Conservation and Investigation of *Cometh the Sun*: A Monumental Weathering Steel Sculpture

Claudia Chemello*  
Terra Mare Conservation, LLC  
Charleston SC, USA  
claudia@terramareconservation.com

Ana Crespo  
Centro Nacional de Investigaciones Metálicas (CENIM)  
Consejo Superior de Investigaciones Científicas (CSIC)  
Madrid, Spain  
a.crespoibanez@cenim.csic.es

Emilio Cano  
Centro Nacional de Investigaciones Metálicas (CENIM)  
Consejo Superior de Investigaciones Científicas (CSIC)  
Madrid, Spain  
ecano@cenim.csic.es

Paul Mardikian  
Terra Mare Conservation, LLC  
Charleston SC, USA  
paul@terramareconservation.com

Curtis Patterson  
Atlanta GA, USA  
curtispatterson@comcast.net  
http://cpattersonsculptor.com  
*Author for correspondence

Abstract

In 2016, Terra Mare Conservation, LLC, was contracted by the City of Atlanta, Georgia, to undertake conservation of *Cometh the Sun*, a monumental sculpture fabricated in weathering steel by artist Curtis Patterson. The collaborative project involved conservators, metal fabricators, metal trades, city public art officials, and the artist. The sculpture has a combined weight of 5.7 tons, and is 15.2 meters in length, 6 meters in width, and 4.5 meters in height. Conservation efforts involved disassembly, replacement of 40 severely corroded areas of steel, artificial patination, sealing of moisture-prone areas, drainage enhancement through the installation of new anchors and footers and a concrete slab, and reassembly. Samples of the original weathering steel patina and new artificially patinated samples of A588 weathering steel were assessed by electrochemical impedance spectroscopy (EIS) using a gel-polymer electrolyte cell. Composition of the natural and artificial patinas was assessed by Raman spectroscopy, and thickness and color were measured. Analytical results demonstrated that the poor performance of the natural patina was not attributable to pollutants but to improper development in areas prone to water retention. These findings highlight the need to follow manufacturers’ specifications when using weathering steel to prevent failure of the protective patina.

Keywords  
Corten steel, weathering steel, monumental sculpture, conservation, EIS, Raman, patina

Introduction

The conservation and long-term preservation of weathering steel sculptures is an evolving subject. The use of weathering steel to fabricate large sculptures began in the mid-1960s as the material was discovered by artists and sculptors. There is now a considerable body of information within the conservation community, as well as ongoing research in academia and industry, contributing to a better understanding of several key aspects about this material from a preservation perspective. Studies have examined the atmospheric corrosion of weathering steel in different environments (for example Kamimura et al. 2006), characterized the rust-like patina that develops (Scott 1991, Crespo et al. 2017), and explained how the patina development is influenced by the length of exposure and a sculpture’s environment (Chiavari et al. 2012). Recent work examines whether an artificially applied patina, often favored by artists to accelerate patina development, may not provide the same protective properties as a naturally developed patina (Ramírez Barat et al. 2016, Crespo et al. 2017). These studies were important to this project as an artificial patina was applied to *Cometh the Sun*, thus presenting an opportunity to contribute to research evaluating the durability of artificial patination of weathering steel.

The conservation of *Cometh the Sun* was a complex and challenging project involving a large group of stakeholders including conservators, the artist, city public art staff, metal fabricators, a concrete contractor, and an engineer. Numerous issues had to be taken into consideration, including the preservation of the artistic integrity of the sculpture, the safety and feasibility of the work,
the complexity of the work needed to arrest the visible corrosion, the costs, and the unidentified risks that could become apparent as the work unfolded.

After 40 years of urban exposure, approximately 80% of the exterior surface of Cometh the Sun was in fair to good condition and 20% had suffered severe corrosion and was in need of stabilization. The areas of severe corrosion were chiefly due to the geometry and placement of the sculpture and included recurrent water pooling, poor drainage, accumulated dirt and organic debris against the metal surface, the proximity of the steel to the concrete slab, and other problems such as broken welds. Corrosion of the footers was acute, with several having completely failed. In addition, some areas of the surface had been repeatedly tagged by graffiti, leaving an uneven patina and a scarred surface (Figures 1 and 2).

