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The Degradation of Stone. Studies and Reports in the 1950s on the Conservation of Stone Material in Florence.

Giorgio Ghelfi

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The Degradation of Stone. Studies and Reports in the 1950s on the Conservation of Stone Material in Florence.

Giorgio Ghelfi, *Department of Architecture*, University of Florence, Florence, Italy

Abstract. The paper examines the issue of the deterioration of stone materials in architecture. The problem is framed by highlighting the main trends observed throughout history, then delving deeper into the intense debate that took place in Florence during the mid-1950s. In the past, conservation interventions for stone materials were carried out with the aim of protecting the surfaces of the materials, but in the 19th century, the importance of internal consolidation of the stone began to be understood, thanks in large part to significant progress in the industrial field. The earliest techniques used silicates. Renowned restoration projects, such as that of Notre Dame in Paris, showcased the use of the first consolidation treatments, marking them in history as precursors of stone hardening. From the early 20th century onwards, institutions such as the Royal Museum of Berlin and the Central Institute for Restoration in Rome played a key role in the development of conservation techniques, laying the foundations for contemporary conservation science. This paper specifically aims to examine the debate on monument conservation in 1950s Florence. At the center of the discussion were the respective directors of the *Opificio delle Pietre Dure* in Florence and the Istituto Centrale per il Restauro. Through archival research and a careful reading of published sources, it has been possible to reconstruct the trends and positions of the two institutions regarding the conservation techniques of stone surfaces, as well as to bring to light the products used in the restoration of the most important Florentine monuments.

Keywords: Stone conservation, Consolidants products, Opificio Pietre Dure.

1 Contextualization of the scientific problem

The issue of the deterioration of stone materials used in decoration and construction has existed since ancient times, with evidence of this problem found in geographically diverse regions. Most written sources, particularly the oldest ones, originate from Europe, where references to classical treatises are frequently found even in more recent publications. However, the oldest treatments, although not prominently featured in the literature, are attributed to the Egyptian civilization [1]. This civilization was among the first to address the need to prevent and delay the processes of alteration in stone materials exposed to atmospheric agents. This was achieved thanks to their extensive knowledge of mummification processes, which were later applied to ornamental materials as well [2]. Other examples of the use of natural protective agents in antiquity can still be observed today among some indigenous populations. In the early construction of buildings with raw earth, there was a need to make the external surfaces impermeable through the cyclical application of natural protective agents. This example, although not related to stone construction, introduces another important aspect of the history of conservation treatments: the timing of the intervention. In ancient times, materials were treated from the early stages of construction without waiting for the degrading action of atmospheric agents, and the intervention was repeated cyclically.

Starting in the 19th century, perspectives on intervention began to change, influenced by significant scientific progress, towards a more "definitive" approach. The great confidence that avant-garde practitioners had in new industrial products led to the first treatments for consolidating disintegrated materials, which involved the initial techniques of silicification. The restoration of Notre-Dame Cathedral in Paris, conducted by Eugène Viollet-le-Duc and Jean-Baptiste-Antoine Lassus, is particularly notable. This project employed the first silicates for hardening the stones of the external surfaces. Although the debate on this topic has not yet been fully resolved, it can be stated that treatments prior to the 19th century – regardless of the techniques used – were solely aimed at protection, not consolidation. It was only from

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the 19th century onwards that chemical and physical knowledge advanced enough to understand the importance of consolidation in its technical-scientific operation. The term "consolidate" was used with this specific purpose for the first time only at the beginning of the 20th century, and it was officially adopted at the end of the 1970s following the outcomes of the first *UNI-NorMaL study commissions*.

