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Palácio do Vimioso Largo Marquês de Marialva, 8 7000-809 Évora, Portugal

general@e-conservation.org

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#### **Imperfect Conservation**

Taking risks is something that we conservators seem to be averse to – I mean, more averse than are most professionals from other fields. And yet, I would say that taking risks is a core trait of our profession. Sure, we take as little risk as possible, but we do take risks. As is the case for many other professions, conservators are rarely 100% sure that a given treatment will be absolutely safe. In this regard, we compromise.

We make compromises in many other senses, too. In fact, we often know that our treatment of choice is not the best possible treatment. In most conservation treatments, things could have been done in a better way. Not because the conservator did anything wrong, but rather because he or she consciously chose a given course of action, fully aware that better technical options existed: a more comprehensive set of analysis, a slower and more gentle cleaning technique, a better and costlier reinforcing material, etc. However, I would argue that, in a vast majority of cases, conservators make sensible and perfectly correct decisions when opting for the less-than-ideal option.

In real life, compromising is a must. Consider medicine: if a person goes to the doctor with the symptoms of a flu, it is unlikely that the doctor will request a blood test, or a germ culture, or whatever medical test is needed to determine as thoroughly as possible that those symptoms are actually caused by a flu. Or think of commercial airliners: the companies just do not do their absolute best to ensure that we fly safely. For example, not every single piece of every plane's engine is carefully checked for integrity after each flight. There is no technical reason why both the dismantling of the engines and the medical tests could not be done, and it is undeniable that they could help to improve the diagnosis of the patient or increase the safety of the planes. And yet, it is a widespread (and eminently sound) practice to not do any of these things. These are good examples of how taking some chances may be sensible if the odds are favourable enough; from a broader perspective, they are also good examples of compromises that are reasonable and, in nearly every case, successful.

Obvious as it may seem, it may be opportune to remind ourselves that sensible compromising does make sense. Conservation does not always seek perfection, rather it seeks efficiency. It does not have to use the best technology available or to be completely risk-free, as it seeks to produce good results within a given set of circumstances. These circumstances include material factors, such as costs and available resources, as well as immaterial factors, such as the values conveyed by the object or the expectations of the target audience. The constraints imposed by reality may in fact be very complex, and even impossible to precisely assess. This is why we conservators feel it perfectly adequate to take some chances; this is why we seldom need hi-tech analysis; this is why we often opt for a goodenough treatment even though we know that a better treatment could be applied.

Most often, conservation succeeds through reasonable compromise. Most human activities do, in fact. After all, how many people could be attended by a doctor if every patient with a flu were subjected to a comprehensive set of medical tests? And how many people could actually fly if planes had to be thoroughly revised after each flight? Indeed, how many heritage objects would fall into oblivion if most of the resources assigned to conservation were spent in treating a few objects to the best of our abilities? At the end of the day, conservation is not that different from so many other activities: compromising is a must. And, as a consequence, the best possible option may not really be the best option.

Dr. Salvador Muñoz Viñas Professor of Heritage Conservation Polytechnic University of Valencia, Spain

# CONFLICTED THOUGHTS ON THE MONUMENTS MEN

By Daniel Cull

In a recounting of past crimes, the proper question to ask is not 'Who was guilty then?'
unless it leads directly to: 'what is our responsibility now?'
Howard Zinn, 513 [1]

Sixty years ago the 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict was developed by the international community in order to prevent a repeat of the acts of cultural genocide and destruction witnessed in the Second World War. To this day the UK has not ratified this convention; despite assurances in 2004 that this was "a priority", and despite cross party support, multi-Departmental support, and support from the Armed Services! Writing in a recent ICOM newsletter [2] Fiona Macalister urged ICOM members to support a Blue Shield campaign to push their local MP's to seek parliamentary time to discuss the bill, and ratify the convention. In a recent Getty Newsletter [3] there was an interesting article about the work of the Blue Shield in the run up to, and after, the invasion of Iraq, and their efforts to minimise damage to the cultural heritage of Iraq. The article reports that increasingly NATO militaries have come to recognise the "force multiplier" potential of cultural property protection (CPP) and have begun to

incorporate some of Blue Shield's

recommendation for training and policies into their strategies, subsequently utilized in Libya, Mali, and Syria. I suspect all this interest in CPP within conservation literature is in no small part thanks to a Hollywood movie about the Blue Shield's predecessors "The Monuments Men".

The movie follows Lt Frank Stokes (loosely based on the famous conservator George L. Stout) and a hapless crew of conservators, art historians and assorted others as they traipse through war torn Europe during the closing stages of the Second World War on the hunt for art looted by the Nazis. This romp of a movie gives us pause to consider the question of whether art and culture are worth dying for. Moreover it demands of those of us working in heritage to consider the role of our technical assistance to the military-industrialcomplex today. The story of the Monuments Men is quite fascinating and it is unsurprising that a dramatic retelling would make its way into Hollywood. The potential for destruction of art in the Second World War has in fact been the inspiration for storylines in other movies such as the 1966 film Is Paris Burning? and the 1964 The Train, but none until now have focussed exclusively on the role of the Monuments Men themselves. This movie is produced, directed, and stars George Clooney and is based on the nonfiction book, The Monuments Men: Allied Heroes,



The Ghent Altarpiece recovered from the Altaussee salt mine at the end of World War II.