Background and history

Born in Shreveport, Louisiana, artist Curtis Patterson attended Georgia State University in Atlanta and became the first African American to receive a Master of Visual Arts in Sculpture from the university. His fascination with the manipulation of three-dimensional space and objects is clearly evident in many of his massive sculptural works, whose symbolism and elements serve as indelible references to the historical contributions of people of African descent (Patterson, accessed October 10, 2018).

Cometh the Sun was commissioned by the City of Atlanta’s Bureau of Cultural Affairs in 1977 and was the first public art commission awarded to Patterson. The sculpture was installed in Gordon White Park at a major intersection that serves as one of the gateways to Southwest Atlanta, an historically black neighborhood. The sculpture was fabricated from 4.8 mm weathering steel and comprises five monolithic conjoined components. The central element of the piece is a disk which symbolically references the sun. This component is undergirded by four monolithic elements that are visually and structurally supported by the central element. Although each of the five elements is very large in scale, none of them has a sub-structure. Each element has several internal angled brackets fabricated from 4.8 mm weathering steel and welded to the joints for additional strength.

Condition of the sculpture in 2016

The sculpture was corroded overall with an uneven dark brown to dark purple patina typical of long-term exposure of weathering steel to the elements, as seen in Figure 1, with streaks and drip marks from water run-off. Numerous areas of green algae staining were visible on the north side and insect nests and accumulated organic debris filled gaps between components and the broken footers. The degree of corrosion varied from minimal to severe, depending on the orientation of each component, its geometry, and whether the surfaces were directly or indirectly wetted, subject to pooling water, or protected from wet/dry cycles. Severe corrosion was noted between conjoined components, which were filled with “pack rust” to a thickness of several centimeters (Figure 2), especially in areas closest to or in contact with the concrete slab where water pooled.

Four areas of graffiti were visible, created by spray paint and scratching into the surface. Additional surface damage was caused by mechanical abrasion of the metal by people climbing and walking on the sculpture and from three partially drilled holes where an attempt was made by the city to take metal samples. An opening in one of the components was the entry point made by the artist during installation in 1977; this was welded closed after installation.

Figure 1. Cometh the Sun before treatment. The numbering system used to track components is seen in the image on the right

Figure 2. Details showing deterioration problems: unevenly corroded surfaces (top left), thick pack rust (bottom left), and delaminating surface layers (right)
Conservation treatment

Disassembly

A disassembly plan was finalized on site on January 16, 2017, which included a numbering system attached with magnets by conservators to track the treatment of each component (Figure 1). During the site meeting, access to the interior of the sculpture was achieved by cutting a manhole on top of component 2. Penetrating oil was applied to all accessible bolts to facilitate removal. Picking eyes were welded onto both ends of components 1, 2, and 3, and on top of 4 and 5 for lifting, and a metal bracket was welded to the side of components 4 and 5, straddling both pieces to keep them together during lifting.

On January 17, 2016, the sculpture was dismantled as seen in Figure 3. Disassembly of the five components required removing the original bolts, and/or cutting them off with an oxyacetylene torch. Each component was individually rigged with a separator bar and slings, and placed onto a flatbed truck for transportation to the metalworking facility.

The most difficult part of the disassembly was the separation of the lower components (1 and 3) from those on top (2, 4, and 5), as they were joined by welding and bolts or a combination of both. Components 4 and 5 were separated using an oxyacetylene torch. The bolts holding component 2 to component 1 were cut off, but the components would not separate. One of the project’s “unknowns” was realized at this point—the original methods of joining used more than 40 years previously could not be readily recalled by Patterson. A hole was cut in the northeast wall of component 2 to access two plug welds securing component 2 to component 3. These were cut out and steel bars used to separate the two components.

