CONSERVAR PATRIMÓNIO

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Balancing artist's intent and durability: conserving a corroded outdoor painted iron sculpture

Equilibrando a intenção do artista e a durabilidade: conservação de uma escultura exterior de ferro pintado corroída

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Abstract

Conserving outdoor painted sculptures (OPSs) is challenging due to their constant exposure to uncontrolled environments. This paper outlines the methodology employed to conserve the *Tree*, a large-scale monochrome iron sculpture by George Lappas which has been situated in a coastal environment for decades. The artwork had suffered extensive metal corrosion and paint deterioration. Following an ethical evaluation of the artist's intentions versus the need for long-term stability, it was deemed necessary to repaint the sculpture completely. A comprehensive diagnostic approach was taken, including XRF, XRD, SEM-EDX, colourimetry and gloss measurement, as well as investigative cleaning. The study addresses the challenges of removing multiple paint layers and addressing various corrosion issues. The final conservation treatment involved using epoxy resin to fill in losses and a durable polyurethane paint system. Combining traditional and modern techniques restored the sculpture's original aesthetic qualities, while maximising its resistance to aggressive environmental conditions.

KEYWORDS

Outdoor sculpture conservation
Painted metal
Repainting
Polyurethane paint system
Artist's intent
Minimal intervention

Resumo

A conservação de esculturas exteriores pintadas é um desafio devido à constante exposição a ambientes não controlados. Este artigo descreve a metodologia empregue para conservar uma escultura monocromática em ferro, *Tree*, de George Lappas, que se encontrava num ambiente costeiro há décadas. A obra apresentava corrosão metálica extensa e deterioração da pintura. Após uma avaliação ética das intenções do artista relativamente à necessidade de uma estabilidade duradoura, considerou-se necessário repintar completamente a escultura. Adotou-se um diagnóstico abrangente, incluindo XRF, XRD, SEM-EDX, colorimetria e medição de brilho, bem como limpeza investigativa. O estudo aborda os desafios para remover várias camadas de tinta e solucionar os problemas de corrosão. O tratamento de conservação envolveu o uso de resina epóxi para preencher as lacunas e sistema de tinta de poliuretano durável. A combinação de técnicas tradicionais e modernas restaurou as qualidades estéticas originais da escultura, e maximizou a sua resistência a condições ambientais agressivas.

PALAVRAS-CHAVE

Conservação de esculturas ao ar livre
Metal pintado
Repintura
Corrosão
Sistema de tinta de poliuretano
Intenção do artista
Intervenção mínima

Introduction

Although traditional outdoor sculptures in bronze and stone were created in collaboration with foundries and quarries, the demand for large-scale outdoor sculptures from the 1970s onwards led to the production of artworks requiring the skills, materials, and techniques used in industrial production [1]. These artworks consist of a substrate, which is mainly made of carbon steel, stainless steel, aluminium, resin, fibreglass, bronze, concrete and wood, as well as surface coatings, which are mainly industrially manufactured layers (primer and pigmented or non-pigmented coatings) applied by brushing, rolling or spraying [2].

The long-term preservation of painted outdoor sculptures presents a significant challenge due to their continual exposure to uncontrolled and sometimes harsh environmental conditions. These include UV radiation, rain, wind, pollutants, human interaction and biological debris from plants and animals [1, 3-4]. These factors contribute to the degradation of both the coating and the metal substrate. Although coatings are often selected for aesthetic properties such as colour, gloss, and texture, they are inherently susceptible to outdoor weathering. The durability of such coatings depends on various factors, including the properties of the materials used (such as corrosion resistance, weathering resistance, chemical and mechanical resistance, UV stability and adhesion), the application method, the coating's thickness and the quality of the surface preparation [5-6]. Over time, degradation at the coating-substrate interface can lead to discolouration, peeling and corrosion, ultimately compromising the sculptures' visual integrity and structural stability [1, 5]. A common approach to maintaining the appearance of outdoor sculptures is to regularly strip and repaint them rather than trying to preserve the original materials [1]. A major challenge in conservation is the absence of regular, proper maintenance and the prevalence of unprofessional interventions, such as repainting by non-conservators using incompatible commercial products without proper surface preparation. These practices often result in layered, incompatible coatings that are prone to failure, accelerating corrosion and deterioration [3].

The conservation of modern art is further complicated by ethical considerations, including the maintenance of the artist's intent, symbolic meaning and original appearance, all of which are directly related to the artwork's true nature [7]. When coatings deteriorate to the point where these qualities can no longer be conveyed, full repainting may be necessary [8]. While the complete removal of original materials conflicts with traditional conservation ethics, recent studies – including projects by the Getty and Dutch museums – have confirmed the necessity of repainting outdoor sculptures to preserve their intended visual characteristics [1, 7, 9]. The American Institute for Conservation acknowledges that achieving the artist's aesthetic vision may necessitate the sacrifice of original materials, while preserving key elements of manufacture and technique [10, p. 163].

Related research has suggested that a durable finish with the correct gloss and colour offers significant benefits, given that protective coatings act as chemical and physical barriers. When selecting a coating, it is important to consider factors such as material transparency, reversibility, ease of application, environmental friendliness and the interaction between the substrate and the coating, as well as weathering and outdoor exposure [11]. The paint system should combine all these characteristics to ensure longevity and extend the time between repainting [1]. A typical system for outdoor steel or aluminium sculptures includes a zinc-rich primer for corrosion protection, followed by an intermediate primer for surface smoothing and a topcoat. The zinc primer acts as a sacrificial layer, protecting the metal in the event of paint failure and removal [12-13]. The topcoat is usually applied in one or two coats. Research on polyurethane topcoats suggests that they strike a balance between aesthetic and performance expectations in heritage conservation, particularly for painted outdoor sculptures [14]. A final clear coat can provide additional protection for the paint system [1, 12].

George Lappas and his monochrome *Tree* sculpture

George Lappas (1950-2016) was a Greek sculptor whose work incorporated geography and cartography, frequently transforming landscapes into symbolic world maps. Born in Cairo, he studied in Athens and the US before completing his sculpture studies in Paris. He lived and worked in France, England and Greece, teaching at the Athens School of Fine Arts (ASFA) for nearly three decades and introducing innovative pedagogical approaches.