Nazi Thieves and the Greatest Treasure Hunt in History, by Robert M. Edsel. The movie is based on true events; Edsel however also co-produced a documentary film, The Rape of Europa, based on the book *The Rape of Europa*: *The Fate of Europe's* Treasures in the Third Reich and the Second World War by Lynn Nicholas. In 2007 Edsel also founded the Monuments Men Foundation for the Preservation of Art [4]. The Monuments Men was the nickname by which the Monuments, Fine Arts, and Archives Program of the Civil Affairs and Military Government Sections of the Allied Army (MFAA) were known. They were established with the purpose of protecting cultural property in all the conflict zones of the Second World War. The group at its height had about 400 service-members and civilians, drawn from 13 countries, working with the military to safeguard cultural monuments and to locate and return art and other items of cultural significance stolen or hidden for safekeeping. They spent the closing year of the war seeking out over 1,000 troves containing an estimated 5 million pieces of artwork and cultural items stolen from wealthy Jews, museums, universities, and religious

institutions. Although the main group was dissolved in June 1946, when the State Department took over its duties, for six years after the end of the war a smaller group, of around 60 Monuments Men continued to scour Europe for artwork that remained missing.

The film opens with a fictionalised re-telling of the foundation of the unit, so sadly you do not get to see an onscreen version of one of my favourite archaeologists, Lieutenant Colonel Sir Robert Eric Mortimer Wheeler, for in real life it was his concern for Leptis Magna that led to the formation of the Monuments Men, instead we open in the wake of the destruction of Monte Cassino as the Allies are gaining on the Axis powers in Italy, art historian Frank Stokes (soon to become Lt Stokes) persuades the US President that the art treasures and cultural heritage of "Western Civilisation" must be saved if victory is to have any meaning at all. He is tasked with assembling a team "the Monuments Men" to undertake this task. A team of seven, presumably channelling Kurosawa, is assembled and after basic training they undergo a

series of misadventures across Europe to protect and search for missing art, particularly the Van Eyck altarpiece looted from Ghent Cathedral, and a statue of the Madonna and Child by Michelangelo. To tell these stories, many of which at their core contain elements of how they occurred in real life, the film takes on many of the tropes of Hollywood at war; drawing on the likes of Saving Private Ryan, Band of Brothers, The Dirty Dozen, Three Kings, and even a little Full Metal Jacket, leaning heavily on the comedic side of these movies and steering clear of the violent side of war, in fact there's barely more than a couple of bullets fired throughout. To my mind the most interesting, and sadly underexplored, character is that of Claire Simone, played by Cate Blanchett, an ex-curator who in occupied Europe is forced to oversee the transportation of stolen art for the Nazi's and secretly keeps a record of it all for the Maquis. Simone's meticulous notes are perhaps the finest examples of the heroism of great collections management ever submitted to celluloid; and a fine example of how resistance to oppressive regimes comes in a variety of forms. In the film, and in real life, Simone initially refuses to give over this information to the Allies seeing them as just another conquering army, although in the end she relents, her view that the Allies advance across Europe was not a liberation but a new occupation is a lesson that has multiple parallels in today's war ravaged world. It is also worth noting that it was Simone's work with the Maguis, and not the professionalisedmilitarised art-experts that was ultimately responsible for the majority of the acts of recovery.

This is not a film that shrouds its ideas in subtlety or nuance, periodically Lt Stokes appears on the radio with a broadcast ostensibly to the Monuments Men, however, his philosophical consideration of their actions are clearly intended to break the fourth wall. The repetition of the films positive



General Dwight D. Eisenhower inspects stolen artwork in the Merkers salt mines.

assertion that is worth dying for art and culture (or their oft-used phrase "civilisation") was, for me at least, uncomfortable; ultimately in the film two monuments men (in typical Hollywood fashion the English and French characters) are killed making this a non-rhetorical question. I was also struck by how the Monuments Men are portrayed as enthusiastically throwing themselves into the war effort. I'd like to think that as cultural heritage professionals we would today be more reluctant for our field to become part of the war effort in the service of one side in an armed conflict. However, it is clear that the military technical services industry and the ideology that drives it has made significant inroads into the heritage field, illustrated by the AIC adopting the hashtag #TodaysHeroes [5] to discuss the Monuments Men, clearly demonstrating that to

their members the confluence of art conservation and militarism is a positive, heroic endeavour, to be replicated today. In fact in the Getty article cited earlier the author was almost indicating the possibility for heritage professionals to be involved in target selection: "with cooperation between heritage professionals and the military and careful targeting the military targets were completely destroyed with minimal damage to the heritage site" [1, 15]. For me this suggests that the line of technical assistance might be tipping too far. Other professional fields have shown that it is possible to withdraw support for the military-industrial-complex. The major body representing anthropologists for example, in considering the role of Human Terrain Systems [6], and citing ethical concerns stated that such work "can no longer be considered a legitimate professional exercise of anthropology" [7].