Fabrication

Corroded sections of weathering steel were removed with an abrasive cut-off wheel. New pieces of A588 weathering steel were welded into place with a Lincoln SuperArc LA-75 MIG filler wire (ER80S-NI1, 0.9 mm diameter) with 75% Ar/25% CO₂ shielding gas. Discussions between the conservators, fabricators, engineer, and the artist resulted in agreement that severely corroded areas, where corrosion had compromised the thickness of the weathering steel by more than 30%, were to be replaced. Approximately 40 new pieces of weathering steel were welded onto the sculpture: eleven on component 1, eight on component 2, four on component 3, four on component 4, and thirteen on component 5 (Figure 4).

After new weathering steel was welded into position, each component was blasted with Black Beauty—a low dusting and low free silica coal slag abrasive—in 20/40 mesh size to achieve a homogeneous surface profile. A chemical patina called Auburn Rust was spray-applied by Patterson to achieve an even color and speed up the natural rusting process. After application, the surface was repeatedly rinsed with water over several days to help build the color, according to the usual practice of the artist (Figure 5).

Reassembly

Prior to pouring a new sloped concrete pad, an anchoring system for the cast-in-place anchors was installed. The footers were made of type 304 stainless steel and the anchor bolts of ASTM F1554-07a grade 55, S1, and A307.
grade 55 modified weldable mild steel. The anchors were leveled and welded onto the bottom channel of the footer assembly and the assemblies positioned and welded to the rebar.

The sculpture was reinstalled on October 25 and 26, 2017 (Figures 5 and 6). Each component was individually rigged and lifted into position. The upper channel of the footer was positioned on top of the lower channel, and components 1 and 3 were individually positioned and leveled with hydraulic jacks. Once the position was correct, the remaining three components were positioned, and components 1, 2, 3, and 5 were bolted together from the interior. Components 4 and 5 were joined prior to arrival on site. No welding was used to join components for the reinstallation. All bolts were new and made of A325 weathering steel. After joining all components, the hatch used to gain access to the interior was welded closed with a Lincoln SuperArc LA-75 MIG filler wire (ER80S-NI1, 0.9 mm diameter) with 75% Ar/25% CO2 shielding gas.

To prevent water intrusion and water pooling between components 1 and 2 and between 1 and 3, Dow Corning 756 SMS Building Sealant, a silicone-modified sealant (dark gray in color), was used as a gasket and applied with a caulking gun. The sealant is a medium-modulus elastomeric product designed for weatherproofing sensitive porous stone and metal substrates. Silicone products are flexible, offer excellent weatherability, and have a low friction surface that reduces dirt accumulation.

The upper channel of each footer was welded to the bottom of the sculpture and to the lower channel, and each end of the footer was capped with a small plate of stainless steel, welded into position. The footers were coated by Patterson using Rust-Oleum Flat Protective Enamel black paint, applied by spray.

**Investigation of the patina**

Two samples of weathering steel were obtained for comparison: one exhibiting the natural patina (NP) of the sculpture developed since installation in 1977 by exposure to the atmosphere (removed from one of the cut off corroded areas), and the second exhibiting a patina artificially developed (AP) by chemical treatment as applied to the new replacement steel. The artificial patina was developed by spraying two coats of a commercial patination product, Auburn Rust, followed by spraying with tap water over several days, the usual practice by Patterson.

According to the manufacturer, this product contains amidosulfonic acid and cupric sulfate and is “used to quickly and attractively rust steel and ferrous metals” (Metal Finishes PLUS, accessed October 29, 2018). Recent
research has suggested that chemical patinas applied to weathering steel affect the protective properties and color of the patina, resulting in an ineffective or unstable method of achieving surface color (Ramírez Barat et al. 2016, Crespo et al. 2017). The aim of this research was to characterize the composition and the protective properties of both the damaged sections and the restored areas for comparison.

The protective properties of each patina were assessed by electrochemical impedance spectroscopy (EIS) using a gel-polymer electrolyte (G-PE) cell specifically developed for analysis of cultural heritage (Ramírez Barat and Cano 2015, Ramírez Barat and Cano Díaz 2015, Ramírez Barat, Cano, and Letardi 2018). The G-PE cell uses a classical three-electrode configuration with an AISI 316 stainless-steel counter and Ag/AgCl reference electrode. The electrolyte was artificial rainwater simulating an urban atmosphere (conductivity 5.4 μS, pH 5.53), gelled with 3% agar. EIS was obtained from 100 kHz to 10 mHz, using a ±10 mV RMS signal at the OCP and 10 points per decade. Figure 7 shows the EIS results for the NP and AP samples. The EIS results demonstrate that both the natural and the artificial patinas are poorly protective, with an impedance of about 700 Ω at low frequencies (0.01 Hz) and barely 200 Ω at medium frequencies.

