acts of vandalism. We then settled that speculating on potential causes of distinct damages would have no productive outcome. On the other hand, the recurrence of such damaging events gave us only one certainty: the total loss of some major elements in the Artists' original work.

While, for the reproduction of the Judge's Scepter, handcrafted pine with fire finishing, along with Jewish putty and glossy spray varnish were used; to produce the remaining elements, a consensual option favoured the use of 3D printing technology.

Producing the left spike meant having a 360° scan of the similar opposite element, undamaged, and still part of the composition. Such was obtained by a hand-held 3D scanner. Later rendering the data through the *Solidworks* software, the three-dimensional reconstruction was calibrated further with parameters such as dimensions, thickness, density, and execution speed. Once these parameters were defined, the information was converted into an

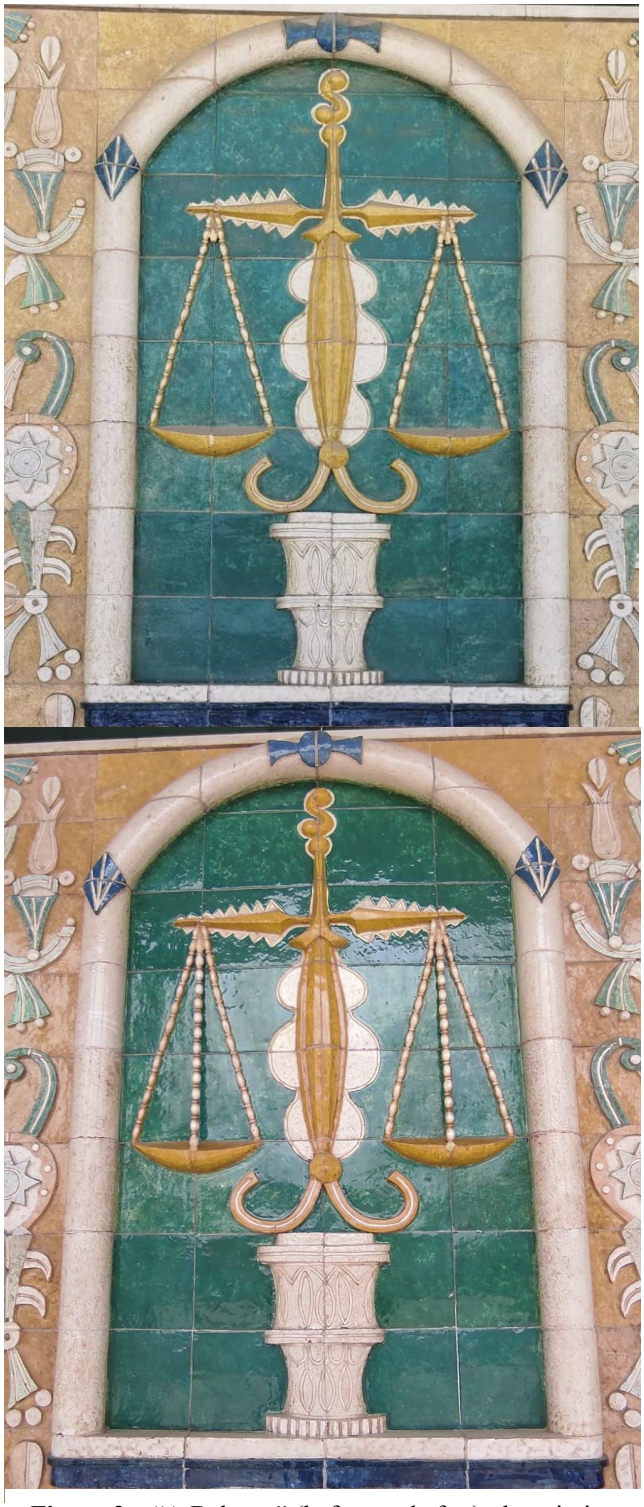

Figure 2 – "A Balança" (before and after): the missing elements were the third lock of both chains holding the Justice scale. The three-dimensional reconstructions were designed from original fragments that had been collected, and from photographic sources featured on the book "Palácio da Justiça, Civil Court and Courts of Police and Execution of Sentences" from 1970.

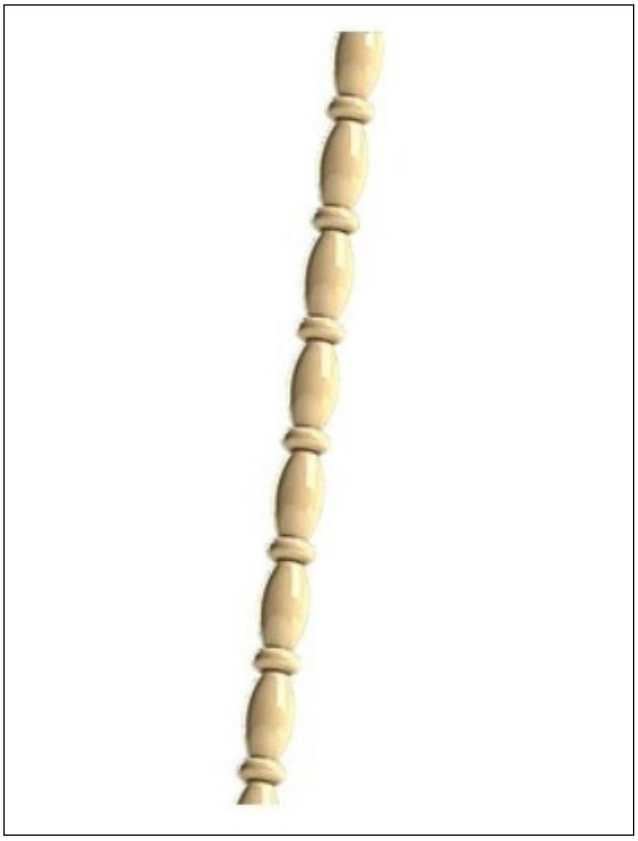

Figure 3 – Detail of the original "chains" holding the scales.

executable file, sent directly to the 3D printer. The object was then printed in monocolour PLA-N, a composite of plastic with nylon, in a construction process led by the successive addition of layers, which form a three-dimensional object. The interior body of the 3D printed objects consisted of a cross structure of light trusses, which gave them the desired lightness and strength, while the external wall was denser.

After printing, the object is completed by means of handcrafting texture and paint, thus faithfully replicating the original piece. The handcraft process is meticulous once the piece completes its 3D printing phase. A designer artist manually obtains the desired texture, through the addition of acrylic resins, whilst polishing it with sandpaper. After this "modelling" development, painting ensued. The monochromatic object (the replica) underwent the application of oil paint, used in conjunction with acrylic paint. Afterwards, they are bonded with acrylic resin to obtain the desired texture. The process is then finished with a UV protective film.

Due to the nature and frequent use of such public space, it was decided (with unanimous approval within the restoration team) that the main goal was to serve the unknown majority: the common bystanders of the area, potential untrained observers. Through an imperceptible use of restorative techniques, it was opted to favour a broader sense of cohesion between all parts of the set. Yet, for the specialist's clinical eye, a clear distinction between the restored part and the original work is evident, therefore elevating, primarily, the Artist & Author.

These small yet striking details which are seen in the replicas, were also made by the designer artist's mimetic painting. Such technique, precise and extremely meticulous, consisted of chromatic reintegration, aiming to re-establish an approximation to the original pieces' traces, singular to the Artist. A full manual reconstruction of the missing parts was seen through after the 3D printed raw object was obtained. As a non-destructive manual technique, reversible materials were used to perform the much-needed rigorous task. It brought the result closer to the artist's pictorial and stylistic techniques. This thought-out option was provided within similar thought patterns as observed on several Jorge Barradas' pieces. Such minute technique had as end goal to not only identify the watermark of his style, but to authentically preserve it.

Therefore, adapted from tested and established theory (Bailão, 2015, p. 261), we opted for the mimetic method, which should follow clear guidelines, such as: preserving any existing formal and chromatic reference of the original work; resorting to photographic or graphic documentation as possible; gathering as many technical studies as possible of the materials before they are applied. Information obtained should provide the hues to be reproduced, the location of shadows, lights, and volumes, as well as the type of perspective (or anatomy, when applied). Studying rigorously the materials, will then allow for the best use of pigments, binders, solvents, and varnishes – as suitable for each singular Artists' work.

When carefully observed, a constant trait emerges from the ceramic production of Jorge Barradas

(Oliveira, 2016, p. 38-39; p. 5-9 from *Annex II*). On certain pieces from the Artist, the top surface of his tile work is filled with small circles, made on a "dirty" white background which overlaps the glaze with another "cleaner" white. Such convolutions are present in almost all tiles and cover the entire bottom of panels. Yet, the white background is not obtained directly from semi-industrial enamel, although it may appear so, but with a white sprinkled with a dark pigment using a sieve. By circling the rounded and blunt end of a brush handle (in this case with a diameter of 2 mm), this dirty white, from afar, gives a cloudy and smoky background. Such are some examples of source validation, through which minute details underwent, to achieve results that were rigorously faithful to what had been identified on the original pieces.

2.1 Replicas: Scanning & Printing

The production of replicas in 3D printing derives from the previous mapping of the specific part (through a 3D scanner). Depending on the nature of this specific object, mapping is carried out in a laboratory/studio environment, or, in alternative, by a handheld scanner.

Our intervention benefited from the fact that the pieces which needed reproduction, had a direct match with the intact opposite pair - the left spike of the "O Juíz de Fora" panel - and the remaining damaged fragments of the scale's chains (from the panel "Balança"). In both situations, a handheld scanner was used to map these objects, allowing the data to shape virtual objects worthy of correspondence to the authentic parts.

Through a sweeping action, this handheld electronic device shoots seven crosswise laser beams, capable of collecting up to 480,000 measurements per second, thus producing a detailed digital image, with a margin error of 64 microns (less than a strand of hair).

In addition to obtaining an incredibly accurate image of each component, the equipment also records the exact placement of three-dimensional parts. All this information is converted into computer files, which can be used as many times as necessary during the hopefully enduring life of the art piece. After a specific part has been mapped and converted into a file, the digital object is processed in a through specific software. This allows for the density of the materials and the printing speed to be calculated and defined, according to the functions and objectives we set for the part. Once the file is rendered, it is sent directly to a 3D printer, and becomes a physical object.

Before the final part of this process, a prototype is produced to ensure a reliable compatibility with the intended design. Once this certainty is consensual among the team, does the final version go into production.

The new parts were assembled using neutral silicone, after insulating the contact points of the original parts with acrylic resin. We proceeded to paint, perfecting the replica to blend in the original panels. It is from this combination of technology and craftsmanship, between digital processes, 3D printing and bioplastic, which new approaches and different dynamics rise in favour of complementary objectives: not only the preservation of cultural heritage (in a lasting way), but also in a fast, sustainable, and economical way.

3. FINAL CONSIDERATIONS

As expected, conducting this project through digital fabrication, by means of 3D printing with PLA-N (nylon) as the main material, as well as combining modern technology with manual artistry, produced results in which so far, everyone involved was pleased, as would consider it a viable option in future conservation and restoration interventions were economical and undistinguishable replicas are needed.

With just one layer of printing, the possibility to manually shape a replica are endless, due to the tension and curves made possible by the material, thus becoming a structural part of the pieces' success.

3.1 Ethical concerns: memory, ecological sustainability & cultural heritage

Before we conclude, addressing poignant concerns of ethical nature are essential.

On one hand, clearly, the use of plastic can be seen as a devaluation of the original intervened pieces. Let us say that each scenario would have a different outcome, and good sense, in this scenario, led us to believe that repairing damaged materials in the truest form of authenticity could never make stolen/damaged parts rematerialize into existence, but would also result in futile taxpayer paid costs of restoration, with no guarantees of achieving better results than our multidisciplinary teamwork. Even if the costs for a single use, now, are still higher than traditional methods, we foresee a saving on the long run.

The area in question, nearby Lisbon's Penitentiary, as well as the nature of judicial court rulings, made these works of art vulnerable and exposed to involuntary and voluntary risks. Therefore, to preserve, as Pierre Nora would say, such example of a place in our collective/national memory (Pierre Nora, 2008, p. 33), such pondering did, indeed, take place. As a team, we stand by our collective choice.

On the other hand, and rather briefly, concerning the use of plastic as counterargument. The ecological crisis of our planet centres on the elimination of single-use plastics massively consumed and discarded daily. Therefore, plastic by itself, is not the problem. When used properly, it is an affordable durable material. Such is our case in using it. We believe in preserving the intervened pieces, so they will remain intact, and, by repudiating vandalism and being unjudgmental towards accidents, reason leads us into concluding that any restoration on the Palácio da Justiça's panels won't occur daily – not even sporadically – and we are assured all institutions involved will follow the best practices available for any disposing of plastic with the minimum environment hazard.

4. CONCLUSIONS

Although the role of traditional conservation and restoration methods remain as valid as before, the use of modern 3D printing technology in interventions akin to ours, have proven to be a useful safeguard for specific cases of restoring public use cultural heritage spaces.

In favour of this approach, we present the following: the parts are easily replaceable in the event of another accident or misconduct attack, for mapping the artwork happens only once; it is possible to quickly produce a new replica for replacement; less durable and time-consuming parts to restore, can now, with 3D printing, have greater longevity; in addition to being produced more accurately, they can be produced as many times as needed, without quality loss and identical results.

As soon as production costs decrease, when the technology involved is widely adopted, the "democratization" of its use will happen, allowing its application to reach a broader spectrum in the preservation of artistic and historical heritage. There is room for plenty more innovation.

In conclusion, two short examples of its potential use: the case of sculptures in public spaces, where 3D printing can be of great use (when - and if - vandalism or theft of bronze pieces continue to rise, 3D mapping can guarantee a faithful reproduction of the original works); it may allow the replacement of original pieces, placed in gardens and other public spaces with quality replicas, while the originals are kept in museums, galleries or other safer locations.

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A TECHNICAL STUDY OF RED PAINTS IN THE RETOUCHING LAYER OF SOME WET-COLLODION GLASS PLATE NEGATIVES OF GOLESTAN PALACE PHOTO ARCHIVE

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ABSTRACT

This study presents a part of a research project on retouching wet Collodion and dry gelatine glass plate negatives from Golestan Palace photo archive in Tehran, Iran, dating from the mid-19th century. The collection belongs to Qajar era. This is a case study on the use of red paint in retouching wet collodion glass plate negatives and aims to help the understanding of retouching material and their application. Red paints in four retouched negatives, and also their binder, identified in this study by means of, micro Fourier transform infrared (μ-FTIR), scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS) and stereo microscopy technique. Elemental analysis performed with (SEM-EDS) revealed the presence of Lead (Pb), and Iron (Fe) elements in the paint. Thus, red Iron & red Lead pigments were identified as the red paints. The results confirmed by micro Fourier transform infrared (μ-FTIR), and a natural resin (probably gum Arabic) is identified as the binder of all paints as well. Red Lead, is realized as a paint to cover the boundaries, create more brightness, and as a binder to adhere masking papers, to the intended areas. Red Iron, is also found as a paint to correct emulsion defects and, make a perfectly clear and clean sky or background. Apparently, all these choices have been made consciously. It is believed that this study will contribute much to better understanding of retouching materials and the need to preserve them.