It's fascinating to see that 60 years from the Hague convention, and 70 years from the end of the Second World War and dissolution of the Monuments Men, as a profession we still have to be concerned with protecting monuments, archives, and museum collections from the ravages of war. It seems to me that perhaps our chosen method, asking wars, and those that make them, to be a bit more careful, might not be working. I can not help thinking that the lesson I have taken away from this movie is that protection without also working towards ending wars and militarism is a futile task. So I would suggest that ICOM's call to support Blue Shield although worthy is a tiny first step, and would ask could not, and should not, we dream a little bigger?

In closing, I should say although I have no interest in giving this film a star rating, it is the best conservation themed war movie you are likely to see this year!

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#### **Daniel Cull**

Preventive Conservator Historic Royal Palaces Daniel.Cull@hrp.org.uk

# THE ARCHAEOLOGY OF THE BOOK: FORMULATING ANALYTICAL RESEARCH QUESTIONS

By Mark Clarke

#### Introduction

In addition to being vehicles for the transmission of texts and images, books are also archaeological artefacts, and an archaeological approach benefits both conservators and historians of the book. Chemical analysis can, for example, confirm provenance, distinguish hands within a manuscript, and identify alterations due to aging or deliberate modification, in the latter case by identifying anachronistic elements.

This is a golden age for the study of the physical properties of works of art in general and manuscripts in particular. Increasingly sensitive analytical instruments have become available, and there has been a renaissance in the philology of artists' recipe books. This has resulted in a greatly improved understanding of workshop methods and materials. Nevertheless, considering the very large amount that has been written about the history of books, their manufacture and their decoration, there have been proportionally very few analyses published. The study of the materials used for making books is in its infancy compared to e.g. those for easel paintings. To establish what was conventional usage for different periods, regions, or ateliers, much more work is needed to build up a substantial and statistically significant corpus of analyses.

Unlike other research fields, in codicology ('the archaeology of the book'), in conservation, and in 'technical art history' there are rarely natural structures in which research topics arise, such as

those in academic research groups. More prejudicial still, unlike many fields in physical sciences and humanities, the interdisciplinary nature of the technical examination of books means that when someone *does* have a concrete question, outside collaboration is almost invariably required. The formulation of an answerable question therefore requires cross-disciplinary 'interpreters' who can explain the requirements and possibilities of their own specialisms. The best programmes of analysis have been done by physicists and chemists working closely with conservators, librarians, and art historians.

This paper suggests how achievable research questions may be framed, and how the results of these investigations may be disseminated in such a way as to inform wider questions than the immediate concerns that drove the initial research.

#### 1. Choice of Purpose

Research questions in the analysis of book materials are rarely driven purely by conservation questions, and more rarely still by purely art historical questions. In this, codicological analysis differs from analysis of paintings, where conservation and authenticity are the two principal drivers. In practice, the analysis of book materials has, with a few notable exceptions, come as close to pure research as imaginable in that it has been driven almost entirely by curiosity.

Research questions do divide broadly into two overlapping areas, namely history and conservation.



MOLAB analyse a manuscript at the Fitzwilliam museum.

Historical questions attempt to ascertain when an artefact was made, where, and by which individual or workshop, and to establish which parts of that artefact are original and which parts were added later (restoration, forgery, or in the case of a book simply several booklets bound together for convenience). But the combination of results from many books should contribute to wider knowledge of developments in the history and technology of the book, the organisation of workshops, of trade and of exchange, and resultant sociological changes.

Conservators seek to avoid, retard or reverse degradation and damage, while at the same time preserving the archaeological material evidence embodied in the object. Conservation questions thus may be divided in two: either concerning individual artefacts (condition and state of preservation, risk assessment for display or digitisation, characterisation of ink likely to degrade, assessment of suitable treatments), or combining the examinations

of individual artefacts to answer more generally applicable questions (what can we do about ink corrosion, or pigment flaking, or red rot, or the brittleness of acid paper?).

Questions that address both historical and conservation questions simultaneously ask firstly how a book or decoration or illumination was executed (pricking, underdrawings, paint layers, etc.) — all indicators of the conformity or independence of individuals with traditions and the relation of an artist to his materials — and ask secondly in what way the present appearance reflects the artefact as originally produced (discolouration, losses, repairs, etc.), perhaps with a view to returning the object to a more authentic or pristine state.