Lappas' extensive travels to countries including China, Russia and Brazil had a profound impact on his artistic practice. Research and personal communication with the sculptor Aphrodite Liti suggest that the sculpture presented in this study is closely related to Mappemonde, created in 1987 and presented at the Venice Biennale the following year [14]. The *Tree* is a sculpture composed of iron alloy plates-matrixes arranged in the shape of a tree and containing abstract global symbols. Like *Mappemond*, the *Tree* reflects Lappas' interest in coded forms, emerging from his thorough research into Mayan hieroglyphs and codes, as well as narrative mapping. While this work is grounded in Lappas's personal experience, it also resonates on a universal scale [15-16].

The artwork presented here is made from pressed iron plates that have been cut into square and round shapes. These are then assembled into the sculpture and joined by autogenous welding or metallurgical joints that match the alloy. Rectangular slats (1.2 × 1.4 cm) and metal strips form the frames at the back of the artwork, joining the plates into a tree shape. All joints are welded. Two vertical curved strips on each side support the structure, forming the tree trunk and connecting it to the double base. The base consists of two curved parts joined by thick hexagonal bolts. The sculpture is painted green to resemble a tree.

The plates were hand-worked with small cut-outs in the form of human figures, animals and ancient hieroglyphics, created with a propane/acetylene torch to leave blank impressions. The artist performed all processes, leaving a personal, lasting mark. The artwork combines traditional craftsmanship with a modern touch thanks to its monochrome finish.

Context and exposition environment

The *Tree* is part of a private collection and its manufacture was commissioned to Lappas in the beginning of the 1990's. It is permanently exposed in the garden of a residence (Figure 1) with close proximity to the sea in a coastal town in the Argolis region of the Peloponnese, Greece. The exposition environment is characterized as non-urban and coastal with transposition and deposition of salts (chlorides and sulphates). By evaluating climate and weather data graphs from 1955 until 2025 [17], it can be determined that the local climate is humid, with wet autumns and winters and mild summers, and is characterised by intense sunlight. The marine environment, rich in air transferred corrosive salts, enhances electrochemical corrosion through surface moisture condensation and temperature fluctuations [18]. The exposure in direct sunlight during the day affects the paint layer.

The effects of the exposure environment were documented, including localised paint loss and extended paint detachment, as well as uniform and localised iron corrosion, accompanied by stress corrosion cracking.

The sculpture underwent occasional maintenance, including mild cleaning, minor repairs and partial or full repainting, over time. These maintenance procedures were carried out by non-conservators and no records exist.

Figure 1. The *Tree* sculpture in its permanent position (photo: private collection).

Aim of project

The aim of this project is to document and implement a comprehensive conservation intervention for George Lappas's painted metal sculpture, *Tree*, to address the degradation of the coating and substrate caused by prolonged exposure to the outdoor environment and inadequate maintenance. The primary goal is to restore the sculpture's original aesthetic qualities while preserving the artist's intent and the authenticity of the materials used. The study addresses the ethical and technical challenges involved in conserving modern art, emphasising a balanced approach between minimal intervention, material preservation, and visual integrity.

The conservation project began in October 2020 and ended in June 2021, carried out during the coronavirus pandemic in Greece.

Materials and methods

The conservation methodology involves a detailed examination of the sculpture's materials, techniques and decorative elements, as well as an evaluation of its current condition, with a particular focus on corrosion types and stratigraphy. This examination is integrated with an understanding of the environmental context to inform targeted interventions aimed at stabilising and preserving the artwork for long-term outdoor display.

Key questions include the following:

- What materials were used to create the sculpture (type of iron alloy, paint layer)?
- What was the original colour of the sculpture?
- What is the condition of the metal surface beneath the paint (stable or active)?
- What is the best method for preparing the metal surface for conservation?
- What are the optimal characteristics of the restoration paint layer to ensure durability and authenticity?

The integrated approach to achieving the project aim and developing a suitable conservation plan for the *Tree* sculpture involved:

1. A detailed visual inspection to assess the technological features and condition, revealing points and/or areas of interest on the metal and paint layers.
2. Sampling of paint, metal and corrosion products for analysis. Samples were taken from characteristic areas of the main body of the sculpture, where all the paint layers were preserved.
3. Application of analytical techniques:
   - X-ray fluorescence (XRF) spectroscopy for alloy identification;
   - X-ray diffraction (XRD) for characterization of corrosion products;
   - Scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDX) for microstructural and compositional analysis;
   - Colorimetry-gloss measurements for paint layer differentiation and determination of original paint colour.
4. Investigative cleaning to study paint stratigraphy, assess the condition of the metal, and identify suitable cleaning methods.
5. Development and implementation of an appropriate conservation strategy.

The initial inspection was conducted in two phases: before and after paint removal. Light, magnifying lenses and a DSLR digital camera were used for photographic documentation.

Samples of paint layers, corrosion products and detached metal were taken using a scalpel. These samples were analysed at the Department of Conservation of Antiquities and Works of Art at the University of West Attica.

XRD and XRF analyses were performed on 10 mg powder samples using a BTX instrument InXitu Inc. (XRD/XRF), which functions as both an XRD and an XRF instrument.

SEM-EDX analysis was conducted using a JEOL 6510LV SEM-EDX to provide images and data on the metal and paint layers. Cross-sections of paint flakes embedded in epoxy resin were examined using a FEI Quanta 250 FEG scanning electron microscope. SEM-EDX imaging was performed at low vacuum (100-120 Pa) and at an accelerating voltage of 10-20 kV with a working distance of 10 mm. Paint cross-sections were imaged using a BSED detector.

An X-Rite SP60 portable tristimulus colorimeter was used to measure colour on the top and original artist's paint layer. For each sample, an average of three measurements taken from the same area was recorded to obtain the L^*, a^*, and b^* coordinates in the CIE LAB color space, in the specular components included acquisition mode (SPIN Specular-Included). Gloss was measured in gloss units (GU) at 20 °, 60 ° and 75 ° using a Novo Gloss Lite meter.

To document the stratigraphy of the paint layers and determine the original colour of the sculpture, investigative cleaning sections were made at selected points on the base and body. This was achieved using a commercial ecological paint remover, 600 ECO Paint Remover gel, combined with the application of a hot air gun and a scalpel, or a scalpel alone.

