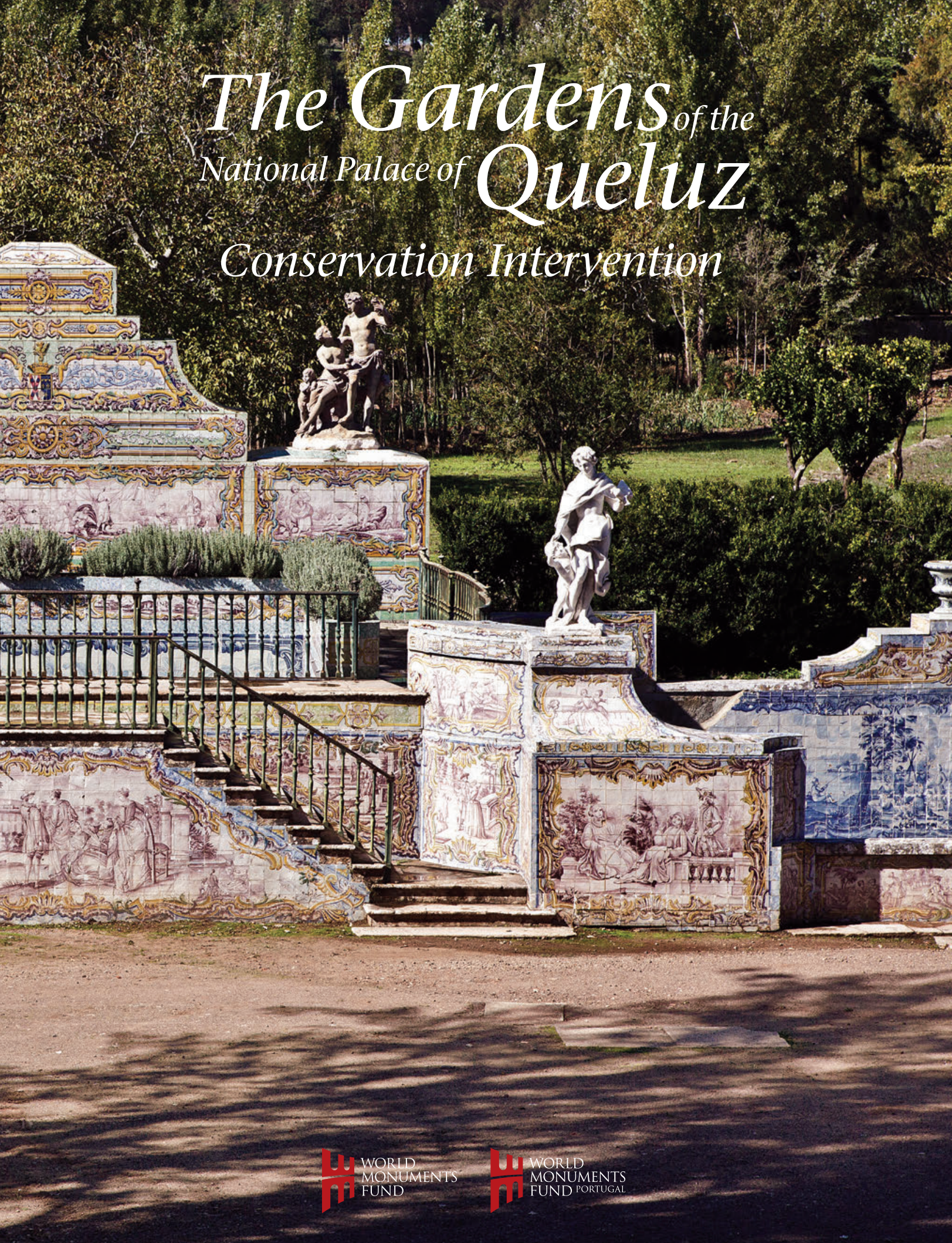

The Gardens of the National Palace of Queluz

Conservation Intervention

WORLD MONUMENTS FUND

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The Gardens of the National Palace of Queluz: Conservation Intervention

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Introduction

Bonnie Burnham
President of World Monuments Fund

On a bright and clear afternoon in June 2011, a group of World Monuments Fund supporters and Portuguese cultural officials gathered in the gardens of the National Palace of Queluz to unveil a plaque commemorating its restoration and to pay tribute to the late Paulo Lowndes Marques. Through a decade of complex and challenging work, Dr. Lowndes Marques, on behalf of WMF Portugal, led the project of the gardens' restoration with probity and enthusiasm. When WMF began conservation work there in 2002, the gardens were facing overwhelming problems. The increased suburban sprawl around Queluz reduced the water availability for both gardens and the hydraulic system feeding its many ornamental fountains during the dry summers. At the same time, it increased the frequency of catastrophic floods of the Jamor River that traverses the gardens—in part through the extraordinary tile-work lined canal—during the wet winters. These problems resulted in an overall feeling of neglect.

Extensive studies, rigorous documentation, and careful conservation work have gone into the gardens since that time. A collaboration between World Monuments Fund, the Instituto Português do Património Arquitectónico (IPPAR), subsequently Instituto de Gestão do Património Arquitectónico e Arqueológico (IGESPAR) and the staff of Queluz Palace brought together expertise from a range of sources, both Portuguese and international. WMF Portugal, through prior projects at the Tower of Belém and Monastery of Jerónimos, has already assembled a world-class stone conservation team, and the Queluz garden conservation project provided another opportunity to bring together these experts for the benefit of a major Portuguese monument. But in other areas, finding appropriate expertise would be challenging. One unexpected and opportune discovery occurred during a visit to Portugal in 2003 of WMF's European affiliates. Strolling through the gardens, conservation experts from WMF Britain quickly identified the extensive collection of lead sculpture in the garden as the work of the eighteenth-century British sculptor John Cheere. Previously unknown to them, this discovery opened a new dimension of exchange, collaboration, research, and support. A joint program between WMF Britain and WMF Portugal allowed a group of Portuguese trainees, working at Queluz under British trainers, to acquire skills to conserve metal sculpture that were not extant in Portugal prior to the conservation work

at Queluz. Several works by Cheere traveled to London for conservation and subsequent exhibitions in major museums there.

Today, the gardens of Queluz have regained appropriate recognition as one of the most beautiful of Europe. The palace itself had undergone extensive restoration, and the stunning rococo ensemble has joined other key monuments of Lisbon and nearby Sintra as one of the sites that visitors must find the time to see.

An essential element of all WMF's work is public access at the conclusion of projects; of equal importance is providing the public with information to understand what they see and appreciate the conservation process. We hope that this volume will promote wider recognition of work that has been done to preserve Queluz.

WMF is grateful to all who participated in this project, most especially Isabel Cruz de Almeida, the tireless and dedicated vice president of WMF Portugal, the donors to WMF Portugal and WMF Britain who supported this project, and our US donors — the Samuel H. Kress Foundation, Annenberg Foundation, and the Robert W. Wilson Challenge to Conserve our Heritage, a financial challenge program that has allowed WMF to make funds available to many of the world's great monuments and sites for their conservation.

Prologue

Elísio Summavielle
Director General for Cultural Heritage

It is a great pleasure to present this publication that marks the completion of the restoration of the gardens, including the many decorative fountains, of the National Palace of Queluz, carried out in collaboration between World Monuments Fund Portugal and the Instituto dos Museus e Conservação. This wide-ranging project dealt with the conservation, restoration, and presentation of the gardens and the great number of statues, both in stone and lead that decorate them, as well as the statue of D. Maria I located in front of the palace. It was a fundamental contribution to the National Palace of Queluz, to the Portuguese cultural heritage and to the world in general.

The investment made by the Portuguese state, through the Ministério da Cultura, subsequently the Secretaria de Estado da Cultura, associated with those made by World Monuments Fund and its Portuguese affiliate, allowed the restoration of this unique piece of Portuguese heritage. Thus the safeguarding of this monument, a priority that needs to be respected, was ensured. The investment was made with the conviction that it will raise the awareness of the value of this heritage and provide returns in public education by inducing an increased number of visits.

Our architectural and landscape heritage is definitely distinctive, captivating both national and international visitors. The strategy adopted in this project has addressed, in the first place, physical preservation and sustainability while simultaneously developing new resources and user programs.

The reopening of the gardens in May 2011 and the ongoing program for progressive restoration of the gardens through an interdisciplinary program ranging from art history, conservation, and restoration to landscape architecture, including biology and plant management, involving diverse institutions and companies, continues to be a success.

The various interventions carried out in this project constituted one of the most extensive restoration projects of historic gardens in Portugal. It has contributed significantly to putting the gardens of the National Palace of Queluz back on international cultural tourism routes, both for its architectonic and landscape values. For this I would like to thank the important contribution of World Monuments Fund Portugal, and in particular that of Dr. Paulo Lowndes Marques, while acknowledging all contributing donors without whom

this conservation and restoration program would have been impossible. It is our hope to continue maintaining and improving this invaluable heritage. Last, but not least, credit is due to Dra. Isabel Cordeiro, Director of the National Palace of Queluz, and her team for their persistent involvement in, and dedication to, this project.

Foreword

Jonathan Foyle and *David Gundry*
World Monuments Fund Britain

The shell of Queluz Palace rose gradually, unsurprising given the hiatus of the Lisbon earthquake of 1755. But in that same year, Dom Pedro's representatives visited England and Italy to secure major commissions for sculptures. This energetic search may have helped maintain the momentum of the project through the disaster.

Anyone shopping for statuary in London would have come across the name of John Cheere (1709–87) as England's foremost supplier of sculptural work, from garden statuary to mantelpieces. He had been apprenticed to a haberdasher from 1725 to 1732, which gave him an understanding of the flow and hang of textiles, but he became a sculptor during the 1730s, landing the conspicuous commission of a gilt statue of William III in St James's Square in 1739. Twelve years later he produced a gilt statue of George II that still stands in St Helier, Jersey, while some garden statuary survives at Wrest Park, Bedfordshire, among other works in Britain.

The commission for lead figures at Queluz was probably the largest Cheere ever received. Some have claimed the number ordered was ninety-eight, but too little evidence survives to be able to confirm this. Nonetheless, it's clear that a full repertoire was needed to deliver sufficient variation of characters and themes. Giovanni da Bologna's *Samson Slaying the Philistine* and a copy of the antique *Hercules* of the Farnese collection were among the connoisseurs' favorites during the age of the Grand Tour. *The Four Seasons* provided a standard theme in garden environments, but more esoteric subjects were chosen to fill out the ranks. Among these, not everyone would agree on the attributions provided for *The Story of Melos* and *The Marriage of Bacchus*.

As Cheere's workshop worked away beating, welding, and smoothing the lead figures into expressive forms, which were anything but leaden, Queluz Palace approached completion. Dom Pedro's impending marriage to his niece and heir to the Portuguese throne Doña Maria I promoted renewed efforts by 1760, which included the creation of the west wing to address the garden and tiled canal. In 1764 the rococo garlands and swags of the principal façade were being designed by the French artist and silversmith Jean-Baptiste Robillon (d. 1782). By the end of the century Portugal's jewel was finished, and Cheere's painted and gilded figures adorned what William Beckford called a "regal paradise."

WMF Britain's involvement at Queluz began in 2003 when the site was drawn to our attention due to the gardens having fallen into an advanced state of dilapidation. In 2004 an agreement was reached between WMF Britain, WMF Portugal, and The Portuguese Institute of Architectural Heritage (IPPAR) that established a partnership between the three organizations with the aim of conserving the sculptures and gardens respectively.

The lead sculptures at Queluz were in a bad way. The majority of the large groups had not been significantly maintained since their manufacture in the eighteenth century, and some of the smaller single figures had been repaired using methods and materials that were well intentioned but ultimately detrimental. Many of the sculptures suffered from water penetration, multiple splits and holes in the lead, plant growth, and deformation where they had been impacted by falling trees and branches.

Rupert Harris Conservation, based in London, was employed to repair the Cheere sculptures on behalf of WMF Britain. The conservation process involved removing the original plaster cores and corroded iron armatures from inside the sculptures and replacing these with new stainless steel armatures. This required some dramatic surgery: the sculptures were cut open before being very carefully reconstructed. Deformation of the figures was corrected and any holes or splits "lead burned," a process whereby the surface to be repaired is suspended horizontally and small amounts of lead are melted onto the affected area so that any fissures are filled. Finally, the conservators reworked the new lead surface in a way that faithfully replicates the surface and tool marks of Cheere's studio so that the intervention is now virtually indistinguishable from the original.

Due to the rarity of lead sculptures in Portugal, there are very few metal conservators with experience of this repair technique. In response to this, WMF Britain set up a workshop at Queluz Palace so that the majority of the sculptures and fountains could be repaired and maintained on-site. This enabled four Portuguese interns to be trained by Rupert Harris, and it is hoped that their skills will continue to be reinvested as time goes on.

However, a few of the most damaged sculptures had to be returned to the UK for repair, including the two named *Wedding of Bacchus* and *Story of Melos.* After conservation these were exhibited in Tate Britain's Grand Manner Gallery from October 2008 until late March 2009, and were enjoyed by thousands of visitors.

A major aspect of WMF's mission is to encourage public access to—and appreciation of—our shared cultural heritage. As John Cheere is among the greatest British sculptors, the London sojourn of these two large sculptures presented an opportunity for them to be admired "at home," not far from where they were originally manufactured.

Yet their ultimate reinstatement at Queluz has been the greatest source of satisfaction, a contribution which we trust will continue to delight the many visitors to the Palace's enchanting and distinctive gardens.

Preface

José Blanco
President of World Monuments Fund Portugal

Conservation of the Queluz palace gardens was the third major project carried out by World Monuments Fund Portugal under the presidency of my dear friend, the late Paulo Lowndes Marques. In all three he had the indispensable collaboration of the Vice President, Isabel Cruz Almeida.

The program at Queluz followed the important restoration of the Tower of Belém and that of the Cloister of the Monastery of the Jerónimos, completed by 1998 and 2002, respectively. At Queluz the restoration and conservation of all the garden statuary, the hydraulic system, the fountains, and the Canal de Azulejos were carried out over a period of seven years (2004–2010) and constitute an excellent example of a fruitful collaboration between public and private institutions and individuals in both the United Kingdom and Portugal, all of whom I acknowledge here with gratitude.

It was in 2003 at Apsley House in London that World Monuments Fund Britain, under the chairmanship of John Julius, Viscount Norwich, signed the first protocol of collaboration with World Monuments Fund Portugal. In 2004 the then-Deputy Director of World Monuments Fund Britain, Kevin Rogers, signed a second protocol with us and the Instituto Português do Património Arquitectónico (IPPAR). Colin Amery, former Chief Executive of WMF Britain also gave considerable support to the project and his help and enthusiasm continued under Jonathan Foyle who succeeded him in 2008. I would also like to include the art historian, Angela Delaforce, who has from the very beginning been closely involved in this Anglo-Portuguese collaboration and who, in 1980, was first to attribute the collection of lead statues at Queluz as being by the English sculptor and caster John Cheere.

In Portugal I acknowledge the excellent collaboration with IPPAR and subsequently the Instituto dos Museus e da Conservação (IMC), with João Belo Rodeia and João Brigola, as well as with two directors of Queluz Palace, Ana Flores and Isabel Cordeiro. I also acknowledge the valuable technical and scientific collaboration in Lisbon with the Departamento de Engenharia Civil of the Faculdade de Ciências e Tecnologia at the Universidade Nova, the Instituto Superior Técnico, the Laboratório Nacional de Engenharia Civil as well as the Department of História de Arte at the Faculdade de Letras of the Universidade de Lisboa.
The ambitious project at Queluz was accompanied by two highly significant technical initia-

tives in the field of specialist training. The first, a pioneering development in Portugal, was the establishment of workshops with the dual objective of training Portuguese conservators in the restoration and subsequent care of objects made of lead. These were organized during 2006 and 2007 by the English firm Rupert Harris Conservation and they were responsible for training four Portuguese specialists. The second workshop series was devoted to restoring and maintaining stone statues. Between 2005 and 2010 nine workshops were organized on "Treatment and Monitoring of Biological Colonization," attended by some one hundred participants, many of whom were members of the staff of the palace and were thus able to acquire the qualifications to undertake the maintenance of the Queluz statues.

A further interesting aspect of the whole project was the temporary return to London of several group statues by John Cheere. Following their restoration in London by Rupert Harris they were put on display at the Victoria and Albert Museum and at the Tate Britain's Grand Manner Gallery. The last group returned to the gardens in 2009.

Overall the extent and quality of the collection of lead statues by John Cheere (indeed, Queluz has the most important display of his work worldwide), together with the Roman seventeenth-century fountain statues, the beauty of the eighteenth-century *azulejos* integrated into the architectural setting, as well as the different elements of hydraulic engineering, all combine to make the restoration project in the gardens at Queluz of unique importance in the wider context of European patrimony and its conservation.

Finally I would like to thank Bonnie Burnham, President of World Monuments Fund, and all her staff who as always have given such generous support to this and every project carried out over the years by World Monument Fund Portugal.

Chapter 1.

The Gardens of the National Palace of Queluz: An Introduction

Isabel Cordeiro, *Sílvia Santa-Rita*, and *Conceição Coelho*

Historic Background

In 1654, King João IV established the Casa do Infantado for the second son of the ruling monarch. He assigned the confiscated old country mansion of Castelo Rodrigo, among many other properties impounded from supporters of the Spanish rulers, after the Restoration of Independence.

Originally, the mansion had been built as a country house in Queluz by the first Marquis of Castelo Rodrigo, D. Cristovão de Moura (1538–1613) around 1580 (Ferro, 2009:13). In 1630, his son, D. Manuel de Moura Côrte-Real (1592–1652), second Marquis of Castelo Rodrigo, remodeled the property—both house and gardens—turning it into an Italianate summer villa. These changes were confirmed by archaeological excavations carried out in 2004 that showed the presence of a garden area on the north end of the canal (Sequeira and Vale, 2004:8). Natália Correia Guedes (1971:65), describes the layout as follows:

> *"(…) turned northwest, having its major axis in the northeast-southeast direction; the kitchen and servants' quarters were located towards the north area, and these were followed, in the opposite direction, by chambers and rooms, sitting rooms and halls that expand towards small private gardens that communicate with the vegetable gardens and orchards, very likely following the house, court and garden scheme current in civil architecture of the seventeenth century."*

It was Dom Pedro (1717–1786), third Lord of the Casa do Infantado and brother of the King D. José I (1714–1777), who upon receiving the Queluz country mansion and surrounding properties planned to convert it into a recreational villa.

The planned work began in 1747, but upon his marriage to the future Queen D. Maria I (1734–1816), it was modified into an enlargement and embellishment project to create one of the most grandiose palaces and gardens in Europe (Rodrigues, 2011:45). The idea was that palace and gardens had to be an organic unit, the gardens being an extension of the palatial interiors where the refined activities could also be carried out. Far from the formalism of the Court in Lisbon, Queluz was to be a cheerful and carefree recreation space.

The first construction phase of the palace (1747–1758) was coordinated by the architect Mateus Vicente de Oliveira. In 1756, the architect and goldsmith Jean-Baptiste Robillion was appointed to the Casa do Infantado, and he took on the design of the second construction phase (1760–1786). This resulted in a change of the aesthetic approach even though Mateus Vicente continued to supervise the work. Robillion, with his expertise, brought refinement, brilliance, and splendor—exemplified by the throne room and the Robillion pavilion—to what would be the royal residence as of 1777. The third phase (1786–1792) was carried out by the architect Manuel Caetano de Sousa, which consisted mainly of the construction of the D. Maria pavilion (Figure 1).

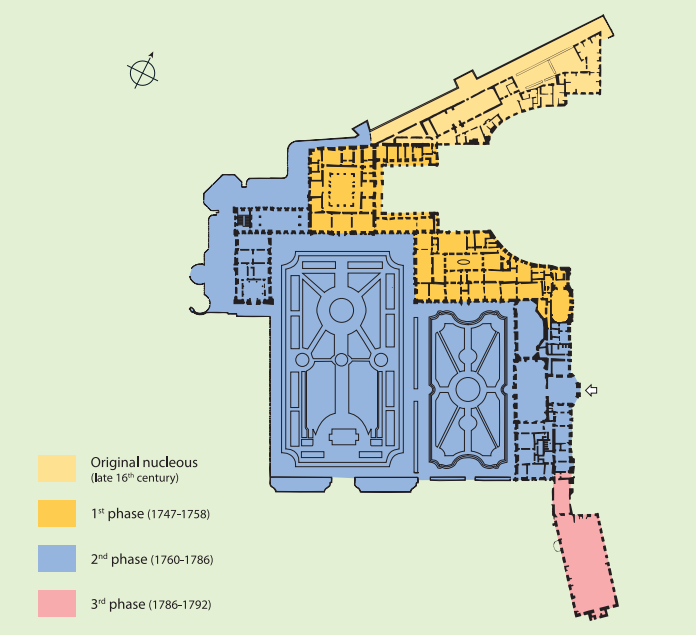

Figure 1. Map of the palace showing the main three construction phases.

The first problem that had to be addressed in this ambitious project was the water required and its distribution. Although the area was relatively rich in water, the irregular rain patterns of summer, typical for the climate of the region, made it scarce in this season (Caldeira Pires. 1924:370).

Water was the primordial element having utilitarian, recreational, and symbolic values. In the refined eighteenth century landscaping, particularly in French-style gardens, water is present in architectural and sculpture groups appealing to the senses and the enjoyment of nature.

Already the second Lord of the Casa do Infantado, D. Francisco (1691–1742), brother to King D. João V (1689–1750), had tanks constructed for water collection. In turn, D. Pedro had groundwater explorations made, in spite of the fact that the Jamor River and some of its affluents traversed the property, and finally decided to acquire neighboring lands that had water sources. This search was continued by Prince D. João, future King D. João VI (1767–1826).

Several groundwater sources were tapped at their origin and directed via conduits to a storage and supply system. By 1752, phreatic aquifers on nearby hills, such as the Pendão source to the northeast and the Gargantada—or Carenque—source to the east-northeast, were tapped and the water brought down by aqueducts and conduits to integrate a comprehensive system including major reservoirs and visiting chambers with skylights or roof-lanterns. The system served both the general public and the royal properties. The overall system of aqueducts, dams, tanks, reservoirs, and conduits made use of the slope of the land, creating a network distribution by gravity that was essential for both fountains and irrigation. The complex hydraulic system of Queluz was developed and perfected by Manuel da Maia, chief engineer and field master of the kingdom in 1752. Its maintenance and correct functioning was one of the key concerns of the various occupants of the palace and its gardens.

The garden, planned as an area of rest and thought, was considered a place for entertainment and amusement, a socio-cultural reflection of the commissioning patron. Its loose combination of nature and art can only be compared to the characteristic of the rococo gardens of the second half of the eighteenth century (Luckhurst, 2011:18). From the beginning, the gardens of Queluz were carefully designed. Both the formal gardens with a French layout, i.e., the Hanging and the Malta gardens, as well as the rest of the park, were decorated with fountains, water-holding basins, and sculpture groups, as was customary at the time. Various influences can be recognized, such as French, Dutch, English, Italian, Spanish, and Austrian (Figure 2). These indicate that whoever imagined the garden consciously and deliberately chose this diversity (Luckhurst, 2011:17).

The maps of the gardens conserved in the National Library of Rio de Janeiro (Afonso and Delaforce, 1989:30 and 33; Ferro, 2009:23) show the main axes that oriented them. The principal axis starts at the center of the ceremonial façade of the palace, crosses the length of

Figure 2. Ceremonial facade of the palace facing the Hanging Garden.

the Hanging Garden, passes the Gate of Fame, traverses the park and ends with a theatrical effect at the Great Cascade (Figures 2 and 3). The latter section is referred to as the Cascade Lane.

As this straight line crosses the Gate of Fame, a semicircular plaza opens and from it other axes fan out to traverse the park in various directions, forming glades that reflect the influence the landscaping of Le Nôtre for the Versailles gardens had in all of Europe (Rodrigues, 2011:47) (Figure 4).

The formal garden beyond the ceremonial façade is the Malta Garden, and the French doors of the throne room open onto it. Both formal gardens had typical box bushes parterres and were profusely decorated with statues such as pairs of lovers from Classical mythology, the four seasons, allegories to the arts, and putti. Many aquatic subjects decorate the main fountains that serve to organize the layout of these parterres.

In 1771, Robillion designed the Gate of Fame, so-called because of the two trumpet blowing equestrian figures, which marks the passage from the Hanging Garden to the park. Since antiquity, Fame has been represented as a female figure transported by Pegasus, the winged horse, while the trumpet is the symbol for fame. These sculptures were inspired by the equestrian statues in the gardens of the Château de Marly. Engravings of the Versailles and Marly gardens circulated in Portugal and were available at the Library of Mafra, created by D. João V (Rodrigues, 2011:83-84).

Between 1757 and 1765, an unusually large royal commission was made to the English sculptor John Cheere (1709–1787) for statues in lead. These, together with the Carrara

Figure 3. View of the Cascade lane showing the Shells' fountain and the Great Cascade at its end.

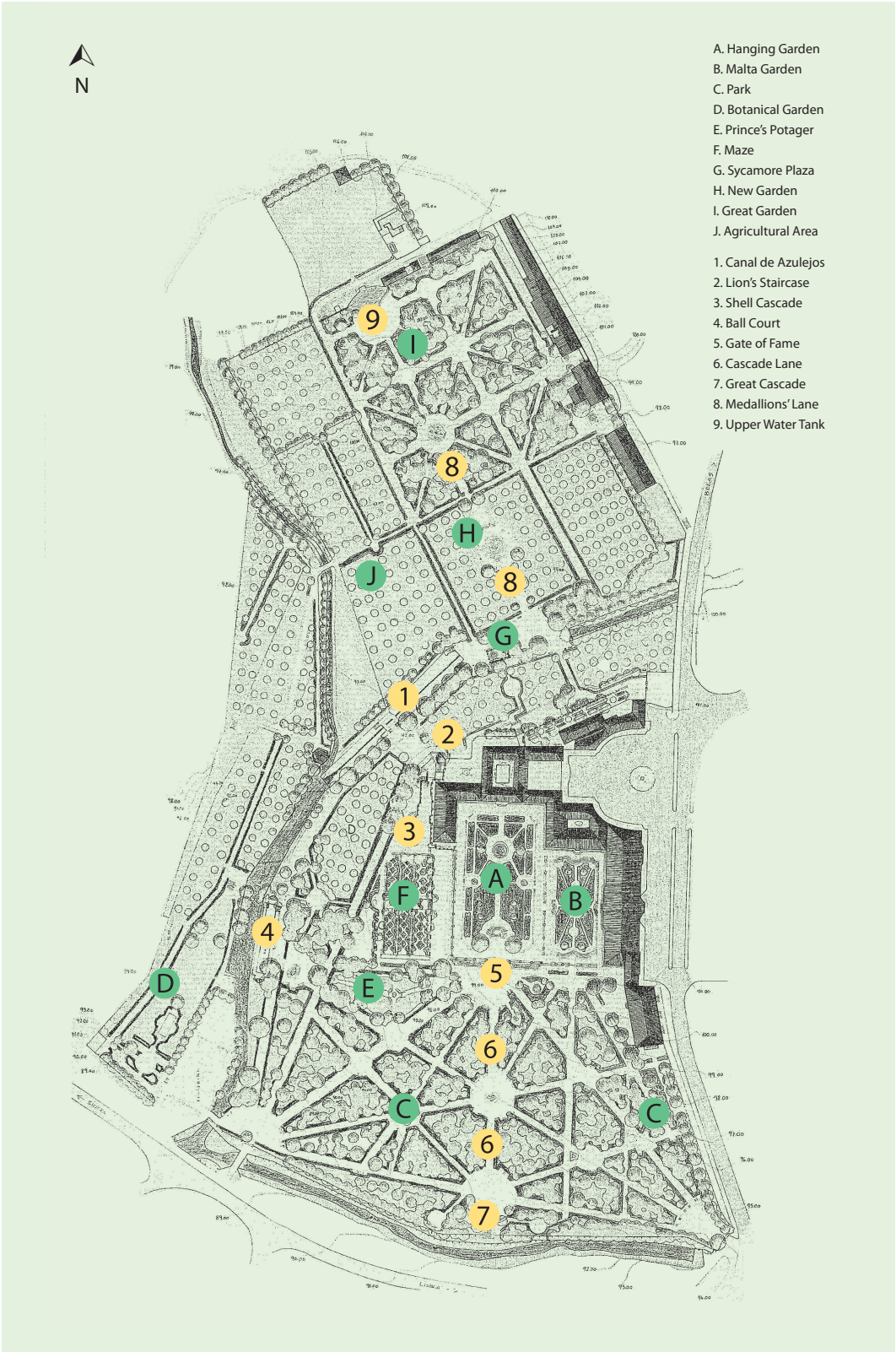

Figure 4. Plan of the gardens showing the various areas of interest. (Original Plan, Universidade de Évora; fonte: SIPA—Sistema de Informação para o Património Arquitectónico, consultada em www.monumentos.pt, em Novembro de 2008).

marble sculptures imported from Italy, served to increase the grandiosity of the gardens of Queluz. The marble sculptures, including statues, busts, and vases, were commissioned through Nicolau Possolo (Arquivo Nacional Torre do Tombo-1), an Italian established in Lisbon. By 1758, 56 crates with marble statues were received, while four years later, marble busts, vases, and slabs arrived at Queluz. These represented one of the major commissions of imported sculptures in Europe, following the then-current international patterns of reference to nature (Rodrigues, 2011:63), such as naked female figures, exotic animals, or love between gods—the favorite subjects of a pleasure garden.