The composition of the patinas was characterized by Raman spectroscopy using a Renishaw RM 1000 Raman with a 634 nm laser and a 50× microscope lens, 10 seconds of integration time, and 5 accumulations. Figure 8 shows representative Raman spectra from different points on the outer surface of the NP sample. The patina is mainly composed of goethite (α-FeOOH), alone or in combination with lepidocrocite (γ-FeOOH) in different ratios. The Raman result from the AP sample (Figure 9) shows mainly lepidocrocite, alone or combined with goethite in some areas.

The thicknesses of the patinas were measured using an Elcometer 456 thickness gauge equipped with a probe for ferrous metals. Several measurements (20 for the NP, 30 for the AP) were taken across the surface of the samples. The NP sample shows a thicker patina than the AP (average 34.5 μm vs. 24.3 μm) but also more irregularity (standard deviation 12.7 μm vs. 6.4 μm).

Lastly, as the aesthetic properties are one of the most important features of a sculpture, colorimetry tests were performed in order to measure the color differences between the two patinas using a Konica Minolta
CM-700d spectrophotometer with an 8 mm diameter mask, CIE standard illuminant D65, and 10° observer. The colorimetric results are reported in CIE L*a*b* color space. Twenty points evenly distributed on the surface were measured in the AP sample, while for the NP the number of samples were limited to 7 due to its size. Table 1 shows the average and standard deviation (in brackets) of the color coordinates. Both samples show an orange color (positive and similar values for a* and b*), but slightly more yellow for the AP. While the lightness is similar in both samples, the chromaticity of the AP shows much higher values, indicating a more saturated color. This is typical of steel patinas, which show brighter colors in the initial stages, moving towards less saturated and darker colors upon aging. The difference in color ΔE is 33.8. When ΔE is greater than 1, the differences between two colors are noticeable (Ghelardi et al. 2015). Therefore, there is a big difference between the appearance of the original and the artificial patina. Nevertheless, the color of the artificial patina will probably evolve over time, approaching the appearance of the original surface.

Table 1. Average and standard deviation (in brackets) of CIE L*a*b* colorimetry results for NP and AP samples

<table>
<thead>
<tr>
<th></th>
<th>L* (10°/D65)</th>
<th>a* (10°/D65)</th>
<th>b* (10°/D65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP</td>
<td>32.3 (2.3)</td>
<td>6.9 (1.0)</td>
<td>7.1 (1.6)</td>
</tr>
<tr>
<td>AP</td>
<td>32.7 (4.1)</td>
<td>16.9 (1.7)</td>
<td>21.7 (4.8)</td>
</tr>
</tbody>
</table>

These analytical results help to understand the accelerated corrosion process of some areas of the sculpture. EIS shows that the naturally developed patina is poorly protective, with impedance values barely above the newly patinated one. It is known that the protective patinas of weathering steel evolve over several years (typically 5–10, depending on the environment), increasing their protective properties (Crespo et al. 2017). This has not been the case for Cometh the Sun in the areas analyzed. The values obtained demonstrate that the patina has not developed properly. Raman spectroscopy shows goethite and lepidocrocite, in different ratios, in both cases. More goethite is present in the original sample, which is, in principle, positive for protection. No other compounds that might have a detrimental effect on the protective properties of the patina, such as akageneite (β-FeOOH), were found. Therefore, the poor performance of the patina cannot be attributed to its composition but to the morphology of the corrosion layers: goethite has not formed a uniform, continuous, or adherent layer, and therefore it is not protective.