#### 2. Choice of Books to Examine

In my opinion it is unfortunate that the majority of analyses of the materials of books has been carried out on exceptional books. While it is understandable that researchers (and funders) will want to work on the remarkable, high-profile, newsworthy items, rather than everyday ones, in consequence we remain largely ignorant about standard manufacture. It is as though the history of architecture was written based entirely on examinations of Stonehenge, the Leaning Tower of Pisa, and the Eiffel Tower. In contrast, analysts of paintings (technically the closest comparable field to that of book analysis), through years of routine examination and routine analysis of a tremendous variety of material (painted by masters and hacks alike), have built up a considerable knowledge of standard fabrication practices. We are thus in a position to appreciate exceptions to those standard practices, and so to derive useful conclusions about age, provenance, authorship, and degree of post-manufacture alteration. In comparison we remain remarkably ignorant about the materials of the conventional early book. And

yet it is precisely an appreciation of what was standard practice that increases appreciation of the exceptional efforts that produced non-standard 'master' works. All books, and especially all book decorations and materials, however low quality, deserve attention: indeed it is the simple material that forms the bulk of surviving material and will thus (i) most likely produce the most statistically significant evidence and indicators for dating and provenance, and (ii) present the greatest conservation burden (consider, for example, the nineteenth century acid paper brittleness).

## 3. Choice of Analytical Techniques

Rather than formulating a research question and then commissioning the appropriate analysis, research questions in the analysis of book materials have often been formulated based firstly on what equipment is available. It seems to be putting the cart before the horse, although excellent results have nevertheless been achieved. There are always logistical problems getting books and instruments in the same room: equipment can often not be moved, and books can be too fragile or valuable to be moved. It is on occasion possible to borrow instruments: for example, the Eu-ARTECH funded project 'MOLAB' offers a mobile collection of portable equipment (www.euartech.org). But it is to be hoped that curators will come to realise that the benefits of a welldirected programme of instrumental analysis are considerable, and that the risk of moving books to laboratory facilities can be made minimal.

#### 4. Sampling Versus 'Non-destructive' Analysis

Historically, the main obstacle to the study of book materials has been the aspiration not to take samples. In consequence, for many years, the only analysis possible was visual examination. But recent advances in non-sampling instrumentation have permitted far more reliable analysis. However, there can still be significant problems.

- 1) As previously mentioned, there are often logistical problems bringing books and instruments together.
- 2) Non-invasive methods cannot analyse all types of materials; notably most organic pigments require sampling.
- 3) In situ non-sampling analysis seems the ideal from a conservation perspective, but not necessarily: for example, clamping a page in place such that an instrument may focus on it can be more damaging than sampling would have been.
- 4) Layer structures are important, from mediaeval miniatures to modern coated papers, but non-sampling analysis only detects either the top layer (in reflective or surface techniques, e.g. visible light spectroscopy or Raman spectroscopy) or may combine all the results from several or all of the layers (in penetrative techniques, such as X-ray techniques).
- 5) Many pigments were used mixed (a fact abundantly clear from historical technical texts), but mixtures can be very difficult or impossible to understand without sampling, especially where inorganic and organic pigments are mixed. Often analysts have detected an inorganic pigment, but failed to detect or even consider possible organic pigments mixed in.

In conclusion, sampling is routine for most types of artefact, remaining rare only for books. But modern analytical techniques can be effective with samples so small as to be only visible under a microscope. The damage-to-knowledge ratio is very favourable, and a well-planned set of samples can be used for years, and sent around to several

laboratories, for many instrumental analyses, including those not yet invented.

#### 5. Putting It All Together: Framing Questions

The main research categories are therefore history and conservation, and may be either specific questions about individual books, or general questions about many books.

#### 5.1. Example Questions About Individual Books

To simply identify, for example, all the pigments in a book is no longer sufficient. While such routine analysis of course remains essential and must be done (routine analysis often throws up unexpected and surprising information, notably intrusive and anachronistic elements), more sophisticated questions must be asked of the data so obtained.

**Dating.** In our present state of knowledge, the simplest and most obvious questions, such as 'when was this book made?', are the hardest to answer. The unavoidable imprecision of terminal dates for the introduction and deprecation of materials such as pigments (such dates being best expressed as a range of probabilities dependant on the rate and spread of adoption, and typically embrace several decades), means that material analysis is unlikely to provide a more precise dating than would conventional palaeography.

**Intrusive elements.** Glaring anachronisms, such as pigments only introduced after the supposed date of a book, can indicate later re-working such as retouching or even a complete forgery.

**Localisation**. An identification of unusual or rare materials will be helpful in narrower localisation (probably by identification of locally-sourced organic pigments, or locally preferred species

of animal used for parchment or leather).

Manufacturing processes. It has been possible to separate elements of apparently homogeneously produced books by the analysis of materials. Examples of such successful analyses have included changes in paper within a twentieth century diary (indicating revisionist elements added later), and the consistent use of two different pigments on the same decorated manuscript showing how the work had been divided between two teams.

Grouping. It is frequently attempted to group individual books to certain common locales of production (workshops or individuals) by means of stylistic and historical evidence. Analysis can of course help. If the materials are the same (the notable materials, that is, not the standard ones) in books that are supposed to originate in the same atelier, this can strengthen the connection, whereas inconsistency in material use will weaken it. Similarly analysis can be used to confirm a common origin of *disjecta membra*: for example DNA analysis of the membranes has been used to reunite fragments of the Dead Sea Scrolls.