The statues were set upon pedestals and positioned according to the development of the garden, so that their locations changed as transformations, adaptations, and innovations were made. This constant search for new scenic effects, typical of eighteenth-century taste, was also carried out in the interior of the palace.

Between 1755 and 1756, numerous lead statues were commissioned by D. Pedro from the list provided by John Cheere (Arquivo Nacional Torre do Tombo-2). The choice of this artist may have been influenced by the important English community present in Portugal at the time. Recently discovered documentation suggests that Sebastião José de Carvalho (first Marquis de Pombal) was involved in the commission and transport of these pieces with the collaboration of the Portuguese Ambassador in London, D. Luís da Cunha Manuel (1703–1775), who actually visited the Cheere workshop and suggested some minor changes to the sculptures (Chapter 3). Of the many statues and sculpture groups received, only fourteen remain, such as the groups of *Cain and Abel*, *Aeneas and Anchises,* and the *Rape of Proserpine*, currently located in the Sycamore Plaza. Nonetheless, this collection is one of the most important of Cheere's work that is still in its original location, since most of his work in England has been lost. Those remaining can be seen in Stourhead and Anglesey Abbey (National Trust), Wrest Park (English Heritage), Castle Howard, and the Victoria and Albert Museum or art galleries.

Cheere statues clearly followed the spirit of the time inspired by the gardens of Versailles and the engravings of Italian antiquities and Renaissance works. They had a unique versatility between mythological and classical figures as well as more prosaic subjects from the Commedia dell' Arte and rural figures and animals (Chapter 2).

At the time, Cheere was viewed as a craftsman rather than an artist. However, recent studies have shown that his work was not a simple duplication, because not all the molds he used were cast. Some were carefully constructed from drawings and engraving, and all of them were reworked to create high-quality copies of the originals. He was a master in finishing details (Grilo and Neto, 2005).

The lead statuary was usually painted. Mythological figures were painted white to look like marble, while various colors were used on prosaic figures, such as shepherds and rustic figures, especially for their dress. The taste for polychromy at Queluz survived till 1820, the date of the last bill for cleaning and painting the statues (Afonso e Delaforce, 1989:19).

It is unlikely that D. Pedro would have had a pre-defined iconographic program for the artworks purchased, since the commissions were made at different dates. Furthermore, neither he, nor the artists, were likely to have access to the Roman and Greek classics, but

rather, to the various treatises (where these subjects were discussed with the required decorum, for example, composition, and propriety in art) that were compiled since the fifteenth century. According to garden treatises of the eighteenth century, sculptures were meant to contribute to natural scenes and to inspire the observer. Therefore the main aim of D. Pedro was that the commissioned statues should embellish and enrich the garden (Rodrigues, 2007).

In the eighteenth century, gardens were seen as symbolizing the opposition of a "cultured" nature to that in the wild. In the trilogy of vegetation/water/stone, the garden served as the ideal stand for celebrating the unlimited imaginative artificiality of the baroque world. D. Pedro, following his humanistic inclination for arts and literature, did not spare any efforts in conferring magnificence to any festive activity carried out at the palace. According to the enthusiastic accounts of the diplomatic corps that had the opportunity to visit the gardens of Queluz and its festivities, the fireworks that illuminated them rivaled the best of Europe (Ferro, 2009:37).

The gardens had some free-roaming animals in them, such as peacocks, swans, and deer. But they were famous for the exotic animals kept in cages. For example, birds such as cockatoos, helmeted guineafowl, and others brought from India, as well as eagles and falcons. Other animals may have been chained, such as monkeys, or kept in pens, such as buffalo. Tigers and lions were known to be kept in a cage close to the Shell Cascade (Arquivo Nacional Torre do Tombo-3).

Baroque parties were characterized by surprises and novelties specially designed for them. Among them, lavishly decorated pavilions and other ephemeral constructions were installed in the gardens, adding to the exuberance and splendor. Among these was the Music Stand, or Chinese House, that bridged the Canal de Azulejos, The wooden structure had its interior finished by the master carver, Silvestre Faria Lobo, who is best known for the work he did in the throne room of the palace.

The Canal de Azulejos, the quintessential rococo azulejo opus, showed the versatility that this material—used for decoration in many Portuguese gardens—could reach. The canal has been described as "(…) an unusual expression, both by its basic architecture and its conceptual originality (…)"(Meco, 2009:115).

The canal is lined with azulejo tiles, both on the interior and the exterior sides, as well as decorated with azulejo-lined planters, urns, and statues. Various artists contributed to manufacturing the azulejos, such as João Antunes (1756), Manuel da Costa Rozado (1775 and 1776), and Francisco Jorge da Costa (1784). In the twentieth century, with the restoration works commissioned by D. Carlos I and D. Amélia, further azulejos were commissioned to Pereira Cão (1900) and Carlos Alberto Nunes (1902).

The canal was created from a section of the Jamor River that flowed through the property and had been partially canalized (Chapter 8). Archaeological excavations found remains of these installations, which mainly had an agricultural function, dating from the sixteenth century. To be noted is that this canal had a different orientation than that from the eighteenth century; the right wall (west side) of the older canal was intersected by the left wall (east side) from the eighteenth century, as apparently by this time the original canal

had been abandoned, having suffered material sedimentation that probably diminished its functionality. The presence of gardened areas along the left wall appears to show that the original river bed was more to the west (Sequeira and Vale, 2004:11).

The decorated section of the canal, some 120 meters long, was closed by a floodgate in 1753. This allowed filling the canal with water so that it reflected the various scenes depicted by the azulejos, such as palaces, sea harbors, and aristocratic or rustic gallantry inspired by Dutch, French, or German engravings (Pereira, 2011:132). The canal could be traversed in boats for observers to enjoy the different scenes and, on occasion, to the sound of music from the music stand.

The construction and decoration of the canal was concurrent with the first and second construction phases of the palace. It was designed by Mateus Vicente, who also directed the actual works. But it was Robillion who, inspired by the recurrent solution used in the opera stage (Rodrigues, 2011:93), managed to bridge the large drop from the palace to the canal by the pavilion that carries his name. The brilliant solution was the Lions' Staircase set at an angle to the palace and facing the center block of the Canal de Azulejos where the music stand had been installed with its two staircases (Figures 5 and 6).

The boating in the canal, chases, horse riding, and bullfights served to entertain an idle court. Other recreation areas in the gardens were, for example, a ball court and a sort of merry-go-round with wooden ponies.

The constant movement of water was introduced in various ways into these spaces and ranged from the whirlpools that form in the cascades, through the flowing water in the canal, to the spray jets of the various fountains. All of them provided a soft and restful mur-

Figure 5. The Lions' Staircase at the corner of the Robillion Pavilion.

mur (Beckford, 1935:112). The water-sprays varied according to the fountain that produced them, the different type of jets they had, the light available and, in some cases, with the music being played, thus contributing significantly to the scenic effect desired.

The waterfalls, or cascades, had the largest architectural support and provided the most spectacular effects while symbolizing the imitation of nature by man. However, they could only function when water and economic resources abounded. Their location was discussed in the garden treatises, and in Portugal they were located at the ends of the main garden axes so as to provide focal points (Rodrigues, 2011:87).

The Great Cascade was designed by Robillion and built in the 1770s. It is located at the end of the main axis of the park that originates at the Gate of Fame. Built with stone from Cascais, it is high enough to obstruct the view beyond the park and was inspired by the water features in baroque Italian gardens (Luckhurst, 2011:29–30). The water flows from various openings, the central one being a carved *rocaille* gargoyle. The two birds that spout water are swans—birds sacred to Apollo—that are singing their last song (Luckhurst, 2011:30). Water for this waterfall is stored in a large tank above it that originally had been decorated with a veranda supporting lead and marble statues.

Halfway along the above-mentioned main axis is a clearing where the Shell Fountain is set. Various paths radiate from it leading to small glades that serve as cozy gardens. The trees planted in this area were mostly imported from Holland (Luckurst, 2011:33). These were elms, lindens, and citrus, frequently trimmed in espalier fashion, as well as chestnut trees. These spaces, decorated with small fountains, sculptures, and benches, were valued as free nature and as places for rest and reflection (Leite, 1995:18).

Figure 6. The Central block of the Canal de Azulejos where the Music Stand was located.

Across the canal, and along the Medallions' Lane that opens from the Sycamore Plaza, is the Medallions' Fountain, also designed by Robillion in 1764. This is an element that provides both visual and auditory entertainment, by its rich design and complex water spray system. The delicate stonework of its elegant basin rim has truncated vertices forming small pools that are decorated with vegetal motifs suggesting medallions. The central element in stone has various decorations in lead, and thirteen water spouts project from masks, putti riding dolphins, and dragons. It is topped by a bird with its head pointed skyward, spewing water from its beak (Figure 7).

Continuing along this lane is the marble Neptune Fountain, attributed to Ercole Ferrata from the Gian Lorenzo Bernini atelier. This fountain had been commissioned by the Count of Ericeira, D. Luis de Meneses, a statesman and politician, for his Palace da Anunciada in Lisbon. The fountain was later sold to the Lords of Belas for their country estate, and in 1945 it was moved to Queluz, to complement that lane of the garden (Rodrigues, 2011:107).

With regards to the actual plantings in the garden, it has been recorded that large sums were spent in the acquisition of plants and flowers, not only at the beginning of the project, but also for the regular maintenance required by such a large space, especially since it had to be ready for the brilliant festivities that were held in it. As in the case of the palace, the gardens were prepared for the arrival of the royal family in summer.

Old maps show the Hanging Garden having open flower beds—filled with flowers—surrounded by box bush hedges. Gerald Luckhurst (2011:25) points out the flowers in bas-

Figure 7. View of the Medallions' Lane showing the Medallions' Fountain. The Neptune Fountain, attributed to the Bernini atelier, can be seen at the end of the lane.

kets and garlands sculpted on the facades above the door and window lintels: ranunculus, roses, carnations, and sunflowers. The preference for hyacinths, jonquils, anemones, tulips, peonies, and different types of ranunculus has been recorded.

The commission of plants from Holland (Arquivo Nacional Torre do Tombo-4), such as the box bushes, yews, and flowers was made just months before the purchase of the lead statuary. In 1755, the Dutch Gerrit van den Kolk was appointed royal gardener in Queluz and stayed there for over twenty years (Arquivo Nacional Torre do Tombo-5). There are records that show that fruit trees were brought from Óbidos and Belas, while box bushes were also obtained from Belém and Ourém.

Topiary, an art practiced by the Romans to turn a bush into a sculpted element, was used to decorate the gardens with further inspiration from Italian designs. At Queluz, the walks and groves, as well as the parterres, were lined by box bush hedges (called "banquettes") as well as by bay laurel and myrtle (Luckhurst, 2011:33).

Orchards and vegetable gardens were also present, being characteristic of traditional Portuguese gardens. But the idealized vegetable garden, called a potager, was already described in the seventeenth-century treatises. In Queluz, the prince's potager fulfilled this requirement, while also contributing to the prince's education (Luckhurst, 2011:34) by being both a conservative and an invigorating area (Leite, 1995:217).

Orchards and orange tree groves were planted according to French aesthetic principles, as enunciated by Jacques Bourceau in the 1638 *Traité du Jardinage* (Azambuja et al., 2009:6). These trees surrounded the gardens at Queluz, and among all of them the pear trees were the most valued (Luckhurst, 2011:35). The main orchards were located close by the botanical garden, enclosed by walls and irrigated by a canal that took its water from the Canal de Azulejos beyond the Music Stand (Luckhurst, 2011;36).

The botanical garden was located where the Portuguese Riding School currently holds its shows. It was not what is usually understood as a botanical garden; rather it followed the intellectual curiosity of the Enlightenment and reflected D. Pedro's interest in exotic plants brought from all corners of the vast Portuguese empire. In particular, pineapples, or *ananas*, were carefully grown in Queluz.

References are found to a hunting ground, identified as "the forest", which apparently was incorporated toward the end of the 1770s. The court participated in these hunts, and they provided one of the most sought-after entertainments during visits from high ranking dignitaries.

By the mid-seventeenth century, the gardens of recreational country estates established during the sixteenth century proved to be more permeable to the new aesthetics than the houses themselves. However, the formalism found in other European gardens during the seventeenth and eighteenth centuries was only applied in part (Leite, 1995:211-212). Thus, Queluz Palace and its gardens were the result of the determination and spirit of D. Pedro. He managed to turn an idea born from the evolution of custom and fashion into a reality. His profound knowledge of the new artistic ideals that swept through Europe at the time resulted in the creation of a space that although eroded by time, is still the symbol par excellence of the eighteenth-century experience.

The Evolution of the Gardens: Transformation, Conservation and Restoration.

In 1794, after the destruction of the original Ajuda Palace that was constructed mostly of wood, Queluz Palace became the permanent residence of D. Maria I, and subsequently D. João, who was appointed regent of the kingdom in 1799. The last monarchs, D. Carlos I (1863–1908) and his wife, D. Amélia de Orléans (1889–1908), no longer lived permanently at Queluz. Nonetheless, they promoted the transformation and recuperation of part of the Canal de Azulejos, as well as building the stables for the queen's horses near the top of the park, across the canal. In 1908, their son, King D. Manuel II, upon assuming the throne, donated Queluz Palace and its dependencies to the national treasury. Two years later, upon the establishment of the Republic, it was classified a national monument.

In the following years, part of the building and the park was occupied by the School of Agriculture. Early in 1930, the north wing was given to the Queluz Consumers' Cooperative and the fire department. However, about that time, following the general movement in favor of the restoration of national monuments, and of the palace in particular, the DGEMN (General Administration of Buildings and National Monuments) began a recuperation plan for the palace and its gardens. In 1936, the DGSFA (General Administration of Forestry and Agriculture) highlighted the importance of respecting the original layout of the box bush hedges that had remained safe and sound during the fire that ravaged part of the building in 1934.

In 1940, to commemorate the centenary of the creation of Portugal and the restoration of its independence from Spain, Queluz Palace and its gardens were opened to the public. The works that had been carried out previously are described in a document of the DGFP (Public Treasury Administration) from that same year:

> *"(...) The gardens and park were also improved by important operations, among which was the difficult and dangerous nature of the general lowering of the ground and the box bush hedges in the Neptune Garden* [Hanging Garden]. *This complicated work allowed to disclose the steps that lead to this garden and served to enhance the imposing effect of the palace façades that look out to it.*
>
> *In the park, the hedges that had long been neglected were taken care of and the paths were repaved.*
>
> *Some fountains, which many years ago had been taken to other properties of the Royal House were brought back to the park to complete the garden design that frame the palace. The so-called Botanical Garden was refurbished with rose bushes that when in bloom turn this garden into an enchanting corner.*
>
> *The Ball Court that had nearly disappeared was retraced, and at both ends two beautiful marble fountains were set. For years, these had been abandoned at the corners of the Azereiros Garden* [Malta Garden] *as they required conditions for installation that did not exist there.*
>
> *The orange tree orchards that were being lost were treated so that in a few years it will be possible to enjoy their decorative effect.*

In the area of the park that had been destroyed, the paths and avenues are being rebuilt and large tree and flower nurseries were made to replenish the needs of the gardens and the park.

This work can only be completed with persistence and continuity, since it is impossible to remake the gardens and constructions lost many years ago, but at least what has remained of the beautiful plan of Robillion can be conserved and restored.

We know that the vast park was adorned with recreational constructions, such as the one of the Jogo do Truque [a card game]*, the Chinese House, the merry-go-round, etc., but they disappeared without leaving traces, likely because of the ephemeral materials used in them. However, we still can admire the canal that brings the water of the Jamor River, lined in its extension by large panels of azulejos full of character and color that contrast with and offer a fresh note among the green masses of trees.*

In various corners, lead and marble statues can be seen, as well as decorative vases, plinths, and busts providing an inkling of a time full of refinement and beauty (…). Only the perfume remains of the lively and animated palace of other times. Imagination is needed to bring it to life, but the beauty of the buildings and the outstanding complexity of its gardens and park were saved from ruin and remain as jewels of the National Heritage for future generation to witness and to deserve the beautiful things of the past" (Arquivo PNQ-1).

In the years both prior and after this event, the correspondence exchanged with the Palace Conservator, Ventura Porfírio, and the DGFP is particularly enlightening with regard to the works carried out, the problems encountered, and the achieved successes. The picture of the restoration work carried out is transmitted monthly as of 1937. The restoration of the lead statues in the Hanging Garden began in 1943 and were still going on by 1945:

"(…) We continue with the restoration of the statue called Autumn. *At the moment we are reinforcing the interior of its walls. The workshop where the restoration is being carried out was visited by the Director of DGEMN, the engineer Marquis of Abrantes, the sculptor Diogo de Macedo, and the architect Baltazar de Castro, to control and evaluate that these works are being well done. As far as we heard, we believe that they were convinced that all the restoration works could be completed and that they are being excellently carried out."* (Ventura Porfirio, 1945)

The following year, Ventura Porfírio (1946) reported that:

"The restoration of the lead statues Spring *and another that was found on the balustrade of the Cascade* (Great Cascade) *has been completed, and the statues are already set on their pedestals. The sculpture groups on the edge of the Neptune Fountain have been taken to the workshop for restoration. It is possibly the most difficult restoration of lead objects in our gardens to carry out, because apart from the damage of time, the terrible restorations and treatments they underwent make our work extremely difficult.*

Nonetheless, we are sure that the experience gained in the previous restorations will help us in overcoming the present difficulties and allowing us to accomplish a good work"

But it is in a 1949 summary document where the overall works carried out and their details are best described by the conservator:

"(...) in the year 1940, after the study carried out by the deceased engineer, garden specialist Jorge de Amorim and ourselves, the need to keep a permanent staff of 30 men for gardening was recognized (…). From this date, the gardens and park at Queluz, with an area of some 15 hectares, benefited from this and achieved an appearance, landscape effects and conservation that without modesty can be called remarkable.

The difficulties during the war years, although they complicated things for us either by lack of man-power or strikes of the day-labormen, were overcome by sheer tenacity. They were hard and difficult years, but in spite of this, the restoration work of the beautiful framing landscape of the palace continued steadily.

Thousands of trees were grown and planted, the orchards were repopulated, new gardens and hot-houses were constructed, the hedges were redone, and the water circuits were improved, etc., etc., etc.

Now, all these works and improvements require a continued and persistent maintenance to be preserved and continued.

The funding will necessarily have to be reviewed as the natural work requirement gets multiplied, otherwise, not only will this initiated labor be interrupted, but most of it will be lost.

Such a vast area of gardens can only be maintained by accepting this heavy responsibility.

The increase of the economic revenue is already verified and will continue to increase as the orchards improve. Nonetheless, the cultivation and exploitation of the gardens of Queluz will never cover all its expenses.

The gardens were, and will always be, luxury items that provide pure aesthetic enjoyment, requiring patience, perseverance, and money.

We try to organize the gardening works so as to make minimum disbursements, but in these services, there are limits that cannot be surpassed (…)" (Arquivo PNQ-2)

Several decades later, much attention was again given to the gardens of the palace, in particular with studies and *in situ* conservation of the heritage. The first reports from the José de Figueiredo Institute (subsequently the National Center for Conservation and Restoration) on the stone statues of the gardens were in 1983, followed by the studies of the stone masonry by the DGEMN and by the LNEC (National Laboratory of Civil Engineering), which were still on course by 1989 (Picchiochi Alves, 1983; 1989).

That same year, the first analyses of the lead statues were made at the IRPA (Institut Royal du Patrimoine Artistique) in Brussels. By the end of the '90s, restoration interventions were carried out on the group of putti on the balustrade of the Malta Garden (by Nova Con-

servação, 1996–97), the Great Cascade (by Compósito, 1998–99) (Arquivo PNQ-3), as well as surveys and other specific studies.

It was in 2003 that the agreement between the former IPPAR (Portuguese Institute of Architectural and Archaeological Patrimony) and World Monuments Fund Portugal would define a wider conservation and restoration project of the historic gardens of the National Palace of Queluz. This project, subdivided into six subprojects dealing with the study and the conservation of the Italian stone statues (see Chapter 5 and 9.1); the restoration of the lead sculpture groups by John Cheere (Harris, 2009; Chapter 2 and 9.2); the restoration of various fountains (Chapter 7, Arquivo PNQ-4); preventive conservation of the Canal de Azulejos (Chapter 8); the restoration of the gardens and the installation of a hydraulic system concluded toward the end of 2010 (Chapter 4). The first four of these subprojects are described in detail in subsequent chapters of this book while the remaining two subprojects are described in the following section.

Recent Interventions

Improvement of the hydraulic infrastructure in the gardens was undertaken by IGESPAR (Institute for the Management of the Architectural and Archaeological Patrimony, which replaced the former IPPAR) in 2007. This new hydraulic system serves to feed the fountains while also providing much-needed irrigation for the gardens.

The new hydraulic system is based on a recirculation system that avoids water waste, an important environmental concern. For this purpose, a new underground receiving tank was installed at the bottom of the garden from which the water is pumped back into the upper tank into which new water is also added as required. The installation of the new pipe system had to be laid taking care to minimally disrupt the gardens. Included in this work was the structural consolidation of the tank of the Great Cascade, which was completed by 2008.

The restoration of the gardens was undertaken by the IMC (Institute for Museums and Conservation), which currently has the tutelage of the palace. The work started in 2008, after the hydraulic system had been installed. Along with improving the security of the gardens to avoid vandalism, they began with hiring and training gardeners. A thorough inventory and diagnostic survey was carried out to allow for the stabilization, conservation, and maintenance of this entire historic garden, and to develop the basis for a master plan to guide the intervention. The aim was to reopen the gardens to the public as soon as possible, which was accomplished by May 2009.

The last three years (2008–2010) were marked by the both complex and systematic tasks required. Following a survey of all existing trees and bushes in the gardens, various tasks were carried out, such as felling trees in an advanced state of decay along the avenues and in the park, required pruning of trees to improve them, cutting and treating all diseased plants, maintaining hedges and box bushes in the gardens, eradicating infesting plants in gardens and the park, and cleaning the orchards. Furthermore, a drip-irrigation and sprin-

kler system was installed in the Malta and Hanging gardens, the Maze, and the Medallions' Lane. The clearing and maintenance of the Forcadas Stream as well as that of the lower water course of the Jamor River was also undertaken. Finally, preventive conservation measures for the restored fountains and basins, as well as the monitoring and preventive conservation of the stone statuary, were adopted.

As of May 2010, not only are the formal gardens (Figure 8) and the park—from the Great Cascade to the marble Neptune Fountain and the upper water tank (*Tanque do Curro*), open to the public, but also the rest of the nearly sixteen hectares that include orchards and wooded areas. From this moment on it is necessary and fundamental to ensure continuity in the maintenance of these grounds.

The increased need for information on the gardens and to highlight the most important points worth seeing required an improved signage system for the visitor circuit. The integrated visitor circuit of the gardens also took into account the activities programs organized by the NPQ that include events for schoolchildren, weekend programs, and thematic visits for the general public. Information about the heritage of these gardens can be found on the institutional website and a recent publication (Cordeiro, 2011).

A master plan for ongoing work and maintenance was created, taking into consideration the original material and the undertaken interventions. Apart from the regular and ongoing maintenance and preventive conservation that will ensure the preservation of the important achievements of the completed project, new tasks need to be carried out for the restoration of the gardens, such as:

- Ongoing, progressive restoration of the gardens, wooded areas, and park, including the treatment of older specimens and the introduction of new species (such as those documented in the 1763 and 1789 inventories or that may require less-intensive maintenance, thus promoting the biodiversity of the park); the gradual restoration of the topiary characteristic of the gardens and the ongoing training of the required human resources needed; the reinforcement of the garden fences; the progressive substitution of felled or dead trees, initiated in 2011 through the support of Portucel Soporcel; and the regular updating of the species inventory.
- Complete the topographical survey of the gardens to allow the regular renovation of the walks, avenues, and paths.
- Install sound barriers along the IC 19—Great Cascade section, and complete the green cypress curtain installed (at the beginning of 2011) in this area adapted to hold outdoor events.
- Reactivate the greenhouses to grow plants and flowers for future replanting in flower beds and vases.
- Improve the drainage along the walls of the Canal de Azulejos, define the required restoration for the azulejo panels, and eventually consolidate the supporting walls. Rehabilitate the bridges over the Jamor river, located by the Portuguese Riding School arena and by the cafeteria.
- Improve the infrastructure required for the visiting public and of areas for commercial licensing.

- Diversify public, educational activities, and programmed events with due respect for the history of the garden and the spirit of the different areas in it following a communication and information strategy to gain public interest.

Agreements with universities are being considered for the development of studies and research on specific areas that still require a better understanding. This, in turn, will promote interdisciplinary collaboration with other institutions, particularly in areas of art history, conservation and restoration, and landscape architecture.

Furthermore, strategies of national and international diffusion will be developed to strengthen the link with cultural tourism routes and improve collaboration with similar national and international institutions. This approach is considered essential in establishing the National Palace of Queluz as a reference institution at national and international levels.

The objective to achieve is the reestablishment of a harmonious aesthetic and artistic equilibrium of the site, characterized by an intimate relationship between the palace and the surrounding gardens and park. This will offer improved accessibility to the public, better interpretation of its history (resulting in improved comprehension by visitors), and ensure the economic and social sustainability and long-term preservation of this monument and all its features.

Figure 8. Aerial view of the Hanging Garden with the Malta Garden to the left. The Gate of Fame can be seen at the end of the main axis, leading to the Cascade Lane.

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Chapter 2.

John Cheere and the Lead Statuary in the Gardens

Rupert Harris

Introduction

The lead statuary in the gardens of Queluz Palace includes the largest collection of works at one location produced by John Cheere, the most significant of a group of sculptors who proliferated lead sculpture in England in the mid-eighteenth century. The English enthusiasm for garden statuary had begun two centuries earlier when the influence of Renaissance Italy permeated north. It is thought likely that this was led by Lord Lumley (Davis, 1991) who, having traveled to Italy in the 1560s, then decorated his gardens at Nonsuch Palace with statuary and ornamental fountains that celebrated Elizabeth, the 'Virgin Queen,' whose cult was carefully orchestrated by associating her with powerful classical references. The European appetite for "the antique" grew, as ancient statues were excavated in Italy, and casts began to be exported to other European countries to be copied, studied, and admired by enlightened rulers and owners of great properties.

In terms of material, it is not known how many garden sculptures were made in lead in England during the reigns of Elizabeth I, James I, and Charles I. Few examples of early lead sculpture remain, the most notable perhaps being the small *"blackamore in led"* at the Red House, Marston Moor, that can be securely dated from Sir Henry Slingsby's diary in 1638 (Weaver, 1909).

Lead had been mined across England for centuries, and the expertise in the purifying and working of it, which had begun in medieval times for the making of ecclesiastical fonts, figures, and architectural fittings, was still widespread; further, Dutch and Flemish artists brought skills that enhanced English ones. The English Civil War (1642–1651) and subsequent Puritan rule (1649–1660) temporarily halted the acceptability of garden statuary in England, and it is likely that most of the lead sculptures that existed at that time were destroyed and made into musket shot.

The restoration of Charles II in 1660, and the increase in European travel among the wealthy and classically educated, revived the art of garden design and the use of sculpture in English gardens became extremely popular. A notable recorded example of late seventeenth-century lead statuary is Arnold Quellin's 1685 commission for Glamis Castle in Scotland, to

produce four lead statues and a bust, "the lead whereof is to bee hardened soe as they may bee of Sufficient Strength and Consistence" and "coloured over after the manner of brass." (Apted, 1984). Increased demand for such sculpture gave birth to an artistic industry based in the Hyde Park Corner and Piccadilly area of London, run by a small but hugely influential group of sculptors that included Van Nost, Scheemakers, and Carpenter as well as Henry Cheere and, later, his brother John. These sculptors and manufacturers of interior and exterior statuary produced their works in stone, plaster, and particularly in lead, chosen due to the ready supply and quality of English lead and for its affordability when compared to cast bronze or carved stone. The French also used lead for the production of the statuary and fountains for the palace of Versailles, and other European examples exist, such as the work of the Austrian sculptor George Raphael Donner (1693–1741).

The Significance of John Cheere as an Artist of Lead Sculptures

According to Weaver (1909), John Van Nost the Elder, the Flemish sculptor who had come to England with William III in 1689, started the first lead yard in Piccadilly, where he produced lead garden statues in considerable numbers. It is likely that he brought with him more sophisticated skills from Flanders (Fulton, 2003). Other artists' yards followed, including those of Andrew Carpenter and Henry Cheere. Henry Cheere (1703–1781) was a very successful sculptor, specializing in carved stone funerary monuments, busts, and fire surrounds. It is thought that Henry trained his brother John, and that in about 1739 he helped John to establish his own practice by purchasing Van Nost's statuary yard, along with his stock and molds—some of which may have originated with Quellin (Fulton, 2003)—and possibly Carpenter's molds as well.

Manufacturing both lead sculpture and ornament, and interior plaster busts and figures, John Cheere quickly dominated the trade for the next fifty years and ultimately made the most significant contribution to the quality, quantity, and variety of English lead garden sculpture. The statuary he provided ranged from antique Greek and Roman and Italian Renaissance figures and groups, to copies of later French and Italian sculptures, to contemporary portrait figures of royalty and noblemen. Pastoral rustic figures, Commedia dell'Arte figures, cherubs, and animals were also produced in large numbers—their modest scale and subjects more affordable and suitable to less magnificent grounds than those at, for example, Castle Howard in North Yorkshire, which boasted a large collection of classical subjects. Casting in lead, and finished to resemble stone or patinated bronze, or polychromed or gilded, was a cost-effective means of mass-producing garden sculptures, allowing the expansion of the market to properties throughout the country and abroad.