In antiquity, the application of natural products was carried out cyclically, especially on the most prestigious and representative monuments. The interventions that are most documented were performed on valuable stone materials, such as marble and travertine. One of the countless examples is the treatments conducted on Trajan's Column in Rome. Studies from the last century have highlighted the presence of ancient conservation layers on the column's surface, found both in the casts from the 17th century and those from the 19th century. Among the oldest techniques, the use of waxes and oils, originally referred to as "ganosis," is undoubtedly one of the most frequently mentioned in literature. It is often found documented in major reference texts. [3]. In Vitruvius's work "De Architectura" and Pliny's "Naturalis Historia," methods for polishing marble surfaces of statues and constructions are mentioned, in some cases also serving conservation purposes. The refinement of techniques and material processing developed during the classical era persisted through the centuries, spanning through medieval and Renaissance art. Particularly, studies conducted in Italy starting from the late 1960s by the National Research Centers focused on the conservation of stone materials, with a particular emphasis on the Renaissance period [4], particularly from the Centro Cesare Gnudi in Bologna, forming the foundation of the knowledge we have today. The studies conducted, starting with the research on the façade of San Petronio in Bologna [5], led to the rediscovery of numerous conservation techniques carried out in antiquity, inaugurating a new research direction. The scope of studies conducted in Italy by research centers – thanks also to extensive dissemination through publications and international conferences – influenced global scientific activity. In particular, in Spain, starting from the mid-1970s – the end of the Franco regime– research intensified in the field of conservation and restoration, with particular attention to techniques used in previous eras. There was significant focus on the remains of Islamic art – present for almost a millennium, especially in the region of Andalusia – with great interest in both structural and surface materials and construction methods. Already, a study conducted at the end of the 20th century on the original materials of the Alhambra in Granada highlighted the presence of ancient conservation applications on the perimeter wall of the *Abencerrajes* – the oldest portion of the *Alcazaba* – and on the Noria Tower of the *Albercones*. [6].

Fig. 1. Giorgio Ghelfi, 2024. Detail of the facade of the Palace of Charles V within the Patronato de la Alhambra y el Generalife.

These treatments were dated to the early Nasrid period, around the 11th century AD, and consisted of patinas based on gypsum and other natural compounds, including red pigment, which is also significant for giving the Alhambra its name, al-Ḥamrā, "the red" in Arabic. The same study also highlighted other treatments of organic origin (oils and casein), which were found on the internal walls of the buildings.
Recent studies on the facades of the Palace of Charles V [7] – built starting from 1527 by order of Emperor Charles V, designed by Pedro Machuca [8], and now annexed to the Patronato de la Alhambra y Generalife – have highlighted a layering of strata on the surfaces of the facades. Investigations have also identified the various materials composing these layers, highlighting the different treatments carried out in various periods. Among these treatments are layers of organic nature–oils and waxes–layers of siliceous origin and multiple layers composed of lime and gypsum. This example serves to illustrate the numerous techniques that have been used in different eras, some of which can now only be identified in certain cases with the aid of modern investigative tools. In many artifacts, extensive interventions have been carried out–especially with aggressive surface polishing–that have irreversibly erased traces of the past. The scientific study of surface conservation treatments–especially for stone surfaces–began in the 19th century, spurred by the Industrial Revolution, which provided new chemical and physical knowledge. However, it was only in the 20th century that studies intensified on the phenomena of stone deterioration. In the 19th century, particularly in France and Germany, historical monuments served as true laboratories where various treatment methods were experimented with, including silicates and derivatives, mastics, cement, and the first silicon esters. In the early decades of the 20th century, the increase in urban pollution showed the first repercussions on the conservation status of monuments, prompting national and international institutions to delve deeper into the problem of material degradation. This condition led to the formation of the first research groups with the aim of scientifically studying the causes of deterioration processes through systematic analysis of chemical and physical processes.
One of the earliest and most important institutions was the *Royal Museum* in Berlin. This laboratory became a model for other museums worldwide, thanks in part to the figure of Friedrich Rathgen, a

pioneer in the field of conservation and applied chemistry in cultural heritage preservation. Between the 19th and 20th centuries, this institute published significant works, such as "Die Konservierung von Altertumsfunden [9]" – a reference text throughout the 20th century in the field of conservation – and initiated the first scientific experiments on consolidating products. From the 1920s onwards, other laboratories were established, such as the *Research Laboratory of the British Museum*, the *Straus Conservation Center of the Fogg Art Museum in Cambridge* (Massachusetts), the *Laboratoire pour l'étude scientifique des peintures of the Louvre Museum* in Paris, the *Gabinetto di* Pinacologia e Restauro in Naples, and the *Gabinetto Restauri* in Florence.

