can be seen in the context of this dynamic cultural reorientation. We have certainly come a long way from Schuchhardt’s wholly fictitious vision of an Iron Age stronghold occupied by a rustic egalitarian Germanic clan.

The General lesson from the re-excavation of the Starosiedle site is that unfortunately it is unwise to rely on conclusions based on excavations from the pioneering period of prehistoric research. There is a growing body of evidence showing that poor methods of excavating and recording of archaeological sites, as well as their reporting within the context of highly speculative interpretations in the pre-war period resulted in publications that are anything but reliable. In many cases, however, wide ranging interpretations accepted today are based on just such reports leading to the fabrication of wholly fictitious visions of the past. It is therefore fully reasonable, and indeed advisable, to re-excavate such crucial sites which were investigated in the pioneer period of archaeology.

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References


CONSERVATION SCIENCES AND CONSERVATION-RESTORATION AREA IN PORTUGAL: A NEW DEPARTMENT

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Introduction

The Conservation and Restoration (CR) area is strategically important for Portugal, a country with centuries of history and where different cultures left their legacy, namely Christian, Islamic and Jewish. Conservation and Restoration of cultural heritage as it is presently accepted is a rather modern subject, and its theory and praxis are the result of the philosophical thinking and the work of Cesare Brandi, Paul Phillips and others, in the 20th century. They constructed a philosophical body and consequent methodological approach that can be shortly summarized by the following words: “Only the material form of the work of art is restored”. Bearing this in mind, the importance of research and development (R&D) for the practice of modern conservation and restoration is obvious.

Science and technology are important to understand the complex evolution which the work of art has endured with time, to propose the most adequate methods and materials to
carry a restoration and, still more important, to be able to preserve the object for the longest time by controlling its environment.

One of the most recent scientific “important areas” in the field of CR is Conservation Science, where Preventive Conservation, Modern Analytical Methods and Technical Art History play a leading role. These keywords were the background for the creation of a Conservation and Restoration Department to educate and train in conservation, as well as to develop research in Conservation-Restoration and Conservation Sciences. The creation of the Conservation and Restoration Department (DCR) at the New University of Lisbon (UNL) has been associated with the proposal of the first Portuguese graduate course in conservation and restoration (DR 6461/98 and DR 12 267/99).

Following the Bologna guidelines, from 2006/07, the DCR offers a bachelor degree in “Conservation-Restoration”, two Masters (“Conservation and Restoration”, “Conservation Science”) and Ph.D. degrees in Conservation and Restoration. These degrees are given by the Faculty of Sciences and Technology (FCT) from the UNL. Six departments of the Faculty are collaborating in the Conservation-Restoration Graduation and Conservation and Restoration Masters.

The UNL graduation course in Conservation and Restoration was the first one in Portugal and when it started, in 1999, was quite innovative due to the central role played by the sciences in its program.

Curriculum Design and Organisation

The underlying principle in the curriculum design is to make use of the sciences for the formation of a coherent and interdisciplinary profile that will allow the future professionals to produce innovation and to develop new materials and methods in conservation of works of art. The professional in CR should not be limited to the use of recipes, being an agent of innovation and modernity. The science for the professionals in CR should not be used as a decorative appendix in the curriculum, but as a powerful tool. This is only possible if the students are well prepared in these disciplines, through a horizontal strategy; mathematic given by the mathematic department, physics by the physics department, chemistry by the chemistry department, art history by the art history department etc.

The DCR, research and teaching, is organized in two big areas of research: Conservation Sciences and Conservation-Restoration. The Conservation Sciences are transversal to all the CR units, and are organized in the scientific laboratory. The CR units are organized in laboratories according to the nature of the materials involved: paintings, paper and textiles, metals, stone, ceramics and glass.