Keywords
Retouching; Photography; Collodion; Glass Plate Negatives; Red Paint

1. INTRODUCTION

The invention of photography as a technological advancement was presented at the Academy of Sciences in Paris, in 1839, and not a long time after, in 1842 the camera entered Iran, during the Qajar Dynasty (1785-1925) [1,2].

Photography in 19th century was a series of technical and practical challenges with long-time exposure needed, and lots of shortcomings. To overcome these and other weaknesses an extra-photographic contribution that consisted of several skills, techniques and materials, was required. Retouching has been an integral part of photography almost since of the beginning of photography.

In the days of glass plate negatives, retouching was still a need. Since collodion glass plates were not as sensitive as late gelatine glass plates and they were suffering from more defects, the number of retouched plates, the variety of retouching techniques, and materials was greater in gelatine types. However, there was a subtractive technique (performed with a knife, scalpel, needle or any sharp object), that was specific

to gelatine emulsions and was never used on collodion glass plate negatives [3].

Today's retouching has nothing to do with the 19th century practice of elaborately recreating negatives with watercolor, gouache, pencils, and abrasives to remove unsightly features of the image, or change the background or the subject [4].

Glass plate negative retouching in 19th century was a set of manual processing techniques used by the photographer to correct the results of imperfect spectral sensitivity, poor technical manipulation and improving the general appearance of the subject.

This was done by covering defects such as scratches, anomalous specks, or blocking some unwanted objects in the image, as well as covering areas with a lack of emulsion (in the corners of glass plate negative, which is common in collodion types). Retouching was also being used to improve or modify the composition, contrast, proper lighting, framing of the subject or changing the artistic expression of photographer.

There have been always different approaches to retouching; not only in terms of its legitimacy and relationship to other arts, but also in terms of techniques and materials. This can be said based on the on the comparison Iranian and also non-Iranian old manuals.

For example, to correct emulsion insensitivity defects in glass plate negatives, streaked and dirty backgrounds, and to intensify certain parts of the image, in different old manuals, different materials and techniques are recommended [5-12].

Despite the numerous retouching detractors, retouching of glass plate negatives became an extended practice and an important part of the work of 19th century photographers, bringing the fashion approach and extending itself as a more part of the studio work. This ability, although very common, took a long time to be revealed in a written way, because it was only possible in secret, without being admitted by the majority of professionals who were using it. Therefore, it is a good reason to study the techniques and materials used in retouching.

The principles and details of retouching can be found not only by reading old manuals, but also by observing the negatives themselves under different lights (reflected light: Standard, Specular, and raking and also transmitted light), comparing them with their positive versions, reading scratched notations in the emulsion, as well as the written information on the original enclosing paper sleeves or envelopes [13].

But one of the most important measures that can be taken to identify retouching materials is to study them through scientific analysis. Despite many recent articles on retouched glass plate negatives [13-16, 3 & 6], there are still few studies have been conducted to identify retouching materials, especially on collodion glass plates, as most of the studies mentioned are conducted on gelatine dry plates.

Pictorial reservoir of Golestan Palace which is located in Golestan Palace (inscribed on UNESCO's world heritage list in 2013) Tehran, the capital of Iran. Golestan Palace photo archive is regarded as the second-best reservoir of old photographic materials after the album house of the Royal Museum of Britain and can be considered as one of the best resources for historical research of the time. This reservoir contains 1040 photo albums (nearly 42500 photos), more or less intact, about 9000 glass plates (collodion and gelatine), almost all taken by famous Iranian photographers who lived from 1789 to 1925, as well as many other different photographic materials including motion pictures, cameras and so on.

Glass plate negatives are the oldest images in this collection. The information presented here focuses on some collodion glass plate negatives (CGN) retouched with red colors which is part of the sub-project of studying collodion and gelatine retouched glass plate negatives, from the main project on study of glass plates of Golestan Palace.

2. MATERIALS AND METHODS

2.1 Study object

The objects of study were a selection from Golestan Palace photo archive collection glass plate negatives prepared at 19th century, codenamed of GP005379, GP005375, GP005378 and GP005378. The selected items consisted of two 18 × 24 cm negatives (GP005375 and GP005261) and 13 × 18 cm negatives (GP005379 and GP005378).

All four negatives were selected from the Golestan Palace photo archive collection, and were manufactured in Iran. They were all retouched in different shades of red color, and different types of retouching. The retouching was in the form of painted masking paper, red opaque paint in dark and light shades and tincture in dark red (Figure 1). The first three (Figure 1. (a, b, and c)) are retouched on the emulsion side, there is almost no retouching on the glass side, and the last (Figure 1. (d)), is retouched only on glass side.

Figure 1 – Two different red colors used in retouched collodion glass plate negatives under reflected: on the glass side; a) GP005379; b) GP005375 (1883); c) GP005378; & on the emulsion side: d) GP005261: (Photographer Agha Reza 1870)

The application of dark and light red color in selected samples, was almost similar to the rest studied retouched collodion glass plates in the collection.

Image of GP005379, is the image of Haji Musa Khan, as it was written on the negative. Image GP005375 depicts the pool house in the mansion of Yar Mohammad Khan Soham al-Dawla Bojnurdi in Bojnourd, belonging to 1883. Image GP005378, is the image of Khosrogerd Minaret, but no specific date or photographer is available. The photographer of image GP005261 is Agha Reza, and the image is related to the year 1870.

In the first three images (Fig.1; a, b, & c), two shades of red colors were used to retouching the image. In images GP005379 & GP005378 (Fig.1 a & c), light red color was used to draw the outlines, but dark red color was used for the background. According to what was seen on negatoscope in these two images, the areas painted in dark red color was more transparent than in bright red color. Image GP005375 was outlined in bright red color, and dark red color was used to overcome the defects of emulsion due to scratches in some parts. In the last image (Fig.1; d), dark red color was used to cover the defects resulting from scratches, of the emulsion.

2.2 Methodology

A set of minimally invasive analytical techniques was developed to identify the red paints, and their binders, if any.

The methodology included observations using optical microscopy (OM), chemical evaluation by Field Emission Scanning Electron Microscope-Energy-Dispersive X-ray Spectroscopy (FE-SEM-EDS), and chemical evaluation by Fourier-transform infrared spectroscopy (FT-IR).

Most samples were collected from the back of papers adhered as masking papers to the glass plates or from the damaged parts of retouched parts of the plates.

2.3 Instrumental

Stereo microscopy

Leica Wild Heerbrugg M8 stereo zoom Microscope, made in Switzerland, with maximum 50X magnification, was used to study the texture and details about the paints.

μ-Fourier-transform infrared spectroscopy (μ-FTIR)

μ-Fourier-transform infrared spectroscopy (μ-FTIR) was used to identify binder of paints, if any, and to study the potential presence of mineral compounds with a complex anion functional group. This method is not only applicable for the minimum amount of the sample, but also enjoys suitable levels of speed, precision and accuracy and is not expensive. Analyses were performed using a Nicolet 510P spectrometer

with IR microscope (MCT/A detector cooled by liquid nitrogen). Interferograms were collected in 64 scans, at a resolution of 4 cm^{-1} in the spectral range 4000–650 cm^{-1}, in transmission mode.

Due to many advantages, μ-FTIR has become an essential analytical tool available to cultural heritage scientists:

1. Relatively fast and simple to use: Little or no sample preparation required for spectral acquisition.
2. Sensitive method that requires very little sample.
3. Non-destructive or micro destructive.
4. Sample manipulation under magnification
   - Isolate areas of interest for interrogation
   - Work with very small samples
5. Multiple sample environments: Samples in the form of liquid, gas, powder, solid, or film can be tested

Field Emission Scanning Electron Microscope Energy-Dispersive X-ray Spectroscopy (FE-SEM-EDS)

Due to the small amount of the samples, Field Emission Scanning Electron Microscope (FE-SEM) with high magnification and separation was used for elemental analysis. Developed by Czech company, Tescan Mirall, the instrument is equipped with advanced Energy-Dispersive X-ray (EDS) features for semi-quantitative element analysis. The microscope used is a field emission that enjoys much higher field depth and separation capability compared to the ordinary scanning electron microscope. The magnification of this microscope is 700,000 times (700,000X).

3. RESULTS AND DISCUSSION

3.1 Stereo microscopy

Visual examination and morphologic evaluation were performed with a precision wire-account magnifier and a stereo microscope to obtain more in-depth information on damages, emulsion abrasion, discolorations, and some other details.

Dark red paints were detected with an opaque look, and not very fine texture, almost intact, except some areas with finger prints and little abrasion and scratches (Figure 2).

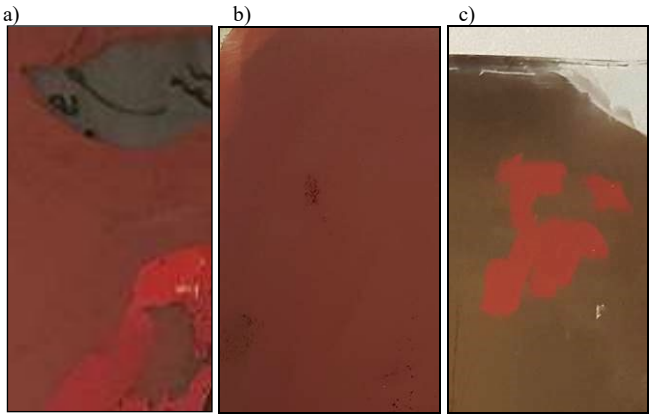

Figure 2 – Dark red almost intact paints used in retouched collodion glass plate negatives on the glass side; a) GP005379; b) GP005378; & on the emulsion side: c) GP005261

Light red paints appeared with an opaque look, dense and fine-textured, and good hiding power. Scratched, peeled, and abraded areas, as well as remnants of retouching papers were also seen in various parts of the paints (Figure 3).

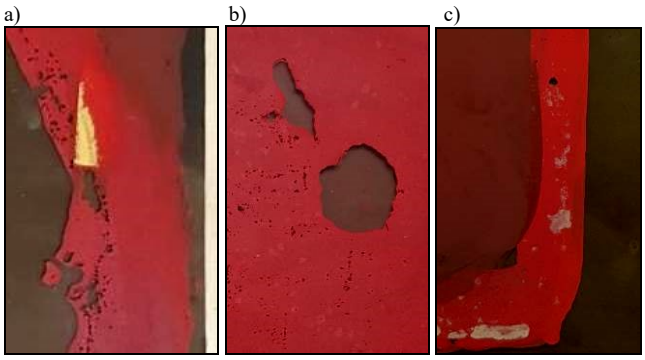

Figure 3 – Light red damaged paints with remnants of peeled masking paper used in retouched collodion glass plate negatives on the glass side: a) GP005379; b) GP005375; c) GP005378

Considering this fact, and extra papers found in the enclosures of these glass plate negatives, it was realized that almost all of bright red color painted areas, had been covered with the paper. While no sign of paper coverage was observed in the areas that were painted with dark red color.

Obtained details helped to present three hypotheses for further studies:

1. Given that red lead, as a common red color used at that time, may darken and turn brown due to the formation of brown lead dioxide in result of exposure to humidity and light [17 &18], it can be hypothesized that red lead is the only red color that had been used, and darkened in uncovered parts due to the exposure. However, a clear gap and sometimes overlapping (figure 2: a) of two shades of red colors (dark and light), was seen under microscope. Given this fact and given that the red lead pigment in the oil binder would be fairly permanent and also has good hiding power and creates relatively opaque colors in this media, another hypothesis is presented:
2. It is possible that these two different shades of red color have same pigment but different binders.
3. The last and the most probable assumption is that the two different shades of red color, were chemically different from the beginning.
Therefore, to prove any of the aforementioned hypothesis, further analysis was needed.

3.2 Field Emission Scanning Electron Microscope Energy-Dispersive X-ray Spectroscopy (FE-SEM-EDS)

The EDS elemental analysis for light red paints confirmed the presence of Pb atoms in all light red paints (Fig. 4: a, b & c) and Fe atoms in all dark red paints (Fig. 5: a, b, c & d), as the main component. This result is consistent with the last hypothesis.

Based on the EDS elemental analysis for light red paints (Figure 4), Lead (II, IV) oxide, $2PbO.PbO_2$ (historically, Pb_3O_4), more commonly known under the name "Red lead", identified as the light red color compound used in the studied retouched glass plates. However, sample GP005375 is more contaminated than two others (i.e. sample GP005379 and GP005378).

Red lead pigment which was also a favourite of Persian illuminators, is thought to have been one of the first artificially produced pigments, but due to its toxicity and discoloration, it is no longer manufactured for artists. Red lead is liable to discoloration in the presence of air pollutants such as hydrogen sulfide. Red lead may photo-oxidize, in presence of humidity and light, and discolor to a light pink or darken to a brownish red, depending upon the environmental influences. For this reason, it is recommended not to use in watercolor painting [19-22].

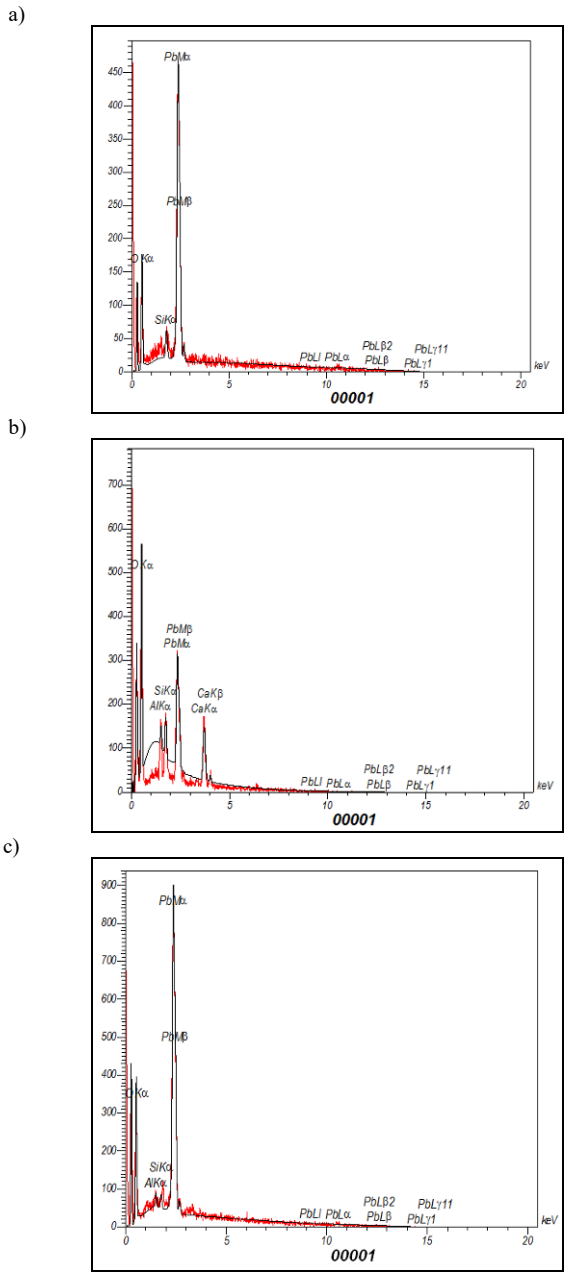

Figure 4 – EDS analysis on light red paints of; a) GP005379; b) GP005375, and c) GP005378, showing the presence of Pb atoms as the main colorant component.