#### 5.2. Example Questions About Many Books

It is a good idea to have a large-scale research question, such that each individual analysis of a book can not only inform us about that book but also contribute to a more global understanding of book history. The 'master question' is always: 'what was used, how, where and when?' This will lead to a better understanding of workshop practices, and more sociological questions such as the demands and expectations of patrons and consumers, and so forth. But this can only be answered by a considerable programme of coordinated analysis to determine statistically significant trends.

Certain questions need specific programmes of research other than the 'master schemes' outlined above. An excellent example is the question 'Is the degradation in these books due to their manufacture or their storage environment, past and present?' One outstanding project to address this is the British Library 'Identical Books Project', where different libraries' copies of the same 400 printed books are analysed thoroughly for indicators of degradation: pH, colour, lignin content, sulphate content, bending brittleness, etc. The study of environmental conditions can further be carried out by the use of surrogate book materials, that is, historically accurate reconstructions based on historical technical treatises and craftsmen's recipe books.

#### 5.3. Interdisciplinary Formulation

Analysts and art historians rarely appreciate each other's issues. Patience is needed, and a willingness to pay attention. The key to designing a research programme is an iterative consultation process.

The book historian, curator or conservator does not want to know much technical detail, just (a) 'can this technique answer my question and if not, which technique can you suggest?', and (b) 'will it damage my object?' Decisions on the ratio of risk of damage to useful information can thus be arrived at iteratively.

Analysts, however, are often surprisingly interested in the questions of art history and codicology, both historical questions and questions of the history of book technology, and will usually benefit from a fairly full statement of a problem: they may then be able to suggest an individual technique, a combination of complementary techniques, or a statistical approach. Furthermore, analysts are often interested in finding

novel applications for their instruments, and in stretching the limits of what their instruments can do (the conservation preference for non-sampling or micro-sampling being a good example).

# 5.4. Meta-analysis

Common in medicine, practiced in archaeology, yet rare in conservation, 'meta-analysis' studies (or 'systematic reviews') critically examine the data of previously executed studies to answer new or larger questions. Such studies consider the validity of the methodology, the specificity and accuracy of analytical techniques used, and the actual results, so as to perform a 'meta-study' or 'virtual experiment' on a far larger range and number of subjects than would be possible for an individual team or project to do¹. More should be attempted in the field of book studies, to add greater statistical validity to what has largely been an ad hoc series of analyses.

#### 5.5. Timetabling and Paying for Analysis

Without specific project funding, the analytical burden typically falls on the conservation department of a library. It is thus subject to considerable pressure and limitation, but nevertheless the conservation environment is in many ways ideal for analysis: there is a conservator present to guard against hazardous procedures or inappropriate handling, and books and instruments can generally more easily be introduced to each other in a pre-conservation state, especially when the spine is broken (permitting flat opening) or better yet, when a book is pulled and disbound<sup>2</sup>. Samples can be removed before conservation treatment (to

<sup>&</sup>lt;sup>1</sup> One such meta-study is M. Clarke, *The analysis of medieval European manuscripts*, Reviews in Conservation 2, 2001, pp. 3-17

prevent contamination by conservation materials) and saved until suitable analytical opportunities become available.

Analysis can be seen as super-documentation, and the opportunity for analysis (or at least sampling) should be seized at the moment of conservation intervention: it will generally be a once-in-a-life-time opportunity to apply otherwise physically or logistically impossible analytical techniques. How good it would be to see libraries prepared to supplement the budgets conservation departments to incorporate such routine analysis?

### 6. Suggested Priority Questions

I would like to identify a few areas which I believe could usefully be prioritised.

- 1) The identification of inks and pigments is still a valid and useful area of research, but both the analysis itself and the questions asked of the results need to be more subtle and more comprehensive: rather than continue to be content with an identification of, for example, 'verdigris', we must investigate the composition, corrosive tendencies and relative stability of different forms of verdigris made according to different recipes.
- 2) The importance of organic pigments should receive more attention. These are the most vulnerable to fading or damage by inappropriate treatment, and the degree of visual alteration is not well understood or quantified. Furthermore, their relatively greater variety means that they have potentially the greatest use for identifying ateliers and identifying places of production.

- 3) Recent advances in micro-sampling and immunological assays allow the analysis of binding media and adhesives with unprecedented precision. This is interesting for the history of technology (the sometimes doubted addition of ear-wax to glaire, as described in mediaeval treatises, has only recently been experimentally identified), but more so for informing conservation choices.
- 4) Proper analysis of parchment species is to be encouraged: a great many codicological conclusions have been published that are based on what I am confident will prove to be incorrect identifications (the visual differences are often misinterpreted, and furthermore it is not commonly appreciated that the physiology of mediaeval goats and sheep were far more similar than today). The question of 'uterine vellum' versus the use of small animals would be one historic debate it would be well to resolve once and for all, and would provide useful localisation data.
- 5) The importance and consequences of layered paper and paint structures has been under-researched and is under-appreciated. For example, in both western and Islamic manuscripts it seems that organic glazes (thin layers added on top of paint) were common. We know almost nothing about these, yet such organic glaze layers are highly vulnerable to cleaning, washing, and light-induced degradation.
- 6) Large-scale digitisation brings new questions: we should investigate what happens to the digitised book that will now be far less frequently consulted: whether pages will become blocked or offset, whether a lack of regular airing will encourage mould growth, and so forth.
- 7) Finally, I would strongly suggest that far greater attention be given to everyday, standard or low quality books, such that we may build up a better picture of common usage.