This Department has achieved in a few years of existence an intensive international cooperation. Agreements and partnerships with foreign universities and research institutes allowed the mobility of students and staff to develop study programmes and/or research activities: Università di Bologna (Italy); Göteborgs Universitet (Sweden); Hogeschool Antwerpen (Belgium); Universidade de Fortaleza (Brazil), Universidad Politécnica de Valencia (Spain); Università degli Studi di Firenze (Italy); Università degli Studi di Perugia (Italy); Università degli Studi di Urbino (Italy); Vysoká Skola Chemicko - Technologická v Praze (Czech Republic); Bayerisches Landesamt für Denkmalpflege (Germany); Courtauld Institute (England); Hogeschool Antwerp (Belgium); Instituto de Recursos Naturales y Agrobiología, Consejo Superior de Investigaciones Científicas (Spain); Istituto di Scienza e Tecnologia dei Materiali Ceramici (Italy); Opificio delle Pietre Dure (Italy).

The DCR acquired the following equipment specially dedicated to the tasks of the Department: Micro-FTIR, Micro-Raman, Micro-XRF, HPLC-DAD, Digital X-Ray Image and DRMS (Table 1). Moreover it is possible the use of state-of-the-art equipment from the other departments and research units within the FCT. In addition, well equipped ateliers are available in the Department to carry out diagnostic and conservation of paintings, metals, ceramics and glasses, stone, textiles and paper.

Research and Development

Conservation and restoration research is oriented to the development of new methodologies and materials for intervention/restoration as well as to preserve the object in the best possible conditions that
will guarantee the longest life-time and better access. In order to achieve these goals, analysis of the materials, construction techniques of the objects and a detailed characterization of its state of conservation is needed, which carried out in the area of conservation sciences. Moreover the R&D of new materials and technologies to be used in CR practice is also a research goal of the conservation science areas. Both areas are strongly interdisciplinary.

Research is carried out in the DCR and within the framework of two Research Centres: Associated Laboratory REQUIMTE (classification excellent) and VICARTE (classification very good).

Due to the interdisciplinary research subjects, there are also research collaborations with other national and international institutions as follows: Nuclear and Technological Institute, Tropical Research Institute, Instituut Collectie Nederland, Courtauld Institute of Art, Institute for Atomic and Molecular Physics-Netherlands, Institute for the Conservation and Promotion of Cultural Heritage-National Research Council, Florence, Italy, and several institutions concerned with the cultural heritage, particularly two National Museums: National Museum Machado de Castro, and National Museum of Contemporary Art.

The cooperation with national institutions has been vital for students training and research activities as summarized in the following paragraphs. Mobility of students and staff has been accomplished with the other public Lisbon universities (UTL and UL).

Internships and PhDs are being made in ten institutes, research centres and universities. It is important to emphasize that the main collaborations were made with the Nuclear and Technological Institute and the Portuguese Institute of Conservation and Restoration. Internships in fourteen museums and private conservation ateliers have been very useful for our department. Cooperation with several museums for conservation and restoration and consultancy activities were also established.

**Metal studies (Figueiredo, E., Araújo, M.F., Silva, R.C.)**

The DCR has been contributing to the study of ancient metal artifacts, particularly to those of archaeological origin. Most of the work has focused in metal composition and metal corrosion of ancient copper based alloys. In close association with other research institutions, in particular the Nuclear and Technological Institute (Sacavém, Portugal) and the Materials Research Centre (Monte de Caparica, Portugal) various studies are currently in progress. Studies focusing relationships between bulk metal and corrosion composition within Late Bronze Age metal artifacts (Figueiredo et al. 2005, 2007a), as well as characterisation of long term corrosion phenomena undergoing in buried artifacts (Silva et al. 2007, Figueiredo et al. 2006, 2007b) have been some of the main issues. Relationships between metal alloy and corrosion layer compositions can give important information on the environmental conditions that artifacts were subjected to, as well as give important clues for the bulk metal characterisation when using superficial non-invasive analytical techniques on corroded metal artifacts. The study of long term corrosion is an important field of work in Conservation Science since most of the artifacts conservators deal with have this type of corrosion, which is not a frequent subject of study in other scientific areas, as in modern material science field. Further information on the specificities and evolution of metallurgical practices which occurred during Copper, Bronze and Iron Age in the Portuguese territory has also been obtained. Analyses of metal artifacts (such as axes, fibulae, spearheads) and scraps and other metallurgical debris (resulting from metallurgical activities) from important archaeological sites such as Fraga dos Corvos in Trás-os-Montes region, Pragança and Vila Nova de São Pedro in Estremadura region and Baiões/Santa Luzia group in Beira Alta region, are currently being undertaken.