The EDS results for dark red paints (figure 5), confirmed that the main component of dark red paints is Fe atoms. As a result, all the dark red paints are kind of Iron red color, (iron (III) oxide: (Fe_2O_3)), probably red bolus ($Fe_2O_3 \cdot xSiO_2 \cdot yAl_2O_3$) or red ochre ($Fe_2O_3$), with some fillers or impurities.

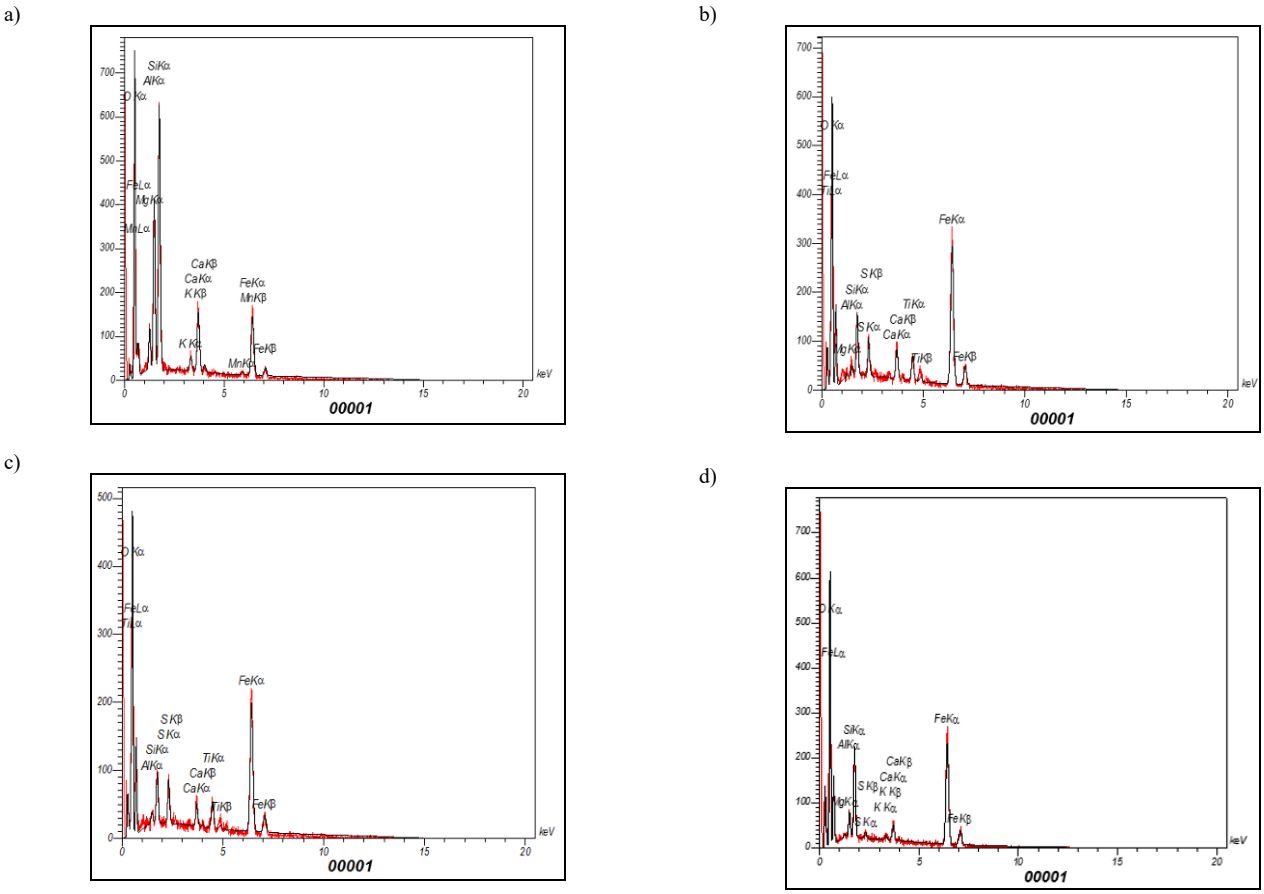

Figure 5 – EDS analysis on dark red paints of; a) GP005379; b) GP005375; c) GP005378; and d) GP005261, showing the presence of Fe atoms as the main colorant component.

Natural red iron (III) oxide can be defined as earthy, metal oxide-rich impure deposits, containing a mixture of mineral components, commonly quartz, carbonate, clays and/or micas as well as metal sulphides; which can be seen in side elements in EDS analysis [23].

3.3 Micro Fourier-transform infrared spectroscopy (µ-FTIR)

µ-FTIR analysis, was used to detect the presence of binder of paints, and to identify them; also, as a complementary analysis method to best identification of the pigments.

For this purpose, after sampling, the samples (500 µg) were mixed with KBr, pulverized, and formed into a disk-shaped transparent pellet.

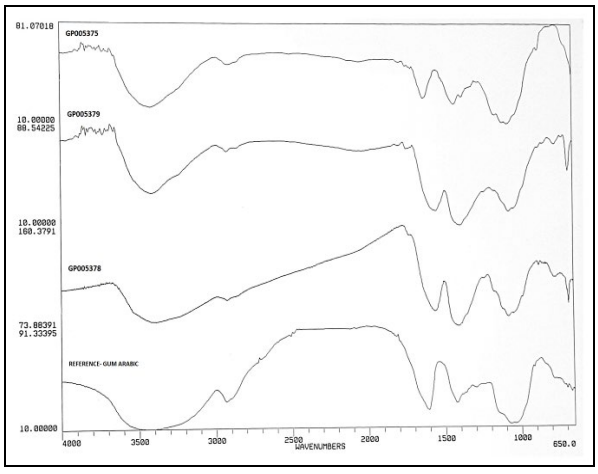

Figure 6 – General µ-FT-IR normalized spectra of light red paints of; GP005375, GP005379, GP005378 confirming the use of natural gum as the binder.

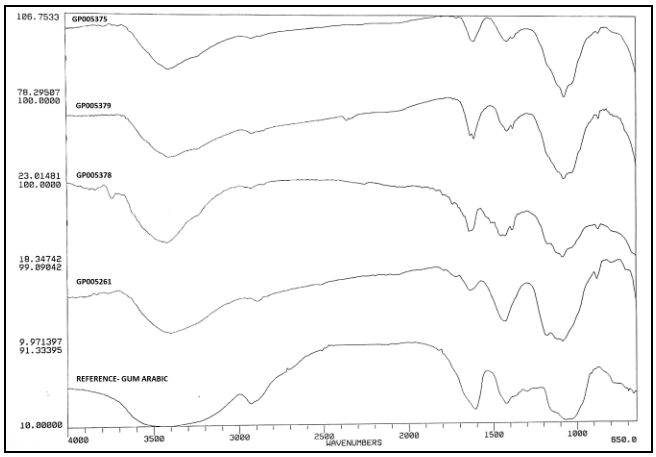

Figure 7 – General μ-FT-IR normalized spectra of dark red paints of; GP005375, GP005379, GP005378 & GP005261 confirming the use of natural gum as the binder.

The use of a type of natural gum, possibly gum Arabic, as binder of the all analysed colors (Fig. 5 & 6) with absorption bands at 3000-3600 cm^{-1} (O-H), 3000-2800 cm^{-1} (C-H), 1600 cm^{-1} (COO) and 1421 cm^{1} (C-H), 1143 cm^{-1} (C-C), 1075 cm^{-1} (C–O–C ether group of the ring), 1037 cm^{-1} (C-C), & 979 cm^{-1} (C-H), was confirmed in all spectra [24].

This is while in some old retouching instructions, it is recommended to avoid adding gum to the color, as it would adhere to paper and spoil the negative [5]

Gum Arabic is a complex polysaccharide, either neutral or slightly acidic, found as a mixed calcium salt of polysaccharide acid.

The high solubility of gum Arabic makes it particularly suitable as a painting medium. The use of plant gums as binding media appears to had been widespread in old photography materials based on several old Iranian manuals [7].

Since there was no sign of oil presence in any spectrum, the second hypothesis was rejected. Considering the physical nature of the colors and also that no other signs of the presence of any other organic material were detected in the spectra of the studied samples, it can be concluded that the colors are all mineral pigments, without any other organic additives.
The FTIR spectra of the light red colors presented in Fig. 6 shows the absorption bands in low frequency regions of 682 cm^{-1} which is characteristic of lead oxide.

The FTIR spectra of dark red color in all four analysed samples (Fig. 7), represent the absorption bands at 1000 cm^{-1} and 900 cm^{-1}, which can be attributed respectively to Si–O–Si, and Si–O stretching bands in red bolus ($Fe_2O_3 \cdot xSiO_2 \cdot yAl_2O_3$) color [25].

4. CONCLUSIONS

This study comprises the identification and application evaluation of two different common red paint, in retouching of 19th century collodion glass plate negatives. In this research two shade of red color were examined, in four collodion glass plate negatives belonging to Golestan palace photo archive. The application of red paints in the selected glass plates was almost similar to the other retouched collodion glass plate negatives in the collection.
The light red colors were applied to trace the outlines of the figures; which is common in collodion glass plate negatives, in portrait and also landscape photography. In portrait photography, it often happens when photographer is confronted with a portrait negative which is perfect in other respects but has a very streaky and dirty background. In landscape photography of blue-sensitive negatives, sky has to become in greater contrast with either the subject or the rest of the image.
In such cases the subject has to be outlined with a thick coat of opaque paint with a good hiding power, and the rest of the background or sky should be covered with a thin coat of opaque paint and or by applying a paper mask.

Based on this study, all the four, light red paints were red lead (Pb_3O_4) with gum Arabic binder; good hiding power and ease to use for outline the boundaries. Moreover, red lead is toxic; and this is probably one of the reasons why it has been used with the paper masks in retouching.
Moreover, in negatives with some emulsion defects (ex. spots of dirt, physical damages like scratches, etc), spotting was needed. In the selected sample and almost all the other retouched collodion glass plate negatives in the collection, dark red color were used in such cases.
According to this study, the main composition of dark red paints used, is hematite (Fe_2O_3) and gum Arabic

binder, which is match any photographic tone nearly enough for general work. This paint has less hiding power than red lead.

According to the obtained results and considering the materials used in retouching glass plate negatives of this era, it should be noted that retouched glass plates need more serious protection measures.

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RECH 6
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TOPIC 5

Matching colours

RECH6 - 6th International Meeting on Retouching of Cultural Heritage
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THE PERCEPTION OF THE CHROMATIC REINTEGRATION FROM THE ADJUSTMENT OF THE WORK CLOTHING. THE LAB COAT AND ITS COLOUR ALTERNATIVES

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ABSTRACT

The present study is focused on the revision of the work clothes of the conservators-restorers, specifically in the lab coat, analysing its colour and the interference it can create regarding the perception of the colours, both of the artwork and of the chromatic palette used in reintegration.

In this way, the study begins with a review of the corpuscular theory of light. According to this theory, it is analysed the absorption-reflection process of the interaction of light with matter, as well as it is explained how the colour of the lab coat can hinder or favour the perception and adjustment of the colours in a chromatic reintegration.

This investigation is reinforced by a process of experimentation in which the light reflected by both white and black lab coats, is analysed through measurements using a lux meter. The measurements are made facing pictorial works characterized by chromatic palettes of dark colours or vivid colours, wearing a white lab coat and a black one. Afterwards, the results obtained are analysed and compared allowing to discover, in a more realistic way, the intensity of the light reflection according to the colour of the garment of the conservator-restorer.

In addition, the present study is complemented with the realization of an opinion survey to international Conservation-Restoration professionals. Through this survey, the aim is to find out whether professionals take this factor into consideration during colour reintegration, as well as their general opinion on this issue.

Keywords
Perception of the retouching; Lab coat; Chromatic reintegration; Corpuscular theory of light; Colour adjustment of the losses; Light control in retouching

1. INTRODUCTION

In recent years, professionals have pointed out, although not in a proven way, the interference generated by the colour of the restorer's laboratory gloves when carrying out chromatic reintegration. Some institutions, such as the Museo del Prado in Madrid, have incorporated the use of black gloves in order to reduce the interference from the white of latex gloves and the blue of nitrile gloves [1].

This event leads to the need to check the personal protective equipment (PPE) of the conservator-restorer. Thus, the study carried out in this research specifically examines the lab coat, its colour, and the interference it can cause in the perception of colours and, therefore, in the development and result of chromatic reintegration of the losses.

It is therefore necessary to first clarify that interferences in colour perception during reintegration work are not caused by the colour of the protective clothing, but by the way that light interacts with it. Consequently, it is important to examine the corpuscular theory of light in order to understand this phenomenon correctly[i].

1.1 Observations on the corpuscular theory of light

Defining light exactly is difficult, but it can be described as a set of electromagnetic radiations that propagates in wave-like movements [2][3][4] and which is essential to the perception of space, shape, and colour [5].

This type of radiant energy is part of the electromagnetic spectrum, which contains a wide range of different types of waves, such as ultraviolet, infrared, gamma rays, etc., each of which corresponds to an interval defined by wavelength (λ) or frequency (f).

Within this spectrum, light is located between 380-770 nanometres in wavelength, which is known as "visible light", since it is the only type of light radiation perceptible to the human eye [6][7].

Likewise, light causes different phenomena depending on how it interacts with matter: it can be scattered, transmitted, refracted, diffracted, reflected and absorbed [8]. As such, these forms of interaction have been extensively explored by many specialists before, which is why only the phenomena of light reflection and absorption have been examined in this study, since they are directly related to the hypothesis put forward concerning the interference of the colour of the lab coat in the processes of chromatic reintegration.

In this way, the property of reflection can be simply understood as the phenomenon that occurs when light strikes and reflects off the surface of objects [9][10][11]. Furthermore, this phenomenon, which is influenced by the characteristics of the surfaces, is determined by the directionality of the scattered light rays, and it is also possible to differentiate between regular, diffuse, and mixed reflections [12] [13].

Regarding to the absorption property, it refers to the ability of a surface to absorb the waves that make up the electromagnetic radiation of light [14].