Results and discussion

Visual inspection

Investigative inspection revealed significant issues with the metal substrate and paint layers. The following problems were highlighted after the paint was removed (Figure 2):

- electrochemical corrosion of iron occurred in areas where the paint layers exhibited cracking, delamination and loss of adhesion to the metal substrate, resulting in the formation of composite corrosion layers containing probably iron oxides and hydroxides, characterised by an increase in volume ('rust');
- active corrosion of iron (weeping iron) and the formation of chloride corrosion products ('spalling') in areas where the original paint layer has been lost and the repainting process has not involved proper preparation of the metal substrate by removing and/or stabilising corrosion products. Areas prone to electrochemical and active corrosion are those that retain moisture, such as hollow base sections, joints between metal plates and frame slats, the slats themselves and lateral buttresses where they connect to the base;
- loss of parts due to crevice corrosion caused by active corrosion and mechanical stress. Paint removal revealed missing decorative elements at the joints, as well as holes in the frame slats, where moisture had entered and caused deep craters and material loss.

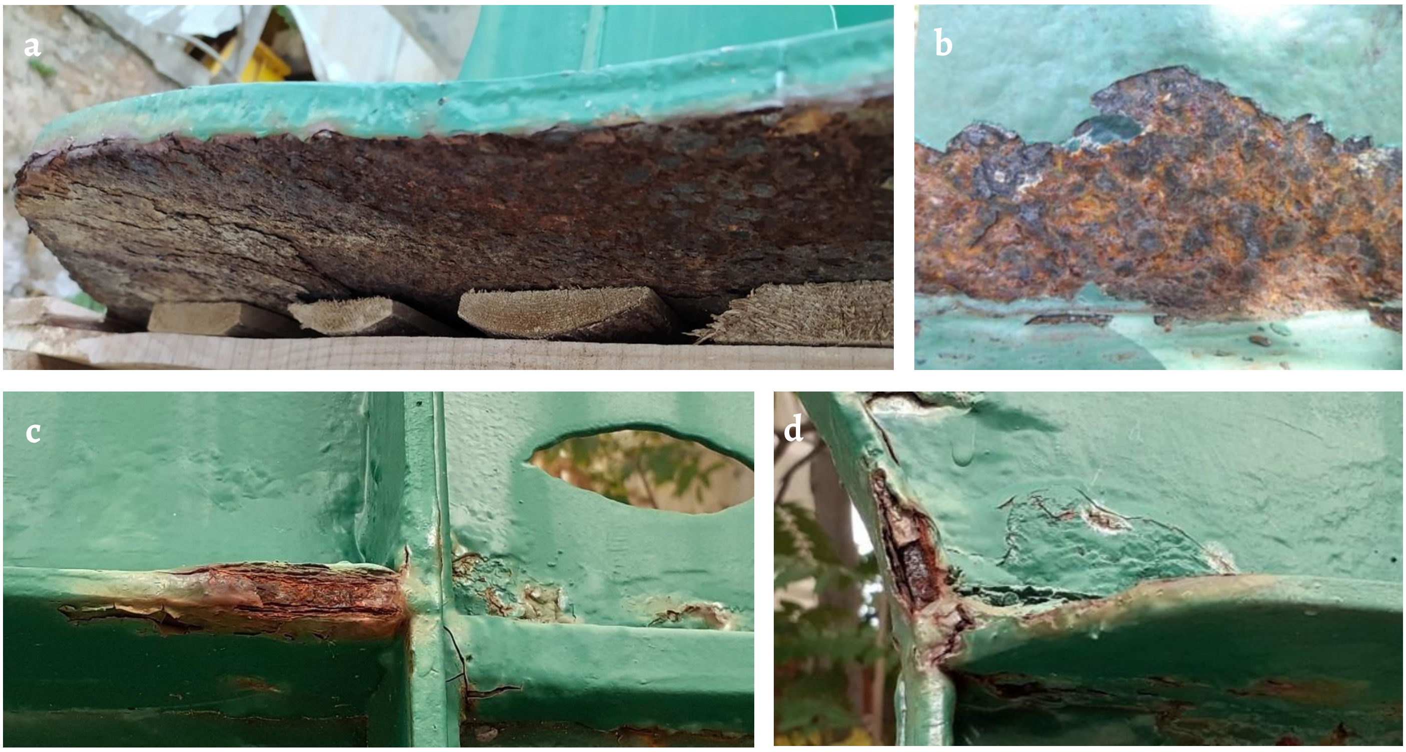


Figure 2. Corrosion types: *a-b)* uniform corrosion with formation of black and brown/orange corrosion products and stress mechanical cracking; *c-d)* bulk corrosion products in areas characterized by spalling and detachment of material.