Energy dispersive X-ray spectrometry (EDXRF) has been an essential tool in the investigations since it allows fast and non-invasive elemental analyses. The micro-EDXRF portable equipment, installed at DCR, allows the analyses of small areas \( \Phi < 100 \mu m \) and has been used with success in the determination of bulk metal composition as well as in the determination of the different corrosion layers composition. Other analytical tools installed at the DCR, such as micro-Raman and micro-FTIR, are also being used for the study of corrosion compounds. In studies focusing on
manufacture techniques the digital radiography at the DCR has proven to be an excellent tool among others, helping to distinguish different components of a given artifact. The digital radiography has also been used in the evaluation of the remaining metal under thick corrosion layers, as in iron artifacts, and for the visualisation of small decoration details on the metal surfaces which can hardly be distinguished by naked eye due to corrosion.

Studies undertaken in DCR have been published and oral and poster contributions have been presented in International Conferences focusing from Corrosion Science to Conservation Science, Materials Science to Analytical Techniques issues as well as Archaeometallurgical themes.

**Deterioration and conservation of stone (Miller, A.Z., Pamplona, M., Macedo, M.F.)**

The rich stone Portuguese Cultural Heritage led the DCR to develop a field of research and education in this area. Stone deterioration and conservation is a multidisciplinary field which requires the collaboration of different disciplines, such as Geology, Biology, Chemistry, Civil Engineering, Materials Science and Ethics. Therefore, the DCR collaborates with national and international universities and research institutes covering student’s formation, research and services to cultural communities. Namely, museums, archives, the Minerology and Petrology Laboratory from the Technical University of Lisbon, the Tropical Research Institute, the UNL’s research unit “Glass and Ceramic for Arts” (VICARTE), the associated laboratory REQUIMTE, the National Laboratory of Civil Engineering, the Bavarian State Department for the Conservation of Monuments, the Instituto de Recursos Naturales y Agrobiología, Consejo Superior de Investigaciones Científicas, Sevilla and several Portuguese Conservation-Restoration enterprises.

Most work developed by researchers and students in stone focuses on petrographic description, petrochemical, petrophysic and mineralogical characterization, deterioration mechanisms, biodeterioration, bioreceptivity, characterization of deterioration products and stone treatments (desalinization, cleaning, protection and consolidation). The Stone Laboratory testing devices include porosity and water capillary absorption; inoculation of different stone samples with microbial cultures for bioreceptivity studies; contact-sponge method, colour quantification and microdrilling resistance for the efficacy and harmfulness assessment of consolidants.

Recent Master thesis comprised studies of mortars compatibility in the application of salt contaminated walls and compatibility of mortars for joints repair in monuments; efficacy testing and development of desalinization plaster; effectiveness evaluation of cleaning, protection and consolidation treatments applied in German stones; conservation interventions on sculptures, including detailed studies of the stone deterioration forms and biodeterioration agents; characterization of black films on granite from churches located in Porto.

A PhD thesis regards the durability of protective and consolidant treatments. Archival information was researched in order to select documented Portuguese monuments which were treated in the last decades with consolidants and water repellents (Pamplona et al. 2007a). Two monuments were assessed in situ (Pamplona et al. 2007b) and a database of reference samples’ properties was gathered. By means of Micro-FTIR analysis, installed at the DCR, the weathering process of the reference samples was monitored. Moreover, new modified alkoxysiloxane consolidants, with adhesive coupling agents and with elasticized segments, were tested in two main Portuguese limestones in collaboration with the Bavarian State Department for the Conservation of Monuments (Pamplona 2007).