Consequently, when light strikes an object, it undergoes a reflection-absorption process that is determined by the type of pigment on the surface of the object, which will absorb part of the light spectrum and reflect the rest. This reflection will correspond to the colour that makes up the material. In this way, black surfaces absorb all the light without reflecting any, while white surfaces do not absorb any radiation and reflect the entire light spectrum [15].

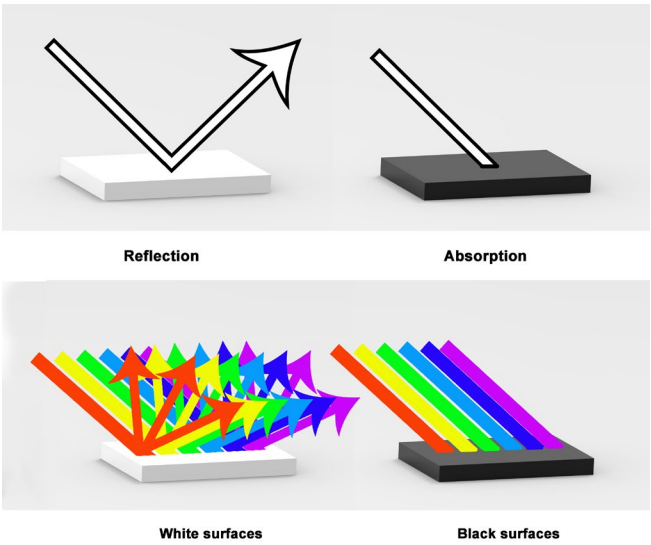


Figure 1 – Detail of the reflection-absorption process of the light on white and black surfaces respectively.

Consequently, this event explains the assumption made in this section. Depending on the pigment present in the restorer's lab coat, a greater or lesser amount of light will be reflected towards the artwork and, specifically, towards the areas with losses that need to be reintegrated, thus interfering both in the perception of the colours present in the painting itself and in those used for the chromatic reintegration. Accordingly, a white garment will reflect the entire spectrum of light and interfere more with the adjustment of the reintegration shades, while a black garment will absorb all light and reduce interference almost entirely.

2. MATERIALS AND METHODS

In order to reinforce this hypothesis, a process of experimentation was carried out in which light measurements were made of the light reflected by both a white and a black lab coat. These measurements, carried out with the PCE-222 lux meter, were taken in the easel and altarpiece painting workshop of the Instituto de Restauración del Patrimonio (IRP) of the Universitat Politècnica de València (UPV), where an average ambient illuminance of 580.6 lux was recorded. In addition, the measurements for this study were carried out on three pictorial works characterised by different colour palettes.

Figure 2 – Sequence of light measurements in front of an artwork characterized by a dark colour palette.

Figure 3 – Sequence of light measurements in front of an artwork characterized by a vivid colour palette.

Figure 4 – Sequence of light measurements in front of an artwork characterized by a chromatic palette of pastel tones.

In order to ascertain the current state of this issue, a survey of international Conservation-Restoration professionals was conducted. This survey was carried out and sent digitally using the "Google Forms®" software tool, which allows for the creation and analysis of this type of study. An anonymous questionnaire has been chosen, combining closed polytomous questions with an open-ended question that allows respondents to answer freely in order to obtain a greater wealth of detail in the answers.

The form was circulated in mid-2021 to expert groups, university professors, independent restorers, specialised forums made up exclusively of Conservation-Restoration professionals from all over the world, museums and other public and private institutions. Among the recipients contacted were specialists from the Museo del Prado in Madrid (Spain), the Museo Nacional Thyssen-Bornemisza in Madrid (Spain), the Universitat Politècnica de Valencia (Spain), the Faculty of Fine Arts of the University of Lisbon (Portugal), the Academy of Fine Arts in Zagreb (Croatia), the Academy of Art of the University of Split (Croatia), as well as the National Gallery in London (U.K.).

3. RESULTS AND DISCUSSION

In the following sections, the results obtained from both the lighting measurements carried out with the lux meter and the responses obtained from the analytical opinion survey are presented.

3.1 Lighting measurements

The development of this experimental process has begun with the recording of a total of five lighting measurements for each artwork, wearing a white and a black lab coat respectively. Subsequently, the average value of the quantities recorded was calculated:

Table 1 – Calculation of the average values of the lighting measurements

	White lab coat	Black lab coat
Painting nº1: average value	675.2 lux	514.4 lux
Painting nº2: average value	662.6 lux	534.4 lux
Painting nº3: average value	653.8 lux	579.2 lux
Total average value	**663.87 lux**	**542.67 lux**

Finally, taking as a reference the average value of ambient illuminance (580.6 lux) recorded in the easel and altarpiece painting workshop of the IRP, the calculation of the differential amount has revealed a greater amount of reflected light when using the white lab coat:

Table 2 – Calculation of the average differential values

Ambient illuminance average value	Average differential value: white lab coat	Average differential value: black lab coat
580.6 lux	**+82 lux**	**-48,2 lux**

3.2 Analytical opinion survey

The form carried out among Conservation-Restoration professionals resulted in a total of 263 responses. Before presenting the results, it should be pointed out that the recorded responses cannot be considered as absolute results, as they only represent a small percentage compared to the large number of professionals currently involved in Conservation-Restoration. For this reason, they should be interpreted as an indication of the current state of the issues raised in the questionnaire.

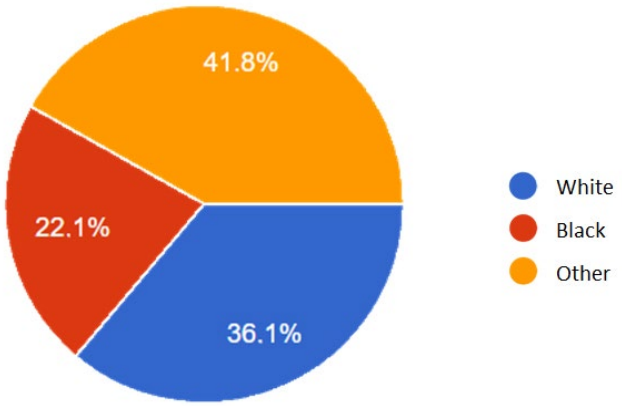
Thus, following are the questions asked in the analytical opinion survey and the corresponding results:

1) *What colour is the lab coat or clothing that you use in your work as a restorer?*

Regarding this first question of the form, the results obtained are as follows:

- 95 participants (36.1%) responded that they use a white lab coat for restoration work.
- 58 participants (22.1%) have answered that they wear a black garment in their work as a restorer
- 110 participants (41.8%) responded that they use other coloured clothing for their restoration work.

Chart 1 – Results obtained to determine the colour of the work clothes of the professionals when performing restoration tasks.



Based on the results of this consultation, it appears that black working clothes are not fully incorporated into restorers' practices. As reflected in the responses received, professionals seem to be more inclined

towards the use of the conventional white lab coat or other coloured work garments.

2) *If you marked "Other..." in the previous question, could you specify what colour? If you do not wear specific work clothing, please indicate it.*

This open-ended question allowed participants to specify the colour or type of work clothes they wear. Furthermore, along with those who answered "Other..." in the previous question, some participants who answered "white" or "black" took the opportunity to specify more extensively on the clothes they wear, as well as their opinion and other questions related to this issue. This resulted in a total of 118 open-ended responses.

Analysing all the individual replicated samples obtained, it becomes clear that a large number of professionals wear white, black, blue[ii] and grey[iii] garments. In reference to this last colour of work clothing, some respondents specifically recommended it for critical reintegration work. Added to that, there were also responses indicating that the white lab coat is only used for tasks involving the use of solvents in large quantities, for work that may be messy or for varnishing.

As well, professionals pointed out to use black and white lab coats, in some cases indistinctly and, in others, depending on the tasks to be carried out, highlighting the use of black for chromatic reintegration work. Likewise, a reply was obtained which specified the use of white lab coats when receiving the public, for reasons of "good image", while black lab coats are used for the reintegration of varnished or dark paintings, without wearing any working clothes for the rest of the restoration work.

In reference to this latter question, a large number of respondents indicated that they do not wear any specific work clothing, they simply wear their everyday clothes, which can include any kind of colour. However, some professionals have expressed that they wear everyday clothes in neutral and dark colours when they know they are going to carry out colour reintegration tasks.

Furthermore, a small number of responses indicate the use of work clothes in other less conventional colours such as light blue, natural linen, beige, olive green, dark green, brown, peach or dark red.
In addition, some of the professionals responded that they wear an apron instead of a lab coat, stating that this is more comfortable for them. In these situations, the specified colours of aprons used include black, dark grey, cream or blue denim.

On the other hand, a limited number of participants highlighted the importance of wearing black gloves, either cotton or nitrile, to reduce reflected light and its interference in the colour reintegration process. Some of them indicated that they complement them with the use of a black lab coat, while others downplay the importance of wearing specific work clothes.

Thus, some responses specified not to wear white lab coats or any light clothing during reintegration work, as they reflect light and interfere with colour adjustment, whereas others participants said that dark clothing should be worn while working with dark works as well.

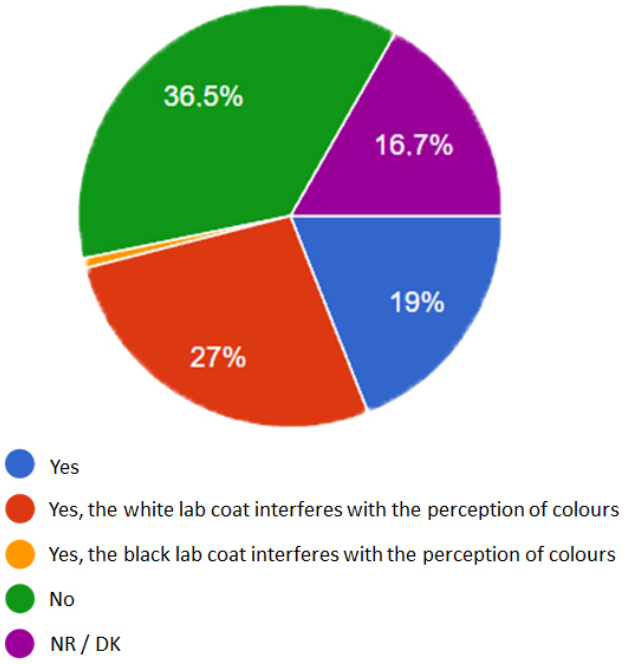
Finally, it is worth mentioning some comments obtained in which respondents specified that they do not wear any particular work clothes, but that they nevertheless think that the colour of the clothes may have an impact on the development of chromatic reintegration. Similarly, a couple of people considered lighting to be a more important issue to take into consideration.

3) *Do you think that the use of a white or black lab coat interferes the results of a chromatic reintegration?*

Based on the responses to this question, the following data was obtained:

- 50 participants (19%) believe that they do interfere.
- 71 participants (27%) think that it is the white lab coat that interferes with colour perception.
- 2 participants (0.2%) think that it is the black lab coat that interferes with colour perception.
- 96 participants (36.5%) believe that the colour of the garment does not interfere.
- 44 participants (16.7%) do not know.

Chart 2 – Results obtained to ascertain the opinion of the professionals.



Thus, the opinion of respondents is divided. The percentage of professionals who believe that the colour of the lab coat can interfere with the result of a chromatic reintegration is almost the same as those who believe the opposite. In the first case, the vast majority believe that it is the white garment that interferes and not the black one. Similarly, a large number of professionals do not know anything about this issue.

4. CONCLUSIONS

The results obtained from the lighting measurements carried out with a lux meter made it possible to demonstrate, using real data, the intensity of light reflected according to the colour of the lab coat worn by the conservator-restorer. In this way, it is shown that a white lab coat reflects a greater amount of light that encompasses the entire light spectrum, interfering with the perception of colours and, consequently, both the development and the quality of the final result of the chromatic reintegration. For this reason, the use of a black lab coat is recommended when carrying out the processes of pictorial restitution, as it reflects less light, thus reducing the possibility of receiving light interferences that could alter the quality of the final result of the chromatic reintegration.

According to the survey carried out, it has been shown that the use of the black lab coat is hardly widespread in the practice of conservator-restorers, especially in the development of reintegration tasks. White lab coats and other shades such as blue or grey seem to be more common. The white lab coat is most popular not only because it is the most commonly used by scientists in laboratories and therefore the easiest to acquire, but also because it gives an appearance of professionalism and a good image that is recognised by the general public. The survey also revealed that work aprons were frequently used as a matter of comfort. However, the use of this clothing might interfere with the development of chromatic reintegration, as the daily clothes not covered by the apron can reflect light to a greater or lesser extent.

Furthermore, the responses obtained show a clear division in the general opinion of professionals. Although the predominant criterion considers that the colour of the lab coat, either white or black, can interfere with the result of the chromatic reintegration, a high percentage of the participants think otherwise. Similarly, the large number of professionals who do not know about this subject (16.7%) stands out, showing the lack of relative studies on personal protective equipment and its interference in the results of pictorial reintegration.

In conclusion, the analytical opinion survey conducted produced very disparate results, demonstrating the lack of knowledge on this topic among professionals. Therefore, despite this first approach to the interference that the colour of the restorer's lab coat can cause in the chromatic reintegration processes, it is clear that there is a need for further studies that analyse this topic in depth, through the development of practical tests which can provide enlightening and conclusive data.

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[i] This theory refers to the way in which light interacts with matter.
[ii] Different shades of blue have been specified such as dark blue, navy blue or dark denim blue.
[iii] Different shades of grey have been specified as neutral light grey, neutral grey, medium grey, grey and dark grey.

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SMART HERITAGE: AN EASY METHOD FOR MATCHING COLORS

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ABSTRACT

In the field of built heritage conservation, conservators frequently face the task of faithfully reproduce -from a chromatic point of view- surfaces and paintings, often having small patches of original color as the only reference. The market provides conservators with effective and specific color measurement devices that enable them to capture, measure and quantify the color of a surface, providing reliable data.
Unfortunately, *in situ* and on scaffolding it is not common to use such sophisticated field-portable tools: as this kind of equipment is often designed for other purposes, its use in built heritage conservation usually necessitates testing and careful calibration. This step is often carried out by visual assessment instead: for this reason, such a procedure is strictly related to the sensitivity of the conservator.
The aim of this paper is to identify an intermediate solution, which would be more effective than visual assessment, easy to perform, and significantly less expensive than portable spectrophotometers.
For this purpose, in this essay a color chart and software - specifically designed for photography – were tested, in order to compare, measure and analyze differences in color reproduction in any color rendition system.
Then, data were tested by comparing them with those obtained by specifically designed equipment.
The results show that the method is able to provide relevant information on color matching, it is quick and easy to perform and definitely affordable, thus it could represent a smart alternative for built heritage conservation.

Keywords
Chromatic reintegration; Color matching; Wall paintings; Color chart.

