The conservation of Giovanni Labus's Scuplture of Bonaventura Bavallieri (1844) and Antonio Galli's Sculpture of Carlo Ottavio Castiglione (1855)

# Science and Art: A Future for Stone

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# SCIENCE and ART: A Future for Stone

## Proceedings of the 13th International Congress on the Deterioration and Conservation of Stone – Volume II

Edited by
John Hughes & Torsten Howind

# SCIENCE AND ART: A FUTURE FOR STONE

## PROCEEDINGS OF THE 13TH INTERNATIONAL CONGRESS ON THE DETERIORATION AND CONSERVATION OF STONE

6th to 10th September 2016, Paisley, Scotland

## VOLUME II

**Edited by**
**John J. Hughes and Torsten Howind**

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Cover image: The front door of the Paisley Technical College building, now University of the West of Scotland. T.G. Abercrombie, architect 1898. Photograph and cover design by T. Howind.

# PREFACE

Standing under the portico of the Paisley Town Hall, completed in 1882, and looking south east towards the West Façade of Paisley Abbey, built in the 13th to 15th Century, it is possible to compare two historical periods in Scottish building where the use of stone was unavoidable. Walking further into the historic centre of Paisley, or any other town or city in Scotland, reveals the ubiquitous use of uncovered natural stone in our architecture, and also the problems that it faces. The challenge in maintaining the essential integral character of our towns for the future, and to recognise and enhance their values is a complex one, but not our challenge alone. Much hard work is still needed to characterise, assess and propose conservation approaches that are compatible with the existing fabric and prevailing philosophies, in Scotland and around the world.

We sought to bring the 13th Congress to a damp Scotland of decaying stone structures, to share our stone-built heritage with the conservation community and also to focus on the needs of stone conservation for our built heritage in Scotland. We hope that by bringing some global attention to the issue, in the country were, arguably, modern geology began, we demonstrate the sharing of our common heritage and our values in seeking its understanding and protection.

In these volumes you will find the proceeds of the work of many people, the conservators, practitioners and even academics and researchers whose concern is the protection of our stone-made cultural heritage. The Permanent Scientific Committee (PSC) of the Stone Congresses worked to review each contribution followed by revision by the authors. The editing effort by ourselves involved direct improvements to text, in many cases, and by one of us in particular to the formatting. However, beyond the title pages and abstracts, after review by the PSC and revision by the authors, proof correction was limited. The contents and accuracy of the papers are therefore the responsibility of the authors.

John J. Hughes and Torsten Howind

Paisley, Scotland, August 2016

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Finally, thanks must go to Alison Wright (formerly of Glasgow University), who bravely bore our application to host the Congress to New York in 2012, without complaint. On this occasion we must also thank the team at the University of the West of Scotland; Georgia Adam, Irene Edmiston, Gaia Frola, Matt Gilmour and Emma Paterson, without whose efforts the Congress could not have been held.

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# THE CONSERVATION OF GIOVANNI LABUS'S SCULPTURE OF BONAVENTURA BAVALLIERI (1844) AND ANTONIO GALLI'S SCULPTURE OF CARLO OTTAVIO CASTIGLIONE (1855)

**I. Ruiz Bazán[1], V. Bresciani[2], A. Balloi[3], A. Quarto[4], I. Marelli[4], M. Colella[5*], C. Sotgia[6] and F. Arosio[7]**

## Abstract

In this project a cleaning intervention of the neoclassical statues in the Brera Academy courtyard was performed with the use of living microbial cells. These living organisms, belonging to the species Desulfovibrio vulgaris, were able to remove chemical alterations, mainly caused by sulfates, from the stone surface of the statues. The method has been chosen because it is highly efficient, respectful to the original material, the environment and the restorer operating it. Thanks to the microorganism's selectiveness, it was possible to remove only the harmful alteration of the stones, respecting the so-called "noble patina" a key element in art pieces. Considering the precarious state of conservation of the hands belonging to the statue of Carlo Ottavio Castiglione, a 3D (Rilievo 3D) survey was taken.

**Keywords**: 3D survey, convergent photogrammetry, bio-restoration, sculpture, marble, cleaning

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## 1. Introduction and historical background

Designed by Francesco Maria Richini (1584-1658) for the Jesuit College, the Brera Academy courtyard (1615) hosts in its arcades stone busts and statues figuring the most illustrious Milanese artists, scientists and philosophers. Thanks to the coworking of: Associazione Amici di Brera, Musei Milanesi, the Milanese superintendence BSAE and the generous contribution of Pirelli it was possible to restore the statues of Bonaventura Cavallieri and Carlo Ottavio Castiglione.