Concerning stone biodeterioration, several works are being carried out in this laboratory. Environmental samples from biodeteriorated monuments are collected, cultured and isolated at laboratory conditions (Figure 1). Determination of the microorganisms’ genera and species are performed through direct observation by optical microscopy (Miller & Macedo 2006, Miller et al. 2007).

A present PhD research is focused on lithotypes from monuments of Mediterranean Basin, which reference samples are artificially inoculated with photosynthetic microorganisms in order to evaluate their bioreceptivity and achieve a bioreceptivity
The microorganisms’ growth is evaluated and monitored by visual examination, molecular biology methods (Figure 2) at Instituto de Recursos Naturales y Agrobiología, Consejo Superior de Investigaciones Científicas, Sevilla, image analysis for quantification of surface covered area by biofilms, and in vivo chlorophyll a fluorescence, using a spectrofluorometer with fiber optic sample accessory, from the associated laboratory REQUIMTE (Miller et al. 2006).

Figure 1. Stone sculpture from Palácio Nacional de Queluz (Portugal), presenting severe colonization by lichens.

Figure 2. Molecular analysis of green biofilms from Santa Clara-a-Velha Monastery (Coimbra, Portugal).

Modern Art Conservation (Ferreira, J.L.)

The conservation of contemporary art requires a new attitude, arising from the use of modern materials as well as the need to understand different concepts. The collaboration between the National Museum of Contemporary Art (Museu do Chiado) and the DCR has been particularly successful. In the past few years several projects have been carried out, where the diversity of conservation problems imposed by contemporary objects has been a great challenge and has contributed to the specialized training in different areas.

Selected projects / case studies are described below. These have been undertaken in the framework of Master or PhD projects.

A mural painting by Estrela Faria, a FTIR study of a vinyl synthetic medium

Estrela Faria (1910-1976) was, in the second half of the sixties, invited to paint a mural at the entrance of a new high school in Lisbon, where she exploited a synthetic binding medium, either for artistic or economical reasons. The aim of this study was to characterize the binding medium and its state of conservation by infra-red microspectroscopy (micro-FTIR), which was identified as a rather well preserved poly(vinyl acetate) (Ferreira et al. 2006).

Julião Sarmento, a Portuguese Artist at Work: Study of Just a Skin Affair, 1988

A detailed study of the materials and techniques used by Julião Sarmento (b.1948) in the painting Just a Skin Affair was carried out. An interdisciplinary approach involved an extensive artist interview and the collaboration with the Portuguese manufacturer of the materials used by the artist. The medium used in this painting was identified, by micro-FTIR as poly(vinyl acetate). The pigments were identified by X-ray fluorescence (µEDXRF), and by micro-FTIR. At least one layer was made with “garbage” and poly(vinyl acetate) (Pereira et al. 2007).

A study of the materials and techniques for the development of a conservation proposal for the object Dans la plage by José Escada

Dans la plage by José Escada (1934-1980), made of cellulose acetate sheets is an excellent example for the special conservation requirements of modern art (Figure 3). Cellulose acetate undergoes a complex, multi-phase degradation process which had to be understood before a treatment proposal could...
be established. Specific material properties associated with the production process and the mere gravitational force have also been identified to add to the deterioration of the object. Upon conclusion of the study, it was possible to propose various options in terms of treatment of deformations and preventive conservation.

Figure 3. Modern art object: Dans la plage by José Escada.

Liasons Dangereuses, Conservation of Modern Art: a study of the synthetic binding media in Portugal
At the present there is a PhD research project at DCR, focused on the study of synthetic materials used by Portuguese artists in the twentieth century. The aim of the study is the molecular characterization of acrylic and vinyl emulsion paints used by the Portuguese artists since the 50’s and the study of their photodegradation and evolution with time. Artificially aged samples are compared to dated works of art from Portuguese artists, namely Joaquim Rodrigo (1912-1997), Lourdes Castro (b.1930) and Ângelo de Sousa (b.1938). Apart from binding media, pigments and other additives present in the paint formulation are being characterized, in order to understand its influence on the film’s lifetime (Ferreira et al. 2007).