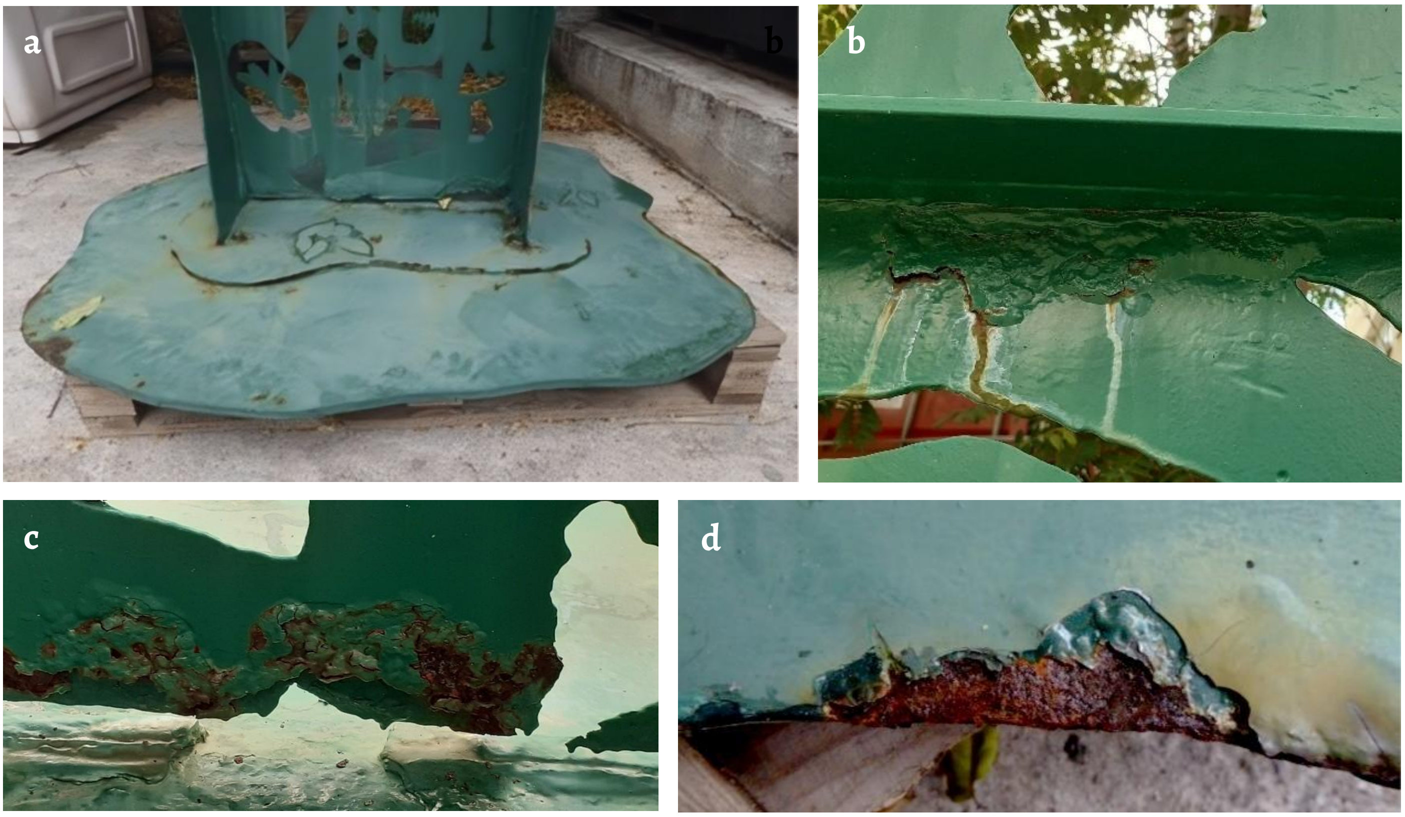


Figure 3. Paint layer degradation: *a)* discolouration and material heterogeneity; *b)* paint detachment; *c)* exfoliation, cracks and blistering; *d)* area with repainting.

Prolonged environmental exposure has significantly deteriorated the paint layer, impacting the appearance of the artwork and the artist's original intent. The following has been documented (Figure 3):

- severe discolouration, blisters, cracks and extensive flaking, particularly where corrosion beneath had expanded;
- paint thickness is locally reduced due to uncontrolled substrate corrosion;
- repaint layers show poor interlayer adhesion, leading to localised delamination;
- material heterogeneity, weak adhesion and surface damage compromise the artwork's appearance and accelerate its degradation by allowing oxygen and moisture to reach the metal, perpetuating a cycle of decay.

Investigative cleaning sections

Cleaning revealed that the sculpture had been repainted several times, often without full paint removal or proper substrate preparation. Local retouching showed signs of wear and tear, and in some cases, evidence of painting over corrosion. Removing the overpaints exposed four to five paint layers with varying green hues, likely due to ageing or inconsistent colour matching. The original artist-selected colour was found to be the initial layer over the metal surface (Figure 4).

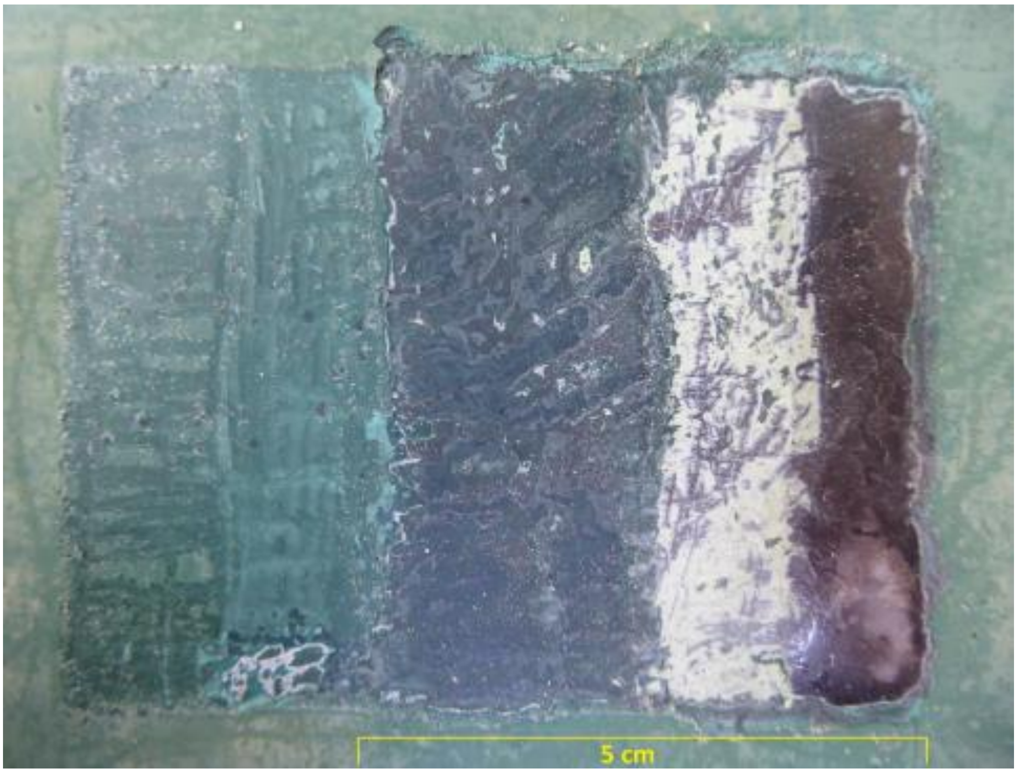


Figure 4. Investigative cleaning section revealing 3 layers of green paint and a white primer.

Diagnostic analysis

XRD results

Observation and processing of the spectra documented the presence of iron oxide-hydroxides (magnetite, goethite and lepidocrocite). The spectra present a lot of background 'noise' and regions of many small peaks due to the amorphous and semi-crystalline nature of the hydrated iron products. Although characteristic peaks of magnetite and lepidocrocite (Figure 5a) and goethite and magnetite (Figure 5b) can be identified.