<sup>&</sup>lt;sup>2</sup> This is also the perfect moment for digitisation.

#### 7. Applicability and Audience of Results

The applicability and audience of research results varies. A detailed examination of an individual object is of immediate concern to those responsible for its curation and conservation, while the more general questions are naturally more interesting and contribute more to the disciplines of 'technical art history' and the 'archaeology of the book'. One of the greatest challenges facing technical codicology is how to make results of specific examinations of individual books widely available in such a way that results may be combined to allow generali-sations to be made. When an analysis has been done, every effort should be made to publish the results, in however abbreviated a form: for example as an appendix to a cataloque, or as an appendix to a yearbook, or on a webpage. This need not be an elaborate text, with an introduction, discussion and conclusions, but a simple, telegraphic even, statement of technique and results, perhaps in a simple table of results per manuscript: the purpose not being a formal academic paper but a simple dissemination of data with which future syntheses may be built.

destroy in a few weeks pigments that have survived for centuries.

The present relative scarcity of book analysis, perceived and genuine, leads on occasion to negative comment (typically by art historians) as to the worth of analysis. This attitude has two manifestations: 'if nobody does it, how can it be useful?' and 'if there is so little comparative data, what use is the analysis of my few objects of interest?' Each leads to vicious circle of non-analysis. But the pioneering has been done: what is needed now is to make analysis mainstream and inevitable.

While not every feature of every book will ever be fully analysed, whatever analysis can be done contributes to the overview. Analysis can be seen as super-documentation: ideally a way needs to be devised to build in to routine examinations some forms of routine, rapid protocols of simple and inexpensive analysis.

#### 8. Conclusions

Analysis is most successful when it complements traditional codicology, or when it answers a specific conservation question. The amount of analytical work done has increased recently, as increasingly sensitive and unambiguous techniques have been developed. Nevertheless, much research has been ad hoc, and it is still true that not nearly enough is known about the materials of books. Regardless of any academic interest, we must make such analysis a priority to know what conservation treatments will be safe and suitable. Furthermore, the recent dramatic increase in demand for exhibition of books may

#### Mark Clarke

Researcher mark@clericus.org

Dr. Mark Clarke is an interdisciplinary researcher specialising in the history of artist's materials, identification of artist's materials, and historical artists' technical recipes, especially mediaeval and early modern. He studied paper conservation at Camberwell College of Arts, conservation science at De Montfort University, and archaeology at Cambridge. He is Associate Professor in the Department of Conservation and Restoration at the Universidade Nova de Lisboa.

# NODEM 2013 Beyond Control – The Collaborative Museum and its Challenges

Review by Paul Henningsson

December 1-4, 2013 Stockholm, Sweden

The 10<sup>th</sup> anniversary of the NODEM Conference series, "Nordic Digital Excellence in Museums", was held between 1-4 December in Stockholm. Participants experienced a rich programme, including pre- and post-conference activities, with the festive seasonal lights of the Swedish capital as its backdrop.

Originally founded within a museum R&D group at the Interactive Institute, Sweden, the NODEM conference has rapidly grown from a bi-annual Scandinavian forum to an international network of professionals, meeting annually to discuss and share creative uses of information and communications technologies (ICT) and digital media to preserve, research, interpret and communicate our heritage.

From the outset, the angle has been multi-disciplinary, attracting curators, engineers, designers, programmers, museologists, exhibit fabricators, educators, archivists, interpretation specialists, architects, conservators and artists, to name but a few. The 2013 edition was no exception and the organising committee had put together an impressive programme, showcasing a variety of digital and interactive projects from Europe, North America, Asia and the Nordic countries.

The conference theme, "Beyond Museum - The Collaborative Museum and its Challenges", connected to shifts in society, where cultural and

#### Organised by

NODEM Network of Design and Digital Heritage, Interactive Institute Swedish ICT, Swedish Exhibition Agency, and Stockholm City Museum

scientific institutions face new social, cultural and economic landscapes, calling for new synergic and sustainable collaborations between public institutions, communities and audiences.

The theme also connected to the given subject interest of NODEM, digital technologies, and our increasingly digital and media saturated lives. Digital technology not only offers a multitude of information, visualisation and communication modalities but also new formats, as well as new uses, challenge long established notions of authority, ownership and publication rights.

The recent developments of smart mobile technologies and social media are being merged with existing digital museum practices, adding yet further chapters as well as challenges to the profession.

#### *Day 1 (1st December 2013)*

Early attendants of the conference were given a guided walk through the Old City of Stockholm, Gamla Stan, given by the Stockholm City Museum, one of the hosts of the conference, along with the Museum of Medieval Stockholm. This museum holds important collections of medieval materials, partly as a result of earlier extensive archaeological excavations on the site. The museum's permanent exhibition includes reconstructions of the Old Town of Stockholm, supported by digital 3D visualisations.