The classical subjects are perhaps the most admirable of Cheere's output, particularly the figure groups; powerful works of art both in their form and their allegorical resonance. The importance of the narrative power of classical themes and the ability to identify the subject (by the figures' attributes, for example) to the eighteenth-century audience should not be underestimated. As in Lord Lumley's time two centuries before, they retained sym-

bolic resonance (illuminated by literature) in the psyche of the eighteenth-century English viewer, provoking emotional and intellectual responses through the classical stories they represent, as well as by their aesthetic beauty, dynamism, and sculptural magnificence (Figure 1).

Both in his own time and until recently, Cheere's work was often not respected; this may be largely due to the major critics of his time, Horace Walpole and George Vertue, who dismissed him because the majority of his works were not original. Early nineteenth-century critics such as Cunningham also wrote with a bias that turned away from the artisanal and collaborative nature of eighteenth-century sculptural practice and emphasized individual creativity, which no doubt has served to further diminish Cheere's importance in art history (Baker, 1995). Cheere's production methods should be read as a direct development of the widespread working practices of the English mason-sculptors. They are known to have adopted practical working methods that included repetition of designs, use of preproduced sculptural elements, collaboration with other sculptors, and subcontracting to skilled artisans. This was particularly true of Henry Cheere (Baker, 1995), who aimed to provide an affordable, fast service to his clients and who would have educated his brother John in these effective operational and commercial practices.

Though the evidence of Cheere's craftsmanship and sculptor's eye is clear, the same could not be said of all the objects produced by the trade as a whole, and Cheere may have been tarred by the same brush that reviled the output of lesser statuaries that produced inferior lead statues in the same area of London, probably as part of a wider supply of vases and urns, fountains and other more prosaic garden ornament, as illustrated by Benjamin Rackstraw's 1738 trade card (Baker, 1995).

Today, the quality of John Cheere's work is not in question, but was he a sculptor or simply a high-quality manufacturer? It is true that many of his works were produced from molds taken directly from casts of the Antique. However, recent research (Fulton, 2003; Neto and Grilo, 2006) confirms that some of his works were sculpted within his workshop, suggested by drawings of sculpture and engraved imagery brought from Europe, or possibly inspired by maquette-sized sculptures that he may have acquired or seen (such as Fanelli's *Venus and Adonis*, which can be seen at the British Museum). Though more research needs to be carried out in this field, it is clear that not only John Cheere's craftsmanship but the artistic quality of his work is consistently high, that he skillfully altered, rescaled and adapted existing models and, moreover, modelled his own sculptures from scratch (for example, his *Demosthenes)* (Fulton, 2003), all of which retain aesthetic integrity, subtlety, and emotional force.

Figure 1. An example of Cheere's *Aeneas and Anchises* at Wrest Park (English Heritage), whose paint has been restored to its original finish to resemble stone.

Encouraged in particular by Moira Fulton's work and by the attention that this project at Queluz and its associated research has brought, John Cheere's status is undergoing reappraisal, and this must continue.

The Significance of the Queluz Collection

It is thought that well over half of all English lead sculpture produced during the eighteenth century, including John Cheere's, has now been lost. This is mainly due to its susceptibility to structural failure and (until recently) the technical difficulty in making repairs. As the sculptures deteriorated, they became devalued and many were disposed of. Similarly, collections were broken up over the years as properties declined and their contents were sold off and dispersed. Much eighteenth-century lead statuary and ornament was also sacrificed to the need for lead in time of war, to manufacture shot.

The significance of the lead statuary by John Cheere at Queluz Palace is great and twofold: Firstly, this collection was one of Cheere's largest commissions and though many pieces have been lost, it still stands out as the largest collection that remains in its intended garden, and importantly it includes the two groups of *Bacchus and Ariadne* (Figure 2) and *Vertumnus and Pomona* (Figure 3), which, as far as current research indicates, are sole surviving examples of these models by Cheere. Further research needs to be carried out as to whether these groups are indeed unique, what Cheere's sources for them might have been, and to what extent they represent original work.

Secondly, Cheere's statuary is rarely signed and the fact that he is known to have used some molds originally owned by other sculptors often makes definitive attribution complex and difficult. While some written records remain in England to illuminate details of Cheere's production, mainly in the form of bills, they are somewhat brief and scattered—whereas the detailed records covering the sale of 9 groups and 57 figures, plus 72 vases or urns (Neto and Grilo, 2006) to Queluz Palace in Portugal is unique in its scope, and is the closest we have to a catalogue of Cheere's output at that time (1755–56). The inventory of 1761 provides unique detail on the colors in which the statues were painted (Caldeira Pires, 1924). Further documentation gives us insight into his methods, such as his instructions regarding the careful unpacking of the works, how they should be fixed in place, and how to clean them and maintain their paint finish (Neto and Grilo, 2006).

Of the 20 lead statues, groups, and fountains that remain in the palace gardens and of the large number ordered from Cheere, it is agreed that 11 sculptures can be positively identified as John Cheere's. These are:

1. *Mars*
2. *Minerva*
3. *Cain and Abel*
4. *Diana*
5. *Apollo*
6. *Bacchus and Ariadne*

7. *Venus and Adonis*
8. *Meleager and Atalanta*
9. *Vertumnus and Pomona*
10. *Rape of Proserpine*
11. *Aeneas and Anchises*

He is on record as providing 138 items, and as it is known that the statuaries at Hyde Park Corner often cooperated with each other (Baker, 1995), it is very possible that he subcontracted some of the work or elements of the manufacturing to other sculptors' yards, due to the size of the order and the short period of time between obtaining the commission and the delivery of the sculpture to Queluz.

The remaining nine lead sculptures and fountains still at Queluz, such as the Neptune Fountain, do not conform precisely in subject, style, or technique to the attributable works of John Cheere nor to those of his English contemporaries. On stylistic grounds alone it is likely that these remaining nine items are of European origin or were even made in Portugal, perhaps with the assistance of French sculptors. The sculptures, and particularly the fountains, draw their design and iconography from the rococo and neoclassical gardens of northern Europe of the late seventeenth century and therefore probably indicate that they were designed by Robillon. The lead sculpture and fountains at Versailles show a stylistic similarity in form and subject to those at Queluz and may well also have been a strong influence; they were also finished, as at Queluz, with paint and gilding. Clearly the French were manufacturing large quantities of lead sculpture eighty years prior to the creation of

Figure 2. *Bacchus and Ariadne.*

Figure 3. *Vertumnus and Pomona.*

the gardens at Queluz, and as Portugal was considered politically neutral to France up until the late eighteenth century, trade between the countries is likely, and French manufacturers should be considered as a possible origin or association for some of the Queluz sculpture. However, it has been suggested that elements by Cheere may have been incorporated into the fountains (Neto and Grilo, 2006) and this theory can be supported by the fact that the female figures around the Neptune Fountain pool bear marked similarities to Cheere's figures (compare their faces with that of *Pomona).*

Manufacturing Technique

From the earliest times lead objects have been made using either the sand or lost-wax casting methods. The techniques used for producing lead sculpture were basically the same as those for bronze, but with one significant difference in that the 'core'—the refractory material, such as sand or plaster, which forms the internal space of a hollow casting—was usually removed from cast bronzes while it was left inside leads. Large bronzes could be cast in rigid, strong sections so the core could be removed before assembling the sculpture using pinned Roman joints. However, lead is a softer material so the structure was inherently weaker; also the ability to lead-weld joints as we would today using mixed gas and air torches was not available until the start of the twentieth century, and although soldering was possible it is not strong enough to hold large, heavy lead sections together. So with large lead castings the core material was left inside in order to provide some support and to allow wrought-iron armatures to be incorporated into the core before casting, which could also be used to secure the statue to plinths or buildings. (It was this practical necessity of retaining the core that has promoted a significant proportion of the deterioration of lead statuary and the conservation problems faced today, as described later in this chapter).

John Cheere and his contemporaries cast their statuary using this traditional method. The surface of the lead was then fine finished and tooled to add texture and refinement to the piece. Cheere's craftsmanship, demonstrated in the quality of his surface finishing (known as *chasing*) in textured areas such as hair, is consistently distinctive and superior to that of his contemporaries (Figure 4). His other distinctive trait is the manner in which he often mounted the bases of his groups such as that of *Aeneas and Anchises* onto stonework, where the lead is formed around a carved piece of limestone to suggest a naturalistic ground (probably imitating the later style of the works that influenced these pieces) (Figure 3).

Original Surface Finishes

It is on record that most English lead statuary was finished and colored before it left the workshop. The larger, classical Renaissance subjects were generally painted to imitate stone or marble (Figure 1). Others were finished to resemble patinated bronze using tinted lacquers and glazes, an excellent example of which survives on the interior sculpture of *Andromeda*

at Osterley Park in Middlesex. Royal portrait figures were often leaf-gilded. Comic subjects such as Punch, Harlequin, and other pantomime figures, and the rustic mowers, haymakers, and shepherds were generally smaller than the classical subjects and were often painted in polychrome (Figure 5) as described in J. T Smith's Streets of London, "…the figures were cast in lead as large as life and were frequently painted with an intention to resemble nature," and more specifically in the 1761 Queluz inventory that describes the color schemes in great detail, for example, "…sculpture representing an elderly man…, with black shoes, red heels and big laces of the same colour, white socks, black trousers, red leather strap holding the trousers up, black dress coat and black Phrygian cap on his head" (Caldeira Pires, 1924).

There are references from Boxwood, Wiltshire, in 1762 to sculptures being oiled, which could suggest that some were sold with a natural-colored surface, though we know those with painted surfaces were also oiled for protection, as described in Cheere's own instruction for maintenance to his client the Duke of Atholl, "…. once in two years it should be washed very clean and oyled over with Linseed Oyles" (Davis, 1991). The written evidence is confirmed by contemporary and earlier paintings of gardens (for example, Dankaerts' 1675 painting of the gardens at Ham House in Richmond), and now by paint analysis of the rare examples of works on which traces of original paint still exist in recessed areas or preserved beneath subsequent layers of paint, as discussed and illustrated subsequently (Figures 11 and 15).

Inevitably, the original artificial surface finishes degraded over time. Although some appear to have been fairly consistently maintained for years, in the end most of the decorative surface finishes were almost universally lost, resulting in a change to our expectations and our perception of what is appropriate and "tasteful," so that by the time Weaver (1909)

Figure 4. Example of Cheere's typical chasing technique.

wrote his thorough treatise on English leadwork, he described the practice of painting lead in "all the colours of the rainbow" as "a superfluity of naughtiness" and elsewhere spoke of "…the exquisite patina that lead takes on when it weathers. This is a charm peculiar to leadwork, and it is of a simple graciousness which makes the figures harmonise with the domestic dignity of English formal gardens in a way that stone never does" (Figure 6). (Weaver was voicing his own view here, clearly not based on the evidence in eighteenth-century records and literature and what we now know from analysis of surviving examples).

Weaver's opinion is still held by many today, and the natural patina of untreated lead is prized. Though the practice of restoring original surface treatment such as the lead groups at Wrest Park, which have been repainted in their original finish to resemble white stone (Figure 1), is acceptable to the modern eye, the polychroming of, for example, the rustic figures is harder for us to accept, particularly when the paint is freshly maintained and unweathered. Though mid-nineteenth-century awareness of historic polychrome liberated sculptors of the time (Luke 1996), it seems not to be a fact that is readily remembered or celebrated, and responses ranging from fascination to discomfort to outright horror have been noted to the recent examinations of the original polychrome exteriors of medieval cathedrals and of classical sculptures themselves, as researched by Prof. Dr. Vinzenz Brinkmann for example, and displayed in a touring exhibition (Brinkmann and Scholl, 2010). One might term this reaction "the shock of the old;" however there are subtle ways to approach the restoration of coloring that would perhaps more accurately reflect the appearance original

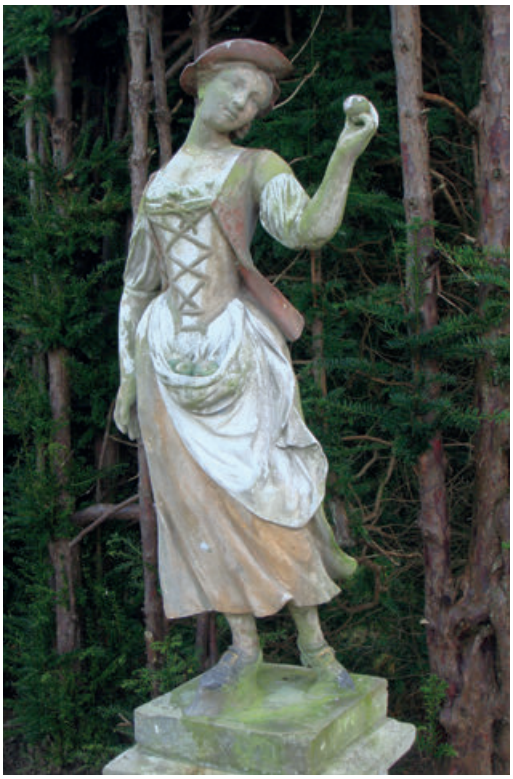

Figure 5. A polychrome lead Shepherdess at Antony in Cornwall (National Trust).

Figure 6. Natural patina on the same model as Queluz's *Meleager and Atalanta* at Anglesey Abbey (National Trust), which is known there as *The Olympian Courtship*.

polychromed sculptures may have actually had for much of their life, given the original use of lead-based paints that would have softened and faded in an outdoor environment more rapidly than modern paints.

The question of whether to restore original surface coatings presents curators with a problematic set of decisions. The new problem of the formation of visually intrusive, dark brown lead dioxide, which has lately been affecting the surface of many lead statues and architectural leadwork (see Chapter 6) may yet influence the conservation community's attitude to the restoration of painted surfaces on outdoor lead statuary. As a general principle, specific evidence should be found before embarking upon restoration to any type of original finish. The aesthetic of a garden or historic property and the taste of the people who enjoy them can evolve, and like Weaver, we have become accustomed to the 'simple graciousness' of the natural patina of lead in a garden setting. However, the knowledge we now have of the original appearance of eighteenth-century garden ornament must not be ignored. Clearly, despite paint analysis evidence, the aesthetic of the gardens of Queluz Palace may not be appropriate for painted finish restoration on the leads. However, it is important to ensure awareness in the contemporary viewer of the exuberance of the original garden by acknowledging that the sculpture here was once decorated in either the monochrome hues of natural stone or richly polychromed and gilded.

Summary of the Conservation Carried Out

Condition

The primary reason for structural failure of lead sculpture is the corrosion of the wrought-iron armatures and fixings within the casting. If water enters the casting and the porous core material becomes wet, the iron corrodes. Rust can expand to ten times the volume of the pure metal. This results in huge expansion pressures being exerted on the lead casting, which after some time will split, allowing more water to enter and accelerate the decay (Figure 7). Rust also weakens the armature or fixing which, if the sculpture is fixed to a stone plinth, can cause fracturing of the stone by the pressure of rust jacking and result in instability and even collapse.

The casting process itself can also contribute a number of problems that can develop into structural failure. Impurities in the metal, if not properly removed during casting, incorrect temperature of the metal at pouring, poorly fired molds, or damp core material can all cause problem areas that can accelerate deterioration and make repair difficult.

When we first examined the collection of Cheeres at Queluz in 2003, their condition was varied. Most had suffered from damage such as slumping and splitting caused by their failing, expanding iron armatures (Figure 7). Others had more dramatic physical damage such as suffered by *The Rape of Proserpine* (Figure 8), and *Venus and Adonis* (which had been struck by a falling tree branch, see Figure 2 in Chapter 9.2). Others, such as *Diana,* were missing attributes (Figure 9), though her quiver was held in storage at the palace, and some were missing parts, such as the drapery on *Aeneas*.

Several had been restored in earlier interventions, most recently during the mid-twentieth century, using improvised and sometimes bizarre techniques, documented in photographs at the time (Figure 10). *S*ome of these methods were found to have been successful at halting deterioration, although today such techniques would be considered unnecessarily drastic.

Principles

Our schedule for the conservation was established largely on the found condition of each sculpture, priority being given to those sculptures with structural failure due to armature problems or those with severe deformation caused in the main by accidents, as described in more detail in the following chapter. Our techniques and methodology for repair had been well-established during our previous twenty-five years' experience in the conservation of eighteenth-century lead sculpture. Although the structural condition of lead sculptures often requires significant intervention to ensure their survival, the conservation work we undertake adheres to the following principles in order to reduce this intervention to a minimum:

- Research, sampling, and analysis of original surface treatments such as paint or leaf gilding.
- Careful assessment of the structural condition and the planning of all conservation work seen as necessary to ensure damage to sculptural detail is minimized.
- Photographic recording of the condition prior to work commencing.
- The removal, where necessary, of past, poorly executed restorations.
- The removal of damaging iron armatures and, where necessary, core material.
- The introduction of new, stainless steel armatures to restore structural integrity.
- The exclusive use of traditional lead-burning techniques using pure lead only, not solder.
- The preservation during the work of as much naturally formed surface patination and surviving original paint or gilding as possible.
- The total avoidance of abrasive or mechanical surface cleaning techniques.
- The employment, where necessary, of localized patination techniques and/or overpainting of areas where repair work has been carried out to ensure the repairs are not visually distracting.

Training

The scheduling of the works to encompass the training of local conservators was an important part of this project. This began with the setting up of an on-site workshop, where we worked on several of the lead figures with four Portuguese post-graduate conservation students. This training program was augmented by two of the students working with us on

Figure 7. Crack in the back of *Vertumnus*, caused by expansion of internal iron armature.

Figure 8. *The Rape of Proserpine*, showing severe distortion from impact damage suffered in the past.

Figure 9. *Diana*, missing attributes of arrow and bow.

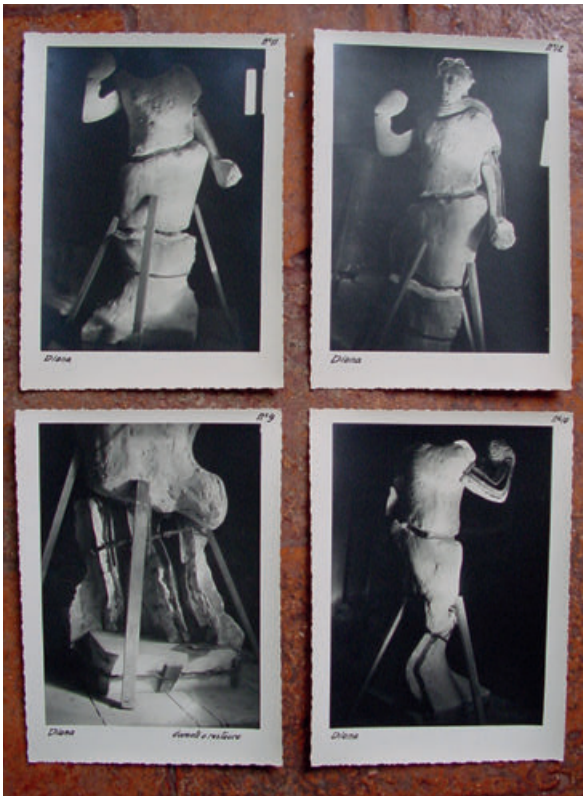

Figure 10. Photographs in the Queluz palace archive showing earlier restoration of the figure of *Diana*.

two lead groups from the collection in our studios in London. Further details on the training program can be found in Chapter 9 of this publication.

Surface Treatment of the Sculptures

As many of the leads had undergone quite radical restoration and cleaning in the past and the overall condition of many pieces was poor, many of the sculptures had lost evidence of their original painted surface coatings during those works. However, two of the Cheere groups retained large amounts of their original paint (Figure 11) and others few traces, some of which were cross-sectioned and analyzed as part of the project. These samples show that these Cheere groups and single figures were painted to imitate stone, of a color resembling the limestone on which Cheere mounted these pieces (as shown later in Figure 15). The retention of this historic evidence of decoration is an important part of the conservation of a sculpture's surface.

Where no original surface coatings exist, the naturally formed light to dark gray patina found on the leads was typical of that found on most lead sculpture exposed to the atmosphere, however many also exhibited a dark brown discoloration of their surface (lead dioxide formation), some in localized areas but others were heavily discolored (such as *Vertumnus and Pomona* and the Neptune Fountain). The presence of this discoloration was visually disruptive to the sculptural form of the compositions and, as such, it was considered undesirable on aesthetic grounds alone (Figure 12). Research into this phenomenon is in its

Figure 11. Remains of original paint on the putto of the *Vertumnus and Pomona* group.

Figure 12.
Intrusive dark brown discoloration on *Vertumno and Pomona.*

early stages; as part of this project a decision was made to carry out further research, which is dealt with in Chapter 6 of this publication.

Example Conservation Treatment: *Aeneas and Anchises*

At the time of our first inspections, two of the sculpture groups were an unknown quantity, as at some time in the past they had been removed from the gardens into storage and covered in a mixture of plaster of Paris, horsehair, and supporting wooden battens (Figure 13), presumably in an attempt to stabilize them until restoration could be undertaken.

These two sculptures were the first to be treated at our studios in London where careful removal of the plaster covering revealed them to be life-size groups depicting *The Rape of Proserpine*, and *Aeneas and Anchises* (Figure 14).

The remains of early paint schemes were found on the surface of *Aeneas and Anchises*. Analysis revealed that the sculpture had received at least six paint treatments up until the early twentieth century (Figure 15). These schemes were all of light gray/stone colors. The red color, visible now on this particular sculpture group, is the remnant of a coat of an oil-bound red iron oxide primer, applied prior to the application of stone-colored paint.

Several parts of this sculpture were found to be missing or damaged beyond repair. Molds were taken from another Cheere cast of the sculpture at Wrest Park, (Figure 1), with the kind permission of English Heritage, and the missing pieces were cast in lead and attached to the sculpture. Damaged areas were then repaired by lead-burning and a new stain-

Figure 13. A figure group later revealed to be *Aeneas and Anchises.*

Figure 14. Revealing *Aeneas and Anchises.*

less steel armature inserted to support the sculpture and the base area (Figure 16).

Before re-siting in the palace grounds, discussions took place with Queluz Palace and World Monuments Fund Portugal and decisions were made regarding the surface treatment that the sculpture should receive to try to protect it from the disfigurement of lead dioxide formation. It was decided to treat the surface with a lead patination oil, and areas where repairs had been carried out were selectively painted to match the surrounding surface color using thin coats of tinted, matte, casein-based paints.

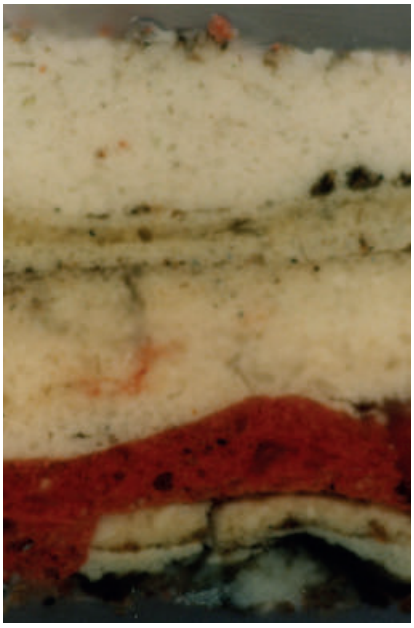

Figure 15. Photomicrograph of a paint layer cross section from a sample on *Aeneas and Anchises.*

Figure 16. New stainless steel armature constructed to support the base.

Exhibitions

Though surviving examples of English lead statuary can be seen in the gardens of many great houses in England, the genre is significantly under-represented in the sculpture galleries of our museums, and until recently, has attracted little academic interest. After conservation in London, both *The Rape of Proserpine* and *Aeneas and Anchises* were placed on temporary exhibition at the Victoria and Albert Museum. Later, following the London-based training workshop, the groups of *Venus and Adonis* and *Bacchus and Ariadne* were also exhibited, this time at Tate Britain. The sculptures were very well received and it is hoped that this initiative has helped to raise the profile of English lead statuary and Cheere's craftsmanship.

Conclusion

John Cheere died in 1787, but lead statues had already begun to fall out of fashion in the late 1760s when the taste for garden design changed to that of a 'natural' landscape. Finally, war with Napoleon (1803–1815) led to the closure of the remaining lead-casting yards in London, and their stock was melted down for ammunition. The nineteenth century, with its admiration for individual artistic achievement, brought a rather hostile attitude to the mass-produced castings of Hyde Park Corner, and without the enthusiasm or technique to preserve them, many were lost to wanton damage or neglect. The conservation and ongoing maintenance of the remaining lead sculpture in the gardens at Queluz is therefore of great importance; much has been learned by all involved in the work, and it is hoped that the project has greatly added to the appreciation of an unfairly neglected, misunderstood sculptor.

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Chapter 3.

An Innovative Artistic Program: The Commissioned Lead Statuary for the Queluz Gardens

Maria João Neto and *Fernando Grilo*

Introduction

At the time the conservation and restoration project of the gardens of the National Palace of Queluz was undertaken by World Monuments Fund Portugal and World Monuments Fund Britain, art historical studies revealed the existence of an important collection of relevant documents. These provided detailed information regarding the commissioning of the lead statuary from the workshop of the English sculptor John Cheere (1709–1787) by the then-Prince of Portugal, D. Pedro, Lord of the Casa do Infantado, and husband to the future queen, D. Maria I (Neto and Grillo, 2006).

The Prince D. Pedro

Who was Prince D. Pedro (1717–1786) and what compelled this member of the Portuguese royal family to give John Cheere such a huge commission? Few studies exist about this figure, described as "shy and highly religious." Nevertheless, D. Pedro was an enlightened prince and sensitive to novelties. He was the grandson of Emperor Leopold I of Austria, the favorite son of D. João V of Portugal, and beloved brother of Maria Bárbara, consort of Fernando VI of Spain—from whom, in fact, he inherited his entire personal fortune. Around 1747, the prince decided to transform an old country mansion in Queluz, in the vicinity of Lisbon, to a summer palace. The project would include the gardens and a park area, in addition of the orchard and vegetable gardens. Queluz served him as a reasonable summer residence, but his royal lineage demanded great splendor which was underlined when, in 1760, he married his niece, Maria, heiress to the Portuguese crown.

The organization and design of the gardens of the Queluz residence were under the influence of his sister, Maria Bárbara, since she also directed the works of the gardens of the Aranjuez Palace, close to Madrid. For Queluz, a decorative plan was developed that included fountains with water sprays, a navigable canal lined with tiles, marble sculptures that were brought from Genoa, and the innovation, in Portugal, of lead statuary.

Versailles as an Example

In the eighteenth century, the fashion for French gardens took hold of Europe, with Versailles serving as the most important model. The aesthetic demanded abundant sculptural decoration, whose production in stone was lengthy and expensive. In England, marble was not abundant and the climate was too harsh for the proper preservation of the statues. Sculptors such as John Cheere were on the lookout for new materials and methods for statuary production. Thus workshops for the fabrication of lead statuary were developed for a faster and cheaper mass production of statues. These workshops created the classical models that were fashionable at the time using lead, making garden statuary far more accessible from an economical point of view. A proliferation of these mass-produced statues occurred, following antique, Greco-Roman models, as well as newly developed pastoral motifs, animal images, and many other shapes. The novelty was not only in the speed and low production costs, but in the precision of details and the paint finish. The latter could provide attractive and innovative appearances, such as white, mimicking marble, gilded, or with natural colors. The paint finish served not only an aesthetic purpose but also as protection for the metal and its conservation, provided the maintenance routine was kept up.

At the time, lead sculpture gained a place in its own right in gardens, alongside the more conventionally classical subjects in stone. Gradually, these also came to be produced in lead. Nevertheless, the characteristics of this material were best exploited through the refinement of detail and rocaille-style polychromy.

In 1746, John Cheere was already referred to as an eminent sculptor by the London press (Friedman and Clifford, 1974:6). However, he was not mentioned by contemporary experts and art critics, such as Horace Walpole or George Vertue, which explains why Cheere fell into historical oblivion. It is likely that Walpole and Vertue did not mention him because they considered artistic creation as reflecting individual genius producing a unique "work of art," and this was not the case for mass-produced objects resulting from the use of molds. Thus the concept of originality could not be applied to a mechanical and craft-based production that was clearly below the artistic level. Nouveau riche and rural clients who were satisfied with poor and crude lead or plaster reproductions were satirized as culturally ignorant (Baker, 2000:121–122). Nevertheless, the list of clients of John Cheere shows another reality. The evaluation of the pieces produced in his workshop in conjunction with the evidence of archival records serve to rehabilitate the reputation of this sculptor (Fulton, 2003a).

The Commissions

The research carried out confirmed the authorship of the lead statuary in the gardens of Queluz, and revealed some important aspects of Cheere's repertoire and how his workshop operated. The commissions made by D. Pedro were certainly some of the largest that this British sculptor ever received. Although the numbers were known, they were

the result of a misinterpretation of isolated invoices that only related to the number of crates transported from London to Lisbon (Caldeira Pires, 1925:283–284, 286; Afonso and Delaforce, 1986:16–17). It is now known that two separate commissions were made for a total of 9 sculpture groups, 57 individual figures, 72 vases, all in lead, with a total cost of £1,143 (Neto and Grilo, 2005). The numbers become significant when comparing them to those spent by the Duke of Athol, one of the most important and loyal clients of John Cheere. Between the years 1740 and 1761, he spent £411 in statues for Blair Castle (Fulton, 2003b:35).