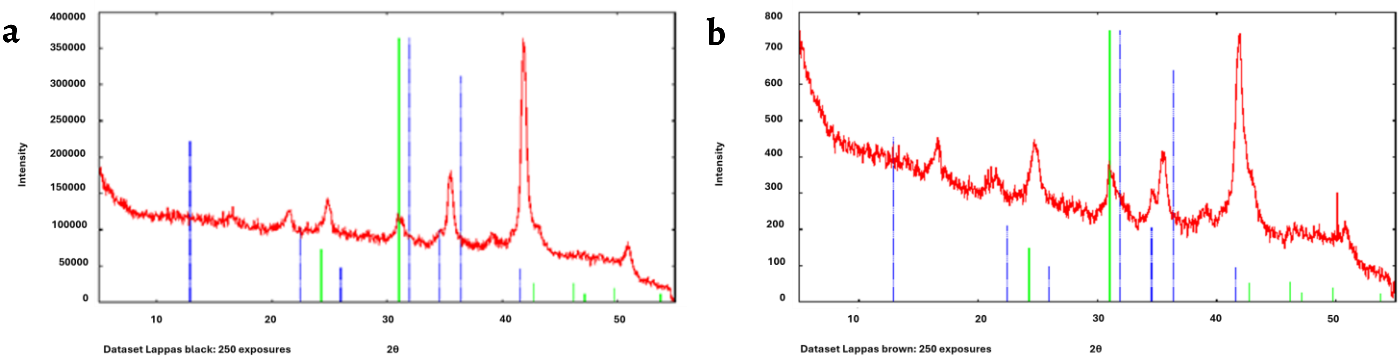


Figure 5. XRD results: *a)* characteristic peaks of magnetite (35,5 °) and lepidocrocite (~14 ° and 23 °); *b)* characteristic peaks of goethite (~21.5 ° and 36 °) and magnetite (35,5 °).

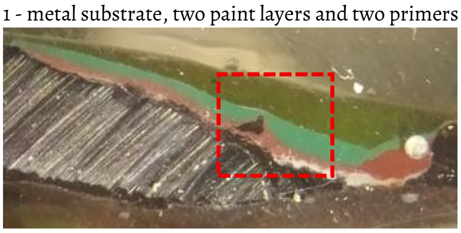
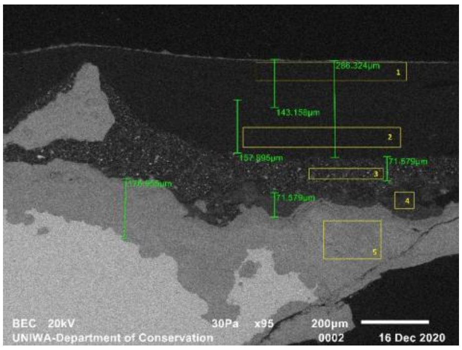
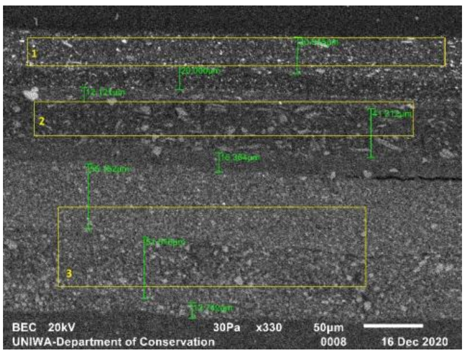
XRF results

XRF spectra identified Fe as the primary alloy element, with Mn and Ni as secondary elements, indicating an alloy steel. Results are based on corrosion layer samples, providing initial evidence of the alloy used in the metal plates.

SEM-EDX results

SEM results (Table 1) confirmed the use of a low carbon steel alloy with secondary trace elements Si and Mn. The presence of Ca can be attributed to the primer layer used to protect the metal substrate present in Layer 4 in Table 1. Cross-section analysis showed three organic paint layers with green earth pigments. The original layer contains calcium-based green earth, while the two repaint layers use silicon-based fillers, each with distinct hues. Two organic layers of preparation were identified – a white primer (possibly Ti based according to the results of Layer 4)) on the metal and a red layer above (possible containing a red iron oxide and barium sulphate as a filler according to the results of Layer 3). The presence of Cl is documented in all layers of samples examined, and the metal substrate. It is probably attributed to the proximity of the sculpture to the sea environment.

Table 1. SEM-EDX results of sample 1 (metal substrate, two paint layers and two primers) and sample 2 (three paint layers). Chemical elements are qualitatively categorised as maximum, minimum or (trace). Categories are based on normalised weight percentages calculated by the microscope's X-ray microanalysis software. Where maxima are > 10 %, minima are < 10 % and traces are < 1 %.

Samples	**Layer characterization**	**Elemental analysis**
1 - metal substrate, two paint layers and two primers  	1 - Outer green paint layer 2 - Inner green paint layer 3 - Red primer 4 - Off-white / grey primer 5 - Metal substrate	**O, C,** Si, Fe, (Ti, Cl, Al, P, Mg) **O, C,** Fe, Si, (Ti, Cl, Al, Ca, P, Mg, K) **O, C,** Fe, Si, Ba, (Cr, Zn, S, Cl, K, Ca, Ti, Al) **O, C,** Ti, Si, Fe, Ca, Mg, (Al, Cl, Na, K) **Fe,** O, (Ca, Cl, Si, Mn)
2 - three paint layers  	1 - First layer of green paint (possibly the artist's paint) 2 - Second layer of green paint 3 - Third layer of green paint (the top layer before conservation procedure)	**O, C,** Ba (S, Fe, Ca, Zn, Cl, Si, P, Cr, Al, Mg, K) **O, C,** Si, Mg, Ca, (Cl, Fe, Al, Ti, Na, K) **O, C,** Ca, Si, (Cl, Mg, Al, Fe, Na, K, Ti)

Colorimetry - gloss measurement results

Both instruments helped identify and systematize differences between repaint layers and the original paint (Table 2). Colour measurements revealed hue variations from previous restorations, aiding in the selection of the optimal shade. Gloss meter results were used solely for documentation, as outdoor exposure had degraded the gloss, rendering it unusable for analysis. Evaluating the results helped to select the colour with which to restore and complete the sculpture's original aesthetic. The industrial painting system selected, uses RAL colour chart, which made it impossible to use the exact artists selection shade found through colorimetry. Nevertheless, the colour ultimately chosen was extremely close and it was RAL 6009, a deep green shade.

Table 2. Colorimetry and gloss measurements of the paint layers.