Nora McGregor presenting "Every book tells a story, but what can 68,000 books tell you?" during the keynote session. Photo by NODEM Network 2013.

## *Day 2 (2<sup>nd</sup> December 2013)*

The conference opening and keynote presentations took place at the conference facility of the Hilton Hotel, close to the City Museum. The hotel was also home to many of the guests during the conference.

Founding Director of NODEM, Halina Gottlieb of the Interactive Institute Swedish ICT, welcomed participants to the conference, together with partners Hans Öjmyr, Head of Exhibition Department of the Stockholm City Museum, and Johanna Rahm, Education Coordinator at the Swedish Exhibition Agency.

A total of 11 keynote presentations were given on the second day, chaired in the morning by Anne Balsamo, Dean of the School of Media Studies in New York City. The afternoon sessions were chaired respectively by Maria Economou, Lecturer in Museum Studies at the University of Glasgow, and Kevin Walker, Head of Information Experience Design at the Royal College of Art in London.

The first group of presentations related to overarching social and cultural aspects of uses of digital media:

Gerfried Stocker, Artistic and Managing director at Ars Electronica in Linz, held the first keynote entitled "Future Museum and Collaborations". Mr Stocker outlined experiences from developing the new Ars Electronica Centre and Museum in Linz. Mr Stocker made the point that person-led facilitation is at the core of communicating around technologies. In order to be engaging, we need to listen and relate to the perspectives that our users bring with them.

Amareswar Galla, Executive Director of The International Institute for the Inclusive Museum, held a presentation titled "Fetishisms to Digital Incarnations. Things - Access, Engagement and Digital Heritage". Mr Galla has a long track record of working with inclusive work for public bodies and authorities. Mr Galla sees the need for more first person accounts from diverse communities



Amareswar Galla presenting "Fetishisms to Digital Incarnations. Things - Access, Engagement and Digital Heritage". Photo by NODEM Network 2013.



Allegra Burnette during her presentation "Supporting the Museum's Mission through Mobile". Photo by NODEM Network 2013.

in heritage interpretations, on site as well as in digital media, referring to the Cultural Diversity Charter adopted by ICOM in Shanghai 2010.

Richard Sandell, Professor of Museum Studies at the University of Leicester, chose the title "Museums, Media and Human Rights". Professor Sandell presented cases from an ongoing research project where museums can be viewed as a setting for societal debates about human rights and values. One example illustrated how digital media can be used for swift response by interest groups, to contest value standpoints taken by a museum and what the implications could be for museums opening for co-creation of content with audiences.

Ramesh Srinivasan, Associate Professor of the Department of Information Studies and Design | Media Arts, University of California, presented "Community Power - Rethinking Global Media". Taking a more philosophical angle on "technology", Professor Srinivasan wished to question the established causal, logical and linear thinking

paradigm of technological engineering. Having worked closely with indigenous communities in web and media projects in various parts of the world, he sees the value of introducing cultural value systems as basis for developing new models for digital networks.

Nora McGregor, Digital Curator at the British Library/BL Labs, presented "Every book tells a story, but what can 68,000 books tell you? New perspectives on digital collections and curation at library and cultural heritage institutions". As a result of increasing digital publication acquisitions, knowledge management and curating of materials are shifting at the British Library in London. McGregor shared parts of this process and meant that letting go of traditional control (curation) over digital collections may breathe new life and new knowledge into heritage materials.

Allegra Burnette, Creative Digital Media Director at MOMA held the keynote entitled "Supporting the Museum's Mission through Mobile". He offered

insights from the museum's recent development of a mobile technology strategy and the renewal of its handheld guided tour programmes. Part of the strategy involved visitor consultations, which indicated that present visitors may privately own smart mobile devices. But for different reasons, they prefer not to use them in the museum setting and did not necessarily find that "high tech" was the selling point of digital tour quides.

Herminia Din, Professor of Art Education at the University of Alaska, presented "Balancing Act: Object, Interpretation, and Technology". Professor Din put forward a case of reason in digital interpretive practices, often seen as a balancing act between target users, technology and subject matter. Some selected current cases showed examples of "blinding" technologies, sometimes forgetting the bottom line of museum exhibitions and programmes: to create meaningful connections with and encounters of our shared heritage (material and immaterial).

The afternoon session concluded with a focus on technologies, design and applications.

Kimmo Antila, Director of the Finnish Postal Museum, lectured on "New Approaches to Exhibition Design: Temporary and Permanent Exhibitions". Antila referred to museological thinking about museum experience models as well as interactive, participatory processes as basis for the renewal of the National Post Museum. Interpretive themes need not only to satisfy audiences expecting "experiences" but can also include difficult topics such as the Finnish Civil War, building on immersive or emotive communication.

Nils Wiberg, Interaction Designer at Gagarin Experience Design, Iceland, presented "Dramaturgy in Interaction". Mr Wiberg presented the notion of dramaturgy in experience design, derived

originally from linear forms of storytelling. The Norwegian Sea Bird Centre was used to illustrate the dramaturgic model behind its interactive concept.