1. INTRODUCTION

Professionals working in the field of cultural heritage often face the challenge of identifying, defining and comparing colors that they encounter in their daily practice [1].
The first factor to be taken into account is that color cannot be considered a physical quantity, because -by its nature- it is the result of sensations of the nervous system that also involve emotional and cultural aspects of the observer [2]. The sensitivity of the human eye to various light radiations is not constant for every wavelength, it varies from individual to individual, and it also depends on the type of illuminant.
Color is therefore dependent on perception and interpretation, and as such it is purely subjective.
The term colorimetry refers to the science of measuring the physical quantities that characterize color, regardless of the subjective response of the observer.
Colorimetry is based on the principle that the properties of the mechanisms responsible for color vision and the relationships between physical stimuli and the responses to these mechanisms, can be described. Through this language an observer can describe a color in a way that is unambiguous and unique [3].
Wyszecki and Stiles define colorimetry as the «branch of color science concerned with specifying numerically the color of a physically defined visual stimulus» [4].
All systems of colorimetry are required to be three-dimensional because of the nature of human vision: this means that the specification of three independent variables is required to describe colors uniquely.
The parameters that allow to identify a color are hue, saturation and lightness:

- Hue or color is the particular visual sensation produced in the observer by light radiation: for

light is composed of a mixture of several wavelengths, the hue corresponds to a specific intermediate wavelength, called the dominant wavelength.
- Chroma or saturation represents the feeling of the degree of concentration of the hue in relation to the white (or grey, or black) content. Saturation varies from values as low as 0% for very pale, almost white colors, to as high as 100%, the limit at which the color is given by the specific pure chromatic composition.
- Lightness (or brightness, or brilliance) indicates the intensity of the sensation of a color: it can be very dark or very bright, and can be measured independently of the hue.

Two colors displaying the same values of hue, saturation, and lightness are identical to the human eye. In 1931, the *Commission Internationale de l'Eclairage* (CIE, International Commission on Illumination) defined a standard chromaticity diagram that includes all the colors visible to the human eye. Like other color codings, this diagram is based on the use of three primary colors which, when mixed together in additive synthesis, make it possible to obtain all the colors existing in nature. However, unlike the RGB or CMYK methods (additive and subtractive synthesis), the chromaticity diagram proposed by the CIE does not depend on the behavior of a display or printing device but is based on the concept of Standard Observer. The Standard Observer is defined from the properties of our visual system and is based on systematic analyses of a large sample of human observers. The CIE system provides a standard procedure for describing a color stimulus in terms of defined illuminants and a defined standard observer.
Only by referring to a standardized method for expressing colors can the definition be immediate and objective [5].
One of the most widely used systems today is CIELab 1976, based on the subtractive synthesis. It is able to describe the entire range of colors perceived by the human eye better than any other color space in use -such as the RGB and CMYK systems- given that these are purely physical systems. In CIELab, E indicates color difference, C indicates the chromaticity difference (i.e. the difference in saturation between two shades of the same color) and L* refers to the brightness difference, while a* and b*, which can take on positive or negative values, describe the chromatic coordinates on the green-red and blue-yellow axes, respectively.

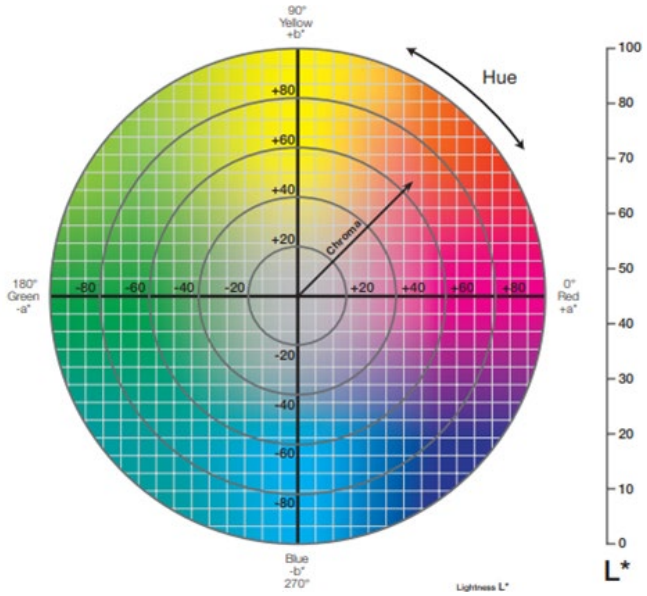

Figure 1 – CIELab color chart (Source: www.xrite.com).

The definition of the color of a paint layer can generally be approached and resolved using different procedures: the first step in identifying the appropriate methodology and instrument is to identify the nature of the problem and/or the purpose of the investigation.
Utilizing instrumental determination of painted surfaces can serve various purposes in the field of conservation: the objective description of alterations in color, caused by exposure to atmospheric agents or other chemical or physical factors, or the objective control of reference samples of color and color atlas, or even the evaluation of variations in color in the production of colored surfaces.
In this study, the objective is to get to the unambiguous description of differences in color between an original surface and a reference sample.

1.1 Color measurements

In some cases, color atlases can be used (such as Munsell's color system) that are based on direct visual comparison by observation under a specific light source between the reference sample and the object under investigation. This type of colorimetric analysis has the advantage of being immediate and not requiring any physical-mathematical theory on the part of the user. However, it presents a number of limitations: the color evaluation carried out by visual comparison of two colored bodies does not allow for taking into consideratiom the surface texture and the reflective

power of the investigated surface. Furthermore, overlapping layers of paint with different degrees of transparency can be found, which are difficult to reproduce and classify with color atlases. Finally, the color atlas system does not allow for quantifying of the difference found between two colors.
The analytical measuring of the chromatic parameters of surfaces in the field of cultural heritage is carried out by colorimeters and spectrophotometers.
The first tool refers to colorimetry, which is the numerical, three-dimensional specification of the visual stimulus for the sensation of color: a colorimeter is a device that mimics the way humans perceive colors.
Spectrophotometry is a non-invasive technique which measures the amount of light reflected or transmitted by a material at individual wavelengths of the spectrum. The optical instrument used to measure how materials reflect or transmit light is called a spectrophotometer.
The spectrophotometer measures the intensity of wavelengths in a light spectrum compared to the intensity of light from a standard source and returns it on a graph called spectral or spectrophotometric curve. The shapes of such curves are often specific for various colorants/pigments, providing a type of fingerprint characteristic of the chemical nature of the material [6]. Spectrophotometry and colorimetry can be useful in many important ways in objective analysis and research, and are commonly adopted for the examination of materials in cultural heritage.

1.2 State of the art and aims of the study

As a matter of fact, spectrophotometry and colorimetry are under-used in the field of cultural heritage conservation.
As spectrophotometers and colorimeters are often designed for other purposes, their use in built heritage conservation and for *in situ* analysis of wall paintings is often hampered [7].
In order to ensure accurate data, proper instrument calibration is necessary in first place, along with multiple testing and measurements to provide for statistically reliable results, recognition of the effect of sample characteristics on the method of analysis, and reference information.
The main limitations lie in the following points:

- The difficulty of having to use instrumentation created for industrial control, and designed for routine operations.
- Consequently, the difficulty of having to adapt this instrumentation to complex and continuously diversified patterns, such as those belonging to polychrome surfaces.
- The need for a technology capable of measuring very restricted areas, and even punctiform ones.
- The need to assure appropriate conditions of repeatability in uneven conditions, and even when using mobile equipment: the correct identification of the same points on a surface, which can be measured several times, has to be guaranteed, in order to obtain a scientifically correct comparison.
- Additionally, few conservation professionals have experience in colorimetry or access to professional equipment. Furthermore, what is to be taken into account is the economic aspect as well, which in many cases turns out to be the first limitation.
- Difficulties in overcoming these obstacles make colorimetric and spectrophotometric techniques a niche tool in conservation, generally reserved for scientific and study campaigns.
- But still, in preservation and conservation of historic facades - especially for those of buildings that are in use - conservators frequently face the task of faithfully repurpose surfaces and paintings from a chromatic point of view.

In most cases, given the difficulty of applying analytical techniques, this step is carried out by visual assessment by a conservator proficient in the field of colorant formulation and with in-depth knowledge of the behavior of colorants in a specific material: the process involves making a series of samples that are tested on the surface to be treated, in order to identify the most suitable ones.
However, this procedure is largely dependent on the sensitivity of the conservator.
From these discussions, one major conclusion is drawn: compromises must be made in order to obtain accurate assessment of color, that is essential in many applications.
The primary goals of the project are to identify an intermediate solution, which would be more effective than visual assessment, easy to perform, and significantly less expensive than spectrophotometry, and to establish a replicable methodology.

2. MATERIALS AND METHODS

The nature of the problem to be solved and the purpose of the measurement must first be defined before an instrument appropriate to the task can be selected: for

the measurement of opaque, uniform, dielectric (non-metallic) materials, most of the existing color-measuring instruments are adequate.
In this study, the aim of the evaluation is to objectively describe a colored surface, and to establish differences in color between an original surface and a reference sample: since the materials have identical colorant composition and surface characteristics, tristimulus filter colorimetry is an adequate technique, and there is no need for more sophisticated equipment.
For these reasons, the present study was addressed to the field of professional photography, and the use of a ColorChecker chart as reference tool for evaluating colors was investigated.
A uniform color field was taken as a reference for the study, and the data acquired from the color chart were tested by comparing them with those obtained by specifically designed equipment.

2.1 Instrumentation

The tool that was tested for this study is the X-Rite's Passport ColorChecker, a target specifically designed for photography and video production, that is able to compare, measure and analyze differences in color reproduction, in any color rendition system, through the related calibration software.
The Colorchecker – Color Rendition Chart was first designed and presented in 1976, in an article by C. S. McCamy and other members of the Machbeth company (Kollmorgen Corporation) [8]. It consists of a series of color patches (greyscale, primary colors, other "natural" colors). The pigments are selected to ensure maximum stability in time and a minimum degree of metamerism: the predefined colors of the Colorchecker vary uniformly with the natural colors when the light source changes, both when the comparison is direct and when a photographic image is taken into account [9].
Issued in 2009, the ColorChecker Passport replaced and enhanced the original chart. The ColorChecker Passport has three targets: a color chart, a large light-grey target for white balance, and a target with patches designed to neutralize or enhance global color shifts in images. The system includes a software to generate DNG Camera profiles from images of the ColorChecker, and it can be used as an Adobe Lightroom plug-in.
The instrument used as a reference is a Ci7000 series X-Rite benchtop reflectance spectrophotometer, paired with the Color iQC software.
Illumination was obtained by a D65 illuminating agent. Defined in 1964, D65 has become the standard solar illuminant reference (midday average daylight of the northern sky) for the industry as well as for various applications with a CCT of 6504K, described and used as a reference in ISO: 3668, ASTM 1729 and DIN6173-2. Finally, In order to guarantee that consecutive measurements have been made in the same area, a graduated mask was used.

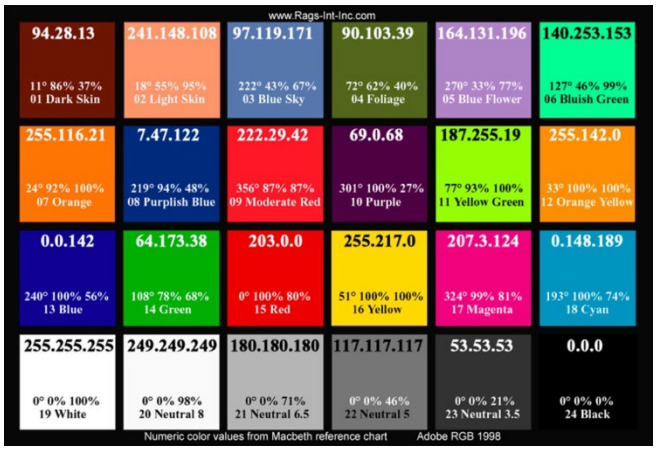

Figure 2 – Values of chromaticity coordinates of the Gretag Macbeth Color Checker (Source: www.xrite.com).

2.2 Color measurements

Two measurements of the same surface were taken, both with the reference spectrophotometer and by using the ColorChecker chart, in order to make a comparison. The first measurement was carried out with the spectrophotometer on a surface sample. The color was measured using a reflectance spectrophotometer according to the CIELab1976 color system. The characteristics of the color measuring instrument are the following: color scale CIELab; illuminant D65; standard observer 10°; geometry of measurement 45°/0°; spectral range 400–700 nm; spectral resolution 10 nm. Before taking measurements, the instrument was calibrated with the white reference tile supplied by X-Rite.
Then, the use of a digital camera paired with a color chart for colorimetry was investigated: the system consists of a digital camera (Panasonic Lumix GH5 + 14mm f/2.5), a ColorChecker Passport target and a source of light with a color temperature of 6500 K.
First, the white balance (WB) was setted by using the light-grey target provided by the ColorChecker. Then, a photograph of the surface was taken incorporating the ColorChecker card in the photographed scene, in the same lighting conditions.

Once the picture of the surface was taken, it was processed using the related calibration Passport ColorChecker software to balance colors by analyzing the chart patches in the resulting image, and to create a DNG custom color profile to be open in Adobe Camera Raw. This process allowed to measure the CIELab coordinates of the surface through the Adobe Photoshop Color Sampler tool.

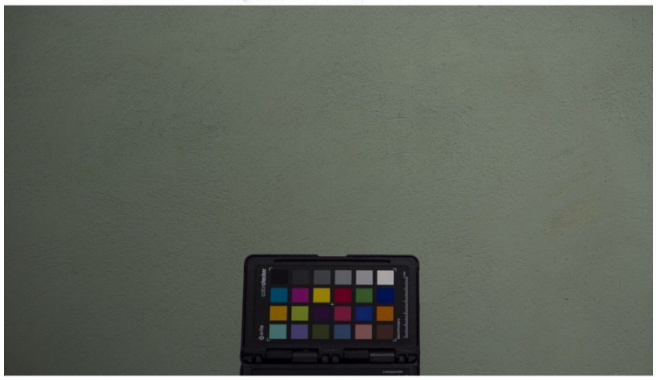

Figure 3 – Sample image taken in daylight.

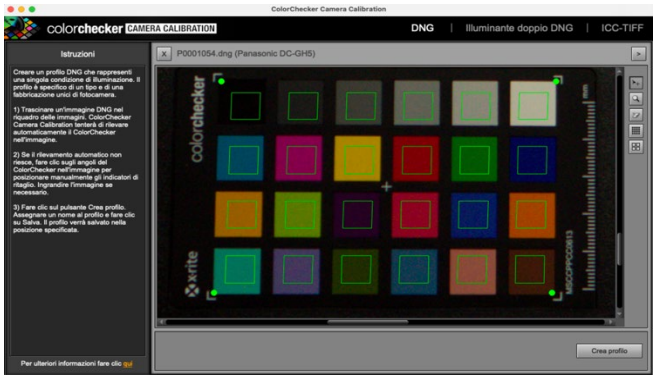

Figure 4 – Color profile creation via Colorchecker Camera Calibration software.