Paint layer	Colorimetry	Gloss measurement	Colour
Final layer preserved on the surface before 2020 conservation treatment, exposed to outdoor conditions for a long period of time	L* 39.26 a* -12.80 b* +4.54	20 ° 0.7 60 ° 7.4 75 ° 27.0	
Original artist's layer recovered from investigative cleaning, exposed to outdoor conditions for a long period of time before previous repainting treatment.	L* 30.77 a* -5.31 b* +2.82	20 ° 2.4 60 ° 18.2 75 ° 40.0	
Selection of surface colour treatment RAL 6009	L* 20.78 a* -8.55 b* +5.21		

Conservation methodology

Visual inspection, diagnostic analysis and investigative cleaning were necessary to design an effective conservation methodology. Full repainting was necessary, with initial efforts focused on testing various paint removal methods to determine the most effective treatment.

Figure 6. Mechanical cleaning of paint layers: *a)* cleaning result of paint layers with commercial paint remover and a hot air gun; *b)* cleaning with an industrial air blast system; *c)* view of a cleaned area with the sandblasting system, reavealing the blackening of the surface due to the process of metal cutting for creating the symbols. The details of the cutting of the symbols are better observed.

Cleaning tests were conducted using a combination of mechanical cleaning with hand tools, such as a scalpel, and a Dremel rotary tool fitted with various brushes and abrasives. The commercial ecological paint remover 600 ECO Paint Remover Gel was also tested. A hot air gun was also used to gradually strip the paint layers down to the metal substrate (Figure 6a).

Finally, an industrial air blast system using quartz sand (0.1-0.5 mm) was employed at a controlled operating pressure (Figure 6b). The paint and corrosion layers were completely removed, including from the underside of the base (Figure 6c).

An epoxy protection system suitable for the marine environment was used. This included a primer (Hempel's zinc metal pigment 97170) that offers cathodic protection followed by a second layer of primer (Hempel's speed dry ZP 500 17500) as a base/preparation coat for the polyurethane paint. Both were applied by spray for optimal penetration (Figure 7a).

Sandblasting revealed three issues that required restoration (Figure 7b):

- openings in the back and slats allowed moisture to enter, causing internal oxidation;
- removal of the corrosion layers left behind hollow recesses and irregularities;
- extensive oxidation resulted in large gaps and material loss.

Gap filling was used to address the material loss (Figure 7c). Milliput Standard 490 (yellow-grey) an epoxy putty was used for larger losses of material, and Milliput Standard Superfine (white) for fine finishes. They were both applied to the primed metal surface. In category 1, the holes were completely filled with epoxy resin. For category 2, small, localised additions were made to smooth the surface without overfilling, adhering to minimal conservation principles. Category (3) involved making major additions to cover gaps and restore the form only to the extent necessary to maintain the sculpture's aesthetic integrity.

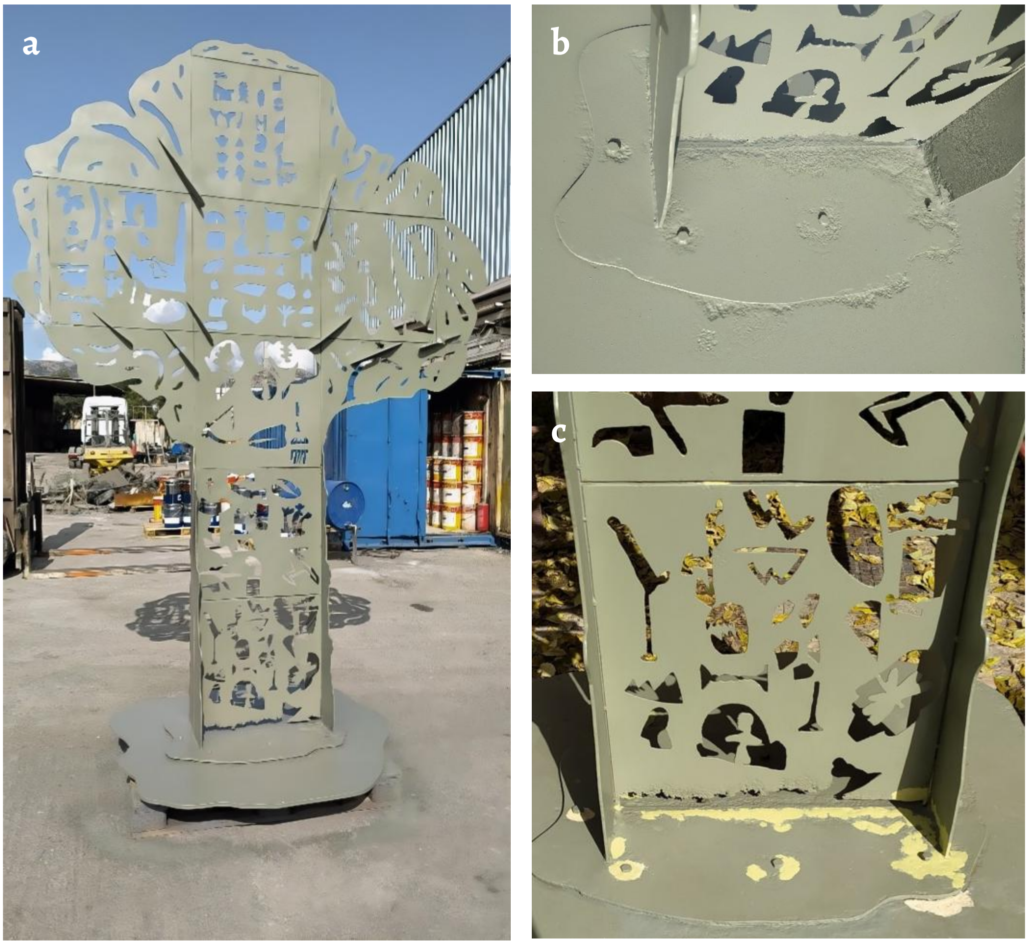


Figure 7. Preparation of metal substrate: *a)* the *Tree* after the application of two layers of zinc-based primer; *b)* hollow recesses and irregularities; *c)* gap filling process.

Figure 8. Repainting with a polyurethane system: *a)* the *Tree* after the application of the polyurethane paint system; *b)* detail of the area of the base; *c)* detail of a plate.