Textiles conservation (Sousa, M.)
The textile conservation performed in the DCR is developed in four main lines: conservation and restoration of textiles, identification and characterization of materials, the development of new methodologies applied in the conservation and restoration of textiles and preventive conservation of textile collections. Furthermore, collaborations with different institutions and groups, namely National Museum of Fine Arts-Lisbon, National Museum Machado Castro, Museum of Fine Arts, Boston and CMRAE-MIT and Museum of Design and Custom, Lisbon allow a broad investigation in the field of textile art. Selected projects / case studies are described below. These have been undertaken in the framework of Master projects.

The colour of carpets
The organic dyes of eight Persian Carpets from Portuguese museum were extracted with recent mild extraction methods and analyzed with HPLC-DAD, installed at DCR, and when necessary with coupled mass spectrometry from Nuclear and Technological Institute. The results obtained were very homogeneous and coherent being possible to establish the dyeing source used for the reds, yellows and blue dyes. With this information and technical/historical details we hope to establish a yield of fingerprint for identification of the carpets analysed (Valsassina et al. 2007).

Discovering the colours of Portuguese Arraiolos carpets
A detailed study of the colour materials used in two middle 17th century Arraiolos carpets from the National Museum of Machado de Castro were carried out prior to its conservation and restoration. The results obtained were compared with an original 19th century recipes collected in the Portuguese Arraiolos village, being possible to confirm the reliability of the original 19th recipes (Marques et al. in preparation).

Study and conservation of a 16th Century Persian Carpet
A late 16th century Persian knotted-pile carpet with a vine-scroll field and cartouche border represents one of the most important recent discoveries in Islamic textiles in Portugal. A detailed material, art historical and technical study was fundamental for appreciating its importance, and specially for undertaking its conservation and restoration (Armindo et al. 2008).

Cleaning old textiles with supercritical carbon dioxide
The use of supercritical carbon dioxide (scCO₂) as a dry-cleaning solvent of old silk textiles was investigated. The harmfulness of the dry scCO₂ method, in which concerns color variation due to the solubilization of the mordant ions, as well
as loss of textile material, was evaluated in comparison to conventional wet-cleaning methods. The cleaning procedures under study were tested in the 18th century religious garments from Virgin and Child from Palácio das Necessidades, Lisbon.

Contrary to the severe loss of material (50%) occurred during the wet-cleaning, the CO₂ at liquid and supercritical conditions proved to be a very safe solvent for the cleaning of very deteriorated silk textiles (Sousa et al. 2005, 2007).

**Technical Art Studies (Claro, A., Melo, M.J.)**
Research and teaching on the materials and techniques in art and archaeology can be considered the paradigm of the DCR approach: strong interdisciplinary projects aiming to a better conservation and access. Inputs from Art History, Materials Science, Chemistry and Conservation are integrated into a single framework allowing a better knowledge of the object.

Several research projects, at a national as well as international level, have been carried out; namely, in the field of Portuguese Medieval Illuminations (Moura et al. 2007), historic dyes (Melo et al. 2007, Seixas de Melo et al. 2007) and the development of novel, non-invasive, analytical techniques for the study of the materials and techniques in Art (Figure 4); such as microspectrofluorimetry (Claro et al. 2007).

![Figure 4. Micro-X ray fluorescence spectroscopy analysis from a Portuguese Medieval Illumination.](image)

Collaboration with the Chemistry Department of Coimbra University, Department of Art History of the New University of Lisbon, Instituut Collectie Nederland and Courtauld Institute of Art were key factor for the development of these projects.

**Ceramics and Glass (Lima, A., Matos, A. P.)**
The Glass and Ceramics laboratory is the most recent facility of the Department of Conservation and Restoration. It was created in 2005 in a close collaboration with the interdisciplinary research unity “VICARTE – Glass and Ceramics for the Arts” located in the same building. The facilities in this research unit allow the preparation of any type of glass or glaze which can be used as models for the corrosion studies undertaken.