It has been suggested that the idea of buying lead sculptures from John Cheere may well have come from Lisbon's wealthy British community. The British consul was the father-in-law of Joseph Wilcocks, Dean of Westminster. Wilcocks knew Henry Cheere (John Cheere's brother) and had been chaplain to the English factory in Lisbon (Afonso and Delaforce, 1986:17). However, the discovered documentation leads us to another charismatic figure in Portuguese history: Sebastian Jose de Carvalho e Melo, future Marquis of Pombal, who was directly involved in the commissioning and shipping of the pieces. Carvalho e Melo had been the Portuguese ambassador in London between 1738 and 1742, where he could certainly have become acquainted with the fashion for lead statuary in garden decoration. Perhaps he even learned of Cheere's yard; the sculptor set himself up at Hyde Park Corner during the minister's time in the British capital, and had no shortage of orders. His workshop benefited from being at the gates of London, opposite Green Park, and attracted the attention of those who traveled along the road to Windsor. The description made by an unknown Irish cleric reflects the visual impact made by the well organized exhibition of statues, as well as the interest it awakened in travelers to visit the workshop (Fulton, 2003a:25). If William Hogarth's engraving of 1753—published in *The Analysis of Beauty* (Hogarth 1753)— corresponds to Cheere's yard (Fulton, 2003:22), an idea can be obtained of its organization, even though the engraving had mainly didactic objectives rather than documentary ones. The reputation of the artist, who had already provided statuary to public figures such as Lord Burlington, was reinforced by the completion of a gilded lead statue of George II for the Royal Square of St. Helier, Jersey, in 1751. The same year, other important works were created for Blair Castle and Stourhead. A year later, he worked for Hampton Court, and in the following year was commissioned for the equestrian statue of William III for Petersfield, Hampshire (Gunnis, 1968:99). At the time, John Cheere was probably the most famous lead sculptor in England.

It is uncertain whether the future Marquis of Pombal had any influence in putting John Cheere's name forward, and introducing lead sculpture to the Queluz gardens. However, we do know that he took charge of the first commission in 1755. A list was sent to the Portuguese ambassador at the British court at the time, D. Luis da Cunha, a man in the confidence of Carvalho e Melo. The list clearly implies an iconographic program according to the prince's taste. The pieces ordered suggested that, initially, it was conceived as a stately garden, with mythological and symbolic sculptures being ordered for it. It was then connected to another area designed for privacy and leisure, for which picturesque and bucolic figures were commissioned. This program featured different types of gardens for different activities, which was unique in Portugal at the time.

The ambassador put all his zeal and thoroughness into handling the commission. He placed an order with John Cheere to produce the pieces on the list sent by the Marquis. He visited the workshop and followed the progress of the sculptures. He also ordered some modifications in terms of decorum, probably following instructions he had received, and the changes were made to some nude statues before they were sent to Lisbon (Arquivo Torre to Tombo-1). Cheere, at the time, was also busy with an unusual order from America for 24 gilded, life-size cows, which puzzled the Portuguese ambassador somewhat. By the end of July 1755, everything was ready and prepared to be shipped on the Camborwell, heading for Lisbon. Thirty seven crates were loaded, containing two sculpture groups representing *Meleager and Atalanta* and *Vertumnus and Pomona,* 23 individual statues with mythological figures such as *Nepture, Meleager, Mercury, Fame, Apollo, Diana, Bacchus, Venus, Ceres, Flora*, as well as a *Gladiator*, the *Four Seasons*, four figures from the Commedia dell'Arte (*Pierrot, Harlequin, Scaramouche* and *Columbine*), four other figures (*Shepherd, Shepherdess, Man with a drum and flute, Woman with a rake*) and 24 flower vases (Arquivo de Tombo-2). The price came to £290 5s 2d, to which were added the costs of packing, shipping, and customs, which brought the total cost to £340 18s 6d (Neto and Grilo, 2006:16–18).

Along with this invoice, Luís da Cunha sent, on his own initiative or at the sculptor's suggestion, the list of pieces produced at the yard, in case Prince Pedro or anyone at the Portuguese court might be interested in placing new orders. Cheere knew how to cultivate good customers, as is evident from his group of faithful buyers over the years (Fulton, 2003b:36). Furthermore, John Cheere, like his brother, Henry, in addition to being good artists were persuasive businessmen (Fulton, 2003b:26).

The list, in French, of all the pieces available at the time were ranked by hierarchy: groups and isolated figures, organized according to subject, size, and price, as in the mentioned description of the Irish cleric. Cheere also adds that he is ready to make *Toutes sortes des fontaines, d'oiseaux de bettes de poisons, & toutes sortes d'ornements en cuivre, marbre, plomb & Pierre, & des petites statues de platre de Paris de couleur de bronze ou polies comme le Marbre* (Neto and Grilo, 2006:18).

It is now possible to confirm which sculptures Cheere sold in or around 1755. His repertoire was much greater than those produced by Carpenter's in 1723, when compared to the latter's yard list, published by Gunnis (1968:83). Mythological themes dominate, followed by prosaic, rural figures and Commedia dell'arte characters. The sizes vary, even with the same representation, between six feet and three feet six inches. The prices also range from £4 14s 2d for a Harlequin, Pierrot, or Scaramouche figures in the smaller size, to £84 for a Aeneas group, which the artist justified by saying that it was a *pièce três Belle & demande beaucoup d'ouvrage*.

Prince D. Pedro, whose taste was formed by the Italian baroque sculpture that his father, D. João V, had ordered for the great basilica at Mafra, was certainly pleased by the shipment received in 1755, and wasted no time in sending a second commission after the Lisbon earthquake of November 1 of that year. Despite now being in Lisbon, D. Luís da Cunha handled the deal, charging his successor in London, Martinho de Melo e Castro, with the

necessary responsibilities to carry out new transactions.

On September 20, 1756, the commission of the 58 crates was loaded and the ship, *Nossa Senhora do Socorro*, set sail, containing seven sculpture groups (*Rape of Proserpine, Aeneas and Anchises, Rape of the Sabines, David and Goliath, Cain and Abel, Venus and Adonis, Bacchus and Ariadne*); six figures (*Hercules, Meleager, Atalanta, Justice, Minerva,* and *Mars*); 16 animals (four monkeys, four lions, four tigers, one harpy, one eagle); 4 perforated groups for large fountain centers and water sprays; 8 putti to decorate cascades; and 48 vases painted in gold and bronze, adding up to a total of 89 figures. The total value of this commission reached £856 13s, but the artist offered a 12 percent discount. The final cost, including shipping and custom fees was £853 14s 1d (Arquivo Torre do Tombo-3).

An Innovative Artistic Program

With this second commission, the prince bought practically every model in the sculptor's repertoire. Therefore, the iconographic program developed for the gardens of Queluz was adapted to John Cheere's works. The thematic unity results from the choice made by the artist in the works he produced, in an attempt to follow the taste of potential clients at the time, aiming to conquer the prestigious international market. Queluz now had an eclectic sculptural program, an innovation in Portugal and as fashionable as any European garden.

In 1763, the first inventory of the possessions of the palace and gardens of Queluz was carried out, and gave the location of these pieces, together with those of the stone sculptures of Portuguese or Italian origin, following an organization proposed by the French architect Jean-Baptiste Robillion (d.1782) and collaborator of the goldsmith Thomas Germain (1673–1748). Based on this inventory, it is possible to attempt a reconstruction of the original arrangement of the lead sculptures, obtained from the two commissions to Cheere (1755 and 1756). However, it is not always easy to interpret the calligraphy in the inventory, and the many changes undergone in these gardens over time also have to be taken into account (Figure 1).

Queluz Palace had grown up around a former noble residence and the various functional spaces were being reorganized at the time. The principal, courtly, and scenic axis of the palace leads directly to a large *parterre*, referred to as the Hanging Garden. The newer bordering buildings also led to other areas in the gardens, which had intimate, playful, but also formal, aspects. To the north, near the azulejo-decorated canal, the statues were grouped around fountains or placed along a shaded grove not far from a sort of merry-go-round with wooden ponies, referred to as Jogo dos Cavalinhos, and a small pavilion, called Barraca Rica, neither of which has survived.

The second commission reinforces the idea that a ceremonial garden was being developed to the south, directly in front of the state rooms of the palace, since the façade was decorated with a considerable number of large statues in classic style placed on the cornice. This disposition together with those on the parterre must have resulted in spectacular

scenery never beheld previously in Portugal. This iconographic and formal scheme of the parterre was increased by lining its entry walk with a symmetrical arrangement of four pairs of animals facing each other.

Cheere sought inspiration directly from classical works that he had at hand. He certainly had access to the famous marble group by Giambologna (1524–1608), *Samson Slaying a Philistine*, currently at the Victoria and Albert Museum, which at the time was at Buckingham House. This was one of the groups sold as *Cain and Abel* for the Queluz gardens in 1756. From the same artist, but probably from an engraving, drawing, or acquired molds, he

1. *Caim and Abel*
2. *Neptun*
3. *Meleager*
4. *Justice*
5. *Hércules*
6. *Rape of the Sabine Women*
7. *Venus and Adonis*
8. *Bacchus and Ariadne*
9. *David and Goliath*
10. *Marble sculpture*
11. *Marble sculpture*
12. *Fame*
13. *Roman gladiator*
14. *Winter*
15. *Autumn*
16. *Summer*
17. *Spring*
18. *Vertumnus and Pomona*
19. *Meleager and Atalanta*
20. *Eagle*
21. *Harpy*
22. *Lion*
23. *Lion*
24. *Lioness*
25. *Lioness*
26. *Tiger*
27. *Ounce*
28. *Group for the tank*
29. *Group for the tank*
30. *Group for the tank*
31. *Group for the tank*
32. *Apollo*
33. *Venus*
34. *Diana*
35. *Ceres*
36. *Flora*
37. *Bacchus*
38. *Shepherd*
39. *Shepherdess*
40. *Man with flute*
41. *Women with a rake*
42. *Pierrot*
43. *Harlequin*
44. *Scaramouche*
45. *Columbine*
46. *Aeneas and Anchises*
47. *The rape of Proserpine*
48. *Mars*
49. *Minerva*
50. *Adonis*
51. *Mercury*
52. *Two foxes*
53. *Eight boys*
54. *Monkey*
55. *Two tigers*

Figure 1. Initial location of John Cheere's sculptures in the Queluz Gardens. (Plan of Queluz Palace and Gardens, 1987), 1987, DGEMN (reproduced courtesy of Queluz Palace).

reproduced the *Rape of the Sabine Women,* from the Loggia dei Lanzi in Florence, as well as the *Neptune* from the fountain in Piazza Maggiore, Bologna. Both were acquired for Queluz, but only a piece of a torso remains from the former group, now exhibited in the interior of the palace (figure 2).

Although Cheere created his pieces without losing the vigorous characterization or delicacy of the originals, he occasionally made a variation on an original he was working from. Such is the case for the *Aeneas and Anchises* group, inspired in the French sculpture by François Girardon (1628–1715), with subtle alterations to the figure of the old man, Anchises, to the mother, and son of Aeneas.

His talent enabled him to move away from standard production and create works based on customers' requests. It should be pointed out that in Prince Pedro's first commission, two of the statues that were ordered and produced, *Mercury* and *Fame*, do not appear on the sculptor's list.

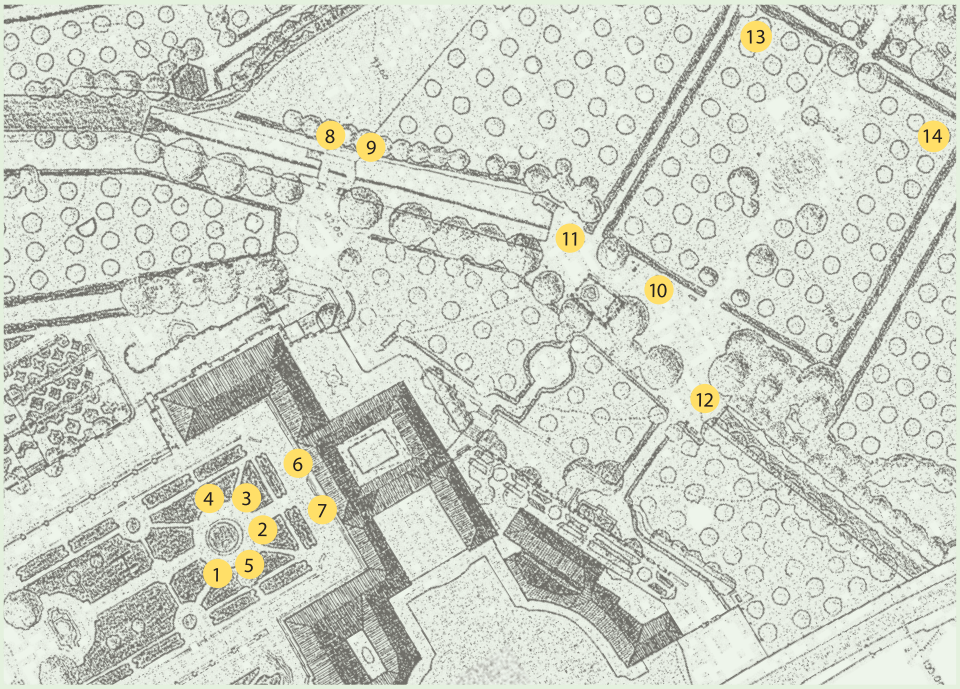
Cheere took particular care in the packing of the pieces due to their susceptibility to deformation. He also took care in providing the client with instructions regarding the way to unpack and clean the statues with linseed oil, and how to renew the original painting. Those responsible for the work at Queluz were notified by the artist that they should only remove the sculptures from their crates at the place where they were to be installed. He also emphasized the need for the statues to always be fixed to their stone base, on which they would have been mounted at the Hyde Park Corner workshop (Neto and Grilo, 2006:14).

John Cheere's pieces had a strong influence on Portuguese sculptors, who then ventured into the production of lead statuary, such as the *Neptune* and the *Nereid* fountains in the Hanging Garden at Queluz. These, which were also thought to have been English, were probably fashioned by the Portuguese sculptor Silvestre Faria Lobo, during the remodeling carried out by the son of D. Pedro, King D. João VI, in 1796.

The works of John Cheere, and other marble sculptures, subsequently had various settings, according to the changes in the garden's decorative and functional schemes. Many of them have not survived. Although it is possible that some could have been transferred to other gardens, others may have been destroyed or severely damaged with time. Currently, there are 19 pieces from John Cheere remaining at the gardens of Queluz from the original 138 that were commissioned. There are 7 groups from the original 9; 7 statues from the original 29; and 5 vases from the original 72. No animal figures nor putti have survived to the present. The groups are *Aeneias and Anchises*, *Rape of Proserpine*, *Cain and Abel*, *Venus and Adonis*, *Bacchus and Ariadne*, *Vertumnus and Pomona,* and *Meleager and Atalanta.* Only three of the *Four Seasons* remain: *Spring*, *Summer,* and *Autumn*, and the figures *Mars*, *Minerva*, *Diana,* and *Apollo* (Figure 3).

Figure 2. Remaining torso from the *Rape of the Sabines* group, exhibited in the interior of the palace.

Although the lead statues that remain in the Queluz gardens are only fourteen percent of those originally commissioned, they still constitute one of the most important collections of John Cheere's work.



1. *Autumn*
2. *Summer*
3. *Spring*
4. *Vertumnus and Pomona*
5. *Meleager and Atalanta*
6. *Minerva*
7. *Mars*
8. *Venus and Adonis*
9. *Bacchus and Ariadne*
10. *Cain and Abel*
11. *Aeneias and Anquises*
12. *Rape of Proserpine*
13. *Apollo*
14. *Diana*

Figure 3. Current location of John Cheere's sculptures in the Queluz gardens. (Plan of Queluz palace and gardens, 1987), 1987, DGEMN (reproduced courtesy of the Queluz Palace).

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Chapter 4.

The Conservation Intervention of the Gardens—An Overview

A. Elena Charola, José Delgado Rodrigues, Luis Aires Barros, and *Fernando M.A. Henriques*

Introduction

The gardens of the National Palace of Queluz occupy around 15 hectares of land. The larger part of this area is a park, while the two formal gardens, the Malta and the Hanging Garden, are right next to the palace. The grounds are decorated with 91 marble statues; 14 lead statues, 35 marble busts; 40 limestone bases; 143 limestone pedestals; 100 vases, some in marble, others in glazed ceramic; 43 balustrades sections, some in marble but mostly in limestone; 18 marble fountains, 6 of which had lead statues or elements decorating them, 6 others have marble ones and the rest are more or less decorated basins; and two cascades. The smaller one, in marble and called the Shell Cascade, is on the side of the Robillion wing terrace, while the large one is mostly in limestone and is in the lowest part of the garden, at end of the Cascade Lane that opens from the Gate of Fame.

Through the garden flows the Jamor River, which enters the property through a short entry canal that has some minor tile decorations. Then it flows underground for a time before resurfacing beyond the Sycamore Plaza, where it enters a canal lined on both sides with azulejos. The tiled part of the canal, generally known as the Canal de Azulejos, is 120 meters long (Figure 1). The water, after passing through the tiled canal, is joined a tributary creek, the Ribeira das Forcadas, and turns south at that point.

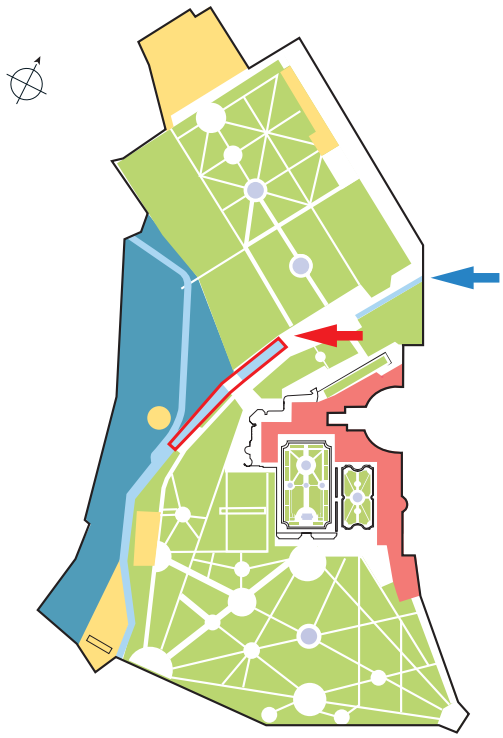

Figure 1. The gardens of the palace showing the canal—in light blue—where it is visible, with the creek that joins it beyond the decorated section, the Canal de Azulejos—outlined in red. Blue arrow points to entry canal; red arrow to the upper end of the Canal de Azulejos by the Sycamore Plaza.

The sheer number and diverse nature of the decorative elements in the garden make their maintenance a challenge. In view of this, a pragmatic approach was developed to address the conservation actions required in the short term, and to delineate a sustainable methodology that could support the maintenance needs in the long term. The present chapter will present an overview of the intervention.

Rationale for the Intervention

In general, the conservation of decorative elements falls under the theoretical approach developed for movable objects, as opposed to that used for immovable ones, such as architectural heritage. However, decorative elements in a garden also need to be considered within the garden conservation framework, making this a mixed category of botanical species and decorative objects.

When considering movable objects, it is generally assumed that they can be sheltered from the environment to ensure appropriate conditions for their protection. But this is not the case for decorative elements in a garden since they are fully exposed to outdoor conditions. Furthermore, it is expected that they will be admired from a certain distance, similarly to the nearby trees and bushes. They are part of the garden, and should be preserved as such.

Therefore, the approach to be applied should be based on that used for the majority of the elements in the garden—the plants. Anyone who has even a small garden has learned that it requires regular maintenance. The grass needs to be cut, the plants trimmed. Therefore, wherever possible, a similar approach needs to be devised for the decorative elements. In the case of the smaller stone decorations that can be reached easily, e.g., statues, vases, and pedestals, such an approach was developed and implemented.

However, all the other decorative elements in the garden required the development of specific approaches. This was the case for the fountains, as these are complex objects that need to be addressed according to the nature of the part in question. While the lead statues appear to be as simple as the stone ones, this is not the case. They are constructed differently, with an inner supporting frame and an outer skin, so they required a different treatment. The case of the azulejos canal, while considered a decorative element, is an immovable object that falls under the approach to be followed for architectural heritage. And its preservation is more difficult because of the water running through it. The intervention in this case was limited to that of preventive measures until a more comprehensive conservation can be undertaken. All of these points are discussed subsequently.

Stone Sculptures

All of the stone elements in the gardens were sculpted from rocks containing mostly calcium carbonate—calcite—as their main component. As such they are prone to acid attack, such as pure rainwater, since its pH is acid (~5.5) because of the carbonic acid formed by the at-

mospheric carbon dioxide, CO_2, dissolved in it. It is evident that if there is pollution in the air, such as sulfur or nitrogen oxides, rain will be more acidic and therefore more aggressive. However, in the mostly rural environment of the gardens these pollutants are not the major deterioration factor.

The following stone types can be identified:

- A Carrara-type marble, used for most of the statues, busts, and two of the balustrades in the Malta Garden.
- Dense Lioz limestone, used for some statues, bases, and pedestals, and the balustrade in the Sycamore Plaza.
- Soft Ançã limestone, used for the balustrades around the Hanging Garden.

The deterioration of these susceptible stone surfaces with respect to rain can be divided into three main areas according to their location:

- Protected areas: these do not get washed by rain and therefore all deposits from the air, such as dust, pollutant gases, and biological components remain on the surface forming a grayish or brownish deposit.
- Regularly rain-washed areas: these remain clean because all surface deposits are washed away and, because the stone surface may be slowly dissolved away, may attain a stark white appearance. However, they may also develop some biocolonization cover.
- Intermittently wetted areas: the occasional presence of moisture favors the deposition of dust and air pollutants, and their reaction with the substrate gives rise to the formation of gypsum crusts, mostly black because of the trapped dust and carbon particles. This occurrence is rare in these garden objects because of its rural environment.

While the presence of gypsum crusts is not critical for the sculptures in the Queluz gardens, evidences of the presence of soluble salts have been found. This particular deterioration factor is mostly apparent in the softer Ançã stone of the balustrades around the Hanging Garden. Given the soft nature of this limestone, it is easily damaged and has suffered many repair campaigns. The mortars used for these repairs are generally less porous than the stone, and if Portland cement mortars were used they may contain soluble salts. These could have migrated into the stone and crystallized in it, damaging the already weak stone. This is clearly recognizable when the deterioration occurs along the mortar-stone boundary.

In a garden environment moisture tends to be rather high, therefore moisture condensation due to temperatures falling below the dew point becomes critical. The presence of moisture on the stone surface due to condensation cycles that occur practically daily in some periods of the year may be more relevant than rain for the enhanced deposition of dust and biological materials, such as spores and bacteria that will lead to biocolonization of the surface by algae, fungi, and eventually lichens. Thus the favorable environment for biocolonization explains why it is by far the most relevant factor in the aesthetic disfigurement and eventual deterioration of the sculptures, as discussed in Chapter 5.

The problem is magnified by the large number of statues and other stone elements in the gardens. The limited resources available to the palace resulted in reducing the maintenance to those statues in the formal gardens. Cleaning of the statues was undertaken only when funds were available and when their appearance was considered to have reached an unacceptable degree of disfigurement. Then they were cleaned either by contracted commercial firms or treated by conservation students carrying out practical experience required for graduation. Hence, various cleaning methods, not all appropriate, have been used, with the result that the appearance of the statues varied significantly depending on the treatment they received. Consequently, some of the statues in the garden were stark white, while others showed different degrees of colonization, giving an overall appearance of erratic maintenance (Figure 2).

Upon analysis of the situation at the beginning of the project, it was realized that it was necessary to develop a routine plan to establish the frequency required for the cleaning. The spacing of the cleaning allowed statues to become heavily colonized, resulting in the need for more drastic methods to clean them—an undesirable feature as with each cleaning, some loss of fabric occurs. Thus, the need for developing the minimum intervention that would prove to be effective in giving the statues a "clean" appearance, while not necessarily a spotless white one, became evident (Chapter 5).

For this purpose, a database was created that identified and located all the statues in the garden, also including all the previous treatments to which they had been subjected, based on the reports available (Vale 2008). Considering the fact that the main problem was biocolonization, an approach was tested whereby a dilute biocide solution (1.5% v/v Preven-

Figure 2. Statues presented various degrees of colonization or cleaning that reflected erratic maintenance.

tol R80) was brushed on and left. The time required for the elimination or detachment of the biocolonization was then evaluated by monitoring the appearance of the treated object over time. In principle, it was found that after six months of the application the object attained a "clean" appearance, or at most required some brushing of the detaching colonization (Charola et al., 2007) (Figure 3).

On the basis of preliminary tests, a workshop approach was developed, as described in detail in Chapter 9. In total, nine workshops were carried out between 2005 and 2009. They were mostly held in the spring and fall, being the most appropriate seasons to address biocolonization problems. The workshops served to demonstrate in practice the effectiveness of the proposed maintenance procedure.

Figure 3. One of the putti groups that were treated during the workshops. Left: prior to treatment in September 2006. Right: six months later, March 2007. No mechanical removal was carried out.

Lead Statues

This subproject was undertaken by WMF Britain as the statues had been purchased from the English sculptor John Cheere. In 2003, a thorough evaluation of all the lead statues was carried out by Rupert Harris, a renowned London metal restorer, and included two statue groups that were found in storage at the palace because of their poor condition (Harris, 2003). As a result of this evaluation, it was decided that these two statue groups should be the first to be restored. That same year, they were shipped to London to be restored at the Rupert Harris restoration studio. These statue groups were then identified as those of the

Rape of Proserpine and *Aeneas and Anchises*. After restoration they were exhibited in the Victoria and Albert Museum in London and were finally brought back to Lisbon in May 2005. They were then installed in the Music Room until a place for them could be found in the gardens.

Apart from the aforementioned groups, there are five other groups of lead statues: *Meleager and Atalanta, Vertumnus and Pomona, Venus and Adonis, Bacchus and Ariadne*, and *Cain and Abel*. There are also seven single statues in the gardens: *Spring, Summer, Autumn, Apollo, Diana, Mars,* and *Minerva,* as five lead vases. Finally, there are six fountains that have lead sculpture, from the complex Neptune and Nereid fountains to the simpler Medallions', the two Monkey fountains, and the Malta Garden fountain. The fountains, presenting a more complex challenge than decorative statues, were a subproject by themselves under the responsibility of WMF Portugal, and are discussed in a subsequent section.

Most of the statues showed serious structural problems, such as the development of cracks and distortions, some resulting from the corrosion of the inner supporting frame. The choice of statues to be restored in the Rupert Harris studio in London was based on the complexity of the required work. These were mostly the statue groups, and six of the seven groups were restored there (Chapter 2). The only group not to require restoration was *Cain and Abel,* located in the Sycamore Plaza. Apart from the aforementioned problems, one of the issues to be addressed was the different appearance that had developed over time on these statues. While some of them, such as the *Cain and Abel,* retained a silver appearance; others, such as the *Minerva* statue at the entrance of the palace (Figure 4), had developed a nearly black color. This issue required the collaboration of an expert in lead corrosion and is discussed in Chapter 6.

Upon the return of the first two statues, two other groups were taken to be restored in London. These were the *Meleager and Atalanta* and *Vertumnus and Pomona* groups. They were returned to the palace a year later, in May 2006. At the time, only the *Vertumnus and Pomona* group was reinstalled in the garden because the pedestal for the other group was askew, the result of a tree growing right next to it.

Following the workshop approach used for the stone statuary, it was decided—in agreement with WMF Britain and Rupert Harris—to organize workshops at the palace to train Portuguese conservators in the art of lead restoration. These are discussed in more detail in Chapter 9. During these workshops, five individual statues were restored: *Spring, Summer, Autumn, Apollo,* and *Diana.* The other remaining statues, *Mars* and *Minerva,* still retained part of their original paint and were in good condition, as was the *Cain and Abel,* so only a surface finish was applied to them for protection and to unify their appearance.

The final two groups to be restored in London were those located on the central block of the canal, known as *Venus and Adonis* and *Bacchus and Ariadne*; these were removed in March 2008. Once restored, they were exhibited at the Tate Museum in London, returning to Lisbon in mid-April 2009, when they were reinstalled by the canal. At that time, the final lead workshop was held near the end of that month, completing WMF Britain's commitment to the subproject. At that point all of the lead statues were restored and installed in the gardens, including the two groups that originally had been in storage, the *Rape of Proserpine*


Figure 4. Lead sculptures in distinct visual conditions. Left: *Cain and Abel* group that still retains its gray appearance. Right: *Minerva* showing the black patina developed on the more exposed areas. This statue still retains traces of original paint.


Figure 5. The two lead groups that were installed on the *Sycamore Plaza*. Left: *Rape of Proserpine*. Right: *Aeneas and Anchises*.

and *Aeneas and Anchises*. These were located in the Sycamore Plaza beyond the *Cain and Abel* group (Figure 5), as historical documentation indicated that the statues had been located there at some time in the past.

Fountains

There are eighteen fountains and two cascades, separate from the water-holding basins such as those along the foot of the Hanging Garden on each side of the Gate of Fame. Of the eighteen fountains, six are adorned with lead elements and six are decorated with marble statues. The remaining six are mostly basins with more-or-less decorated rims.

The Shell Cascade is on the side of the Robillon wing terrace, while the Great Cascade is at the end of the avenue that opens from the Gate of Fame. Of the eighteen fountains, six have lead statues or decorations, most of which are of Portuguese manufacture, as discussed in a previous chapter (Chapter 3). One is in the Malta Garden and four are in the Hanging Garden: two large ones, the Neptune and Nereid, and two small ones, the so-called Monkey Fountains. The last is the Medallions' Fountain, across the canal, on the Medallions' Lane that leads to the large marble Neptune Fountain, attributed to the Bernini workshop (Chapter 1) (Figure 6).

In the Sycamore Plaza, two fountains are found, one by the *Cain and Abel* group, called

Figure 6. View of the Medallions' Fountain with the Neptune Fountain at the end of the Medallions' Lane.

the Dragons' Fountain, and the other one near the entry canal, called the Dragon's Basin. Yet another Dragon's Fountain is located by the edge of the maze at the lower level of the Hanging Garden on the canal side.