The colour paint was sourced from an industry survey of manufacturers producing paint systems for heavy industrial applications. The company used was Technochrom and the selection was made after consulting the chemical engineering department and providing images of the sculpture and information on the exposure environment. Such communication was essential since the decision was made to add an opacifier to reduce the satin gloss of the paint and achieve better aesthetic results given that the sculpture is exposed to sunlight. According to these, the selected polyurethane paint system was Technodur (RAL 6009), a two-component, aliphatic, polyester-based, chemical reaction polyurethane paint, suitable for the marine environment (Figure 8). The paint was applied in two layers using a soft-bristle brush and roller; the second layer was applied after 48 hours. The paint dried within 24 hours and reached full hardness and mechanical strength after seven days at 20 °C.

Conclusions

The survey methodology used for the case study of G. Lappas's monochrome *Tree* resulted in the identification of technological aspects, such as construction materials and techniques and the original colour layer, and highlighted issues related to conservation treatments in such cases.

The pressed iron plates are made from a steel alloy (probably low-carbon) containing Mn, Ni and Si as secondary trace elements, combining XRF and SEM results. This is a widely used steel alloy for construction applications, where manganese is added primarily to control sulfur, enhancing workability and preventing hot shortness during hot working. It also contributes to increased strength and toughness [19]. XRF identified manganese (Mn) and nickel (Ni) as trace elements, and the sample was dust from iron corrosion products. SEM-EDX identified manganese (Mn) and silicon (Si) as trace elements, and the sample was a detached piece of paint where flakes of corroded metal were attached. The difference lies in the samples and instruments used: a BTX instrument from InXitu Inc. (XRD/XRF), which focuses mainly on XRD data, requires the combination of XRF results from the powder analysis of the corrosion products and SEM-EDX of Layer 5 from the paint coating layers sample for the identification of the metal substrate.

This technological information is important for future conservation needs regarding the restoration of the lower plates, which have suffered severe material loss. It was decided not to replace the lower plates with new material during this intervention, but considering the corrosive exposure environment, this could be deemed necessary in the future.

Examining paint samples and investigating cleaning sections using colorimetry helped identify the number of repainting interventions and select a suitable RAL paint colour that corresponds to the closest RAL equivalent to the original colour and attempts to represent the artist's intent.

The XRD and SEM results revealed the impact of the coastal environment on the metal substrate, identifying iron oxides, oxides-hydroxides and chloride corrosion products.

Evaluating the different stages of the intervention process revealed interesting findings and provided valuable insights for similar applications.

The paint remover gel was rather effective at removing paint from metal. However, its action was limited to the top layer of paint when overlapping layers were present, despite mechanical scraping, necessitating multiple applications. Although successive paint layers were stripped down to the metal surface using mechanical cleaning with hand tools, removal was inconsistent, leaving degraded primer and poorly cleaned areas in hard-to-reach places such as joints, corners and recesses. The propane/butane torch effectively removed paint, exposing clean metal or the artist's primer in specific areas. However, cleaning hard-to-reach areas and removing corrosion remained problematic. Sandblasting provided total removal of paint and corrosion from all surfaces, ensuring uniform results. It also revealed details of corrosion and manufacturing techniques that had previously been obscured, including marks from metal cutting and the artist's hand-drawn symbols.

Sandblasting provides access to, and achieves good cleaning results in areas that are difficult to reach with power tools. Examples include joints, soldered connections and welds. It also ensures uniform results thanks to the ability to set a constant pressure rate.

The selected epoxy putty (Milliput) is renowned for its durability, temperature resistance and ease of use. It can be easily applied and formed with wooden moulding tools and sanded with fine abrasive papers [20-21].

The new paint system, which matches closely to the original colour, successfully restores the sculpture's communication with the viewer as intended by the artist. The durable finish is expected to be highly resistant to the marine environment, water, impact, friction and sunlight, as suggested by related research [14].

Finally, about the conservation process, it should be noted that the project schedule was impacted by the Coronavirus, as special attendance permits were required. Such issues should be considered, as the primer layer must be applied immediately after cleaning with air blasting. Due to accessibility restrictions imposed by the lockdown during the Coronavirus pandemic, the conservation work was not completed until June 2021. An assessment of the treatment stages, as well as the requirements of the methods and materials used, revealed that the conservation work took approximately 41 days (Figure 9).

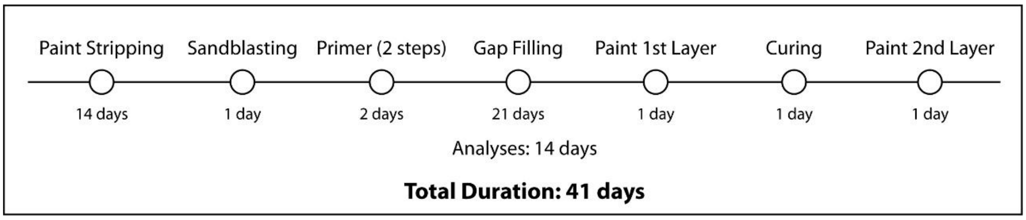


Figure 9. Schematic presentation of the actual time required for the conservation of the sculpture.

Conservation of modern and contemporary art has evolved into an independent field with its own strategies, theories and ethics. This challenges traditional concepts such as retouching, reconstruction and reversibility [22-24]. Some artworks, such as George Lappas's *Tree*, blur the line between modernity and tradition, thereby complicating conservation decisions. Ethical dilemmas have arisen, such as how much infill is required and whether corroded metal plates should be replaced. The chosen approach aimed to preserve the sculpture's originality, including Lappas's handmade metalwork, while restoring its intended aesthetic. Only gaps that were particularly distracting were filled, as replacing the oxidised metal would have compromised the sculpture's authenticity.

The sculpture was stripped and repainted to remove the tarnishing caused by the handcrafting process, and the technological aspect of metalworking was emphasised through sandblasting. Regular maintenance is essential for future conservation to counter environmental degradation. Depending on weather conditions, the new paint system should last 10-20 years, with periodic inspections preventing the need for major interventions.

This project shows that effective conservation strategies for modern sculptures need a thorough approach that balances an understanding of the artist's materials, techniques and intentions with an awareness of the sculpture's condition and its exposure environment, while respecting artistic integrity and aesthetic values.