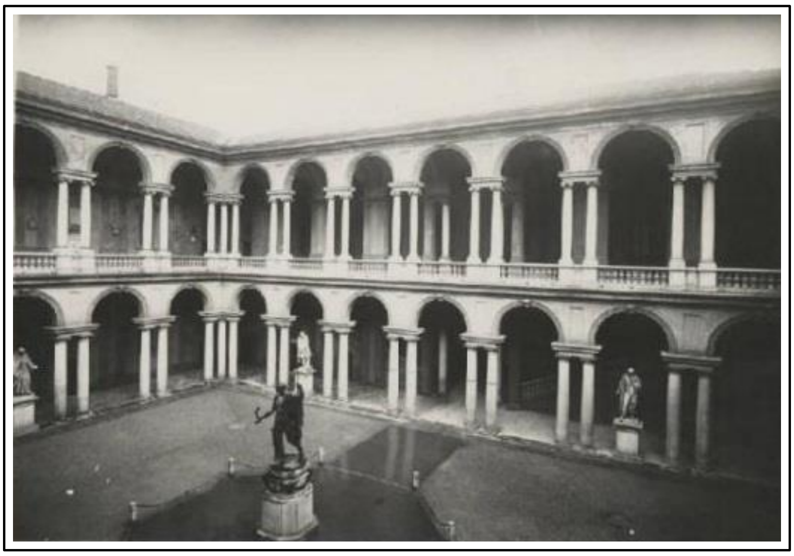

*Fig. 1: Brera courtyard (Silver Bromide fixed on paper (1920-1940) from: Raccolte Grafiche e Fotografiche del Castello Sforzesco, Civico Archivio Fotografico, RI 14344).*

Of Milanese birth Bonaventura Cavallieri (1598-1647) studied mathematics at the University of Pisa where he was student of Galileo Galilei. Bonaventura's fame is due to his approach to the method of the indivisibles, useful to determine areas and volumes. His studies were of fundamental importance for the future development of infinitesimal calculus. The statue representing this great mathematician was created by Giovanni Antonio Labus (1806-1857) who was a teacher at the Brera Academy and operated in the most outstanding construction sites of his times like the Duomo of Milan and the Arco della Pace. This extremely eloquent statue is one of his greatest achievements.

Carlo Ottavio Castiglione (1784-1849) was a numsimatist and a scholar of Semitic and Indo-European languages. In 1819 he published a detailed description of Kufic coins, minted by the Normans and kept in the Brera cabinet. His main work regard the study of oriental languages and researching the origins and history of the city of Barbary (Tripoli) whose name can still be found on ancient Arab coins. Sculptor Antonio Galli (1812-1862) studied at the Brera Academy and moved to Rome to work in Thorvaldsen's studio. After this Roman stay he returned to Milan to work in the Duomo construction site. Galli presents Castiglione purposely seen from below with an intense look pointing his finger directly to a coin held in his hand.

*Fig. 2: Initial phases of the conservation of Antonio Galli's sculpture of Carlo Ottavio Castiglione (1855). Height of statue plus the pedestal 503 cm (198 inches), Just the statue 305 cm (120 inches). The original surface appears hidden by a layer of aged protective varnish.*

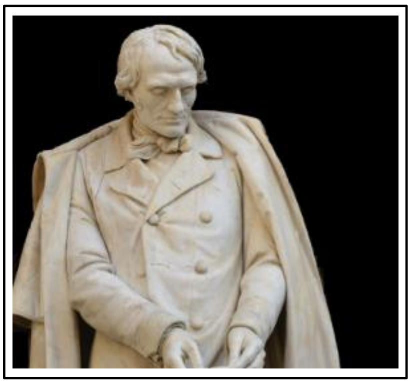

*Fig. 3: Final phase of the conservation - Cleaning by sulphate reducing bacteria has given back the surface's original smoothness caused by the use of fine chisel for surface finishin and revealt a compact saccharoidal white limestone that is very similar in appearance to Venato Apuano marble.*

## 2. 3D Survey by convergent photogrammetry

Since the hands are probably the most fragile parts on the sculpture a 3D model of the hands of the statue has been created as a preventive measure before the restoration to allow for future reproduction of those pieces. Due the difficult morphology of this area of the statue, we chose the convergent photogrammetry technique, which is one of the most used methods on sculpture. The basis of this method is the reinterpretation of the conic perspective through the use of an assemblage of pictures taken of the sculpture. Unlike lasers, this method does not reflect light back to the camera which makes it very useful for mapping complex surfaces. Another advantage of this method is that we obtain a map of the real texture of the surface which can then be incorporated in the 3D model thus significantly improving the accuracy documentation. With this high degree of accuracy it is possible to create an exact replica of the object.