2 The debate on monument conservation in Florence during the 1950s

Delving into the mid-20th-century debate on stone conservation, it is impossible not to assign a primary role to the Istituto Centrale per il Restauro, particularly during Cesare Brandi's tenure. Since its establishment in Rome in 1939, the ICR (Istituto Centrale per il Restauro) has been one of the most significant research centers in the field of conservation and restoration. In addition to conducting intensive scientific research, the Institute maintained research collaborations with leading restoration laboratories nationally and internationally, also contributing to the establishment of other research centers, such as *The National Gallery of Ireland* and the *Restoration Institute of Cairo* in Egypt. From the 1950s onwards, the ICR became increasingly concerned with the serious problem of "stone crumbling," responding to numerous requests received from Italian Superintendencies in previous years [10]. The issue of monument degradation was so severe that it became one of the primary research fields of the ICR during that period and in the subsequent decades. The institute's chemistry department collected samples from Italy's most important monuments and tested them with products from market-available companies, assessing their effectiveness and durability. Additionally, on-site application tests were conducted, as evidenced by interventions at the Arena di Verona (Verona, Veneto) and the archaeological site of Heraclea Minoa (Agrigento, Sicilia). The institute initiated a nationwide awareness campaign on the issue of stone degradation, establishing relationships with numerous institutions. Of particular significance– an aspect to be explored in this contribution– is the collaborative relationship with the *Opificio delle Pietre Dure* in Florence regarding methods for consolidating stone surfaces. The OPD (Opificio delle Pietre Dure*)* – founded in 1588 by Grand Duke Ferdinando I de' Medici–was already a prominent and renowned institution in the restoration field worldwide by the 1950s. It began its restoration activities in the latter half of the 19th century, dedicating itself entirely to the conservation field in the 20th century. The relationships reconstructed through research conducted in the archives of both institutions [12], combined with the main bibliographic sources, refer to some correspondences between the respective directors of that period, Cesare Brandi and Lando Bartoli. In the same year that the Ministry of Cultural Heritage and Activities issued the *ministerial circular on November 25, 1959*, titled "Conservation of sculptures exposed to atmospheric agents," Brandi contacted Bartoli to obtain information regarding a restoration intervention conducted by the OPD five years earlier on the Canonici Door of the Cathedral of Santa Maria del Fiore in Florence. Brandi's interest arose following an inspection at Giotto's Campanile, during which he also observed the restoration intervention on the Canonici Door. The director of the ICR was highly sensitive to the issue of stone consolidation, and the results of the ICR Chemistry Department's research did not yield satisfactory results. Many efforts of the department were invested in experimenting with the first acrylic resins, predecessors of the "famous" *Paraloid B72* – used in the 1960s on the surfaces of the Siena Cathedral – without achieving acceptable results.

Bartoli's response reached the ICR just two days after Brandi's initial letter and provided a detailed description of the restoration operations previously carried out on the Canonici Door. The intervention took place in March and June of 1953, and consolidation was achieved by immersing various parts of the marble decorations–particularly the candelabrum and lintel of the door–in a bath containing a silicate solution. This bath was held in a completely tin-plated metal container adhered to the object and moved accordingly to the area being treated. As Bartoli further explained, the duration of the bath for each area was between 3 to 4 days, and the silicate solution used corresponded to *a dose of 1 kilogram of salts diluted with 7 liters of water at a temperature of 40°C*. Great attention was paid to maintaining the temperature of the bath consistently, achieved through the use of an electric heater that compensated for nocturnal temperature variations with daytime levels. Bartoli also emphasized that during the restoration work, they chose not to apply a waterproofing agent after the consolidation treatment to avoid potential alterations in the marble's coloration. Finally, he also specified the origin of the products used: *Flintox*