![Figure 5. Micro-PIXE analysis from 16th century stained glasses from Batalha Monastery (Portugal).](image)

The chemical characterization of ceramics and glass objects and archaeological findings has been an important research area. For the first time in Portugal a systematic study in archaeometry is being undertaken on Portuguese glasses from the 15th-20th centuries (Schalm et al. 2005, Lopes et al. 2006, Lima et al. 2006, Medici et al. 2006). At the same time glass corrosion of potash glasses are being carried out having in mind the study of the Stained Glass from the Batalha Monastery (Vilarigues et al. 2004, 2005, 2006). This research is being conducted in a fruitful collaboration with the Nuclear and Technological Institute using their ion beam facilities for non destructive techniques and the nuclear activation analysis for the characterization of very small samples (Figure 5). In the Scientific Laboratory of the DCR the characterization of glasses and ceramics has been made using non destructive techniques, like the micro-X ray fluorescence.
spectroscopy using a portable instrument and Raman spectroscopy.

The research in potash glass corrosion in collaboration with the Nuclear and Technological Institute is giving origin to a PhD thesis on the study of the stained glass from the Batalha Monastery.

A PhD research focusing the study of corrosion mechanisms of glazes and enamels has just started in association with the Materials Research Institute from the Penn State University (USA).

Other studies focusing on the characterization of Late Bronze Age and Early Iron Age ceramics collected during two archaeological excavations at Lower Alentejo, using petrographic and chemical analysis are in progress.

Regarding the conservation of glass and ceramics, a study on the ageing of epoxy resins is being currently done and innovative filling materials using luminescent glass are being developed in close collaboration with VICARTE.

The Ceramics and Glass laboratory also collaborates from the beginning with Portuguese institutions and museums, namely the Glass Museum in Marinha Grande and the Santa Clara-a-Velha Monastery, in Coimbra, in the conservation and restoration of objects and archaeological artifacts from their collections.

References
Marques, R., Sousa, M., Oliveira, C.M. and Melo, M.J. Discovering the colours of Portuguese arraiolos carpets. (manuscript in preparation).
Pursue is dialkyl/dimethyl ammonium chloride and alkyl(dimethylbenzyl) ammonium chloride – a quaternary ammonium compound from Amway India Enterprise. This product was tested against 11 fungal strains and 5 bacterial strains that were isolated from different monuments of sandstone of India and found to be potent biodeteriogens during the screening experiments. The present study was aimed to test the efficacy of Pursue against the microbes colonizing sandstone.

Material and Methods

In-vitro retardation of fungal growth was studied using poisoned food technique (Dev et al. 2004). In the experiments mineral salt media (supplemented with 3% sandstone powder) was employed and mixed with Pursue to yield mixture of 0.6%, 1%, 2% concentration. The practical set up without any chemical served as control. Similarly turbidimetric method (Stanier et al. 1988) was used for bacterial strains and other preparations were same as in case of fungi. The growth of colony in control set was compared with that of various treatments and the difference was converted into % inhibition

\[
\text{% inhibition} = \left( \frac{C - T}{C} \right) \times 100
\]

Where C and T are the radial diameter of the colony in control and treatment, respectively (in case of fungi) and absorbance of bacteria in control and treatment, respectively.

Results

To study the efficacy of Pursue 11 fungal strains Curvularia geniculata, Aspergillus flavipes, A. sydowii, Trichoderma koningii, Papulospora sp., Cladosporium cladosporioides, Verticillium alboatrum, Cephalosporium acremonium, Paecilomyces sp., Alternaria alternata, and Fusarium oxysporum and 5 bacterial strains Bacillus globiformis, Pseudomonas aeruginosa, Micrococcus luteus, M. roseus, Nocardia sp. were considered for in-vitro analysis. Pursue inhibited the growth of Aspergillus sydowii, Trichoderma koningii, Paecilomyces sp., Fusarium oxysporum at 0.6%, 1%, and 2% concentrations. In case of Curvularia geniculata and Alternaria alternata (Figure 4), although the growth was checked at all concentrations yet slight growth was observed on the discs of fungi that were used in experiment. The fungi Cladosporium cladosporioides, Verticillium alboatrum (Figure...