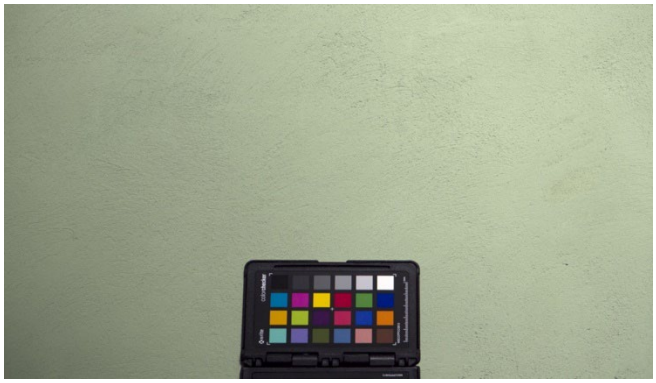

Figure 5 – Same image after WB and color calibration via Colorchecker Passport software.

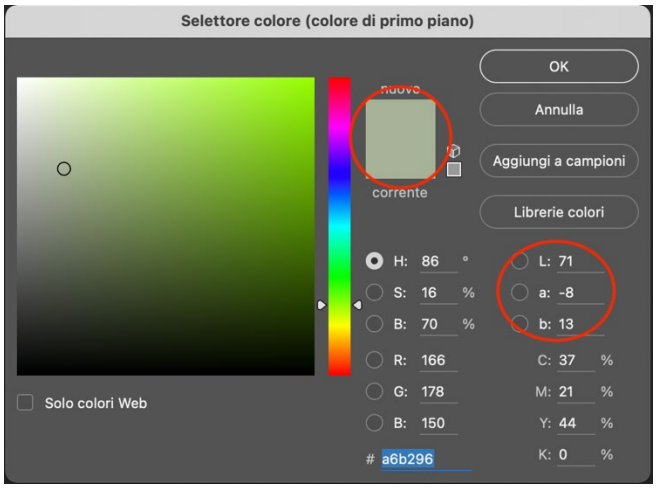

Figure 6 – Color coordinates through the Adobe Photoshop Color Sampler tool.

3. RESULTS AND DISCUSSION

All the results of the measurements were given in terms of CIELab color space values. The values in lightness (ΔL*), chromatic coordinates (Δa* and Δb*), and total color (ΔE*) were then calculated using these parameters according to EN 15886 (2010), i.e. the European standard describing the procedure to adopt for color measurement of cultural heritage objects using the CIELab method.
ΔE is an industry standard overseen by the International Commission on Illumination.

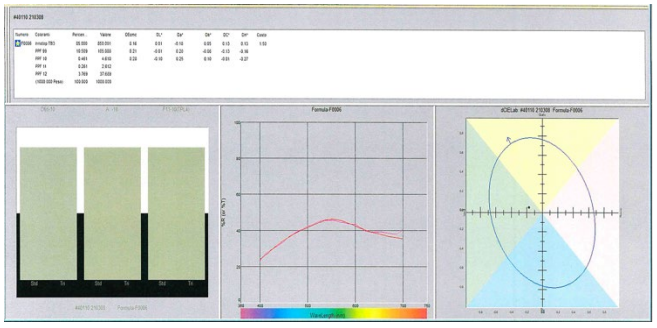

Figure 7 – Spectrophotometer output graphs. The black dot in the graph on the right indicates the accuracy of the result provided by the instrument (ΔE < 0.5).

The spectrophotometric analysis yielded the following results: in CIELab L* 71.77, a* -6.30, b* 11.05; in RGB 170 – 179 - 155; in CMYK 35% - 22% - 41% - 0%. The software also provided a color reproduction formula with a ΔE < 0.5, i.e. with a color variation from the

original painting that cannot be perceived by the human eye.

The ColorChecker method provided the following average results: CIELab L* 71.12, a* -8.57, b* 13.14; in RGB 166 - 178 – 150; in CMYK 38% - 20% - 45% - 0%.

The total color difference, ΔE*, between the two measurements (L^*_1 a^*_1 b^*_1 and L^*_2 a^*_2 b^*_2) is represented by the geometrical distance between their positions in CIELab color space.

It was calculated using the CIE76 color difference formula: $\Delta E^*_{ab} = \sqrt{(L^*_2 - L^*_1)^2 + (a^*_2 - a^*_1)^2 + (b^*_2 - b^*_1)^2}$

The measurement yielded the following result:

$\Delta E_{ab} = \sqrt{(71.77 - 71.12)^2 + (-6.3 - -8.57)^2 + (11.05 - 13.14)^2} = \mathbf{3.15}$

This result shows that the two methodologies provided a very similar response.

On a typical scale, the ΔE value will range from 0 to 100; referring to the standard perception scale, this color difference is perceptible to the eye but is only slightly above the value 3, which is generally referred to as the threshold value above which the human eye can perceive color differences.

Table 1 – Chromaticity coordinates of the spectrophotometer and Colorchecker outputs

	Spectrophotometer output HEX (#): AAB39B
	CIELab 71.77 -6.30 11.05
	RGB 170 179 155
	CMYK 35% 22% 41% 0%
	Colorchecker output HEX (#): A6B296
	CIELab 71.12 -8.57 13.14
	RGB 166 178 150
	CMYK 38% 20% 45% 0%

4. CONCLUSIONS

The project presented here is a preliminary stage for the study of alternative methods for the colorimetric evaluation of opaque surfaces, such as those of wall paintings, in built heritage conservation.

The results obtained in this first step, although partial and provisional, suggest the method to be able to provide relevant information on color matching.

A major limitation to the practical application of spectrophotometric measurements in the field of conservation of built heritage is the availability for conservators of such sophisticated and expensive instrumentation, and the requirement of specific training - or professionals - for their use.

The Colorchecker method is based on the use of tools and software that are commonly used by conservators for other purposes, and therefore easy to perform, and definitely affordable.

The method proposed is not intended to replace spectrophotometric techniques, but to be applied as a smart alternative in peculiar situations where there is no access to specific equipment.

A number of considerations have to be made with regard to the replicability of the method on different surfaces and the behavior of the ColorChecker with regard to the phenomenon of metamerism, as well as with regard to the degree of accuracy of the measurements in carrying out the various steps.

Although these observations highlight the possible obstacles of the tested method and the limits of its applicability, this research is intended to be a feasibility study paving the way for more comprehensive and analytical research.

AKNOWLEDGMENTS

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TOPIC 6

Digital technologies as resources for the chromatic reintegration process

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PICTORIAL RECONSTRUCTION OF PALOMINO'S CEILING BY DIGITAL TECHNIQUES

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ABSTRACT

The case of the Palomino's frescos in the church of Santos Juanes, in Valencia, Spain, is a challenge that requires new alternatives to traditional mural painting restoration for several reasons. The destruction and alteration of more than 50% of the 1000 m^2 of pictorial surface, what is preserved has two levels of materiality. Part of it is detached and adhered to wooden boards, while another part is preserved in situ in its original plaster. Finally, as a place of worship in use, it is necessary to make the symbolic message represented in the mural legible. Based on the digital treatment of the image, we put forward the use of video mapping and an image transfer method for the recovery of the pictorial and ornamental ambiance previous to 1936.

Keywords
Digital reintegration; Image transfer; Digital coloring; Videomapping.

1. INTRODUCTION

The Palomino's frescos in the church of Santos Juanes (fig.1) have suffered different events that have affected their state of conservation. A large part of the paintings was destroyed in the fire of 1936. Part of the burnt paintings were detached and partly relocated in the vault later. In the previous decade, one third of the paintings that were not detached have been restored as part of the technical approaches that seek to provide a solution to the pictorial set. At present, a new phase of intervention has begun in which an aesthetic reconstruction system generated by digital images is being used. This technique aims to recover the pictorial and functional ambiance of this religious space.

Figure 1 – Photograph of the vault taken by J. Alcónat the beginning of the 20th century.

For this reason, through new technologies, we understand that it is possible to find a global solution for the entire pictorial set of the church, adapting the process to each one of the different cases presented by the mural set. First, we find in the vault the paintings that have already been restored recently and that did not undergo any previous intervention after the fire[2]. Secondly, the continuation of the vault with fragments of detached paintings, repainted and placed on wooden supports nailed to the wall and finally, an apse in which there is no trace of any painting.

The objective of this process is not only to revalue the aesthetic aspect of the valuable preserved fragments but also to recover its meaning and facilitate legibility, all while respecting its historical value. All this process, starting from a black and white photograph and the reference to other works still preserved by the same author, Antonio Palomino.

These investigations are part of the development project for the restoration of the mural paintings, sculptures, stucco, ornamentation, and altarpieces of the Santos Juanes church set, currently carried out by the Instituto de Restauración del Patrimonio (IRP) of the Universitat Politècnica de València (UPV) coordinated by Ph.D. Pilar Roig Picazo, with funding from the Hortensia Herrero Foundation.

2. MATERIALS AND METHODS

2.1 Global Chromatic solution

To fulfil the objective of trying to give a global solution to Palomino's work, it is necessary to find a chromatic solution to the apse of the church due to the absence of its original frescos (fig. 2). In this case, based on the digital treatment of the image, we put forward the use of video mapping for the recovery of the pictorial and ornamental ambiance previous to 1936.

Figure 2 – Current indoor view from the Santos Juanes church.

Using a B&W photograph and taking chromatic and iconographic references from other pictorial works that are in the same space-time context as the original work and are executed by the same author, an aesthetic approach to the work would be realized through video mapping technique. Knowing the point where the reference photograph was taken, through the optics of the projectors and calculated deformations of the image, it is possible to make the fit of the image to the concave surface of the apse.

From the geometric model generated through a 3D scan, a study is made to carry out a videomapping proposal. For the projection design, it is necessary to carefully study the space requirements and analyze the position of the projectors, seeking a balance between simplicity, budget, and image quality.

In the case of the retouching of the vault paintings, where fragments of original painting are still preserved, other graphical historical B&W photograph, taken by J. Alcon before the fire, were used to start the work. To be able to adapt the image to the semi-cylindrical surface of the vault, a digital processing was carried out in several ways such as straightening, rectifying, and scaling of the historical photograph. All this thanks to the calculation of the point of capture of this photograph[3] (fig.3) [1].

Figure 3 – Straightening, rectifying and scaling of the old photograph.

After the previous process, the following step was a digital colouring based on the superposition of the captures of the existing fragments to the picture taken by J. Alcon, taking the colours of the original painting as a reference (fig. 4). The creation of the virtual final image also requires colour management calculations to be transformed into a printed reality. So that the print

is adjusted to the tonal characteristics of the mortar used and that the colours, once transferred, reproduce the real colour of the images.

Figure 4 – Left: preserved fragments after cleaning andconsolidation. Right: digital reconstruction and colouring.

The last step was to print and transfer the image to the wall. This was done with Papelgel®, a temporary support for the transfer of inkjet and pigmented printing inks. The mordant of the ink is that of its own formulation, generally of the alkyd type. Papelgel® is only a temporary printing medium that does not provide or require mordant.

In the previous phase carried out in 2008, where the painting had not undergone previous interventions, this transfer was made without any type of adhesive. It was applied directly to the wall so that the small amount of mordant in the ink and the porosity of the wall acted as a receptor coating. In this way, the transpiration of the wall is prioritized, and the incorporation of other materials was avoided [2].

In the current phase of the intervention this system is intended to be applied to the rest of the vault, where we find fragments of paintings that were detached and placed on a wooden support and nailed to the vault in the 1960s. Once the removed fragments are relocated to their original position and on a new support adapted to the shape of the vault, the process of transferring the image generated from the coloured photograph is carried out. In this case, a transfer system is used that is the same as in the previous phase, but this time a layer of pressure sensitive acrylic adhesive is added to the transfer with Papelgel® in the form of a dotted texture. This adhesive improves the stability and quality of the transferred image, and its function is to enclose the ink drops in a layer and ensure that they remain on the surface. In this way, the fidelity of reproduction and aesthetic integration is significantly higher [3].

In order to guarantee that the dots pattern adhesive system meets the aesthetic and material stability and compatibility requirements, colorimetry, glossmetry and surface water behavior tests have been carried out together with accelerated aging tests under UV radiation.

3. RESULTS AND DISCUSSION

3.1 Digital coloring process

Both to color the projected image of the apse and the transferred image of the vault, we have started from the black and white photograph. The process is very similar but with some specific differences, taking into account that in this case there are no original fragments from which to extract the color palette. First of all, to start the digital coloring process of the apse it is important to identify the existing characters, both the main and secondary figures, as well as the rest of the figurative and scenographic elements.

In the process of recreating the paintings digitally, the workflow must be taken into account from the outset. The different parts of the paintings are separated by layers and worked individually, on one hand the base color, on the other the shadows and finally the lights. This phase allows to have total control in a fractional way to be able to manipulate the elements individually. In addition, a palette with different digital brushes is created to simulate different types of brush strokes and finishes, modifying its texture, thickness, stroke pressure, transparency, and opacity.

It is also necessary to create a digital color palette, based on technical and analytical studies of real colors of the preserved fragments and contemporary works made by Palomino (fig.5). These colorimetric references transformed into digital space allow working according to the brightness, contrast and saturation of each color, evolving the digital pictorial technique to simulate Palomino pictorial technique [4].

3.2 Mapping technical aspects

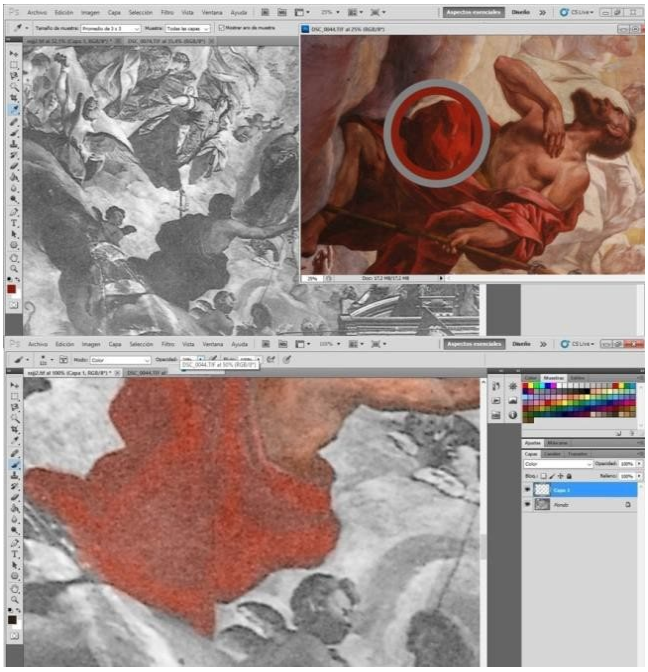

Figure 5 – Digital coloring taking as reference pictorial works from the same author.