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REFERENCES

1. Lowinger, R.; Mack, A.; Moody, E.; Perugini, F.; Rivenc, R.; Golfomitsou, S., 'Making it last: training conservators in sustainable solutions for treating outdoor painted sculpture', *Studies in Conservation* **69**(sup1) (2024) 208-217, https://doi.org/10.1080/00393630.2024.2336794.
2. Beerkens, L; Learner, T, *Conserving outdoor painted sculpture, Proceedings from the interim meeting of the modern materials and contemporary art working group of ICOM-CC Krφller-Móller Museum*, eds. L. Beerkens & T. Learner, Otterlo, The Netherlands (2013).
3. Learner T.; Rivenc, R., 'Conserving outdoor painted sculpture: outcomes from a focus meeting', *in Conserving outdoor painted sculpture, Proceedings from the interim meeting of the modern materials and contemporary art working group of ICOM-CC Kröller-Müller Museum*, eds. L. Beerkens & T. Learner, Otterlo, The Netherlands, (2013) 13-22.
4. Learner T.; Rivenc, R., *The conservation of twentieth-century outdoor painted sculpture meeting report*, The Metropolitan Museum of Art, New York (2015).
5. Oh, S.-J.; Wi, K.-C., 'A basic research for preservation of works exhibited in the outdoor sculpture park - a scientific analysis of painted work "conversion" exhibited in the Cheonmasan sculpture park', *Journal of Conservation Science* **37**(4) (2021) 391-401, https://doi.org/10.12654/jcs.2021.37.4.08.
6. Molina, M. T.; Cano, E; Ramírez-Barat, B., 'Protective coatings for metallic heritage conservation: a review', *Journal of Cultural Heritage* **62** (2023) 99-113, https://doi.org/10.1016/j.culher.2023.05.019.
7. Pullen, D.; Heuman, J., 'Modern and contemporary outdoor sculpture conservation challenges and advances', *The Getty Conservation Institute Newsletter* **22**(2) (2007) 4-10.
8. Mack, A.; Sturman, S.; Escarsega, J. A., 'Adapting military camouflage paint for matte outdoor sculpture', in *Modern paints uncovered: proceedings from the modern paints uncovered symposium*, eds. T.J.S. Learner, P. Smithen, J. W. Krueger & M. R. Schilling, Getty Conservation Institute, Los Angeles (2007) 66-74.
9. Beerkens, L.; van Basten, N.; Learner, T., 'Saving the colors. Decision making in the conservation of outdoor painted sculptures', in *CESMAR7 Conference, Colour and Conservation*, Il Prato publications, Milano (2015) 150-156.

10. Wharton, G., 'The challenges of conserving contemporary art', in *Collecting the new: museums and contemporary art*, ed. B. Altshuler, Princeton University Press, Princeton (2007) 163-178.
11. Clare, T. L.; Swartz, N. A., 'Chapter 19 - Characterization of high-performance protective coatings for use on culturally significant works', in *Intelligent coatings for corrosion control*, eds. A. Tiwari, J. Rawlins, L. H. Hihara, Butterworth-Heinemann, Amsterdam (2015) 641-671, https://doi.org/10.1016/B978-0-12-411467-8.00019-2.
12. Benson, P., 'Some considerations in determining new paint systems for use in the treatment of painted fiberglass and steel outdoor sculptures', in *Conserving outdoor painted sculpture*, *Proceedings from the interim meeting of the modern materials and contemporary art working Group of ICOM-CC Kröller-Müller Museum*, eds. L. Beerkens & T. Learner, Otterlo, The Netherlands (2013) 87-94.
13. Langenbacher, J.; Rivenc, R.; Flavin, A., *Documenting painted surfaces for outdoor painted sculptures: a manual of laboratory and field test methods*, Getty Conservation Institute, Los Angeles (2017), http://hdl.handle.net/10020/gci_pubs/documenting_painted.
14. Defeyt, C.; Langenbacher, J.; Rivenc, R., 'Polyurethane coatings used in twentieth century outdoor painted sculptures. Part I: comparative study of various systems by means of ATR-FTIR spectroscopy', *Heritage Science* **5**(1) (2017) 11, https://doi.org/10.1186/s40494-017-0124-7.
15. Spinari-Pollalis, T.; Liti, A.; Tzirtzilakis, G., *George Lappas. Encapsulation - Mappemonde - The Secret Book*, Catalogue exhibition, Kastaniotis publishing, Athens (2018).
16. Lappas, G., *George Lappas - Mappemonde*, Biennale of Venice, Aperto (1988).
17. 'Climate and Weather in Greece: A Traveler's Guide', in *Hikersbay* (2025), https://hikersbay.com/climate/greece (accessed 2025-07-13).
18. Alcántara, J.; Fuente, D. d. l.; Chico, B.; Simancas, J.; Díaz, I.; Morcillo, M., 'Marine atmospheric corrosion of carbon steel: a review', *Materials* **10**(4) (2017) 406, https://doi.org/10.3390/ma10040406.
19. Tasker, J., 'Austenitic steels: non-stainless', in *Encyclopedia of materials: science and technology*, 2nd ed., Elsevier, Oxforf (2001) 411-415.
20. Webb, M., 'Methods and materials for filling losses on lacquer objects', *Journal of the American Institute for Conservation* **37**(1) (1998) 117-133, https://doi.org/10.2307/3179915.
21. Neuman, I.; Martin, J., 'Where east meets west: the conservation of a modern, large-scale, black lacquer sculpture exhibited in a public', in *Objects specialty group postprints*, vol. 4, eds. V. Greene & J. Griswold, AIC, Norfolk (1996) 42-61.
22. Beerkens, L., 'Side by side: old and new standards in the conservation of modern art. A comparative study on 20 years of modern art conservation practice', *Studies in Conservation* **61**(sup2) (2016) 12-16, https://doi.org/10.1080/00393630.2016.1155336.
23. van Basten, N.; Langenbacher, J.; Defeyt, C.; Rivenc, R., 'Local treatment for monochrome outdoor painted metal sculptures: assessing the suitability of conservation paints for retouching', in *Conservation of sculpture parks conference*; Spark - Conservation of Sculpture Parks, Sisak (2018) 143-154.
24. Nagy, E. E.; Lippincott, A.; Lippincott, D.; Chasse, J.; Prosser, R., 'The treatment of a large painted outdoor sculpture: Kiosque l'évidé (1970) 1984, by Jean Dubuffet', *Journal of the American Institute for Conservation* **62**(1) (2022) 28-57, https://doi.org/10.1080/01971360.2022.2031456.

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