On the avenue to the Great Cascade, there are three fountains. The remaining six are located in different places between the avenue to the Great Cascade and the Canal de Azulejos. Two of these, located by a ball court parallel to the lower part of the canal, are not connected to any water source and were not restored at this time, since they only require routine maintenance like that applied to the stone statues.

The actual conservation work on this subproject required a full year for completion, from August 2009 to August 2010. This was carried out by a Portuguese firm (Nova Conservação, Lda.), who had some of its conservators trained in the lead workshops. The most difficult part was the cleaning of the lead figures in the three main fountains: Malta, Neptune, and Nereid, located in the formal gardens. The reason for this was the extreme differences found on the lead surfaces. For example, the Malta Fountain had the central dolphin coated with an extremely hard calcareous concretion. However, under this layer, the lead surface presented a uniform reddish color resulting from normal lead weathering, as discussed in Chapter 6. Therefore, the calcareous concretion was painstakingly removed by mechanical means to avoid damaging this "patina" (Figure 7 left).

On the other hand, the surface of the statues in the central block of the Neptune Fountain presented extreme differences. Some areas were brown-black while others still retained a grayish-white color (Figure 7 right). Several tests were carried out to find a way to balance the appearance of the lead surfaces so as to not totally remove the passivating layer that had formed on them. Details of the intervention are given in a subsequent chapter (Chapter 7).

Figure 7. Concretions and patinas in the lead sculptures. Left: detail of the mechanical removal of the whitish concretion that covers the reddish patina formed on the dolphin of the Malta Fountain. Right: detail of the complex decoration of the central block of the Neptune Fountain showing the wide variation in color acquired by the lead surfaces, ranging from gray through reddish to nearly black areas, depending on the water flow over them, apart from the evident concretions on the most exposed parts.

Most of the major work required in the fountains was completed during the intervention carried out. However some problems remained unaddressed, such as the condition of the basins of fountains located in areas where the ground is sloping. There, soil erosion along the inclined paths from many years of neglect left the basins partly exposed as the earth that protected them was washed away, as shown for the basin of the Great Cascade (Figure 8).

Figure 8. The Great Cascade after intervention. The water runs down the rugged stones that have been left with their acquired patina resulting from years of water circulation over them. Note that the basin has a thicker rim at its base that marks the level to which it should be buried.

Furthermore, the water quality needs to be addressed. Prior to the intervention, algae proliferation was excessive and led to the blocking of water spouts, while water hardness led to deposition of calcareous concretions on the sculptures. The water hardness is the result of the high concentration of calcium and magnesium ions present in the water used to feed the fountains. High light exposure and poor maintenance of the exposed water surfaces result in a proliferation of algae. The problem does not have an immediate and definitive solution, but requires systematic maintenance to mitigate it, as detailed in the maintenance recommendations included at the end of this publication.

Canal de Azulejos

The tiled part of the canal extends from the end of the Sycamore Plaza to a small tile-decorated structure, adapted from an early twentieth-century conservatory. There a bridge

crosses the canal, and below it a floodgate was once installed. When this floodgate was closed, the canal would fill with water and small boats could be rowed up and down the stream.

The tiled decoration of the canal dates from the mid-eighteenth century. The decorated canal is between 8 and 13 meters wide and 120 meters long. The interior walls of the canal are decorated with some 50,000 azulejo tiles, not including the center block, where a wooden music stand was installed for musicians to play during festive occasions, when the canal was filled and the royal family and guests could tour it in boats.

The water that flows through this canal comes from the Jamor River watershed, and when it leaves the decorated section of the canal at the point where the floodgate used to be it is joined by the tributary creek, Ribeira das Forcadas. Another important creek, Ribeira da Carvoeira, runs around the palace property to the east and joins the waters from the canal and the Ribeira das Forcadas when these left the property as described in more detail in Chapter 8.

For many years, the canal has suffered severe and catastrophic floods. One of the worst was the 1967 flood, which toppled over a section of the east side canal wall close to the center block. This was subsequently rebuilt—rather poorly—and this area shows bowing of the tiled surface.

In view of this, several studies were commissioned to evaluate the structural stability of the canal walls (Salgado 2006, Triães and Coroado, 2006) as well as the frequency of major floods (Rocha and Fernandes, 2006 and discussed in Chapter 8). The conclusions drawn are presented in Chapter 8.

These studies were complemented with archaeological (Sequeira and Vale, 2004) and historic studies (Pereira and Luckhurst, 2005). Furthermore, the whole tiled canal was laser-scanned (with a 0.01% precision) so as to allow future monitoring of any changes in the tiles or the distances between the walls. The complete photographic record that was made at the time served to prepare detailed maps of the canal sections by their superposition with the laser-scanning record.

These maps were used to carry out a complete conditions survey that was completed in 2005 (Pinheiro 2005) (Figure 9). By 2006, the digitalization of the condition survey was also completed. Figure 10 shows both the result of the detailed photography carried out at the time of the scanning as well as an example of the condition survey.

It was considered that routine maintenance of the canal tiles could be carried out by trainees in azulejo conservation under a workshop system. This was discussed with both the National Museum of Azulejo (MNA) and the Polytechnic Institute of Tomar (IPT) but was not implemented, because the issues that beleaguer the canal needed to be addressed first as discussed in detail in Chapter 8. In the meantime, one of their conservation students did her required practical experience by carrying out a conditions assessment and performing some preventive conservation to avoid the loss of tiles (Ferreira, 2007).

The roots of sycamore trees that lined the walk along the palace (east) side of the azulejo canal, as well as those of the trees on the west side, caused structural instability in the retaining walls and contributed to the localized detachment of tiles. As their branches hung

Figure 9. Condition survey of the canal. Note how close the sycamores were planted to the canal walls.

Figure 10a. Example of a section of the canal as photographically documented and superimposed on the digital laser scanning map.

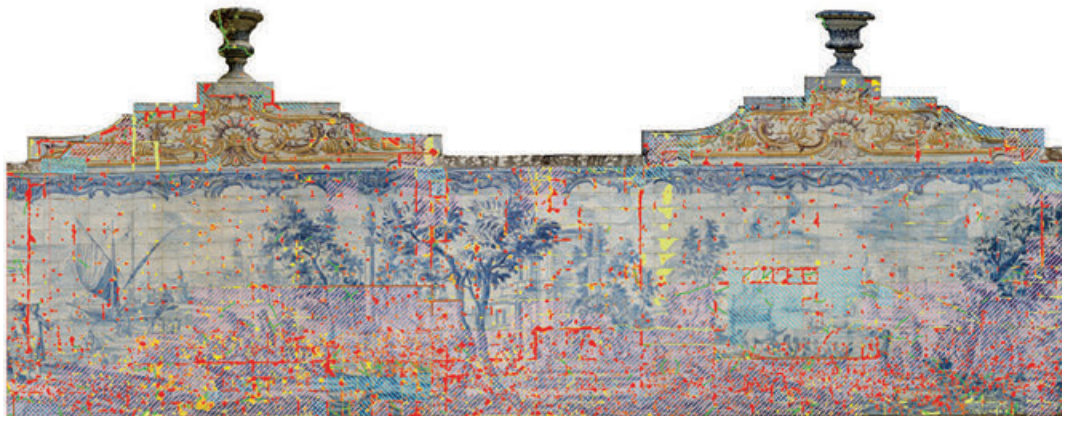

Figure 10b. Example of the condition survey of tiled canal. This survey was carried out on the maps obtained by laser scanning. Note that the major concentration of deterioration is found at the bottom of the panels, the sections that would be more frequently in touch with water during any flooding.

over the canal, the possibility of any one of them falling into it during a storm was considered a serious threat that prompted the decision to have them felled. This was carried out during the winter of 2008–2009 (Figure 11).

Figure 11. View of the sycamores just prior to and during their felling in January 2009.

In February 2008, a major flood occurred that caused further damage to the canal by detaching some tiles from an already-damaged area. Luckily, most of them were recovered and stored together with all those that had been collected in the past awaiting a conservation intervention. In the meantime, the area has been closed to prevent further loss of azulejos as shown in Figure 12.

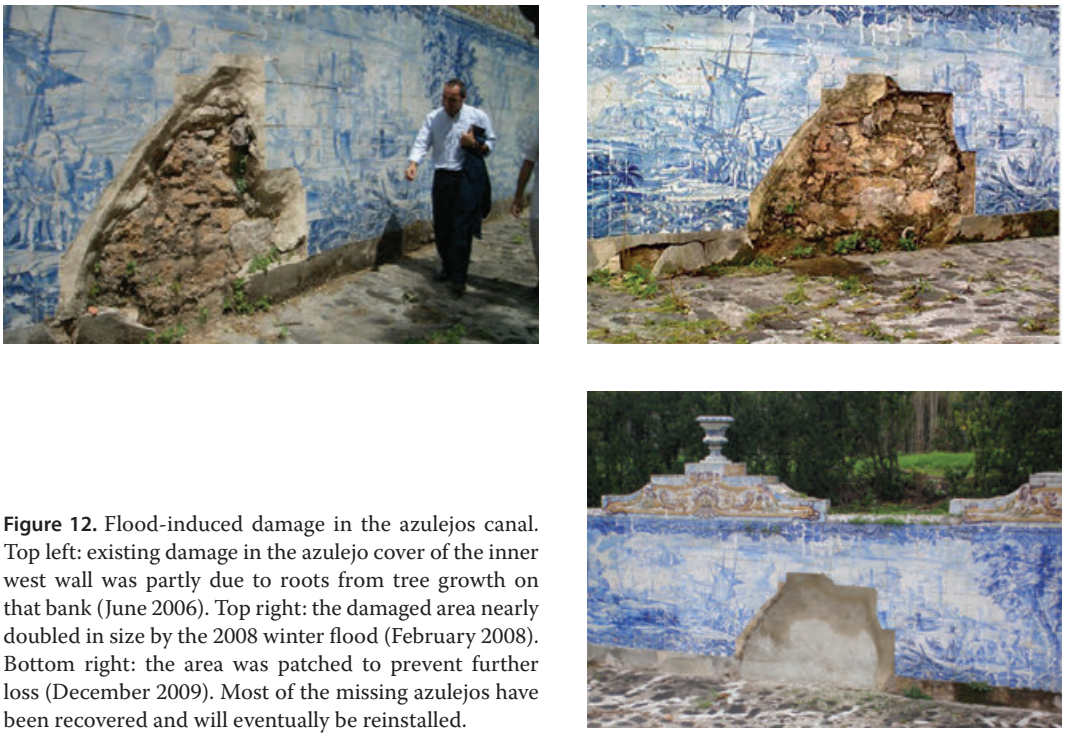

Figure 12. Flood-induced damage in the azulejos canal. Top left: existing damage in the azulejo cover of the inner west wall was partly due to roots from tree growth on that bank (June 2006). Top right: the damaged area nearly doubled in size by the 2008 winter flood (February 2008). Bottom right: the area was patched to prevent further loss (December 2009). Most of the missing azulejos have been recovered and will eventually be reinstalled.

However, the most serious damage was to the floor of the canal where it enters the subterranean passage that leads to the Canal de Azulejo*s*. Here the canal is paved with large stone blocks, but the force of the floodwater managed to dislodge some of them, leaving a hole some 2.5 meters deep in the floor of the canal. The repair of this section took place from late autumn 2008 to early winter 2009.

The floods were being compounded by the vegetation that clogged the end of the canal, limiting the volume and rate at which the water could circulate through it. Therefore, a cleaning campaign of the latter section of the canal was carried out by the palace staff to improve water circulation. To control the potential floods that occur in the Canal de Azulejos, it would be necessary to keep the Jamor River free of clogging debris, which demands continuous maintenance as discussed in more detail in Chapter 8.

This situation suggested that during the current project the best approach was to carry out a preventive conservation intervention of the azulejos in the canal to minimize their loss and deterioration rate, while leaving their eventual restoration to a future time. Following the principle adopted during this project, it is then suggested that training institutions can collaborate in organizing practical training workshops to conserve the azulejos themselves.

Thus, during 2009 preventive conservation was carried out at the Canal de Azulejos to stabilize the tiles and prevent further loss from subsequent damage to the supporting wall. This activity, in conjunction with the regular monitoring necessary for identification of possible detachments of the azulejos, can be considered part of the standard maintenance required to preserve this outstanding and unusual decorative element.

Conclusion

The conservation intervention of the gardens of the National Palace of Queluz was a complex project. Firstly because of the variety of materials and structures involved in it: different types of stone, metals such as lead and iron, glazed ceramic in the azulejos of the canal as well as the retaining walls themselves, an extensive water supply system, and a torrential river that frequently floods. And secondly, because of the composite nature of some of the objects, such as the Canal de Azulejos (an item with a mixture of geotechnical, hydraulic, and cultural implications); the gardens, with a large variety of art objects immersed within a natural environment; and the fountains, containing both lead and stone objects and fitted with feed pipes.

In any conservation project, the most important point is defining the objective of the intervention and the most appropriate methodologies to implement it. For example, if the object is to be cleaned, how clean should it be? And to be able to develop the appropriate methodology to attain this objective, it is of fundamental importance to understand the nature of the problem. In a word, the diagnosis of the problem and the definition of actions are critical.

A conservation project has to consider not only the solutions to the problems, but also any potential negative side effects that may derive from them. In the case of the Canal de

Azulejos, the changes that occurred in the flow of water in the Jamor River over the years have altered the original situation. Subsequent interventions—such as raising the bed of the canal—may have served to stabilize the retaining walls but have also has caused more damage to the azulejo decoration. This illustrates how a conservation intervention that solved one problem may have contributed to increasing another.

Therefore, it is fundamental to use internationally accepted conservation principles as guidelines for interventions of cultural heritage. The three key principles were respected during this project. For instance, minimal intervention is best illustrated by the stone and the Canal de Azulejos subprojects, while the lead subproject is an example of the use of compatible materials. No action was taken in any subproject that would interfere or hinder a future treatment or intervention. Finally, sustainability should also be considered, since it is essential for the regular and long-term maintenance of the overall systems operating in these gardens. Thus, the intervention carried out has aimed to respect these principles so as to safeguard these nearly three-century-old gardens for future generations.

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Chapter 5.

Stone Statuary and Biocolonization

José Delgado Rodrigues, *A. Elena Charola,* and *Marta A. Vale Anjos*

Introduction

As described in the previous chapter, there are many stone elements decorating the extensive gardens of the National Palace of Queluz. Of these, some are carved in marble, but most were fashioned out of dense limestone. Also, some stretches of balustrades used a soft limestone easily prone to deterioration. Marbles and dense limestones show comparatively little deterioration, except for the presence of biocolonization that tends to be highly invasive and prevailing, given the garden environment, unless regular control methods are carried out.

At the beginning of the project, biocolonization varied widely from object to object, depending on their exposure conditions, such as the presence or not of neighboring tall trees (see Figure 1 of previous chapter). Objects fully covered with lichens and algae were quite frequent in sheltered areas. The analysis of past cleaning procedures and the studies and tests carried out for this project (Vale Anjos, 2006) allowed for the development and application of a proper methodology for the project (Charola et al., 2007). This is based on the application of biocides at the time biocolonization reaches undesirable levels and leaving the surface to spontaneously lose the colonizers (Delgado Rodrigues et al., 2011). It is hoped that this simple approach will be followed in the future as a regular and long term maintenance strategy.

The fountains present a totally different scenario from that of the sculptures. Because of the complexity of the interior water circuit, these only can be addressed during a comprehensive restoration intervention. Therefore, they have undergone fewer interventions over the years. The degree of biocolonization cover and its developing rate vary from place to place in the garden according to the exposure to sunlight, proximity of the building, or other sheltering effects. Once cleaned, algae can reappear within a year and the foliose lichens may take about four years to develop.

The Garden Environment

The climate in Queluz is temperate and seasons are normally mild. Rain falls mostly during the winter months (November through April), with a total yearly average of around 850 millimeters. July and August are the hottest months, with temperatures reaching 40º C or more. Winter temperatures may come close to 0º C, but freezing events are very rare. The extensive presence of vegetation—in particular that of dense-foliage trees—influences the local conditions and creates different localized microclimates that significantly influence the development of biocolonization and the extent of its coverage.

The palace and its gardens are located in a semi-rural area. Although a heavily trafficked road passes by the southern end of the property, air pollution is not a serious problem and the area can be considered a rural environment. Daily direct exposure to sunlight and permanent shade from large trees create two extreme exposure conditions for the stone elements in the gardens. The colonization intensity of a given object and the recolonization rate, once it has been cleaned, strongly depend on these conditions.

Biodeterioration of Stone

Of the two stone types used in the decorative elements, the marbles of the statues have been attributed an Italian origin, possibly from Carrara, while the limestones are Portuguese. Of these, two main types are present: a very low-porosity limestone quarried in the nearby region (Lioz limestone) and a highly porous variety quarried near Coimbra (Ançã limestone). Limestone was used mostly for pedestals and balustrades. The compact variety, Lioz, is extremely resistant and in general is in a good state of conservation and was therefore also used for the stone basins of the fountains. The porous variety was mostly used for balustrades, and those balusters showing deterioration suffer powdering and scaling, particularly in areas next to cement patching.

The sculptures have suffered most from biocolonization, either directly by micropitting and/or etching, or indirectly through poor past cleaning practices as discussed below. The situation is different for the fountain basins as biocolonization develops because of the presence of flowing water. Thus endolithic algae develop mostly in the stone basins (Ascaso et al., 1998) ,while epilithic algae cover the decorative elements in the areas where water runs over them.

Extensive biocolonization is a major problem, with lichens being the most aggressive colonizers. There are several species, ranging from foliose to crustose types, of different colors: orange, white, black, and green. A diffuse darkish biocolonization is also present. During wet periods, the green algae are clearly visible, especially in sheltered areas that become dark during the dry and hot summers. In many places, the diffuse dark colonization constitutes the main colonizing component that in some situations can completely obliterate the stone surface.

Effects of Cleaning Interventions on Recolonization

Inspection of the sculptures that underwent a recent cleaning interventions showed that this procedure was in many cases pushed to extremes, particularly when grit blasting was used. In these cases, the stone can be significantly eroded, losing any remaining finish, as illustrated in Figure 1. This is totally unacceptable for the case of sculpted objects.

Figure 1. Surface conditions left by two different cleaning methods. Left: application of a biocide and soft brushing (area is about 30 by 40 centimeters). Right: aggressive grit blasting (area approximately 10 by 8 centimeters). Note the overall smoother surface of the stone resulting from the significant loss of original finish.

Figure 2. Recolonization pattern on sculptures treated with a water repellent after a restoration intervention (1999). The disfiguring green stripes appear soon after treatment, illustrating that the water repellents do not provide sufficient protection against biocolonization. The photographs show the intense biocolonization that developed after five years (photos 2004).

The surface roughness resulting from a cleaning intervention will affect the subsequent recolonization rate. Thus, the relatively smoother surfaces left by grit blasting are slightly more resistant to recolonization than those resulting after application of a biocide and soft brushing. However, the loss of material induced by this abrasive method is far more than that caused by biocolonization (Delgado Rodrigues et al., 2011). Furthermore, objects cleaned at very close intervals will inevitably erode faster, as clearly shown by many of the sculptures cleaned in the past that have lost important sculpted details.

As discussed previously, the fountains can only be addressed through a total restoration intervention (Delgado Rodrigues and Charola, 2011). In the specific case of the marble Neptune fountain, a thorough restoration was carried out in 1999 (Theriaga Gonçalves and Proença, 2003). After the cleaning, the figures decorating it were treated with a water repellent resulting in an enhanced localized biocolonization along the water paths as shown in Figure 2. This and other similar situations in the gardens have shown that water repellents cannot protect the surface completely from algae growth on the surface, and when applied are responsible for the enhancement of the green stripes that develop on the newly cleaned areas (Charola et al., 2008a and b; Salvadori and Charola, 2011).

Addressing Biocolonization on Sculptures

Given the high variability in environmental conditions and the consequent colonization and recolonization rates as well as their respective intensities, it became apparent that a highly practical conservation approach had to be developed. In fact, the previously used approach—cleaning/recolonization/cleaning—proved to have a clearly negative effect as mentioned above. Furthermore, these focused interventions led to situations where nearby standing sculptures were highly contrasting, i.e., treated vs. untreated, resulting in an aesthetically unacceptable presentation of these decorative elements.

The first task in the project was to catalog all the stone elements, including their conservation history, to complement the partial database available at the palace. At the same time, a detailed biocide-testing program was carried out to find an appropriate biocide treatment (product, concentration, and application method) (Vale Anjos, 2008). The study was carried out with two biocides, Preventol R80 (a biocide based on a quaternary ammonium salt) and zinc chloride, in concentrations of 1.5, 2, and 3 percent weight/volume, and in one to four applications. The effectiveness of biocides was monitored by using a portable fluorimeter prototype developed through the ONSITE project (On-site monitoring of biological colonization of stone and plaster surfaces using field portable fluorescence based techniques) (Delgado Rodrigues et al., 2004). This equipment measures the emission intensity of chlorophyll fluorescence, which is proportional to its concentration. The emission values can be used directly as measured or transformed as the ratio of the values measured in wet conditions versus those measured in dry conditions. The experience acquired in that project showed that this ratio is especially relevant to discriminate biocolonization from high natural background fluorescence stones as well as live colonizers from dead ones. In fact, this ratio is close to 1 for

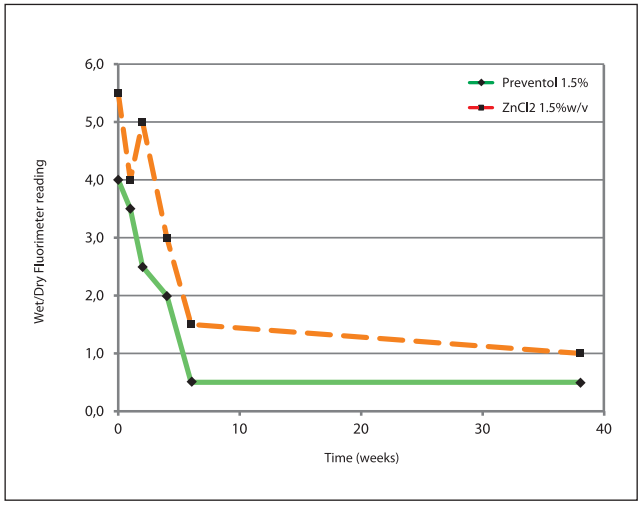
non-colonized areas and for dead organisms, while it departs clearly from 1 when live chlorophyll-bearing specimens are present. Table 1 provides the data of the effectiveness of both biocides on gray diffuse colonization after each of the applications and somewhat more than nine months from the initial treatment. It can be seen that Preventol is slightly more effective and that a single application is sufficiently effective as compared to several applications.

Table 1—Wet/dry ratios measure before and after successive applications of Preventol 1.5% and $ZnCl_2$ 1.5% w/v to gray diffuse biocolonization.

Time (week)	Notes	Prev.	$ZnCl_2$	Prev.	$ZnCl_2$	Prev.	$ZnCl_2$	Prev.	$ZnCl_2$
0	Before 1st appl.	6	5.5	5.5	5.5	5	7	6	4.5
1	After 1st appl.	2	1.8	2	4	3.5	4.5	3	3.8
2	After 2nd appl.			0.8	1	2.5	3.5	1.8	2
4	After 3rd appl.					1.3	1.3	1.5	1.5
6	After 4th appl.							0.8	1
....	Long-term action	...	...	...	...	...	...	...	...
38	At week 38	1	2	1	1	1.3	1.3	1	0.8

Note: Values at week 0 correspond to the untreated object, which then received the first application. The subsequent reading was taken one week later and then the second application was carried out. This procedure was repeated at the noted times for the third and fourth application Last reading (38 weeks) was taken after somewhat over nine months (data adapted from Vale Anjos, 2008).

Figure 3 shows the plot of the wet/dry ratios obtained after each of the four applications of the two biocides applied to orange lichens and including the reading after nine months. The behavior is similar to that of the above gray diffuse colonization as well as for other monitored lichens. It is evident that the biocides continue to be effective for quite some time after the last application. This led to the conclusion that leaving the treated areas alone for some time might be a more efficient way of eliminating biocolonization than trying to remove it all at once.



Note: Values at week 0 correspond to the untreated object, which then received the first application. The subsequent reading was taken one week later and then the second application was carried out. This procedure was repeated at the noted times for the third and fourth application. The last reading (38 weeks) was taken after slightly more than nine months (data from Vale Anjos, 2008).

Figure 3. Example of the wet/dry ratio of measurements taken with the fluorimeter before and after successive applications of Preventol R80 1.5% v/v and ZnCl2 1.5% w/v to areas colonized with orange lichens.

The conclusions from the study provided the basis for developing the practical conservation approach, as follows:

- A single application of a 1.5% concentration of Preventol R80 is effective in removing moderately dense colonization.
- Biocide-treated areas showed progressive loss of bioactivity during six to nine months after application, suggesting that washing surfaces soon after treatment reduces the action of the biocide.
- Thick lichen-colonized areas require higher concentrations of biocide. A concentration of 3% Preventol R80 proved to be adequate for these situations.
- Dead lichens fall off spontaneously and progressively over a period of about a year.
- Treated areas eventually reach a visual appearance well harmonized with the surrounding elements.

In brief, the approach is based on the use of low concentrations of Preventol R80 (in the order of 1.5 percent w/v) when a maintenance intervention is considered, and of 3 percent for situations of extreme density. After brushing on the biocide solution, the object is left for several months without any additional action. In most cases, the dead colonization detaches spontaneously and the result can be evident as soon as two months later (Figure 4). Brushing is not required to remove the dead colonizers, except for some stubborn cases. Reapplication should only be carried out whenever recolonization moves from the incipient to moderate levels. This criterion reduces the required applications to a minimum. So far, the sculptures treated under this new approach have shown that recolonization does not occur much faster in comparison with more aggressive cleaning methods.

Figure 4. *Architecture* sculpture before a single application of Preventol 1.5% (June 2010) and two months after application. The spontaneous detachment of the colonizing lichens, particularly on head and bust has left the statue with an acceptably clean appearance.

Recolonization will appear at rates varying from place to place, and shows a high dependence on the local environmental conditions, with the fastest rates being observed on sculptures that are under or very close to large trees (Delgado Rodrigues et al., 2011). For example, comparing a pair of busts located near the Gate of Fame (Figure 5)—one of them shaded most of the time by a tree, while the other is exposed—it can be seen that the former tends to colonize more and faster.

Figure 5. A and **C** busts shortly after being cleaned and reinstalled in the garden (June 2010). **B** and **D** appearance after eight months of exposure (February 2011). **A** and **B** bust in an exposed area with no direct cover. **C** and **D** bust shaded by trees. The faster recolonization suffered by objects in shaded conditions is clearly evident.

Similar situations can be found in varying degrees for all elements distributed in the gardens. The shaded groups tend to develop a more uniform biocolonization pattern, while the exposed groups concentrate the biocolonization in those areas where water collects either through rainfall or by surface condensation. This is particularly noticeable on surfaces facing north and on protected areas of the statues, such as the undersides of arms or when an overhanging detail acts as a natural shelter.

Figure 6 shows a pair of putti before treatment, nearly a year after the application of the biocide carried out in 2006, and then five years later.

From the above example it is evident that the developed approach is effective, and that recolonization for objects that are not in too shaded an area is still at an acceptable level five years after treatment.

Figure 6. Left: a group of putti before treatment (2006). Center: one year after treatment (2007). Right: five years later (2011).

Conclusions

Biocolonization of stone elements exposed outdoors is a natural and inevitable process. So far, there is no "perfect" solution to protect these objects. However, it is possible to mitigate this process and reduce the deterioration rate by controlling the amount of biocolonization developing on the stone.

The experience gained in this project has shown that a minimalistic approach applied consistently at appropriate times is the best to achieve the desired protection. For this purpose, regular monitoring of the objects is fundamental to determine when incipient biocolonization reaches a moderate level. It is at this point that the application of a low concentration of biocide will be most effective. Monitoring is fundamental, because of the differences in colonization rates between objects depending on their particular environment.

Finally, it is important to remember that coherent aesthetic presentation is part of the value for any site. In a garden environment, for decorative stone objects that are at nearly three hundred years old, a certain degree of colonization is acceptable and to be expected. This is the aim of the approach developed for the stone sculptures in the National Palace of Queluz gardens.

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Chapter 6.

Natural Patination of Lead Statuary

Virginia Costa and *A. Elena Charola*

Introduction

Lead tends to have a very low corrosion rate in most natural environments because of the nature of the deposits that form on its surface. Their relative insolubility, compactness, and adherence to the surface protect it from further attack. Upon exposure to atmospheric conditions, lead generally takes on a grayish appearance resulting from the rapid formation of lead carbonates, such as hydrocerussite ($PbCO_3.Pb(OH)_2$). If exposed to a polluted atmosphere, a thin layer of lead sulfate, anglesite ($PbSO_4$), can form that produces a similar grayish appearance. In a less-polluted environment, such as that found in the gardens of the National Palace of Queluz, the hydrocerussite may turn into cerussite, lead carbonate ($PbCO_3$) and, in certain circumstances, will further oxidize to litharge, red lead oxide (PbO), or its dimorphous massicot, yellow lead oxide (PbO), or minium, red lead oxide ($2PbO.PbO_2$) and even to plattnerite, brownish-black lead dioxide (β-PbO_2), often referred to as puce oxide in the UK. How much of each of these compounds is formed depends on the chemical composition of the metal, the initial surface finish, and the environmental conditions (Costa and Urban, 2005).