Through the analysis of the photograph and together with the 3D model, the approximate point of view and orientation from where this photograph was taken is found, calculating the XYZ position. With these data it is possible to carry out a reprojection of the photograph on the geometry, thus obtaining a representation of the position of the photograph on the structure (fig.6).

Figure 6 – 3D simulation of the apse's pictorial texturing through video mapping.

Regarding the position of the projectors, the geometry of the surface must be considered, in order to project the entire concave surface, it would be necessary to have two projectors on the cornice to cover the sides and a third for the central area, this being a higher optics.

The total projection area covers a total of about 200m^2.A light value between 75 and 100 Lumens/m^2 is established as acceptable, a range that would be achieved with projectors of 10,000 or 12,000 Lumens of power. Understanding that the perception of quality and brightness of a projection lies in the control of light pollution.

Another important aspect in this type of pictorial restitution is the resolution of the projection. 4K resolution little more than doubles FullHD, with 4K projectors you get four times as many pixels. Therefore, the higher the resolution, the higher thequality of the set[4] [5].

3.3 Image transfer method

To transfer the image, water is applied in a controlled manner to remove the temporary support Papelgel® and leave the ink on the surface. The original fresco paint is only slightly moistened at the perimeters of thegaps.

To check the stability of the new ink transfer method for the color retouching of the vault paintings, different tests have been carried out. After four cycles of 250 hours at a constant temperature of 40ºC and 50% of relative humidity, the results obtained are positive. The ΔE* detected place the system according to the American Society of Testing and Materials (ASTM) at level 2 as "Very Good permanence". The stability of the acrylic polymers used as adhesives has also been verified since the transfer does not show any signs of loss of cohesion or adhesion [6].

The ink is removable with solvents of polarity fd 45-60. Image transfer is only carried out in the gaps coated for this purpose. This is a strict inpainting concept. As the ink is transferred to a non-original replacement stucco both structures can be removed mechanically without risk to the original fragments.

Image transfer by discontinuous dots of adhesive accredits the stability of the system, providing the reintegration with sufficient elasticity to adapt to the irregularities of a wall support and preventing future delamination.

4. CONCLUSIONS

New technologies make possible to find a global solution to the entire pictorial set of the church of Santos Juanes in Valencia, although each area has different casuistry, it is possible to find a specific process that adapts to each one that, in addition, complement each other obtaining a joint solution. The difficulties found during the digital work have been mainly the lack of information and quality of the photographic material and the adaptation of the virtual model to the real geometry of the architectural space.

Moreover, mapping allows the viewer to return the aesthetic and functional values of the work, without using an invasive way, it favours a vision of its historical-artistic context. Without physically altering the heritage, the final audiovisual presentation can reach multiple information levels, helping the observer understand, for example, the technique and pictorial materiality of the frescos and, at the same time, discover the different iconographic representations.

The reconstruction of missing fragments through the transfer of the printed image allows the conserved fragments to be formally and iconographically contextualized, with a faithful approach to the lost originality provided by photograph.

The materials of the transfer system tested have been subjected to quite aggressive tests, so it is considered that in a controlled mural environment they should be capable of ensuring good physical and chemical stability, comparable to traditional techniques such as watercolors or other procedures commonly used in chromatic reintegration of these works.

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NOTES

[1] Transfer system one was implemented in an area of 150 m^2 in 2008. The results are shown in fig. 4 and it has not undergone any noticeable chromatic changes since then. Transfer system two is currently being applied after laboratory tests and actual experience on a fragment of San Nicolás wall decoration in 2016. The videomapping system has only been tested on virtual models.

[2] 25 years after the fire, 2/3 of the preserved painting was removed and replaced. The painting removed from the apse disappeared in the process.

[3] There are several photos with partial framing, but to generate the basic image of the vault, two photographs of large general shots and a third for the apse have been joined together to create the basic image of the vault.

[4] Pre-project on the technical study for digital restitution through video mapping on the central apse of the Church of Santos Juanes of València by Playmodes Studio S.L.

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THE INFLUENCE OF FILLERS ON THE CHROMATIC REINTEGRATION PROCESS ON EASEL PAINTINGS: ANALYTICAL STUDY FOR SKIN COLOR

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ABSTRACT

Mimetic chromatic reintegration in easel paintings is usually achieved by levelling the surface of losses (lacunae) with a white filler, followed by its retouching with an appropriate paint.
This investigation aimed to understand how different formulations of fillers (colored fillers and white fillers covered with three kinds of paints: watercolor, gouache, and mastic resin) influence mimetic reintegration. Colorimetry, using a smartphone with a color measurement application, and Fiber Optics Reflectance Spectroscopy (FORS) measurements were made on 29 samples of fillers and on the surface of the pictorial layer of our case study - a painting by Veloso Salgado.
The combined use of these techniques allowed us to choose the most similar material filler system. The pigmented fillers gave us the best results to perform a safer and faster chromatic reintegration procedure. This procedure appears to be suitable for contemporary art as which usually do not present a protective layer. Also, the use of pigmented fillers simplifies the color achievement.

Keywords
Easel Paintings; Fillers; Chromatic reintegration; FORS; Colorimetry.

1. INTRODUCTION

The use of white fillers, followed by an appropriate surface toning, is a standard restoration intervention for losses, whether on flesh tones or other painted elements on a canvas [1].

Chromatic reintegration is usually the final step in a conservation and restoration intervention and can cause a visual impact on the overall aesthetics of a painting. The main goal is to reintegrate the losses allowing the viewer to appreciate the artworks without the interference of the loss or the chromatic reintegration itself [2].

When considering the materials for filling losses in easel paintings, scant attention is paid to the broad offer of brands and formulations. Consequently, the matching color becomes more complex and time-consuming due to some problems of texture, levelling, absorbency, among others. So, the success of chromatic reintegration starts with the appropriate selection of the filling material [3], to reduce these inconvenient consequences.

Recognition of the influence of filling materials is so far done empirically. Initiatives on this subject are not so

numerous, as well as the studies that combines both techniques of color measurements focused on flesh skin tone. In addition, reflectance spectroscopy is a technique mostly used for pigment identification and in this case, the data comparison between samples is also a new field of investigation.

As the name implies, the objective of the mimetic method of reintegration is to achieve the color as much similar as the original on the painting [4]. The correct choice of the filling material can simplify this process.

The main goal of this investigation was to propose a methodology to support the choice of an appropriate filler formulation using colorimetry and reflectance spectroscopy, specifically on the flesh (skin) zones. To accomplish this the following objectives were specified:

• Identify the constituent materials of the painting under study, reviewing the scientific publications about the painter, Veloso Salgado, on his paintwork [5] [6] [7]. Also, to review the state of the art concerning analytical equipment over color and pigments identification, focusing on colorimetry based on applications for smartphones and, on FORS [8] [9].

• Select the filling materials and the pigments to formulate the colored or pigmented fillers. For comparative purposes, traditional fillers (made of skin glues), synthetic formulations and fillers manufactured commercially, were tested.

• Preparation of a mockup with 29 samples for analysis:
- 21 non-pigmented formulations
- 8 pigmented formulations

Over these 21 non-pigmented formulations three paints were used: 7 samples were painted with Winsor & Newton® watercolour, 7 samples with Royal Talens® gouache, and 7 with samples with mastic resin from Maimeri®. Samples were dried for one month after mockups conclusion.

The 8 pigmented formulations were prepared with a mixture of pigments according to the output of FORS database, that indicated the most similar pigments to the ones measured on the surface of the pictorial layer from the painting.

• Make use of portable and low-cost equipment, supported by previous studies with the same kind of devices, aiming to measure the samples and the painting.

• Validation of the methodology on a painting. The chosen painting, conceived by José Maria Veloso Salgado (2 April 1864 – 22 July 1945), is from the Faculty of Fine Arts, University of Lisbon. Veloso Salgado is a Portuguese artist regarded as one of the country's foremost masters of Naturalism with many works on historical painting, landscapes, and portraits. The chosen painting, made around 1889, represents a male nude. The relevant presence of chromatic layer losses on the flesh was the criteria for selection (Figure 1).

Figure 1 – Oil painting by Veloso Salgado, analyzed during this study.

2. MATERIALS AND METHODS

Below we present the methodology used, which allowed us to prepare and select the most appropriate materials for filling losses in the easel painting selected as a case study.

2.1 Measurement of color and visible light reflectance parameters at the painting

Colorimetry and reflectance spectroscopy measurements were made at intact flesh tone areas from the painting surface, adjacent to paint losses.

Colorimetry was made under a smartphone application (Color Picker®) with an Android 9.0 operational system. The visible reflectance data was achieved with a FORS device (Figure 2), model Gorgias® manufactured by CHS Opensource, operating with a halogen tungsten lamp, color temperature of 3.000 K, a detector CCD Toshiba TCD1304DG with 3648 pixels, and fiber optics cable with seven channels of 600 micron wide each.

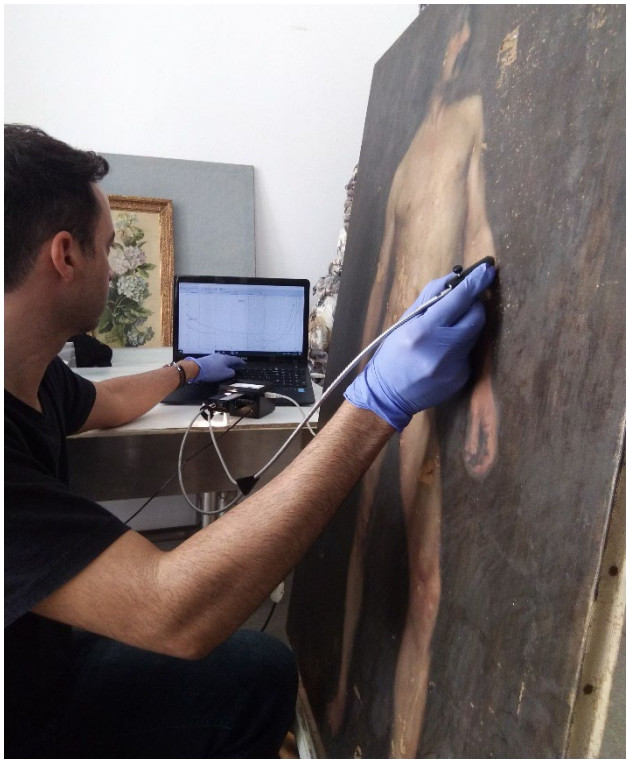

Figure 2 – Measurement of light reflectance by FORS.

2.2 Bibliography survey of the chromatic layer constitution

Literature was collected [5] [6] [7], focused on previous studies about the stratigraphy and the identification of pigments used at this painting and other paintings from the artist.

During a previous study [5], a micro-sample on the border of a loss was removed to observe the chromatic layer structure. This result was used to comprehend the painting technique used by the artist.
X-ray fluorescence and Raman spectroscopies were applied on the same sample to identify the pigments used by Veloso Salgado on the flesh zone.

The literature also showed the methodologies from other artists at the same time and academic references (Portugal and France academies by the end of 19th century).

2.3 Mock-up creation

A mockup of 29 samples was created according to the proposed formulations (Figure 3). The first 21 filling materials were prepared with calcium carbonate and gypsum, combined with three different binders: a traditional one - rabbit skin glue, and two synthetic – the vinylic Mowilith DS 5/2® and the acrylic Plextol B500®. A ready-made putty was also used, Modostuc Bianco®, on samples 19, 20 and 21 (as seen on Figure 3).

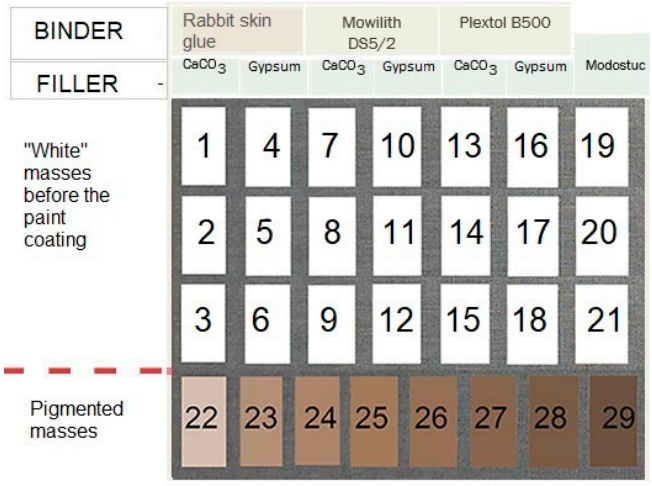

Figure 3 – Mockup scheme before the application of the paint coating to samples 1 to 21.

2.4 Painting's application over samples 1 to 21

Samples 1 to 21 were coated with paints typically used for conservation [10], such as watercolor from Winsor&Newton®, gouache from Talens®, and mastic resin from Maimeri®. We aimed to paint the samples

with pigments similar to the ones used at Veloso Salgado's painting. The inputs from literature on scientific studies [5] [6] [7] [11] considering the flesh area composition were essential to the decision-making process (Figure 4).

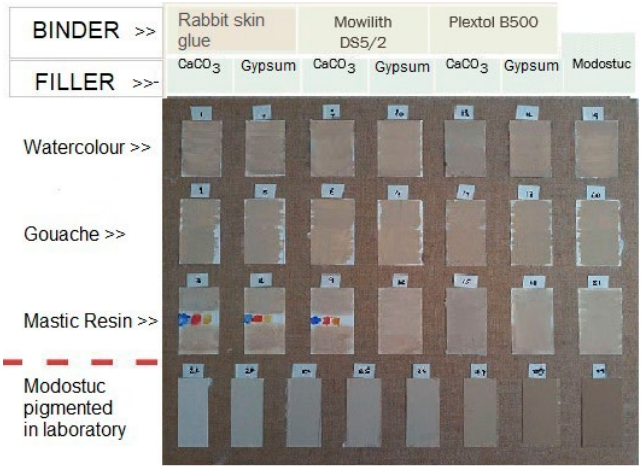

Figure 4 – Mockup ready for the measurements.

2.5 Painting's application over samples 22 to 29

The last eight samples from the mockup were prepared with an industrial putty (Modostuc Bianco) with the gradual addition of pigments accomplishing a lightness scale. Samples were painted with a mixture between Burnt Umber (PBr7) and Raw Siena (PY43). These two pigments were identified by a FORS measurement at the area representing the flesh (skin) from the painting.

2.6 FORS and colorimetry measurements on the 29 samples from the mockup

FORS and colorimetry measurements from the 29 samples were made. We aimed to compare the results of the mockup samples with the "original" flesh color from the painting and choose the two most similar samples. So, two samples were chosen:
- a sample from the "filler + paint" system (between samples 1 to 21)
- a sample from the "pigmented filler" system (between samples 22 to 29).