## 3. Diagnostic phase

Two samples where taken: the first from the sculpture of Carlo Ottavio Castiglione in a yellowed area, the second from the sculpture of Bonaventura Francesco Cavalieri in a blackened area. Sample 1 was embedded in polyester resin to prepare a specimen of the cross section. First the cross section was examined by optical microscopy before proceeding with investigations including the use of an electron microscope (ESEM) and a FTIR spectophotometer. Especially, the latter was used to determine inorganic and organic compounds, for example products due to previous conservation work, which might be responsible for surface alteration. For the characterization of the composition of sample 2, which consisted of powder, XRD and EDS analyses was carried out.

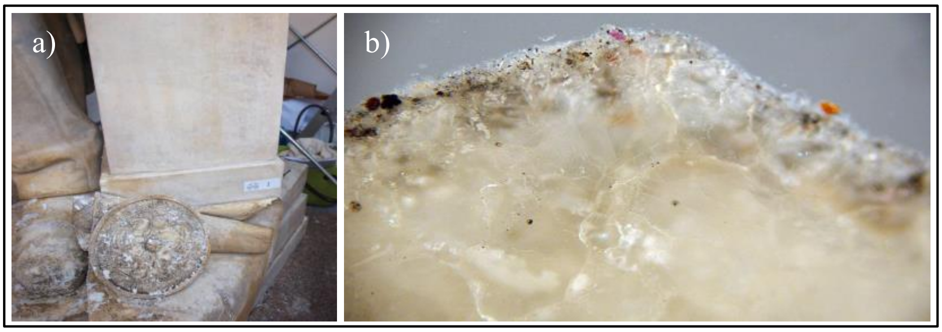


*Fig. 4: a) Sampling point for sample 1; b) Micrograph of the cross section of sample 1 (magnification: ×240).*

In both samples analysed it has been revealed the presence of gypsum and specific air pollution: this is related to a widespread surface sulfation. In particular in sample 1 the electron microscope images show an advanced state of decohesion of the stone material. The spectrophotometric FTIR analysis has revealed calcium carbonate, gypsum and silicate but also very weak absorptions of probably synthetic resin and/or oxalates. The oxalates are usually referred to the organic substances degrade. In sample 2 both XRD analysis and EDS measurements could confirmed the presence of sulfates in the form of gypsum (calcium sulfate dihydrate) and of bassanite (calcium sulfate hemihydrate). The EDS analysis has revealed silicates and also fluorine: these can be linked to conservation attempts based on fluorinated compounds or fluorosilicates undertaken in the 1970s and 1980s.

## 4. Conservation

The conservation work took place in the months of June, July and August 2015 in the Brera Academy courtyard. In the case of Antonio Galli's sculpture of Carlo Ottavio Castiglione Castiglione the cleaning effort has given back the surface’s original smoothness produced by a fine chisel. The Bonaventura statue surface is rougher, with intentionally visible circular furrows made by the chisel. The statues in which we intervened are made of white compact saccharoidal marble, which is thought to be an apuano marble in between the common white Carrara marble and the so called Venato Apuano marble. It is a white marble with intense grey veins which the sculptor has let fall obliquely on the drapery.

During these conservation interventions there was no access to first hand data specifying the quarries from which these marbles came from. Judging by the aesthetic appearance of these marbles it can be assumed that this type of sculpting stone comes from Tuscany more specifically from the zones between Minucciano (Lucca), Cantonaccio and Fivizzano

(Massa Carrara). The tone is compact and of a medium fine grain, with a light greyish colour with abundant dark grey veins. These dark grey veins intersect each other, creating an intense dense superficial weave. There are also rare small (not more than a couple of millimetres) grey spots on the surface. A large part of the surface is covered by deposits of atmospheric particles and a conspicuous sulfation. Thin section analysis has revealed sulfation to measure circa 5 mm deep. In particular the ESEM images have revealed a remarked decohesion in the intergranular spaces of the calcite crystals (Fig. 5).