Patina Development on the Lead Statues

At the time the project was undertaken, the lead statues in the gardens presented wide variations in appearance. While some showed a fairly uniform grayish patina, such as the *Spring* statue and the *Cain and Abel* group, others—in particular those in the fountains—showed a dark reddish-brown to very dark gray finish, such as the central block in the Neptune and the Medallions' fountain, respectively. Still other statues had retained some traces of the original paint that protected them, such as the statues of *Mars* and *Minerva* at the main entrance door to the palace.

In May 2006, upon the reinstallation of the *Vertumnus and Pomona* group after its restoration carried out by Rupert Harris in the UK (2005–2006), it was found that the newly

formed pale gray finish rapidly acquired a reddish-brown hue, clearly evident four months later. X-ray powder diffraction analyses carried out by the Portuguese Conservation Center (IPCR) on this group as well as on other sculptures, *Spring* and *Summer,* showed the presence of hydrocerussite ($PbCO_3.Pb(OH)_2$), cerussite ($PbCO_3$), and plattnerite (PbO_2), the latter certainly causing the brownish aspect (Oliveira, 2006). This unexpected event prompted the study of patina development of lead surfaces under the conditions found in the gardens of the National Palace of Queluz.

After an initial evaluation of all the lead sculptures, it became evident that the reddish-brown compound was present mostly on the exposed areas of the statues, as clearly visible in the central block of the Neptune Fountain (Figure 1).

Figure 1. Appearance of the central block of the Neptune fountain. Note the dark brown-black color of the figures in this block. Different lighting affects the color hue, as seen in the above figures taken in summer (left) and winter (right).

Figure 2. The *Cain and Abel* sculpture group. Center: a detail of it taken on a cloudy day. Right: a close-up view of the folds of the clothing where the black deposit can be seen in some small areas.

In less exposed statues—such as the *Cain and Abel* group, which is under a tree—an overall grayish appearance is observed (Figure 2a), although small dispersed spots of this brown compound were evident. A closer examination of the latter indicated the presence of a brownish surface underlying the gray layer (Figure 2b) revealing its omnipresence and suggesting that it might be a very stable compound (Costa, 2007a).

Patina Formation: Field Studies

A study was undertaken to better understand what causes the formation of the reddish-brown deposits on the surface of the statues, and its dissimilar occurrence depending on the statues' placement. Three main reasons were considered as contributing factors: 1) differences in lead composition, 2) differences in the surface condition of the lead, and 3) differences in the local micro-environment.

In order to determine if the appearance acquired by the statues could be attributed to differences in the chemical composition of the metal, representative samples of both features—gray and reddish-brown deposits—were collected and their cross sections analyzed by scanning electron microscopy and energy dispersive X-ray spectroscopy (Wouters, 2008). The results showed conclusively that there are no significant differences in the lead composition of the various statues that could account for the observed difference in appearance (Costa, 2008a).

To evaluate the role played by any previous surface treatment, as well as that of local micro-environmental conditions in the formation of the various compounds, an *in situ* testing system was carried out, in which lead samples were exposed at various sites in the gardens (Costa, 2007b). The samples were subjected to different pre-treatments in order to simulate different surface conditions, and three of them will be reported here: (a) mechanically polished, (b) sensitized in an acetic acid atmosphere, and (c) passivated in a sulfuric acid solution (Figure 3).

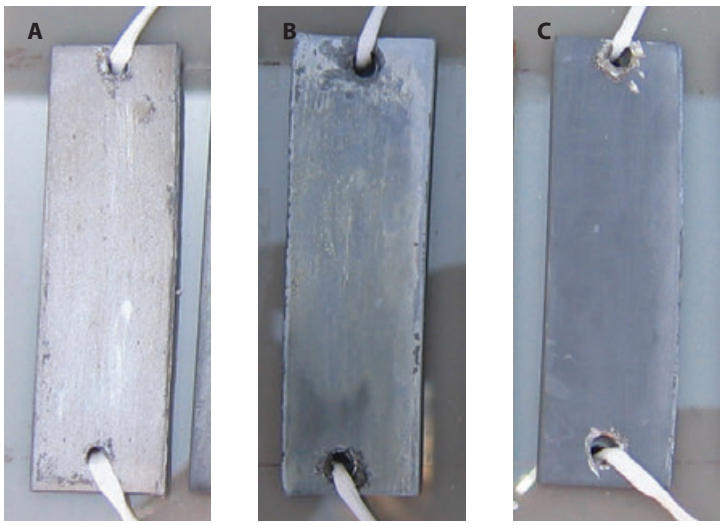

Figure 3. Appearance of the differently prepared lead samples before exposure: **A** mechanically polished, **B** sensitized in an acetic acid atmosphere, and **C** passivated in a sulfuric acid solution.

When considering the environmental conditions, the results obtained for the nine exposure sites can be reduced to three groups that reflect the varying appearance of the statues, from light gray to brown-black. The three groups correspond to the following conditions: very mild, such as indoors (in a palace room), mild outdoors (the Nereid Fountain), and severe outdoors (the Neptune Fountain). Evaluations were carried out after 8, 12, and 15 months of exposure (Costa 2008a, 2008b, 2009). Table 1 summarizes the changes observed on the samples after 15 months of exposure and Figure 4 shows the aspect of a sensitized sample exposed in an outdoor "severe" environment. A close examination of the reddish-brown underlying layer showed it was continuous and well adhered.

Table 1—Appearance of differently treated coupons exposed at different sites

Initial	After 15-month exposure		
	Very mild indoors	Mild outdoors	Severe outdoors
Light metallic gray (mechanically polished)	dull gray	dull whitish gray	dull dark gray
White layer (sensitized in acetic acid atmosphere)	unchanged	gray+red-brown	reddish-brown
Light gray (passivated in sulfuric acid solution)	unchanged	whitish gray	gray+reddish-brown

These results confirm that, as suspected, the environment has an important effect in the development of the reddish-brown surface product. Under protected conditions, as inside a palace room, the initial appearance did not change over the entire exposure period, even in the case of previously sensitized surfaces. Instead, lead samples exposed outdoors present a more or less rapid evolution of the initial surface product, the reddish-brown product becoming evident earlier for the samples in the severe outdoors location.

Regarding the role played by the initial surface condition, it was evident that the sensitization, as resulting from pretreatment with acetic acid, induced a more rapid development of the reddish-brown product, which started underlying the initial white carbonate layer and ended by replacing it almost completely. On the other hand, passivated samples, such as those treated with sulfuric acid, present a slower appearance of the reddish-brown product, and the polished samples did not show any changes, except turning matte at the end of the tests.

Figure 4. Appearance of a sensitized sample **B** after a 15-month exposure to an outdoor "severe" environment.

Samples representative of the above described behavior were analyzed by Raman spectroscopy and the results summarized in Table 2 confirm that the reddish-brown product is plattnerite (Bernard et al., 2010).

Table 2—Raman spectroscopy analysis of some of the samples treated and exposed for 15 months at different locations in the palace.

Pre-treatment	Location		
	Very mild indoors	Mild outdoors	Severe outdoors
mechanically polished	Litharge + hydrocerussite	Litharge + hydrocerussite	–
sensitized in acetic acid atmosphere	Plumbonacrite	Litharge + hydrocerussite	Hydrocerussite + plattnerite
passivated in sulfuric acid solution	Lead oxides + anglesite	–	Plattnerite

Notes: Litharge (PbO); Plumbonacrite, white lead oxide hydroxide carbonate ($PbO.Pb(OH)_2.PbCO_3$); Anglesite ($PbSO_4$); Plattnerite, (PbO_2).

Formation of plattnerite at the expense of white lead compounds, such as hydrocerussite, cerussite, and anglesite, have been found to occur under specific environmental conditions, such as intense light and high humidity (Giovannoni et al., 1990; Aze, 2005).

Conclusions

The studies have shown that the reddish-brown patina consists mostly of plattnerite. It has been seen that it can develop in a relatively short period of time depending on the starting surface condition (presence of a carbonate layer) as well as on the local micro-environment (intense light and high humidity). Furthermore, the reddish-brown layer formed is continuous and well adhered to the surface.

Since this patina has not been observed to cause any damage and appears to provide a protective function to the underlying lead, its removal is not necessary unless required for specific restoration reasons. Moreover it has to be taken into account that the reddish-brown patina may eventually re-form on the cleaned statues over the years.

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Chapter 7.

Conservation and Restoration of the Ornamental Fountains in the Gardens of Queluz

Nuno Proença and *Marta Raposo*

Introduction

The ornamental fountains that were addressed in this project were mostly designed by the French architect Jean Baptiste Robillion, with elegant *rocaille* decoration (Afonso and Delaforce, 1989). Some were composed in a graceful combination of elements carved in stone—limestone or marble—and groups of figures or decorations in lead, of high technical and artistic value, conceived under the influence of the English sculptor John Cheere (Neto and Grilo, 2008; Chapter 3) in the second half of the eighteenth century.

The conservation of the fountains was carried out between August 2009 and July 2010. A team of an average of ten conservators/restorers was used, and specialized professionals were called in for specific tasks, such as the documentation of architectural and sculpture components, hydraulic issues, soldering, and scaffolding installation.

For various reasons—logistical, visitor management, and events organized in the gardens—the intervention began in areas along two of the main axes of the gardens (Figure 1): the Cascade Lane leading from the Gate of Fame to the Great Cascade (addressing four shell fountains and the Great Cascade); and by the Medallions' Lane that leads from the Sycamore Plaza across the canal (Dragons Fountain and and Dragon's Basin), to the Neptune Fountain (the Medallions' and the Neptune fountains). The final phase corresponded to the conservation of the fountains in the two formal gardens: the Hanging Garden (Neptune, Nereid and the two small Monkey fountains), and the Malta Garden where its fountain was addressed.

Guidelines for the Interventions

From the beginning, all procedures followed a conservation and maintenance methodology that used an approximation approach aiming to stabilize the various materials while trying to find balanced and integrated solutions, particularly with respect to the presentation of statues and decorative elements in the context of the historic gardens of the palace.

Figure 1. Map of the gardens of the National Palace of Queluz showing the location of the 14 fountains that were restored (Original Map University of Evora, via SIPA downloads from www.monumentos.pt, on November 2008).

To achieve these objectives, the work was carried out following the points listed below:

- Reducing deterioration agents.
- Treating active deterioration processes, both from remedial and preventive perspectives, so as to slow their rate.
- Reestablishing both integrity and aesthetics to the fountains while taking into account their functionality and context in the garden.
- Documenting—in the full meaning of the word—existing conditions and actions taken to serve as a working tool and as a link between past, present, and future.

The methodologies applied to the various materials present—adapted and adjusted during the actual intervention—were developed from the following:

- Technical and scientific publications relevant to the behavior of the various materials in question (Costa and Urbain, 2005; ICOMOS-ISCS, 2008). Records of previous interventions, particularly those during the twentieth century (DGEMN, 1962), and information on the hydraulic system of each fountain. For the specific case of the lead statues, information obtained from historic and technical studies previously carried out was consulted (Neto e Grilo, 2008; Costa, 2008; Wouters, 2008) as well as the treatment reports from the restorations carried out on the Cheere statues (Harris, 2009).
- Detailed conditions survey of all fountains and their elements through graphic and photographic records.
- Practical and logistical expertise gained through previous similar projects of comparable complexity and duration that required defining priorities, a balanced and realistic management of the ongoing work, and a careful selection of material and human resources.
- A phased approach—with a multidisciplinary perspective discussed with members of the scientific committee—according to the needs that allowed making validated decisions during the interventions.

Taking into account the initial state of conservation of each fountain and the objectives of the intervention, it follows that the major portion of the work undertaken consisted of cleaning operations, both of stone and lead elements. Nonetheless, the labor required to restore 13 fountains and the Great Cascade to fully operational conditions cannot be discounted. This also implied ensuring that all the basins were completely watertight as well as inspecting, repairing, and substituting faulty parts in the hydraulic systems of each fountain, particularly those with water jets and sprays.

Documentation and Information

Projects such as this one present a unique opportunity to increase our knowledge about the objects to be conserved. Given the historical and decorative value of these fountains, as well

as their functional conception, one of the first tasks was to peruse all relevant bibliography and research all iconographic sources, while gathering technical and scientific documentation regarding both the materials and their conservation and restoration.

As outlined above, during the intervention the following documentation was compiled:

- A total of approximately 9,000 photographs were taken, including each fountain in general or details of it, its initial and final condition, and of the conservation activities carried out.
- Laser-scanned 3-D survey with an orthophotographic recomposition (60 recompositions, see Figure 2), from which the 2-D rendering of the various elements of each fountain could be created, resulting in a total of 60 drawings.
- Conditions survey, including specific conservation or restorations carried out, on the 2-D drawings (Figure 3). The on-site, hand-drawn data was subsequently and progressively introduced and added to electronic files (a total of 212 condition surveys).
- During the intervention, preliminary reports on the activities being carried out were presented to WMF Portugal and the authorities of the National Palace of Queluz. At the end of the intervention a final report was also submitted (Nova Conservação, 2011).

Figure 2. Laser scanning survey of the sculpture group in the Malta Fountain. Left: cloud point image. Right: 3-D rendering.

Independently of the usual written and photographic documentation on the various phases of the work carried out, a scaled survey of both the architectural and sculptural elements (Figure 3) produced an important document to record the various objects. This set of documents will hopefully serve as the basis for future graphic documentation, such as the state of conservation, undertaken conservation/restoration measures, and maintenance operations.

Figure 3. Survey of the sculpture group of one of the Shell Fountains. Left: regular photography. Right: 2-D rendering (© Luca Fabiani).

Although visitors were allowed to view the progress during the restoration and conservation work carried out at the fountains—with due precautions for the safety of the visitors—in some cases, scaffoldings had to be installed because of the length or height of the surfaces to be treated, e.g., the Nereid and the Neptune fountains (Figures 4 and 5). In these cases, two didactic panels were installed by the protective barriers, where an explanation of the approach and methodologies used was given. This compensated in part for the fact that the fountain was not visible while providing information about the needs and objectives of the intervention.

At the same time, the official website of the National Palace of Queluz, through the Institute of Museums and Conservation, IMC-I.P., posted and periodically updated the progress being made on the fountains during their conservation and restoration. This information also aimed to educate the public about the artistic and historic value of the gardens and highlighted the need for ongoing maintenance and conservation works to preserve the gardens and their decorative elements for the future.

Figure 4. Laser scanning of the Nereid Fountain.

Figure 5. Scaffolding and didactic panels located at the edge of the restricted area by the Neptune Fountain.

State of Conservation of the Fountains

All fourteen fountains were in rather poor condition, especially with regard to their operational requirements, including leaks in their basins and malfunctioning hydraulic systems. Over the years, this malfunctioning had negative consequences for the conservation of the various materials and an inevitable impact on the ornamental water programs of the gardens.

The type, degree, and amount of the main forms of deterioration and alteration found in each fountain depended not only on the materials present (Lioz limestone, marble, lead, and azulejo tile) but also on the complexity of the water system and sprays, as well as their

Figure 6. Condition of one of the Shell fountains prior to the conservation and restoration intervention.

location within the gardens. The latter was an important component, since it includes exposure to rainwater, light, and UV radiation; thermal variations; and biological agents such as microorganisms, plants, and animals.

Apart from the generalized biocolonization of the stone (Figure 6), and even on calcareous concretions over lead statues (Figure 7), the development of algae in the water interfered with the functionality of the hydraulic system, particularly for the jet sprays, while the growth of roots from nearby trees contributed to blocking and breaking water pipes, as well as inducing fractures and opening joints in the stone basins

The lack of regular maintenance had much to do with the condition found in the fountains and contributed to the malfunctioning of the ornamental water sprays, thus promoting the formation of calcareous concretions and encrustations on both stone and lead elements. Examples of this can be found in the Medallions' and the Neptune fountains, whose basins had not been emptied and cleaned for over 10 years.

The lead sculpture groups presented several conditions. Apart from the mentioned calcareous concretions, distortion of the lead, fissures, and some loose decorative elements, as well as various patinas, were found on their surface. These included the usual and stable lead carbonate and basic lead carbonates, and some very localized ones, such as a yellowish lead chlorophosphate, pyromorphite [$Pb_5(PO_4)_3Cl$], or the more ubiquitous reddish to dark brown-black lead dioxide, plattnerite [PbO_2]. These analyses, carried out through X-ray diffraction, complemented those previously undertaken (Costa, 2008; Wouters 2008).

In the case of the complex Neptune Fountain, the figures of Neptune and the muse were carefully examined with a portable endoscope to determine their condition, both with regards to their shape and to the state of the internal iron structure that had been introduced in the latter half of the twentieth century (see Figure 14).

Figure 7. Condition of the Nereid Fountain where calcareous concretions were found on the lead objects.

Main Conservation/Restoration Activities

Stone and Related Materials

To address the stone elements, the following activities were carried out:

- Biocide treatment (between one and three applications) monitoring its effectiveness with a fluorimeter (Biofinder) (Delgado Rodrigues et al., 2004; Charola et al., 2007).
- General cleaning by simple or controlled pressure washing with localized mechanical methods for the removal of dirt, roots, and calcareous concretions. In some instances, chemical cleaning with poulticing was used.
- Sealing of fissures and fractures with appropriate commercial premixed injection mortars as for the Nereid fountain (Figure 8).
- Cleaning out of faulty joints, then filling and repointing with mastic and restoration hydraulic mortars (Figure 9).
- Reconstructing relevant missing parts with restoration hydraulic mortars including reinforcements where needed (Figure 10).
- Reattachment of loose fragments with appropriate adhesives (Figure 11) and stainless steel pins where necessary.

Figure 8. Grout injection into a fracture of the center "shell" of the Nereid Fountain.

Figure 9. Sealing joints in one of the Shell fountains.

Figure 10. Filling in missing areas in the balustrade of the Neptune Fountain in the Hanging Garden.

Figure 11. Reattaching a fragment of the Lioz limestone vase of one of the Monkey fountains.

- Removal of unstable elements within sculpture groups and their reinstallation, particularly on decorative elements as well as on the basins' moldings, such as those on Medallions' Fountain (Figure 12), the Dragons Fountain (Figure 13), and the marble Neptune Fountain.

Figure 12. Removing the central block of the Medallions' Fountain to access the water distribution circuit.

Figure 13. Resetting the decorative edge of the Dragons' Fountain by the Sycamore plaza after cleaning it, clearing out roots and debris, and leveling the base.

Specific situations required consulting structural engineers to define the approach and work to be done, such as those carried out on:

- The marble Neptune Fountain that required a concrete ring around the lower part of the basin to stabilize it (Appleton, 2009).
- Installation of crack monitors along two rather significant fissures in the central stone "shell" of the Nereid Fountain so as to record and evaluate any changes over time (Appleton, 2010).

With regards to the treatment of other materials associated with stone objects, the main interventions were:

- Patching the exterior of the basin of the Great Cascade with hydraulic lime mortars.
- Addressing the azulejo floor of the basins of the Malta and Medallions' fountains and the Great Cascade. This included washing, plus some mechanical cleaning, resetting loose tiles and substituting those that were so damaged as to no longer be functional, and sealing and repointing the joints.

Lead Sculpture Groups

One of the main problems was cleaning the lead sculpture groups in the fountains. From a technical (and theoretical) point of view, the chosen cleaning procedures should be effective while not damaging the metal, and result in a satisfactorily aesthetic presentation required for appreciating the high technical and artistic quality of form and detail of these decorative elements.

This required decisions to be made on a case-by-case basis as the work progressed, and called for various cleaning methodologies that were applied individually or in combination, including manual mechanical removal, ultra-sound application (Figure 15), and chemical solutions varying in nature, formulation, and application. The choice of methodology depended on the condition of the surface and took into account the goal of harmonizing the surface being treated with the rest of the sculpture and its group.

Independent of the cleaning operations, any small fissures encountered were sealed with elastic, highly water- and UV-radiation-resistant epoxy resins. When structural strengthening was necessary figures were dismantled, reinforcement was introduced, and then reinstalled.

Figure 14. Endoscopy carried out to evaluate the interior condition of the Neptune lead statue.

Figure 15. Removal of calcareous concretions on one of the lead sculptures using ultrasound.

Figure 16. Detail of lead surfaces on the Neptune Fountain after applying the multilayer protective coating.

Figure 17. Replacement of the hydraulic distribution system in one of the Shell fountains.

Once these operations were completed, any chromatic differences resulting from soldering were adjusted by in-painting, and then the whole group was treated with a final multilayer protective coating of acrylic resins and microcrystalline wax (Figure 16).

Rehabilitation of the Hydraulic Systems

Conditions of the hydraulic systems in the fountains varied widely. These ranged from total obstruction of the pipes to simple blockages in the nozzles of the water jets. Therefore the work to be carried out depended on the existing condition at the fountain in question, so that it could be reurned to a fully functional state. This included:

- Exploration and sounding of the water circuits to identify the adduction and distribution ones.
- Dismounting and cleaning of the pipes and water spray nozzles.
- Repairing leaks in the lead pipes by soldering.
- Covering existing pipes with new tubing.
- Total or partial substitution of pipes and their support systems (Figure 17).
- Installing new nozzles similar to the existing ones.
- Substitution of water regulation faucets.
- Rehabilitation of the manholes and introduction a new additional one for the Medallions' Fountain.
- Rehabilitation of the water entry valves.
- Rehabilitation of the drainage valves.

Figure 18. Neptune Fountain in the Hanging Garden showing the water jets in action after the intervention.

Figure 19. The east Shell fountain on the Cascade lane in the foreground, and the west Shell fountain (upper left corner) after the restoration and conservation intervention.

- Installation of a pressure meter or flow meter in the Hanging Garden Neptune Fountain.
- Installation of a filter in the adduction pipe of the Medallions' Fountain.

Final Considerations

The maintenance recommendations of the Scientific Committee of WMF Portugal for the gardens of the National Palace of Queluz (Charola et al., 2010)—included as the last chapter of this publication—provide the guidelines for the short- and long-term preservation of the fountains. We highlight that the conservation of this heritage is an ongoing process that requires both monitoring of the objects in question and their surroundings with the necessary control of vegetation and soil erosion, and the maintenance of the hydraulic systems.

The completion of the described intervention achieved yet another objective of the conservation project of the gardens of the National Palace of Queluz. It served to restore some of the most important fountains (Figures 18, 19, and 20)—key elements of the architectural and landscaping objective of this site—bringing back to the gardens at least part of its past brilliance and splendor.

Figure 20. The central sculpture group in the Nereid Fountain, after the restoration and conservation intervention.

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Chapter 8.

The Canal de Azulejos: Conservation Problems and Perspectives

José Delgado Rodrigues and *A. Elena Charola*

Introduction

The gardens of the palace are crossed by the Jamor River that runs on a roughly north-south course from its upper watershed to its mouth in the Tagus River. It enters the gardens of the Queluz palace in a northeast to southwest direction. It then it flows underground for a time before reappearing again when it enters the Canal de Azulejos. Once it leaves this highly decorated section, it collects the water from a tributary creek, the Ribeira das Forcadas, and bends further southwards. In this final section, the river has only reinforced banks and is practically running in its natural condition. When it leaves the property it is joined by another important creek, the Ribeira da Carvoeira, just before passing below the IC19 highway (Figure 1).

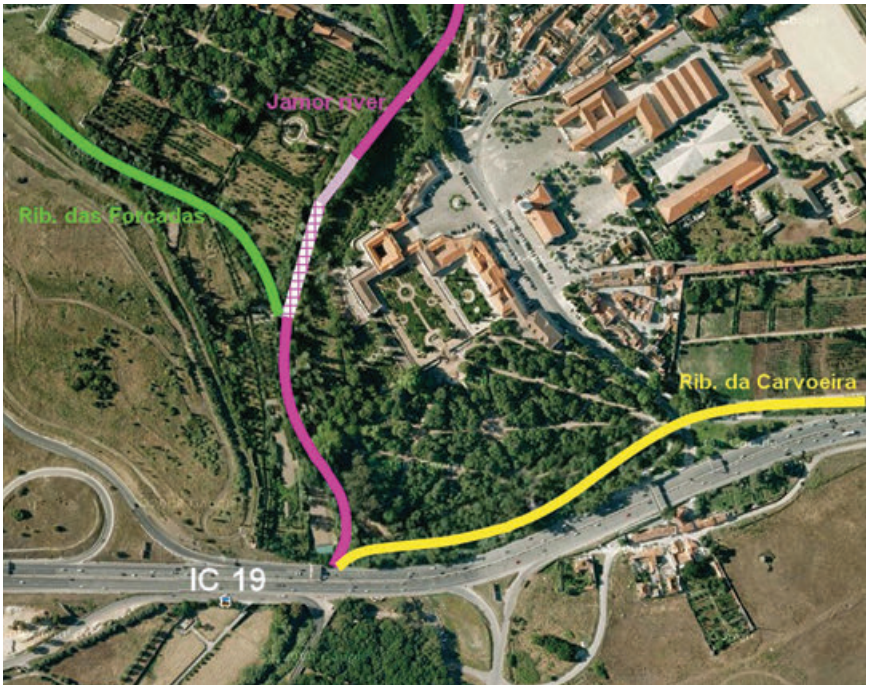

Figure 1. Satellite view of the palace and its gardens. The Jamor River (in pink) runs in part underground (dotted section) then runs through the Canal de Azulejos (checkered section). At the exit from the canal it is joined by the Ribeira das Forcadas (in green). When it leaves the palace property it merges with the Ribeira da Carvoeira (in yellow).

The Jamor River was channelled many years before the property passed into possession of the royal family in the first half of the eighteenth century (Pereira and Luckhurst, 2005). It enters the palace property in an open canal usually referred to as the entry canal (Figure 2). Then it flows underground until it passes the Sycamore Plaza, where it resurfaces as it runs into the Canal de Azulejos proper.

Figure 2. View of the Jamor River when it enters the gardens of the palace. Note that even this modest canal section was embellished with a band of elegantly decorated azulejos.

The decorated section of the canal runs along the avenue that borders the former maze and the Prince's Garden (see Figure 1 in Chapter 4). In this section, about 120 meters long, the inner walls of the canal are covered by decorated azulejos dating from the mid-eighteenth century. The retaining walls of the canal, some 8 to 12 meters wide, are about 2 meters high at the beginning and reach over 3 meters in height at the end of the decorated section, where the floodgate was installed. The latter served to fill the canal with water and allow pleasure boats to float up and down it. Above the pillars that held the floodgate is a small wooden bridge that crosses over to a small tile-decorated structure, adapted from an early-twentieth-century conservatory that currently serves as a cafeteria (Figures 3a, b).

The floor of the canal was originally far deeper, so that when the canal was filled the water would barely reach the azulejo decoration. In the 1940s, the floor of the canal was raised, presumably because of structural problems, so it is now practically at the level of the lowest row of tiles at the beginning of the canal (Figure 3a) and progressively departs from it toward the south, reaching a distance of about one meter at the end of the decorated section (Figure 3b). The

floor of the canal is paved with stone masonry to protect it from erosion, and is sloped toward a deeper center trench that is sufficient to carry all the water during the dry seasons (Figure 3a). As mentioned, the overall flow is north to south.

Figure 3a. The beginning of the Canal de Azulejos proper. In the distance, the center block. Note that the azulejo cover starts right at the floor of the canal and, as this slopes down, the undecorated wall becomes evident as can be seen in the center block.

Figure 3b. End of the decorated section of the canal. To the right, the tile-decorated structure adapted from an early-twentieth-century conservatory. Below the bridge, at the end of the canal, the flood gate was installed. Note that the azulejo decoration is over one meter from the floor.

Conservation Issues

As mentioned, the water from the decorated canal joins the Ribeira das Forcadas right beyond the point where the floodgate used to be and acquires a more natural appearance, despite being partially lined with walls to protect its banks. When it leaves the gardens, it is joined by the Ribeira da Carvoeira that runs around the palace property to the east and then flows into the culvert below the IC19 highway.

The floodgate installed at the end of the Canal de Azulejos was used to fill the canal with water, reaching the base of the azulejo decoration. It was deep enough for boats to be rowed from one end to the other for the amusement of the royal family and their court. Figure 4 shows a postcard from the early twentieth century with the canal filled with water. The floodgate system worked until the mechanical system failed and was dismantled in the late 1990s; therefore filling the canal with water is no longer possible.

Figure 4. Postcard from the beginning of the twentieth century showing the canal filled with water.

Initially, it was considered feasible to reinstall a floodgate, but historical research showed that the last times the canal was filled, the tiles were severely damaged (Pereira and Luckhurst, 2005; Ferreira, 2007). This was on the occasion of the filming of the movies "Bocage" and "O cão do ortelão" in 1935 and 1995, respectively. For this last movie, the lower five azulejos rows had been prepared for the water level to reach this height so as to reduce damage (Ferreira, 2007). Nonetheless, damage resulted because the filming required the canal to be filled with water for some months (Ferreira, 2007). After the filming, many tiles detached from the walls and a conservation intervention was necessary to address the induced damages. Based on these experiences, the installation of the floodgate was rejected, especially considering the increased hazard it would create in the case of a catastrophic flood.

Since the eighteenth century, the canal has suffered many severe and floods: the first one in 1763, four in the nineteenth century, and three in the twentieth century. During the 1967 flood, a section of the east side canal wall, close to the center block, toppled over. This was subsequently rebuilt, rather poorly, with the consequent result that this area shows buckling and distortion of the tiled surface (Figure 5).

Figure 5. Rebuilt section after the 1967 flood, showing the buckling of the azulejos. The bridge over the canal corresponds to that of the center block.

In light of these problems, two studies were commissioned from the LNEC (National Civil Engineering Laboratory). One was to deal with the frequency of major flooding of the river (Rocha and Fernandes, 2006), while the other evaluated the stability of the retaining walls (Salgado, 2006).