salts. A product patented by the company *RIW (Remember its Waterproof)* in England was marketed in Florence by Tommaso Accorti, located on Via de' Pecori, Florence. Within the OPD archive, a brochure for the *Flintox* product was also found, although it described *Flintox Crystals* rather than *Flintox Salts*. The brochure described it as "a complex mixture containing fluosilicates" and prescribed its use in the same quantities as those used for the Canonici Door: *1 kilogram per 7 liters of water*. It is, therefore, plausible to consider that it is the same product. Along with the report, Lando Bartoli also sent a list of restorations carried out by the OPD in previous years that involved the consolidation of stone materials. From 1929 to 1931, the triforia of the arcades of the Church of Orsanmichele in Florence were restored; from 1949 to 1950, interventions were made on the rose window of the Orvieto Cathedral using a 20% waterproofing solution; from 1951 to 1954, both Angevin monuments and the rose window of the Santa Chiara church were restored in Naples; in 1948-49, the Fountain of the Cathedral of Perugia was restored; in 1959, the portal of the Evangelist in Ravenna was restored, and in 1953, the Canonici Door and the statue of Donatello from the Opera del Duomo were restored in Florence. In these last two cases, as reported by documentary sources, *Flintox* products were used. Additionally, for the Donatello statue, a waterproofing agent–*Toxloxpore*–was applied through immersion. *Toxloxpore*, also manufactured by *RIW*, was described as a "weatherproof and weather-resistant waterproofing solution that ensures an effective and durable coating."

Research in the archives of the Opificio delle Pietre Dure institute has revealed references to other types of treatments conducted in Florence during the same period but not endorsed by the institute itself. The development of industrial preparations of silicon esters, particularly "silicones," during the 1940s allowed for the introduction of new families of products onto the market. These products, categorized as "organic silicon-based compounds," are predecessors of "ethyl silicate." As documented in an article published in the "Bollettino Ingegneri" in 1959 [13], the dissemination of these products was extensive, and with the favorable opinion of the Superintendence for Monuments of Florence and the Fine Arts Office of the Municipality, widespread application on damaged architectural works undergoing restoration began. Following an initial trial conducted on the exterior surfaces of the Church of Orsanmichele, treatments were applied to various buildings, including Palazzo Pandolfini in Via San Gallo, Palazzo Boutorline in Via dei Servi, the facade of the Basilica of San Marco, the obelisks of Santa Maria Novella, the old Porta S. Gallo, Palazzo Strozzi, the new headquarters of Fondiaria in Piazza della Libertà, and some portions of the facades of S. Maria del Fiore. Through archival research, it can be determined that the product used for the facades of the Church of Santa Maria del Fiore was applied in 1958 and was called "Nubex," a silicone-based water repellent from the British industry J. Freeman Sons & Co. Ltd, Cementone Works, and marketed in Florence by the ACEF Consortium, located at Via Aretina 59, Florence.

The "silicones" were not appreciated by the director of the OPD, Lando Bartoli, as stated in his letter dated January 27, 1960, addressed to the Ministry of Antiquities and Fine Arts. He believed that the application of silicones served exclusively a protective purpose and not a consolidating one. This is why no interventions carried out by the Institute with the use of these products are found, except for this purpose. On the contrary, consolidation using fluosilicates was preferred. This method of consolidation stemmed from the significant influence of Piero Sanpaolesi, the technical director of the Restoration Workshop of Florence within the Uffizi Gallery, who, in the 1940s, was considered almost definitive on a national scale. However, in the following decades, some works consolidated with this technique began to show serious signs of degradation, to the point of choosing to abandon it.

3 Conclusions

In summary, the conservation of stone materials has a long history marked by a continuous evolution of techniques and materials influenced by scientific studies and practical experiments. Collaboration between institutes and the development of new technologies have played a fundamental role in the progress of conservation techniques. The snapshot provided by the Florentine scenario of the 1950s highlights the various factors that characterized national and international restoration. Despite some research centers beginning to apply a well-defined methodological process, knowledge in the field of materials was not sufficient to adequately address degradation and alteration factors. There was still a restoration practice lacking in the knowledge that would only begin to emerge from the 1970s, such as the nature of the

material and the analysis of degradation and alteration factors. Especially in the case of silicones, applications were made "en masse" without considering the different lithotypes. Another fundamental aspect was the test of time. The importance of testing and monitoring products was not yet fully understood, leading to hasty evaluations without waiting for the test of time. Additionally, another aspect of further study by the author will be the significant submerged scenario of those artisan workshops where, despite international trends, interventions continued to be carried out with traditional techniques and products.

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