According to Kamimura et al. (2006), when a patina has properly developed on weathering steel, the corrosion rate does not exceed 0.01 mm/year. For Cometh the Sun, considering that in some areas almost complete corrosion of the whole thickness of the plates had occurred, the corrosion rate was 0.12 mm/year. The thinness of the patina can also be explained by its low compactness and adherence. While a properly developed patina exceeds 100 µm (Asami and Kikuchi 2002), the thinness of the patina in the samples analyzed is probably the result of a corrosion layer that delaminates and loses material as it grows, and is unable to reach a greater thickness.

The fact that no other compounds apart from goethite and lepidocrocite were found in the corrosion layers suggests that the poor performance of the patina is not related to pollutants but to other conditions less favorable to its formation. It is known, and strongly and repeatedly advised by the manufacturers, that correct formation of the protective patina on weathering steels requires repetitive wet/dry cycles. The use of weathering steel buried in soil, submerged in water, or in areas where water is retained precludes the formation of the protective rust. For Cometh the Sun, the failure of patina development in areas where poor drainage and installation issues were identified resulted in severe corrosion.

**Conclusion**

This challenging project accomplished the conservation of a monumental work of contemporary art fabricated from a material that requires a pragmatic and nuanced approach to its care and long-term preservation. Working with an interdisciplinary team from industry helped conservators identify appropriate solutions that corrected problems inherent in the initial design and installation. Investigation of the artificial patina confirmed that the accelerated corrosion that takes place to provide rapid color development does not protect the surface of the steel in the same way as a naturally developed patina. Conversely, analysis of the naturally developed original patina also revealed that it was poorly protective and not well developed due to water retention in some areas, which prevents the wet/dry cycles necessary for the development of a protective patina.

The use of weathering steel in contemporary sculpture comes with a number of strict specifications from manufacturers which may be restrictive and difficult
for artists to implement. This case study illustrates the critical importance of following the specifications for fabrication and use of weathering steel, particularly regarding the need to conform to wet/dry cycles and avoid water entrapment for optimal protective patina formation. If these are not observed, dramatic failure may occur, causing accelerated deterioration and the need for significant conservation intervention.

Acknowledgments

The authors would like to thank the artist Curtis Patterson, the City of Atlanta, Georgia, Jesse Slagle and the team from Holland LP, Tim Foecke, and Jon Tirpak. The analytical work for this project was partly funded by the project GEOMATERIALES 2-CM Program Ref. S2013/MIT-2914 (Comunidad de Madrid). A. Crespo acknowledges MINECO for the doctoral grant BES-2015-071472 and Sagrario Martinez for her help with the Raman analysis.

Notes

1 See, for example, www.nssmc.com/product/catalog_download/pdf/A006en.pdf.

Materials list

Abrasives media
Black Beauty Abrasive
www.blackbeautyabrasives.com

Auburn Rust (amidosulfonic acid and cupric sulfate)
Metal Finishes PLUS
http://metalfinishesplus.com

Paint
Rust-Oleum Flat Protection Enamel
www.rustoleum.com

Silicone caulk
Dow Corning® 756 SMS Building Sealant
www.pksupplies.com/

Welding rods
Lincoln SuperArc LA-75, .035” diameter
www.lincolnelectric.com

References


Authors

Claudia Chemello is principal and senior conservator of Terra Mare Conservation, LLC. She is a Fellow of the American Institute for Conservation and Coordinator of the ICOM-CC Metals Working Group.

Emilio Cano is tenured scientist at the Centro Nacional de Investigaciones Metalúrgicas (CENIM)-CSIC in Madrid, Spain. He is assistant coordinator of the ICOM-CC Metals Working Group.

Ana Crespo is currently completing her Ph.D. on Artificial Patinas in Weathering Steel Sculpture at the Centro Nacional de Investigaciones Metalúrgicas (CENIM)-CSIC in Madrid.

Paul Mardikian is co-founder and senior conservator of Terra Mare Conservation, LLC. He is a Fellow of the American Institute for Conservation and served as assistant coordinator for the ICOM-CC Metals Working Group for nine years.

Curtis Patterson is a sculptor based in Atlanta, Georgia. Patterson has a Master of Visual Arts in Sculpture from Georgia State University, Atlanta. He has produced several major works for prominent cities in the United States.