The frequency of floods is increasing because the upriver area above the palace is being developed; therefore far less vegetation covers the hill and less rainwater is being absorbed

by the ground. Consequently, a higher flow rate occurs during heavy floods. These are estimated to occur every 20 years, while major floods are expected to occur every 50 years. The 1967 catastrophic flood that destroyed part of the canal was estimated to occur once every 500 years.

The higher flow rate during heavy floods was aggravated by a lack of maintenance of the section beyond the end of the canal where the river is joined by the Ribeira das Forcadas. This partly canalized section was profoundly clogged by the growth of reeds, canes, and all manner of plants that blocked it almost completely, causing the water level in the decorated Canal dos Azulejos to rise far higher. Also, the bridge piers of the IC19 under which the Jamor River and the Ribeira da Carvoeira flow are angled for a flow direction of the latter, since it originally carried much more water than the Jamor. This additional obstacle to the water flow also contributed to increasing the flood levels in the canal.

During the project, the maintenance carried out on the final segment of the river—after it leaves the Canal de Azulejos—significantly improved the discharge of water from the decorated canal, but the poor hydraulic design of the bridge piers remains a problem. In February 2008, a major flood damaged the floor of the entry canal just where it enters the culvert that runs under the Sycamore Plaza. This section is paved with large stone blocks, and the strong current of the flood removed some and destroyed others, leaving a deep, 2.5-meter-wide hole in it. As mentioned in Chapter 4, this was repaired in early 2009.

The conservation of the unique Canal de Azulejos is based on the structural stability of its retaining walls, especially after the many catastrophic floods it suffered. The study carried out (Salgado, 2006) suggests that the retaining walls of the canal are in good condition and no signs of structural instability were identified during the on-site inspection. However, there is a freestanding wall at the confluence of the Jamor river and the Ribeira das Forcadas that separates both water streams that may suffer faster deterioration because of its double exposure. Furthermore, the riverbed in the decorated zone is protected with stone paving that helps to protect it from erosion and also contributes to load stabilization of the wall foundations. However, the drainage system on the outer sides of the canal walls, along the parapets above the retaining walls, is not well designed and may result in damage to these low walls and their tile cover. This is a point that needs to be addressed, as suggested in the maintenance recommendations.

Although the structural safety of the retaining walls was found to be at a fairly satisfactory level, it was pointed out that the thick roots of the sycamore trees on the east side and other large trees on the west side posed a major threat to the walls and panels (Salgado, 2006, Triães and Coroado, 2006) (Figure 6). Based on these studies, it was decided that the felling of the sycamores lining the east walk and other large trees on the west bank was necessary. This was carried out during the winter of 2008–2009.

Figure 6. View of the inner west wall of the canal showing an area with azulejo loss (compare with Figure 12 in Chapter 4) partly due to the root growth of larger trees, such as poplars growing on the west bank that were propagating into the canal bed (May 2004).

The Decorated Panels

The Canal de Azulejos proper extends from the Sycamore Plaza to where the floodgate used to be and where it is joined by the tributary creek. While the inner walls of the canal are covered with eighteenth-century azulejos, those in the center block are more recent (Figure 7). Historic studies have shown them to be from the early twentieth century following the alterations introduced during the nineteenth century (Sequeira and Vale, 2004).

Figure 7. The center block of the canal, where the music stand was installed, as seen from the palace side after completion of the project (2010).

There are about 50,000 azulejos lining the interior sides of the canal, not including those of the center block. The stylized bat wings and shell-like features, typical components of the rococo style, are abundantly used on the exterior decoration of the canal walls and on the decorative mounts on top of the wall, where glazed ceramic vases are installed (Figure 8). Some preliminary studies on the composition of the chacotte and the glazing of these azulejos were carried out at the IPT (Polytechnic Institute of Tomar (Ferreira, 2007).

The tiles used for the inner decoration of the canal are mostly traditional blue-and-white azulejos of exquisite design and manufacturing quality. The panels are finely drawn, incorporating painting details to highlight a three dimensional illusion created by their composition and the use of halftones of blue and of white brush strokes as shown in Figure 9.

The azulejo panels represent a variety of landscapes, such as sea harbors, landing scenes, towers, and castles, very likely copied from engravings popular at that time. The adjacent scenes were separated by sets of trees and human images that serve as transitional elements (Figure 10). They constitute a typical example of the "historicized" panels from the first period of the rococo style, and a reference work for the end of this period. Originally, when the floodgate was closed, the canal was filled with water that reached the base of the azulejo decoration and was deep enough for boats to be rowed from one end to the other, making the trip a mini virtual "world tour."

Figure 8. Decorations details typical of the rococo style.

Figure 9. Example of an azulejo-decorated panel. Notice the exquisite quality of the drawing and the use of half-tones of blue to accentuate the 3-D illusion. Note the colors used on the decorative mounts that support the glazed ceramic vases. At this point the separation of the azulejo cover from the canal bed is about 50 centimeters (assuming the azulejos are about 14 centimeters square).

The research also established that the decorated panels underwent multiple restorations: two in the eighteenth century, and at least five in the twentieth century (Ferreira 2007). These entailed the replacement of tiles and reconstruction of stretches damaged by violent flood events or the filling of the canal for the filming of the aforementioned movies. Therefore, the present azulejo decoration of the canal is a mixture of original and replaced tiles.

Figure 10. A closer detail of another section showing the high manufacturing quality of the tiles. The photograph also shows that many of the tiles are deteriorated and that some have been replaced, identifiable by their lesser design quality.

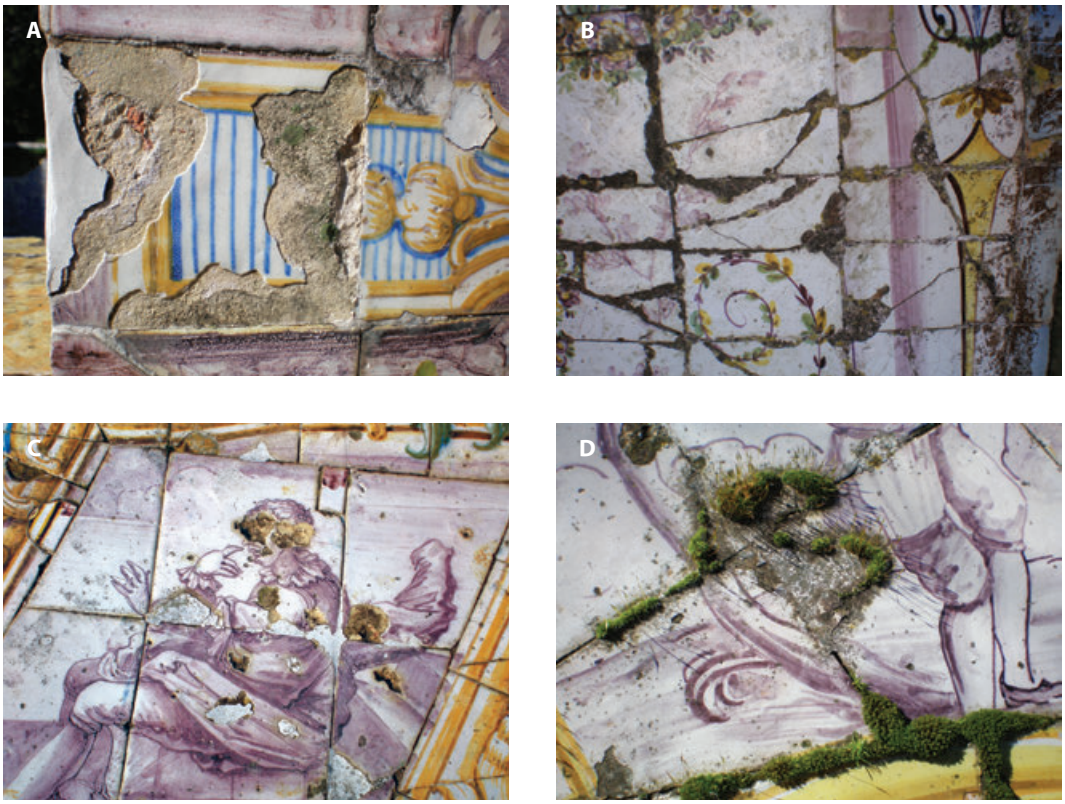

Figure 11. Common deterioration features in the glazed tiles. **A** Loss of the glazing; **B** fractures; **C** past repair patching; and **D** biocolonization.

The decorated tiles show all the kinds of damage features that typically can be found for this type of material, such as detachment of the glazed layer, fractures, loss of adhesion from the setting mortars, and biocolonization, to which past repair incongruences come to add further inhomogeneity (Figure 11). Wet/dry cycles are a major cause of degradation, and the poor adhesion of the glazed layer to substrate may be present in several situations.

Conclusions

To undertake a comprehensive intervention on any object, it is fundamental to understand all the factors that cause and contribute to its deterioration. In the case of the Canal de Azulejos, a large structure, decorated with glazed tiles and with water running through it, many studies were required to understand the problems that threaten it. The sheer size of the canal and the number of azulejos decorating it make this a major intervention.

The various studies carried out allowed a better understanding of the nature, the history, and, especially, the main problems that affect the canal. Furthermore, the laser scanning of the complete canal has provided a valuable document that will serve as a reference point for future monitoring of any changes that may occur in the decorated canal. However, to define the intervention required at the canal, all these studies need to be complemented with a clear definition of the objective to be reached for the panels, the canal itself, and the tributary creeks.

Defining the aim of such an intervention is a complex issue that requires a thorough analysis and balance of the various values involved. A decorative azulejo panel in the interior of a building, where it has been relatively protected from the exterior environment, where the value of the individual azulejo tiles is practically intact, will require a totally different approach than that for azulejos on an exterior structure that have suffered much damage during their lifetime, especially when over 50,000 tiles are being considered. The presence of azulejos from various periods and differing quality—a consequence of the multiple damaging events that the canal has suffered—has to be taken into account. From a conservative point of view, the stabilization of the existing tiles was the first intervention required, and this was carried out. But there are areas, such as the 1967 reconstructed section where the tile cover is buckling and partly detached from the substrate, that will eventually need a thorough intervention to ensure their preservation. But restoring this section is in itself a major intervention that needs careful planning within the framework of the total intervention of the canal tiles.

The minimum intervention principle should probably be the guideline. In this case, punctual interventions could be carried out such as required for the above mentioned section. Most of the remaining tasks could be considered as preventive maintenance but even in this case guidelines need to be established. For example, in many situations where the glazing has been lost and no figurative elements were present, this could be solved by the use of a synthetic resin. Where areas have been damaged and part of the design lost, some aesthetic reintegration may be justified, but then it is important to define if and whether it is to be repainted or not, to what a degree, and how to do it.

In summary, the project has served to provide a clearer picture of the problems that affect the canal, address the most urgent ones, and point out the framework that needs to be established when undertaking the required interventions. The thorough documentation carried out will serve as a reference point for its future.

Portugal has a vast and rich heritage of azulejos decorating architectonic surfaces. However, conservation work has focused frequently on the most valuable decorations, generally found in interior spaces. Therefore, conservation of exterior-surface azulejos—usually not the most appreciated—has not received significant attention. Only recently have the scientific and professional communities progressively acquired further knowledge in the conservation of these azulejos, and this should certainly help improve the restoration practice. And perhaps, as originally considered, a workshop system may be implemented in the future to train conservators as well as to provide the regular maintenance that this three-century-old canal requires.

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Chapter 9.

The Workshops: Framework and Implementation Strategy

A. Elena Charola, *José Delgado Rodrigues*, *Luis Aires Barros*, and *Fernando M. A. Henriques*

Introduction

During the conservation intervention project of the garden of Queluz, given the sheer magnitude of the project and its complexity, diverse and innovative approaches had to be developed. One of the concerns was the maintenance that is required after the completion of a conservation intervention. In the case of the decorative stone elements, a relatively simple approach could be developed, as most of these elements suffer mostly from biocolonization and are reachable from a simple ladder. Thus, the workshop approach was used to help train both students and palace staff in the problems and the solutions required, with special emphasis on the need for regular monitoring to determine when the simple biocide treatment is to be applied, given that this treatment should be sparingly used because of health hazards, particularly for the plants in this garden environment.

This simple approach could not be used in the case of the stone sculptures that adorn the top of the palace or the monument to D. Maria at the rotunda next to the palace entrance. These had to receive a formal conservation intervention, particularly since some of them had fractures and structural problems from previous interventions, requiring important logistic support as well as security measures that cannot be implemented within the framework of a workshop.

Similarly, the case of the lead statues required a different approach. In the first place, the problems these statues suffered were more severe than the biocolonization of the stone sculptures, and required a professional expert in dealing with metal restoration, and specifically, large lead objects with an inner structure supporting them. Since the lead-working craft had nearly been lost in Portugal, it was decided that the opportunity provided by the restoration of the lead statues by Rupert Harris through the involvement of WMF Britain was an opportunity to train Portuguese conservators in this specific field. This was the basic task the lead workshops carried out.

Finally, a similar training workshop approach was proposed for the conservation of the azulejos lining the canal. However, because of various problems presented by the canal,

the idea could not be implemented during this project. However, it is left as a possibility to be implemented in the future as it could serve, after a conservation approach is defined, to address the specific conservation issues of the azulejos as well as help train conservators in the restoration of azulejos in the built environment.

Stone Workshops

The aim of the stone workshops, formally called Treatment and Monitoring of Biological Colonization, was to develop a simple maintenance routine for the easily accessible statues and other stone decorative elements in the gardens. An added bonus was the schooling of students, conservators, and palace staff in the rationale of this routine as well as the practical *in situ* application. The practical execution was carried out with the invaluable help of Dra. Alexandrina Barreiro of the Portuguese Conservation and Restoration Institute (*Instituto Português de Conservação e Restauro*) who also addressed the health issues, biocide preparation, and manipulation, as well as overseeing the application of the biocide to the various sculptures and balustrades.

The workshops included lecture sessions that provided the attendants with a basic understanding of the materials and their nature, the decay processes, and the theoretical framework of conservation interventions, as well as prepared them to handle and apply potentially hazardous products. The lectures covered the following topics:

- Introduction to the aim of the workshop
- Introduction to conservation theory
- The stone in the decorative elements and their deterioration
- Biocolonization and its control
- Health risks and safety issues in the handling of biocides
- Preparation, manipulation, and application of biocide solutions

An initial three-day workshop was carried out in collaboration with the then-Portuguese Center for Conservation and Restoration (IPCR) in the fall of 2005. It proved very successful and therefore two other workshops were organized for the spring and fall of 2006 for palace staff members. These were followed by a fourth and fifth in the spring and fall of 2007, which were mainly attended by the same enthusiastic participants of the first three workshops. They were limited to two days, as it was not considered necessary to repeat the lectures that were given during the first day.

In October 2007, at the request of the New University of Lisbon, an extra workshop was organized for their students. Two further workshops, in collaboration with the university were carried out in the spring and fall of 2008. The ninth and last workshop was carried out in collaboration with the University but following the original open format of the WMF Portugal workshop, in spring of 2009. Table 1 gives a complete list of the workshops and their attendance.

Figure 1. Participants working during the stone workshops: **A** photographic documentation and biocide application (first workshop); **B** and **C** biocide application (third and fifth workshop); **D** condition survey of a vase (sixth workshop); **E** lecture session; **F** preparation of biocide solutions (both ninth workshop).

The participants were required to prepare brief reports outlining their activities, such as the documentation of the object, its condition, and a description of the biocolonization present and the treatment applied. In total, nine workshops were organized and nearly 100 participants attended them.

The evaluation of these workshops by the participants was very positive, indicating that they not only served the development of a regular maintenance plan for the cleaning of the stone sculptures but that they contributed to the formation and development of conservation students, professionals, and staff at the palace (Figure 1).

These workshops showed that the approach followed at the Queluz gardens has the potential to serve as a methodology paradigm to be followed when biocolonization is the main deterioration problem of stone objects in a garden environment.

Table 1—List of stone workshops carried out during the conservation project

Workshop	Date	Total participants	Palace staff	Other Govern. Instit.
1	Nov. 21–23, 2005	6	–	–
2	Apr. 10–12, 2006	15	2	1
3	Sept. 18–20, 2006	8	2	1
4	May 28–29, 2007	5	2	1
5	Oct. 1–2, 2007	5	2	1
6	Nov. 30, Dec. 7, 2007	15	–	–
7	Apr. 23–25–26, 2008	5	2	1
8	Oct. 4–6, 2008	6	–	–
	Oct. 11–12, 2008	11	–	–
	Oct. 10–17, 2008	10	–	–
9	June 7–8, 2010	20	–	–

Lead Workshops

The aim of the lead workshops had a twofold objective: the actual restoration of some of the lead statues and the specialized training of Portuguese conservators in the restoration of lead objects. Rupert Harris and his crew of three assistants, A. Martin, M. Rodda, and J. Rumsey, are to be thanked for generously accepting the challenge of organizing these workshops. Both Harris and the IPCR agreed that the restoration workshop required should be installed at Queluz Palace. For this purpose, a storage room on the ground floor of the Robillion wing was cleaned, adapted, and furnished with the necessary equipment to carry out the workshops. The first workshop was scheduled to occur the last two weeks of October and the last two weeks of November 2006.

Four participants attended the first workshop and four individual statues were partly restored: *Summer, Autumn, Apollo,* and *Diana*. The workshop included the removal of the statues, their transport to the workshop, the evaluation and preparation of a condition report, the actual restoration, and the writing of a report (Figure 2). The evaluation sheet completed by the students qualified the workshop as good to excellent.

The second lead workshop, limited to two weeks, took place during the last two weeks of October 2007 (Figure 3). The same four participants attended, so as to continue their training. However, only three of the four candidates attended regularly. During this workshop, the treatment of the four individual statues was completed and the five small lead vases were restored as necessary.

Figure 2. A the four participants and the Rupert Harris' training team during the first lead workshop; **B** removal of the *Adonis* statue; **C** participants working on two different statues. All photos from the first workshop.

Figure 3. Two moments during the second lead workshop.

The top two participants were selected to complete their training at the Rupert Harris Studio in London for two weeks in June 2008. During that time they worked on the restoration of the two last statue groups: *Venus and Adonis* and *Bacchus and Ariadne.* These groups returned to Queluz Palace toward the end of April 2009. At that time, all the statues that had been restored were patinated and a finishing coat of patination oil was applied to them prior to their reinstallation in the garden.

Chapter 9.1

The Language of Stone: A Participant's Viewpoint of the Stone Workshops

Maria Luísa Silva Vieira

Introduction

To carry out the workshops on treatment and monitoring of biological colonization at a site such as the National Palace of Queluz, it is important to be aware of the entailed responsibility given the historical and cultural values carried by this monument. Furthermore, the palace—both in its interior and in the gardens—is imbued with a symbolism resulting from the golden moments of the royal family that can be appreciated immediately by whoever visits, admires, or is interested in the preservation of this national heritage. Thus, he can be easily "carried away" to interact with its past times:

> *"When in the middle of the Gate of Fame one looks at the "ceremonial façade" and sees the beautiful setting of the two architectures—masonry and greenery—and their decay, it has to be considered, what this residence must have been in its glory days when the eighteenth-century lifestyle enlivened it; the conclusion is reached that there is no amount of imagination that can recreate it, with regards to its pomp, vibrancy, sumptuousness, and color, similar to Marly, Versailles, and Saint Ildefonso. If a magic wand could animate this scene, make the fountains run, fill the paths with pin-ups and coxcombs, relight the old fireworks, revive operas and concerts, hunts and labyrinths, the bulls and plays, the intrigues and confidences, no spectacle would match it in courtly and gallant expression, in splendor and elegance."* (Sequeira Matos 1932:28)

With apprehension of the gardens' magnificence and in accordance with the project plan developed by the various institutions collaborating with WMF Portugal, we first attended various lectures illustrating national and international case studies. These also provided information on geology and biology and their interaction leading to stone deterioration. The importance and need for measures to prevent health risks and work accidents during the practical work carried out was also emphasized. In this manner, the guidelines for the workshops (a total of nine) were established. They included the preparation of a report on the work carried out.

Methodology

The first workshops had as an objective the application of a biocide solution—Preventol solution 1.5% or 3%, depending on the degree of biocolonization present on the surface, following the results obtained from previous studies (Vale Anjos, 2006)—to various limestone pedestals that are located in the open areas that contour the south end of the park garden near the so-called Iron Gate, the Great Cascade, and the former Botanical Garden, now the arena of the Portuguese Riding School.

The same methodology was used for the richly decorated limestone balustrade in the Sycamore Plaza that encloses the Dragons' Fountain and the *Cain and Abel* lead statue group, as well as the marble vases that adorn it.

Figure 1. Balustrade of the Sycamore Plaza. Left: detail of the biological colonization prior to the application of the biocide (April 2006). Right: appearance after four years (June 2010).

Once the basic principles were defined, it was the responsibility of each participant to acquire the experience that would aid in preventing biological recolonization, thus contributing to the preservation of this integrated heritage (in harmony with the natural and architectural heritage). The responsible acceptance of this challenge (the personal dedication that this cause certainly deserves) and the continuation of these tasks led to an understanding of the cause and effect correlation, the potential harmfulness, the durability, and the periodicity required for these treatments. Furthermore, it was clear that the applied biocide was currently the best solution (while not precluding improved products in the future) to protect the stone elements in a garden environment from the deterioration caused by biocolonization that also irreversibly ravages *our* (worldwide) heritage.

This increased motivation served to sustain the interest as the work expanded to the treatment of other elements such as statues, vases, and further balustrades that adorn the formal Malta and Hanging gardens. The practical methodology followed the same pattern: location of the object, visual observation, general photography from various angles, condition survey, mapping of lichens and other biocolonization (Figure 2a), and its photographic documentation (Figure 2b). In addition, some tests, such as water absorption using the sponge test (Tiano and Pardini, 2004, Vanvoorde et al., 2009) and its correlation with biocolonization, in conjunction with the measurement of temperature and relative humidity,

were carried out. These were followed by preliminary soft brushing of the surfaces, careful preparation of the biocide solution, and its thorough application on the stone surface. This application was carried out by brushing the surface uniformly, avoiding an excess of liquid that could run off, which in the future could develop lighter-colored stripes, as a spray application is not recommended.

Figure 2. Putti. Left: Condition survey mapping prior to the biocide application (September 2006). Right: General appearance after two years of the biocide application (October 2006).

Once the field work was completed, it was followed by a month of reflection to elaborate the individual report, and then a six-month hiatus to observe the first positive results of the applied treatment as the more evident ones appear only after approximately a year, as this application seldom gives immediate results. One of the necessary conditions in these projects is the patience and perseverance necessary to await results. While abrasive methods can give immediate results by removing part of the surface, the present approach has the virtue of working at a slower rate so that the stone surface gradually loses its bicolonization cover, reverting to a lighter color and its natural patina in harmony with the natural environment, so that the ornaments shine once again in the garden.

Figures 3 and 4 show two marble statues, mounted on the west balustrade of the Hanging Garden, that were treated with a 3% biocide solution during the fifth workshop carried out in October 2007.

After approximately three years of the biocide application the stone nearly recovered its original appearance through the loss of most of the biocolonization. However, in some areas, such as the lower part of the arms or under the chin where water may collect, recolonization is already occurring.

Figure 3. *Ceres*, the goddess of agriculture. Left: detail of the face colonized by various lichens prior to the application of the biocide (October 2007). Right: appearance after three years (June 2010).

Figure 4. *Hercules and the Lernean Hydra.* **A** detail of the face, arm and right hand showing various biological communities prior to the biocide application (October 2007); **B** appearance after three years (June 2010). **C** detail of the hydra head prior to treatment; **D** after three years.

Conclusions

The present paper summarizes the activities carried out during the workshops. The experience gained has shown that simple treatments, such as brushing on a biocide, can be effective if time is allowed to act. Biocolonization, especially in a garden environment, is recurrent and therefore using more aggressive methods, such as sandblasting, may contribute to a faster erosion of the stone surface. Although biocolonization does lead to irreversible damage, reducing the growth of the most damaging species, such as lichens, will increase the "life span" of these elements while leaving them with a "natural" patina, in harmony with the garden environment.

Thus, it is important that we minimize the surface loss of the statues that we have the fortune of appreciating today—witnesses of the historic times when the royal family enjoyed this summer retreat—so as to preserve them for future generations as recommended by the Charter of Venice (ICOMOS 1964).

The knowledge gained, both in theory and in practice, during this WMF Portugal project, has emphasized that preventive treatments must follow a regular maintenance schedule accompanied by documentation and based on the systematic monitoring of stone elements in order to determine the appropriate time for biocide application. This will reduce to a minimum any potential risk to the gardens, as well as decrease the number of required applications. This "preventive maintenance" needs a regular and long-term approach so that our heritage does not reach a state requiring costly intervention because our inertia and passivity has let it happen.

The enriching experience acquired leads to an individual assessment—with a critical and objective spirit—while showing the way of how to achieve the various tasks involved in the preservation of this heritage site, to recognize the changes and signs that indicate deterioration or lack of maintenance, and the readiness to learn from the knowledge shared by researchers and professionals. The methods to use going forward include simple techniques that could be implemented with relative low cost and few human resources, although they would require responsibility, organization, and monitoring.

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Chapter 9.2

Lead Sculpture Restoration Workshops: An Overview

Marta Raposo and *Valéria Vieira*

Introduction

Within the framework of the conservation and restoration project of the gardens of the National Palace of Queluz, a series of workshops on the restoration of lead sculpture were organized with the aim of training local restorers to participate in future interventions. The workshops were led by Rupert Harris and his team—a British firm specializing in metalwork conservation and restoration, with major experience in lead objects and sculptures.

Four participants were selected to attend these workshops, each with a different background in the conservation field that ranged from practical experience and technical courses to a more theoretical approach obtained in academia.

The first workshop—two two-week sessions in the fall of 2006—took place in a small studio that was set up at Queluz Palace. During this workshop, the preliminary restoration work was carried out on four lead statues—*Diana, Apollo, Autumn,* and *Summer.* In the fall of the following year a second workshop—limited to two weeks—was held to complete the restoration work on these statues. We were selected to complete our training by working at the Rupert Harris Conservation Studio in Londonfor two weeks in the summer of 2008. There we had the opportunity to help in the conservation of the last two sculpture groups to be restored by Rupert Harris, *Adonis and Diana* and *Bacchus and Ariadne.* Along with gaining more experience, we had the opportunity to learn about other metal restoration work and observe some casting techniques (namely lost-wax for bronze casting) at a nearby foundry.

An important point of the workshop in Britain was the visit to the gardens of two historic properties built in the eighteenth century, Wrest Park and Anglesey Abbey. These gardens, contemporaries of Queluz Palace, had several lead sculptures by John Cheere, some only differing in size and finishing from those at Queluz, but that also showed similar surface staining.

Workshop contents

Craftsmanship and Condition of the Sculptures

Following an introduction about lead—its properties and main deterioration problems (Costa and Urban, 2003)—its use, particularly for eighteenth-century statuary produced in England, was discussed. Special attention was paid to the work by John Cheere at his Hyde Park workshop (Fulton, 2004a, b). Reference was also made to the 1940s restoration interventions carried out on some statues in the Queluz gardens based on available records by a Portuguese restorer, as well as the recent ones carried out by Rupert Harris on the first four restored groups, *Aeneas and Anchises*, *The Rape of Proserpine*, *Vertumnus and Pomona*, and *Diana and Endymion,* between 2003 and 2006.

The four statues to be restored had to be surveyed to observe their condition and understand the most relevant deterioration problems. These were related to physical issues, such as fractures, fissures, *craquelure,* and distortions, as well as structural problems such as the corrosion of the supporting iron structure. Chemical alterations such as the brown-blackish staining—referred to as puce oxide and identified as plattnerite (lead dioxide)—was discussed as posing an aesthetic problem in the presentation of the statues. Figures 1, 2, and 3 show some examples of the problems encountered.

Figure 1. Discoloration (brownish lead dioxide) and fissures detected on the *Apollo* statue.

Figure 2. *Venus and Adonis* by the canal, exhibiting significant distortion of the head position.

The statues to be restored were moved from their location in the gardens to the studio at Queluz with some logistical assistance from a local conservation company (Nova Conservação, Lda). As the lead sculptures are very heavy, lift slings were used to sustain the figures in a forklift, which carefully raised and moved them onto pallets (Figure 4). Their original setting on the stone plinth had to be marked as soon as they were removed. Once at the studio,

the sculptures were raised, sustained, and turned over with the help of slings and a lifting structure. Most of the time the figures and elements remained supported by wooden trestles using blankets to cushion them.

Figure 3. Fissure in *Autumn*'s leg, through which it is possible to see the severe corrosion of the iron inner structure.

Figure 4. Lifting *Autumn* from its stone pedestal.

Following visual analysis, a careful photographic record was made. As the major deterioration was related to the poor condition of the old inner iron armatures, it was decided to remove and replace them with new ones. For this purpose, it was important to mark the lead where it was to be cut and draw lines to make sure that the separated parts could return to their original position, maintaining the statue's original shape.

Removal of the Inner Iron Structures

Cuts were preferentially made in smooth, undecorated places of the sculptures (arms, legs, necks, on the back or chest) using diverse manual and electric saws (Figure 5). To remove the corroded structures, it was necessary to find weak points and old lead fixations. Another inconvenience encountered during this procedure was the presence of large screws (Figure 6) presumably installed during former repairs. All separated elements were carefully marked and photographed.

The New Inner Structures

The old supporting structures were replaced by new stainless steel armatures, individually designed for each of the statues in question. To build them, stainless steel 314 bars were used, after being correctly dimensioned and cut for proper weight distribution. To connect the bars it was necessary to weld them together, and workshop participants had the oppor-

tunity to learn and train in this technique (Figure 7) then apply it during the construction of the new armatures (Figure 8).