*Fig. 6: The removal of aged yellowed protective layer and dirt has revealed the original surface texture the statue of Bonaventura which presents signs of scratches and abrasion related to the use of a fine but large chisel (circular furrows) for the surface finish.*

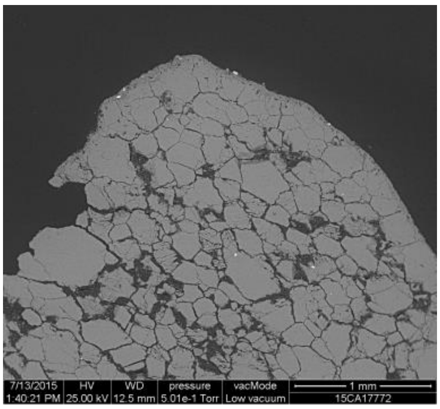


*Fig. 5: SEM-BS image (low vacuum mode) of sample 1 showing the intergranular decohesion is apparent throughout the thickness of the sample.*

Since the statue hands had reached such a critical state it was opted for consolidation by submerging them in a low viscos acrylic dispersion with either Primal™ B60 or Primal™ WS-24 (by Rohm & Haas) and water (dip coating, Fig. 7). The web of acrylic dispersion which is generated inside the pores increases the mechanical properties of the treated surface, reducing its porosity though not obstructing the pores and respecting the surface's qualities. The consolidation resulted in the creation of bridges in the spaces in between the grains of the degraded stone.

Sulfation caused by smog is a widespread problem in all major urban centres. Sulfur dioxide in the presence of humidity, is transformed into sulfite ions, these in contact with oxidants such as oxygen become sulfate ions. Sulfate ions, once in contact with the stone, cause a consequent chemical transformation of the calcium carbonate ($CaCO_3$) into calcium sulfate dihydrate or gypsum ($CaSO_4 \cdot 2H_2O$) During the crystallization of gypsum, airborne pollutants, such as carbonaceous particles (soot), are embedded in the mineral matrix and cause the formation of black crusts in sheltered areas. Sulfate-reducing bacteria belonging to the species *Desulfovibrio vulgaris*, thanks to their metabolism are able to dissociate gypsum into $Ca^{2+}$ and $SO_4^{2+}$ ions. $SO_4^{2+}$ ions are then reduced by the bacteria into $H_2S$, while the $Ca^{2+}$ ions react with carbon dioxide to form new calcite. The commercial name of the microbial product used in this work is Micro4Art, made by Micro4yoU Srl and distributed by Bresciani Srl.

With the help of Dr. Annalisa Balloi sulfate-reducing bacteria through a gelatinous medium were applied on sulfated areas that appeared altered. The gelatinous medium was left overnight on the stone surface until the desired result where obtained. The bacteria contained in the gel attack and eliminate the sulfate. Local interventions of traditional cleaning were limited to the removal of varnish drops that had fallen from above. These interventions have been performed by swabbing soluble non-polar solvents. The conservation intervention was then concluded with a mild application (4% micro-dispersed acrylic in water) with a protective patina on all the surfaces, to reduce the absorption of meteoric and condensation water (albeit for a limited time).


*Fig. 7: a) Scheme of the consolidation system adopted (dip coating); b): Dr. Annalisa Balloi during the application of sulfate-reducing bacteria through a gelatinous medium on the areas that were altered and covered by sulfates.*

*Fig. 8: Signature of Antonio Galli on the statue of Carlo Ottavio Castiglione (1855) before the application of sulfate-reducing bacteria by a gelatinous medium.*

*Fig. 9: Signature of Carlo Ottavio Castiglione's statue (1855) during the cleaning using sulfate-reducing bacteria applied to the surface with the aid of a gelatinous medium. The cleaning has brought to light (for example in the right area of the cartouche) some punctual spots along the surface. FTIR analysis carried out by Palladio Analisi s.r.l. laboratories identified calcium carbonate, gypsum, silicates, and very feeble traces fluorosilicate absorptions, which are most probably left by residues of protective and polishing products used in the past.*

## 5. Conclusion

The use of sulfur-reducing bacteria was found to be much more effective when removing sulphate from stone surfaces than the traditional solvents, which sometimes can cause harm to both the art piece and the operator. Other advantages of Bio-Restoration are:

- Growing bacteria on large scale does not require great disbursements are easily applied on surfaces.
- Using bacteria does not imply any ethical conflict, since these microbes are not genetically modified.
- Bacteria represent no harm for sculptures and people working with them.

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