2.7 Execution of chromatic reintegration at the painting with the chosen samples

An exercise of chromatic reintegration was made at some paint losses from the painting, with the two selected samples, according to the methodology. Both chromatic reintegration areas were analyzed by FORS and compared with the original area enabling the validation of the methodology.

3. RESULTS AND DISCUSSION

3.1 Selection from the "filler + paint" group of samples

Below we present (Figures 5, 6 and 7) the first group of results. These show the comparison between measurements from the first 21 samples on the mockup separated by the type of paint for better visualization and, the one obtained at the painting:

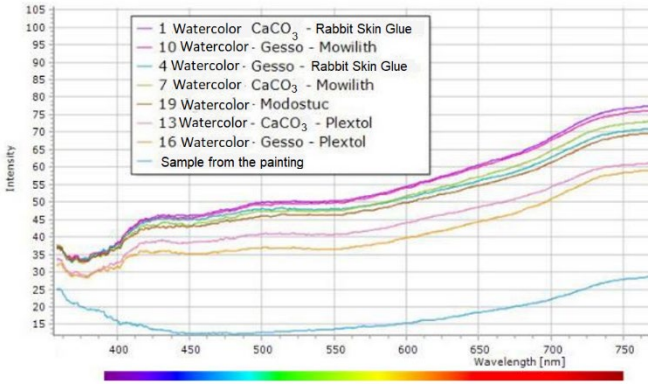

Figure 5 – FORS results obtained for watercolor samples and flesh color from the painting (sample).

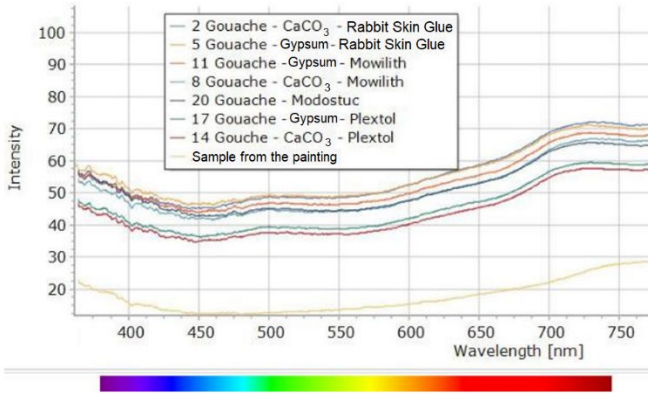

Figure 6 – FORS results obtained at gouache samples and flesh color from the painting (sample).

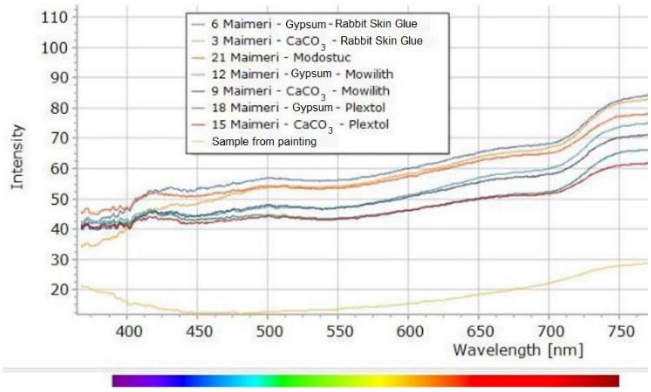

Figure 7 – FORS results obtained for mastic resin samples and flesh color from the painting (sample).

As we can see above on the visible spectrum frequency (mainly above 450-750 nm), the curves present similar shapes between themselves and the Veloso Salgado painting. We consider that without support from colorimetry, the FORS outputs are not conclusive enough because the similarity of the obtained spectra.

Below, we present the ΔE results from CIE Lab color space when compared with the measurement at the painting:

Table 1 – ΔE results from samples 1 to 21, compared to flesh tone at the painting.

CIE Lab color measurements					
Sample	Paint	Lightness	- a +	- b +	ΔE
21 Modostuc	Mastic resin	61	2	6	9,9
7 CACO3 + Mowilith	Watercolor	61	0	4	11,8
8 CaCO3 + Mowilith	Gouache	61	-1	4	12,1
17 Gesso + Plextol	Gouache	58	-2	4	11,0
3 CaCO3 + Rabbit S. Glue	Mastic resin	62	1	4	12,2
4 Gesso + Rabbit S. Glue	Watercolor	58	1	3	11,0
1 CaCO3 + Rabbit S. Glue	Watercolor	63	1	4	12,9
12 Gesso + Mowilith	Mastic resin	63	1	4	12,9
14 CaCO3 + Plextol	Gouache	59	-2	3	12,2
6 Gesso + Rabbit S. Glue	Mastic resin	64	2	5	12,8
9 CaCO3 + Mowilith	Mastic resin	62	0	3	13,2
20 Modostuc	Gouache	60	-3	3	13,1
10 Gesso + Mowilith	Watercolor	64	0	4	13,8
16 Gesso + Plextol	Watercolor	58	0	2	12,1
18 Gesso + Plextol	Mastic resin	60	1	2	12,7
19 Modostuc	Watercolor	61	0	2	13,4
2 CaCO3 + Rabbit S. Glue	Gouache	63	-2	3	14,4
5 Gesso + Rabbit S. Glue	Gouache	60	-2	2	13,5
11 Gesso + Mowilith	Gouache	61	-2	2	14,0
15 CaCO3 + Plextol	Mastic resin	59	-1	-1	15,4
13 CaCO3 + Plextol	Watercolor	57	-1	-1	14,9
Measurement on the painting		54	+ 3	+ 13	

According to the results above, we can recognize that sample number 21 presents the lowest ΔE value, and through this criterion, it can be selected for the real case intervention at the painting.

3.1 Selection from the "pigmented fillers" group of samples

Below we can see (Figure 8) the FORS spectra from the eight samples prepared on a lightness scale, with a controlled addiction of pigments.

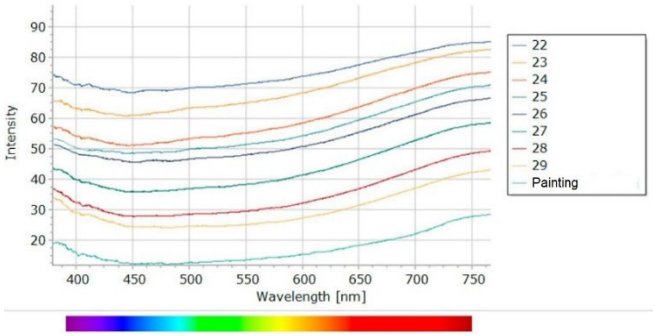

Figure 8 – FORS results from pigmented fillers compared to the measurement at the painting.

As we can see, there is a similarity between the spectra obtained at the samples and the one obtained at the painting.

But to quantify this similarity, a complementary technique, colorimetry is necessary once the comparison between the spectra is merely qualitative.

The comparison through ΔE calculation follows:

Table 2 – ΔE results from samples 22 to 29, compared to flesh tone at the painting.

CIE Lab color measurement - Masses pigmented on laboratory				
Sample	Lightness	- a +	- b +	ΔE
22	70	-6	-4	25,0
23	69	-8	-4	25,2
24	64	-4	-1	18,6
25	62	-3	-1	17,2
26	62	-2	-2	17,7
27	60	-1	+2	13,2
28	54	+1	+5	**8,2**
29	48	+2	+6	9,3
Painting measurement	54	+3	+13	

We can conclude that the most similar sample is #28. Still, due to the changes on saturation and lightness after varnish application above the mass, it will be chosen the lightest one, sample #27, assuming this darkening is sure to occur due to Modostuc properties.

At Veloso Salgado painting, sample #27 will be applied close to the sample #21 but on separated losses, and to a final comparison, a visual evaluation will be done together with a FORS measurement on both reintegration areas.

3.2 Intervention at the painting with the chosen samples 21 and 27

With the selection of the samples made, an intervention was executed at a selected area at some paint losses. The chosen area was located at the right leg, according to Figure 9.

Figure 9 – Zones of chromatic layer loss at the right leg (A) selected for the real case intervention with samples 21 (detail B) and 27 (detail C).

The filling materials and the varnish were applied at the zones of loss. It was used Laropal A81 due to the good photochemical stability [12] and brightness compatibility with the original surrounding surface. The final aspect follows below (Figure 10).

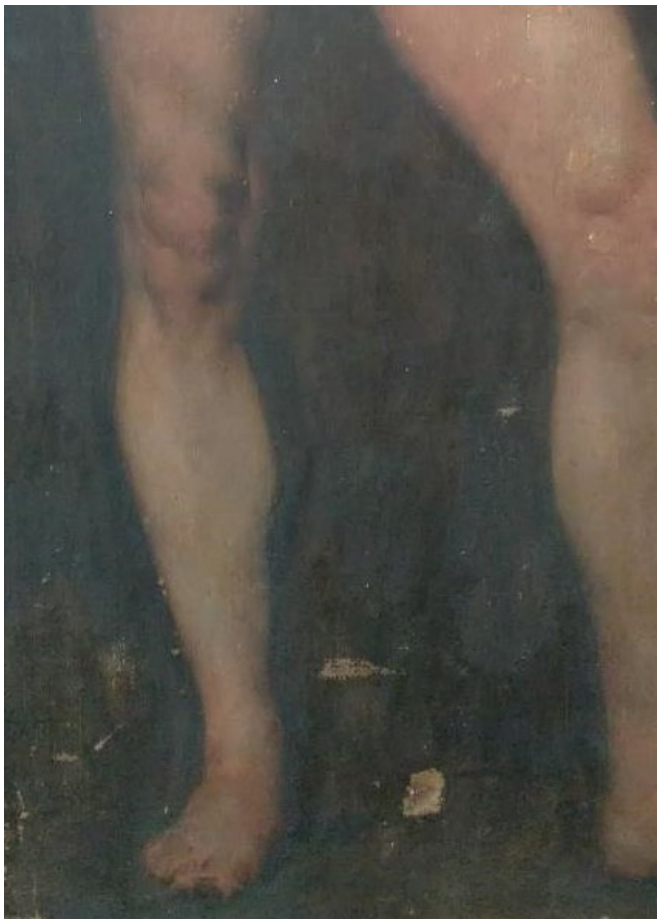

Figure 10 – Final aspect from the intervention with the selected masses.

3.3 Comparison between the final interventions with FORS

FORS was used after the intervention to compare the reintegration result with the one obtained at a near zone of the original flesh tone.

Below we can see both spectra (Figures 11 and 12):

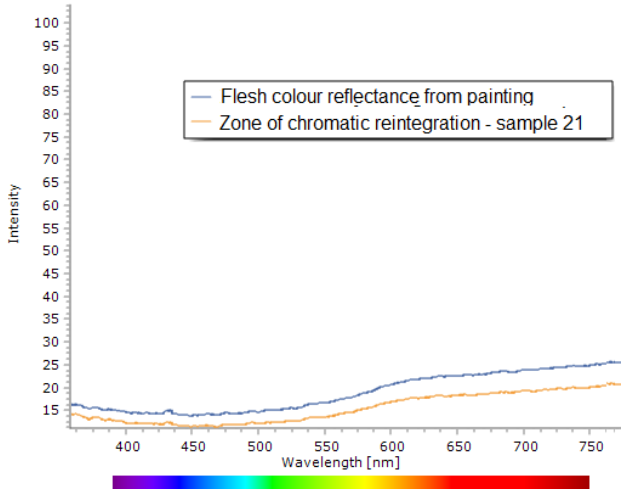

Figure 11 – Comparison between FORS measurements obtained on flesh color area at the painting and the nearest chromatic reintegration zone with sample 21 from the mockup.

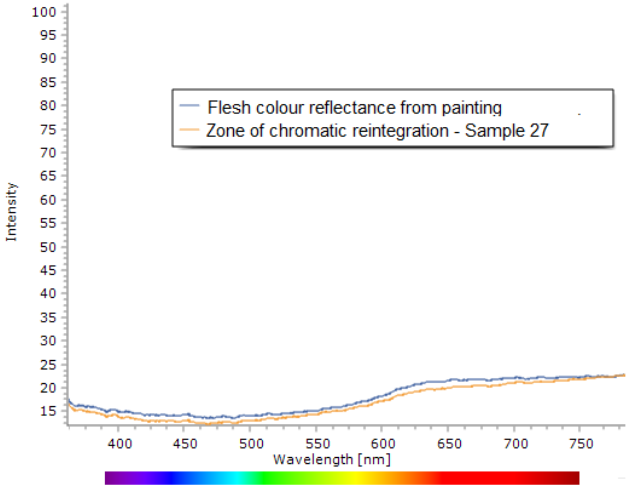

Figure 12 – Comparison between FORS measurements obtained on flesh color area at the painting and the nearest chromatic reintegration zone with the sample 27 from the mockup.

As we can see, reintegration made with sample 27 (a colored mass with controlled addition of pigments) achieved a better agreement with the visible light reflectance spectrum from the original painting.

4. LIST OF MATERIALS USED

- Calcium Carbonate ($CaCO_3$) from Kremer Pigment.
- Gypsum ($CaSO_4.H_2O$) from Inart.
- Natural binder: Rabbit Skin Glue from R&C.
- Synthetic binders:

Mowilith DS 5/2 from Celanese, and Plextol B500 from Synthomer.

- Ready-made putty: Modostuc Bianco, from GIMOD.
- Paintings:

Watercolor from Winsor&Newton Professional Line, tones Titanium White (PW6), Yellow Ochre (PY43), Indian Red (PR101) and French Ultramarine (PB29).

Gouache from Talens Extra Fine Quality, tones Titanium White (PW6/PW5), Yellow Ochre (PY42), Vermillion (PR4), Light Ultramarine Blue (PB29).

Maimeri Restauro Varnish Colors, tones Titanium White (PW6/PW4), Yellow Ochre (PY43), Cadmium Red Medium (PR108) and Ultramarine Blue (PB29).

- Pigments: Ferrario Color, tones Burnt Umber (PBr7) and Raw Sienna (PY43).

5. CONCLUSIONS

We conclude that the combined use of FORS and colorimetry was suitable to detect differences between several filling materials formulations at the mockup and at an original zone in the case study painting.

Also, the combined use of these techniques allowed us to choose the most similar color and execute a more safe and time saving chromatic reintegration procedure.

Pigmented fillers for chromatic reintegration appeared to be a suitable methodology for contemporary art considering that many of the easel paintings on a contemporary concept of production do not present a final varnish layer.

Also, the use of pigmented fillers simplifies the retouch process. The combined methodology of FORS and colorimetry allowed minimal use of different pigments. In this way, we can reduce unpleasable results. Color alteration through time and other problems, like metamerism, can also be minimized.

A smartphone is also a low-cost resource, available to every conservator-restorer. The application selected presented good correlation results between the samples themselves and became a good strategy when this kind of comparison was demanded, with low financial investment.

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