Figure 5. Cutting *Autumn* to remove the old, corroded iron structure.

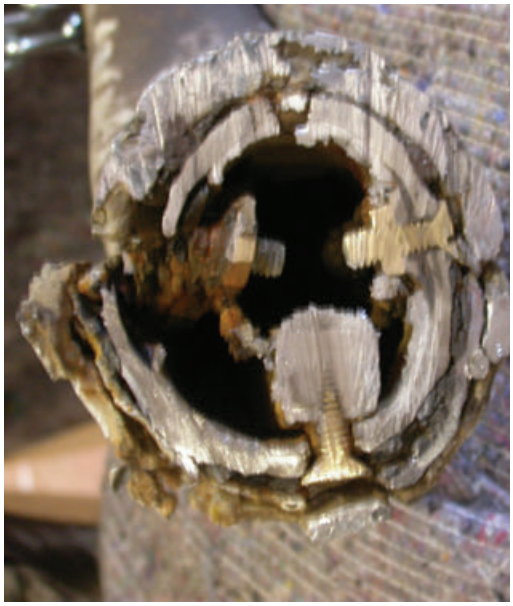

Figure 6. Set of screws found in the arm of *Autumn*, presumably from former repairs.

Figure 7. Learning to weld.

Figure 8. New armature in stainless steel fixed inside the central body of the figure.

Lead Burning

One of most important techniques for lead objects conservation and restoration is lead burning. This is used to rejoin the separated elements (Figure 9), fix the stainless steel armatures in the interior of the figures, and repair fissures and fractures as well as filling gaps. A correct lead burning without cracks is fundamental, as it will prevent water penetrating into the statue, the origin of the original corrosion of the iron armature. A very important aspect to consider before lead burning two separated parts from a sculpture is to check their correct position through marks made on them prior to the cutting.

Lead Pouring

In order to fix the armatures in place, as well as to balance the weight distribution, small amounts of lead are poured into the elements that terminate the sculptures, such as hands and feet. The piece receiving the molten lead is properly isolated and supported with sand to ensure that there are no distortions caused by heat or spilled lead through invisible cracks and discontinuities.

Re-Shaping

Any statues that suffered distortion must be carefully and accurately reshaped. This consists of taking advantage of the malleability of lead to gradually remold the form by means of rubber hammers or lead burning, in the case of missing material.

Finishing

Finishing activities basically consist of mechanically removing the excess material at lead burned joints (Figure 10). Finer tools (from rasps to shaves and files) were sequentially used as the material was taken off and the repaired area smoothed with fine-grain sandpaper. For a better reintegration of the decorated parts, punch detail instruments were used as well.

Figure 9. Lead burning on the head of *Autumn*.

Figure 10. Finishing lead burned surfaces.

Final Considerations

The workshops organized have allowed participants to gain a better understanding of the techniques used in lead statue conservation and restoration, from both a theoretical and a practical point of view. This included the various working methods as well as the necessary complementary structural work.

The opportunity to have direct hands-on training by working on six lead sculptures (*Diana, Apollo, Autumm, Summer, Adonis and Diana,* and *Bacchus and Ariadne)*, under the direction of Rupert Harris and his team, was extremely valuable for the subsequent work

carried out on the lead groups found on some of the fountains in the gardens of the National Palace of Queluz.

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Chapter 10.

The Conservation Project Implementation

A. Elena Charola and *José Ibérico Nogueira*

Introduction

The complexity of the conservation project of the gardens of the National Palace of Queluz required that it be subdivided into six subprojects. These were:

1. Restoration of the gardens.
2. Restoration of the hydraulic system.
3. Restoration and conservation of the lead statues.
4. Conservation of the stone sculptures and decorative elements.
5. Restoration of the fountains.
6. Conservation of the Canal dos Azulejos.

The first two subprojects, the restoration of the gardens and the installation of an improved hydraulic system for the fountains and irrigation of the gardens, were undertaken by the Ministry of Culture, first through IPPAR (the Portuguese Institute for Preservation or Architectural and Archaeological Patrimony), and subsequently by the institution that took on the tutelage of the National Palace of Queluz, the IMC (Portuguese Institute for Museums and Conservation).

The third subproject, the restoration of the lead statues, was assumed by WMF Britain as these were the work of the English artist John Cheere. They constitute one of the most important collections of his work.

The last three subprojects, dealing with the decorative stone elements, the fountains, and the Canal dos Azulejos, were carried out by WMF Portugal. The contributions of each of the three partners to this project is shown graphically in Figure 1.

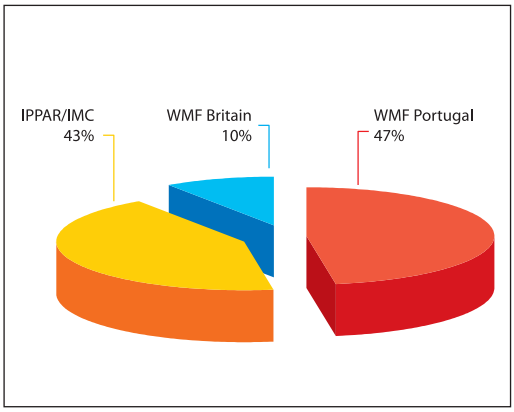

Figure 1. Percentage contribution made by each of the three partners to the total cost of the project.

It had been estimated that the project would be completed within five years from the time the actual

work started. The preliminary studies for this project started in early 2003, but the actual project can be considered to have started late in 2004 when the first two groups of lead statues were taken to London for restoration. It was successfully completed by mid-2010, taking only one year longer than the original estimated time frame. Table 1 shows a simplified project schedule.

Table 1. Simplified schedule for the conservation of the gardens of the National Palace of Queluz

	2003	2004	2005	2006	2007	2008	2009	2010
Hydraulic system	Preliminary studies			Works begin	Works continue	Works completed		
Gardens	Preliminary studies					Tree removal by canal started. Main gardening works begin	Tree removal by canal ended. Main gardening works continue	Main gardening works completed.
Lead Statues	Preliminary studies	1st set of two groups to London	1st set returns, 2nd set to London	2nd set returns. 1st PNQ workshop	2nd PNQ workshop	3rd set to London London workshop	Protective finish applied and all statues re-installed	
Fountains	Preliminary studies						Work begun	Work completed
Canal de Azulejos	Preliminary studies	Laser scanning begins	Laser scanning completed Condition survey completed	Digitalization of scanning and condition survey completed		Flood damages to bed of entry canal. Repair of damage begins	Repair of entry canal damage completed. Preventive conservation work completed	
Stone Statues	Preliminary studies	Stone database prepared	1st workshop	2nd and 3rd workshop	4th to 6th workshop	7th to 8th workshop	9th workshop	Statues on palace restored

Project Coordination

The coordination of the project was intricate, because three independent entities were to work on six subprojects, some of which had to be implemented before others. For example, the installation of the new hydraulic system had to be done prior to the restoration of all the fountains and the cascade. Furthermore, since water pipes were laid throughout the gardens, it was difficult to have the garden project begin with all the open trenches on the property. These also interfered with the movement of the lead statuary, since cranes and/or forklifts that needed a smooth path to drive on were used.

The organization of the lead workshops was carried out in collaboration with WMF Britain and Rupert Harris. Implementing them at the palace required that one of the store-

rooms in the Robillion Pavilion be adapted to house the equipment necessary to manipulate the heavy statues. It also required the installation of running water and a sink, proper electrical wiring, and adequate light, to make this place operational as a lead conservation workshop. Finally, it had to fulfill the safety and health regulations to protect the restorers working in it.

While on some subprojects, such as the stone one, the implementation was relatively easy to carry out, in others it required selection of the best contractor, as for the case of the Canal dos Azulejos or the restoration of the fountains. For the former, five different contractors were hired to carry out:

1. Laser scanning of the canal.
2. Conditions survey.
3. Digitalization of all this information.
4. Repair of the floor of the entry canal.
5. Stabilization of the tile cover and its preventive conservation.

In the case of the latter, a single contractor, Nova Conservação, was hired to carry out this subproject.

Cost Evaluation

The total cost of the project can be subdivided into the six subprojects that made it up. This is represented graphically in Figure 2.

Furthermore, it is also relevant to determine the main activities that are carried out. For the specific case of the gardens of Queluz, the following three categories can be identified:

- Technical Consulting.
- Conservation Work.
- Coordination and Administration.

Figure 3 shows the cost percentage of each of these categories for this project.

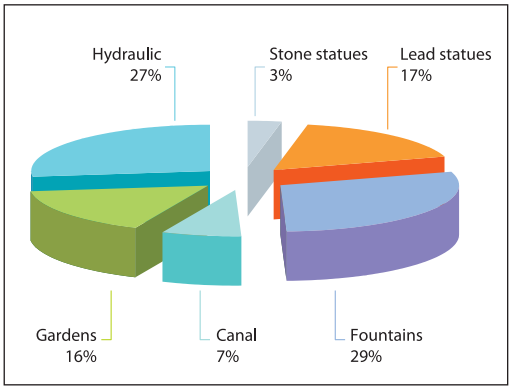

Figure 2. Cost percentage for each subproject in the conservation of the gardens of Queluz project.

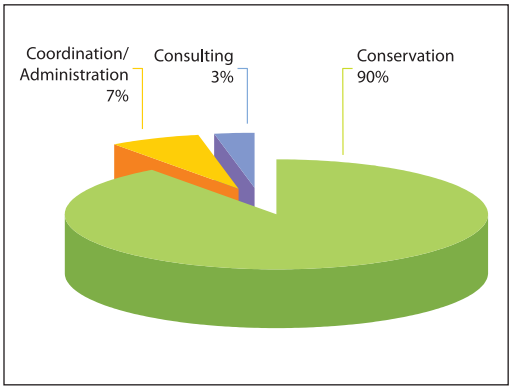

Figure 3. Cost percentage of the main activities carried out during the conservation of the gardens of Queluz project.

This distribution follows the same pattern as was found for previous projects undertaken by WMF Portugal, such as the conservation of the exterior of the Tower of Belem and of the cloister of the Jerónimos Monastery in Lisbon. The technical and scientific studies that are required in order to develop appropriate conservation measures fall in or below the range of the coordination and administrative costs of the project.

Concluding Remarks

The conservation project of the gardens of the National Palace of Queluz was an extremely complex project to carry out. In the first place, because of the variety of issues that had to be addressed, from the installation of the hydraulic infrastructure to serve the current needs of the gardens to the actual restoration of the gardens and the many and varied decorative elements in it. Three institutions collaborated in the management of this project making the coordination of this project a real challenge. This was further complicated by the reorganization that the Portuguese Ministry of Culture underwent during the time the project was underway. Finally, a major flood damaged a section of the entry canal floor.

In spite of this, the project was quite successful. This can be attributed to the careful planning of the project, the scientific and technical studies undertaken, the few issues that cropped up during the implementation that required further studies, the appropriate selection of contractors, adequate monitoring of ongoing works, and good administration of the financial management. These are key points in the development of an appropriate framework for running complex projects such as this one.

In conclusion, the final result achieved during this project was excellent, and it is hoped that the regular maintenance required for the gardens and the decorative elements will maintain them at the present level, taking into consideration that insufficient care or excessive actions will lead to progressive deterioration of this valuable heritage.

Chapter 11.

Maintenance Recommendations

A. Elena Charola, *José Delgado Rodrigues*, *Luis Aires Barros*, and *Fernando M. A. Henriques*

Introduction

The long-term success of any conservation/restoration intervention is based on subsequent regular and sustained maintenance. For this reason, it has been the practice for WMF Portugal to prepare maintenance recommendations that should, if appropriately followed, ensure the long-term preservation of the various decorative elements in the garden.

This document represents the formal conclusion of the technical part of the project. It contains a brief description of the problems faced during the project, the main solutions adopted, the expected behavior of the treated objects, and a set of recommendations regarding measures to be implemented. These recommendations are divided according to materials and type of the decorative objects considered.

1. Stone Statues

From the studies and experience gained since the beginning of the conservation of the gardens of the National Palace of Queluz project in 2004, the following summary regarding the issue of biocolonization of the stone elements, including the marble statues, can be made:

- Biocolonization will develop faster on more porous stones than on denser ones.
- In general, green algae appear first and lichens subsequently. However, in sun-exposed areas, the transition from algae colonization to lichens is very fast.
- While the presence of algae can be highly disfiguring to the sculpture, only minor damage is caused to the stone surface. Damage is of more concern when lichens appear in the subsequent colonization stages and may then require a more specific treatment.
- Biocolonization will develop faster on statues located in shaded and damp areas. On a clean sculpture, green algae colonization may appear in less than one year.
- For partially shaded areas, this may take between two and five years.

- For fully sun-exposed areas, this may take some six years.
- Except for fully shaded areas where algae can reappear very rapidly, after a simple application of a biocide (Preventol at 1.5% concentration) it takes at least two years for recolonization to become evident.
- For heavily colonized surfaces, where a higher concentration of biocide was used (e.g., 3% applied to the highly lichen-colonized balustrade around the pool and *Cain and Abel* lead sculpture in the fall 2006) it took over four years for recolonization to appear.
- It probably took decades for the heavily and completely colonized sculptures once present in the gardens to reach that condition. The observed cases of recolonization indicate that the process starts in the most favorable places, but it never happens all at once on the entire sculpture. So, in the early stages, only minor areas of the object have to be addressed to eliminate the colonization.
- The estimated recolonization times will vary from year to year depending on the severity of the winter, the amount of rain, or the lack thereof in summer.

Based on these observations, and considering that the statues are ornaments within a garden setting, the following recommendations are made:

1. It is suggested that sculptures and other stone objects not be cleaned on a regular basis as this will inevitably induce more damage than that caused by the biological colonization.
2. Extensive and aggressive cleaning inevitably leads to excessive contrast between cleaned and uncleaned objects and therefore this approach is **not to be used** as normal maintenance practice.
3. A limited amount of biocolonization on these elements is acceptable since it provides an aged appearance in accordance with the age of the palace and its gardens and leads to a coherent aesthetic presentation of the site.
4. The highly diverse environmental conditions, e.g., sheltering effects and exposure orientation, lead to an endless number of microenvironments and recolonization rates. Consequently, maintenance actions are to be taken when spot inspection so recommends and not defined by calendar time.
5. If possible, biocide application should be limited to only those areas where colonization has reached an intrusive dimension, which will more likely occur in the shaded areas or in those that are more frequently wetted, such as the top of the heads and shoulders.
6. In general, localized biocide application is enough to solve the problems. It is recommended that this application be carried out whenever recolonization moves from the incipient to moderate levels. The colonizing species detaches spontaneously within months after the biocide application and in general no mechanical action is necessary to remove them.
7. Application of the biocides has to be carried out on a regular basis, but only as determined by monitoring of the sculptures.

8. The application of water repellents has shown to be counterproductive and therefore it is not recommended for sculptures in gardens.

From the above, it is clear that there is not a fixed rate for biocide application, but that this will depend on the object, its previous history, its environment, and the weather sequence. Therefore, the only activity that should be regularly established is a routine monitoring. This should also include photographic documentation of the objects, so as to obtain a record that will allow determining when each object or group of objects needs retreatment.

Any comprehensive intervention on a sculpture should be exclusively carried out by professional conservator-restorers. However, the simple application of a biocide without any subsequent action can be done by a person with some training in this task, such as those who attended the workshops organized under the framework of the project.

2. Lead Statues

From the studies carried out by Dra. Virginia Costa, the experience gained during the workshops carried out by Rupert Harris and including his recommendations, and the knowledge acquired during the intervention on the fountains, the following summary can be made:

- It appears that originally all the lead sculptures were once painted. Some still retain paint in the most protected areas and a few others conserve evident traces of paint. Besides the aesthetic function, the paint coats also had a protective function, and this fact has certainly played a role in preserving the excellent detailing that the sculptures still exhibit.
- The paint loss has exposed the lead surfaces to direct environmental factors and the sculptures have progressively acquired, through a corrosion process, a stable and protective patina.
- Once the statue has been cleaned, as required for the implemented structural interventions, its surface has to slowly re-form the stable patina.
- The patina that develops on the surface of a cleaned lead statue depends on the previous history of the statue, such as the degree of cleaning it underwent, the application of any surface protecting agent and the environment that it is exposed to.
- Initially, the most common patina formed is based on the white lead carbonate or the basic lead carbonate. These patinas will give the dark gray lead a light gray appearance, such as the one that developed on the *Cain and Abel* group.
- Some sculptures have developed intense dark brown patinas that were shown to be formed of lead dioxide (lead IV) plattnerite. In theory, very aggressive environments are required to produce this lead (IV) oxide, but the exact combination of factors in these environments and the precise mechanism that creates it is not yet known. The relevant literature on this matter does not provide sufficient information.

- Apparently, the formation of the darker brown lead oxide, the lead dioxide plattnerite, is faster on areas in full sunshine, and where water or moisture is most likely to run over the surface.
- All statues treated by Rupert Harris received at least two coats of the oil plus alkyd resin product (April 2009 and October 2009) to delay the normal corrosion process. This was also applied to those that were already stable, such as the *Cain and Abel* group.
- The sculptures recently cleaned and protected with patination oil during the workshops carried out (e.g., *Summer* and *Autumn*), soon acquired a disfiguring appearance, with the remnants of underlying brownish and whitish stains showing up. The normal maintenance care that consists of applying patination oil seems difficult to implement locally and from the gained experience, it does not appear to be the best solution to the problem.
- In view of the above, the sculptures set in the fountains of Neptune, Nereid and those of the two Monkeys, received a different treatment approach, once the sculptures had been cleaned of the soiling, concretions, and extremely dark and unsightly patina. The treatment consisted in the application of an oxalic acid solution that served to passivate the lead surface. This was followed by the application of Paraloid B44 and microwaxes.
- The sculptures in the Malta and the Medallions' fountains had a fairly uniform corrosion layer and did not require passivation. They only received an application of Paraloid B44 and microwaxes. The same application was carried out on the three statues around the Neptune Fountain: *Spring*, *Summer,* and *Autumn*, to unify their appearance with that of the fountain sculptures as well as to the statues of *Mars* and *Minerva*.
- The sculptures are subject to frequent soiling from perching birds, which constitutes a serious problem that requires regular cleaning.
- When water flows over the sculptures in the fountains, incrustations of calcium carbonate form on their surface, contributing to their defacement by obliterating surface details. These incrustations are difficult to remove, requiring specific tools and intensive labor. They are the result of the hardness of the water supplied by the wells that is concentrated by evaporation during its circulation through the tanks and fountains, a situation that needs to be corrected in future management actions.

Based on these observations the following recommendations are made:

1. In principle, lead patinates to a lighter or darker gray with time. Uniformity of this patina will depend on the exposure of the statue. It is expected, however, that the new patination approach (passivation+Paraloid B44+waxes) will result in improved durability of the finished appearance without requiring frequent direct maintenance actions on the lead surfaces.
2. Given the unsatisfactory past experience of the recently cleaned lead sculptures that required very frequent maintenance (i.e., under six months) and taking into account

that carrying out direct actions on the lead surfaces requires qualified skills, it is recommended that **no action** involving the treatment with or manipulation of chemical products be carried out on a routine basis by the palace staff.

3. Dust, soiling, and particularly bird droppings will accumulate over time. It is recommended that these be removed by gentle washing with soft brushes at least once a year, and more often if required by the appearance of the sculptures.
4. Measures should be implemented to reduce the hardness of the circulating water to acceptable levels to minimize the formation of incrustation on the wetted surfaces of the statues in the fountains.
5. The hardness of the circulating water should be monitored regularly, at least twice a year.
6. Monitoring of the changes in the appearance of the sculptures should be documented on a regular basis, for example, every six months, to assess the evolution over time of the applied coating.

3. Stone Basins of Fountains

Most of the fountains that were restored during the project were in poor condition, particularly with regards to their water retention capability. In general, the basins of the fountains had part of their foundations exposed, so that they were unbalanced, i.e., one side was supported by an earthen embankment while the other side lacked this support. Therefore, the stone blocks that form the basin sides had little or no protection, resulting in the separation of the blocks and consequent leaks. This problem has developed as a result of the continuous soil erosion due to surface runoff that removes the rammed earth of the surrounding walks. In some cases, thick roots from the nearby trees had also contributed to the rupture and leakage problems. In the Neptune Fountain attributed to the Bernini workshop, heavy reinforcement had to be implemented to counteract the unbalanced situation that existed there.

While some measures were taken to provide initial protection of the most unstable foundations, and intervention has strengthened the masonry that forms the basin sides, many of them are still in a precarious situation. It is therefore imperative that these foundations be buried to the appropriate depth with an additional supply of soil to provide the required embankment for their protection.

To maintain the fountain stone basins in good condition implies that comprehensive remediation work be carried out on all the garden paths that converge toward them to diminish the currently ongoing soil erosion that is enhanced by the overall slope in the gardens. In particular, it is important to improve the areas that surround the fountains at risk, such as the Great Cascade, the smaller fountains near it, and the Neptune Fountain.

For this purpose, new rammed earth has to be added and appropriate surface draining systems have to be fashioned for all sloping paths so as to concentrate the excess water run-off in these drains, rather than allowing the water to wash freely over all the paths and eroding their surface. The drains, appropriately protected by paving blocks to diminish soil

erosion, should be designed so as to direct the water into the neighboring wooded patches or gardens.

Careful detailing is necessary to provide the required protection for the stone basins of the foundations while keeping the erosion rate as low as possible. Although a certain latitude is acceptable for the nature of the material to be used to cover the surface of the walkways, a brief inspection of that present suggest that *tout-venant* from basaltic quarries was probably the original solution used in the gardens. Therefore it is suggested that this type of material be considered when selecting a borrow pit, i.e., an excavation dug to provide fill to build up ground elsewhere.

4. Water for the Fountains

As mentioned previously for the case of the lead statues in fountains, the hardness of the water is a critical factor, not only for these elements but also for the stone ones. While a working hydraulic circuit has been installed, it did not include an appropriate filtering system or water-softening installation. The water that enters the hydraulic circuit of the fountains in the gardens has the following problems:

- Although the water has a high nitrate concentration, the development of algae is apparently controlled by the relatively low concentration of phosphates present in the water.
- The nutrients present in the supply water can be enriched by the decomposition of organic matter, such as leaves, bird droppings, dead fish, or other organisms, that may develop or fall into the fountains, and will contribute to an increased growth of algae.
- Residues of fertilizers used in the gardens or surrounding areas may infiltrate the hydraulic system and contribute to algae proliferation.
- It has a high concentration in calcium ions and can be considered as hard, i.e., incrusting water.

Consequently, the development of algae may result in the blocking of the jet spouts in the decorative fountains, while the high water hardness will result in calcareous deposits on those areas that are frequently wetted by water with subsequent drying. To reduce algae proliferation, the covering of the large upper tank could be a first approach, as this measure will reduce the direct proliferation of algae, and prevent debris from falling into the water and forming an organic deposit layer in it.

Most of the hardness is inherent to the supply wells and therefore it is necessary to implement a softening system at the outlet of the pumping system. To reduce the progressive percentage of hardness due to evaporation from the exposed water surfaces in the fountains, and to limit the light input to the aquatic ecosystem, the introduction of decorative water plants may be considered, although the most appropriate species of water plants needs to be determined.

Once the hardness of the water from the wells is kept at a satisfactory level, regular control of the hardness in the circulating water will serve to define when additional water is to be added to compensate the hardening effect due to evaporation.

Apart from the suggested installation of a softening system, an arrangement of filters should be considered. The specification of the most appropriate filtering systems to be installed should be requested from professionals in this area; nonetheless, some general recommendations can be made. The water recirculated through the upper tank carries a certain load of living algae that from there reenter the circuit. Thus, the installation of a filtering system in the outflow pipes will help reduce the circulating biomass. The obstruction of the fountain spouts is a direct consequence of the biomass formed and circulated in the hydraulic system. To avoid or at least reduce the incidence of this phenomenon, it is suggested that thin filters be installed locally to retain the biomass in suspension in the water. This could be implemented at the outlet of the upper tank where the water enters the hydraulic system to the fountains and at the outlet of the lower (or collecting) tank when it gets pumped back into the upper tank.

For general maintenance the following recommendations are suggested:

1. Regular cleaning of tanks and fountains in the water-circulating system.
2. Installing a cover on the upper tank to prevent debris from falling into the water while reducing the amount of light that reaches the water thus diminishing the development of algae.
3. Introducing decorative water plants (species to be determined) with large leaves to cover about 50% of the exposed water surface.
4. Reducing the use of fertilizers and pesticides in the areas close to the fountains.
5. Barring the presence of fish in the fountains.
6. Using barley (*Hordeum vulgare*) straw extract to prevent the development of new algae while reducing nutrient concentration, following the manufacturer's instructions regarding the amount and manner of application for the different fountains, according to their specific problems.

It is understood that regular monitoring is needed to detect any problems that may develop in the fountains, such as clogged spouts. This also includes the monitoring of the water hardness in the hydraulic circuit, at least twice a year to detect any significant changes that may need to be addressed.

5. Canal de Azulejos

One of the main problems of the canal is the periodic occurrence of floods. This has been a natural phenomenon since its construction that probably has been aggravated by new construction and development in its upstream watershed. While it is impossible to eliminate this problem, it is important to bear in mind that cooperation between palace authorities and the local or national entities responsible for the surroundings and their planners is of

utmost relevance for the mitigation of the flood impacts in the gardens.

It has been shown during the current intervention that some actions can help significantly in mitigating the problem presented by this bane. For example, keeping the water course that flows within the gardens as clear as possible from clogging vegetation, especially canes and reeds, both in the entry canal and at the exit part beyond the area decorated with azulejos will allow water to run through faster, thus preventing its overflow. Similar maintenance of the upper streambed will also contribute to minimize disastrous flood peaks.

For this purpose, regular monitoring and clearing of the canal floor is required. The monitoring should also be extended to the azulejo-covered surfaces to determine if any of them are at risk of detaching, so as to be able to avoid losses of loose tiles once a flood does occur. Therefore, whenever any signs of imminent detachment are detected, it is imperative that urgent remedy measures are taken to counteract them. It is suggested that any reattachment of tiles be carried out only by trained conservators.

While the walls of the canal appear to be fairly stable, the area reconstructed after the 1967 flood on the east wall is probably the least stable and needs to be monitored.

The draining ditches along the canal walls need to be redone to achieve suitable flow conditions and regularly maintained to prevent water from eroding the soil at the base of the visible wall.

In summary, the following maintenance actions are suggested:

1. Regularly clear the water course banks from clogging vegetation, especially canes and reeds and any fallen branches.
2. Reestablish appropriate drainage and flowing paths on the outer sides of the Canal de Azulejos. These should be conveniently lined to prevent soil erosion and other potential damage to the walls.
3. The area with the buckling azulejos layer seems to be structurally safe, only the azulejo cover appears to be out of the plane. At the time this area undergoes a conservation intervention, a thorough inspection of the underlying masonry structure should be carried out.
4. The freestanding wall between the Jamor River and the Ribeira das Forcadas requires regular monitoring and maintenance.
5. Inspection of the canal floor masonry cover and reintegration of any losses, especially after flood events.
6. Inspection of the tile-covered surfaces to determine the risk of detachment, especially after severe flood events.

Glossary

English and Portugues names of gardens, main fountains, and other features at the National Palace of Queluz including past names by which they were designated

English	Portuguese	Other names
Malta Garden	Jardim de Malta	Jardim dos Azereiros Jardim Novo
Hanging Garden	Jardim Pênsil	Jardim de Neptuno Jardim Grande
Prince's potager	Horto do Príncipe	
Maze	Jardim do Labirinto	
Ball Court	Jogo da Pela	Jogo da Bola
Cascade Lane	Alameda da Cascata	
Sycamore Plaza	Largo dos Plátanos	
Medallions' Lane	Alameda das Medalhas	
Malta Garden Fountain	Lago do Jardim de Malta	Dolphin Fountain
Neptune Fountain	Lago de Neptuno	
Nereid Fountain	Lago da Nereida	Lago de Anfitrite
Monkey Fountain (E & W)	Lago dos Macacos (N e P)	
Dolphin fountain	Lago do Jardim de Malta	
Shells' fountain (E & W)	Lago das Conchas (N e P)	
Shell fountain (E & W)	Fonte das Conchas (N e P)	
Great Cascade	Cascata Grande	
Shell Cascade	Cascata das Conchas	Cascata Pequena Small Cascade
Azulejo Canal	Canal de Azulejos	
Dragons' Fountain	Lago dos Dragões	
Dragon Fountain	Fonte do Dragão	
Medallions' Fountain	Lago das Medalhas	Memnon Fountain
Neptune Fountain (Bernini)	Fonte de Neptuno	
Gate of Fame	Pórtico da Fama	Fame's Gate Main Gate Portal of Fame Portal da Fama
Rape of Proserpine	Rapto de Proserpina	Rape of Persephone
Aeneas and Anchises	Anquises e Eneias	
Cain and Abel	Caim e Abel	Samson and the Philistine
Venus and Adonis	Vénus e Adónis	Story of Melos Dido and Aeneas Sucessos de Melanto Dido e Eneias
Bacchus and Ariadne	Baco e Ariadne	Wedding of Bacchus Núpcias de Baco
Meleager and Atalanta	Meleagro e Atalante	Diana and Endymion Adonis and Diana Sucessos de Endimão
Vertumnus and Pomona	Vertumno e Pomona	Sucessos de Vertumno
Mars	Marte	
Minerva	Minerva	
Spring	Primavera	
Summer	Verão	
Autumn	Outono	
Apollo	Apolo	Adonis Adonis
Diana	Diana	

http://www.pnqueluz.imc-ip.pt/pt-PT/jardins/jardins_esculturas_cheere/ContentList.aspx

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