Bartek Gudowski, Digital Innovator, presented "Bringing the Digital Museum to Your Home". Mr Gidowski has a background in many early prominent digital projects such as the Virtual Nobel Museum, among others. Mr Gudowski took the opportunity to showcase current examples of advanced visualisation technologies.

Finally, Ebbe Strandell, Chief Technical Officer at ABBA the Museum, spoke about "User Interactivity at ABBA The Museum". Mr Strandell gave a tour of the highlights of digital and interactive designs at ABBA the Museum, explaining a few of the choices made by the development team and the intended experience outcomes by visitors to the new music-ridden exhibition.

In the evening of day two, the City of Stockholm's held a Welcome Reception for participants and guests at the Stockholm City Hall. The Hall was inaugurated in 1923 and was made famous by the Nobel Prize Banquets, which take place in the ceremonial halls on 10th December every year.

## *Day 3 (3<sup>rd</sup> December 2013)*

The third day contained the special sessions of international contributors. Parallel short paper presentations, talks and workshops, organised according to different themes, were held at the Hilton Hotel and Stockholm City Museum.

The different themes explored a number of theoretical and practical issues, relating to areas such as management of resources, ICT and learning, interaction and user interface design, curatorial practices and contemporary art, digital



Ramesh Srinivasan presenting "Community Power - Rethinking Global Media". Photo by NODEM Network 2013.



Richard Sandell presenting "Museums, Media and Human Rights". Photo by NODEM Network 2013.

preservation and visualisation and user and partnership collaborations.

In addition, participants could sign up and join expert workshops covering specific aspects of the conference theme.

Over 60 presentations were held this day in an open pick-and-mix format that unfortunately is difficult to review in the format of this article. In addition, being chair over one of the themed sessions prevented this reviewer somewhat from exploring the different topics and papers presented. Here follows some brief reviews of just a few international case studies, which hopefully will interest readers of this journal, as a glimpse of the many inspiring facets of the conference theme.

Within the "Experience Design Inside / Outside Museums" thematic session, Gabriella Giannachi, Professor in Performance and New Media at the University of Exeter, UK, spoke about "Exeter Time Trails", a prototype for a web based app for smartphones, linking existing digital collection material to walking around the city of Exeter in

the UK. The rationale is based on crowdsourcing of content with the general public, as well as blended learning activities of a group of young people not currently in education.

During the "Support for Archiving, Documenting, Preservation, Visualization and Recreating" thematic session, Joel Taylor, researcher at the Norwegian Institute for Cultural Heritage Research, presented "Digitization and Digital Interaction as a Barrier to Democratic Heritage?". He reconnected to questions raised in the keynote sessions and spoke about ownership issues in heritage; who owns and defines heritage and how notions of "democracy" are often formulated as reasons for digitisation programmes, such as transnational initiatives through the EU.

Another interesting thematic session was "Curatorial Challenges", in which Chiel van den Akker, from VU University Amsterdam, presented "The Online Museum and Its Contribution to E-humanities". Digital hermeneutics explores limitations of computer automation on the one hand, and interaction of people and technology on the other.

Recapitulating two chief discourses of museology, information (collection documentation) and interpretation (collection exhibiting) Dr. Akker made the point that it is clear that both are needed and also are present in online museum resources. However, cultural institutions need to make explicit distinctions between the two in order to benefit from their respective uses. Mainly descriptive content materials serve heritage professionals, and such online resources lose their appeal, or remain undiscovered to most groups of users.

Finally, during the thematic session "Social Media for Creative Expression, Communication and Content", Sigurd Trolle Gronemann, Univeristy of Copenhagen and Erik Kristiansen, University of Roskilde, presented "Here We Go Again: Co-construction of Museums and Audiences on Facebook". Relating to a growing school of online visitor studies, the Danish research team has analysed modes of communication with users in social media channels, among nine different museums and visitor attractions. A few examples illustrated how museum institutions, implicitly or explicitly, affirm their own authority in social media channels by not choosing to comment user contributions, or restating particular stances, rather than exploratively inviting further dialogue. Not responding equally to user contributions, counteracts the building of trust and sharing, necessary for online social media environments.

After a full day of special sessions, participants and guests gathered at the Museum of Medieval Stockholm, for drinks and socializing, before being treated to "julbord", traditional Swedish Christmas food and drinks, served at the Museum of Medieval Stockholm. In conjunction, special demonstrations were held by exhibitors in the NODEM EXPO, showcasing, for example, high definition 3D scanning technology as well as positioning technologies for handheld digital guides.

# *Day 4 (4th December 2013)*

After the days of scheduled presentations and workshops, participants were invited to a post-conference tour of three high-profile museums and visitor attractions in Stockholm: The Vasa Museum, Abba the Museum, Museum of Spirits and Museum of Music and Theatre. This was an opportunity to connect, in practice, to some of the challenges discussed during the sessions as well as exploring some unique features of Swedish culture.

Further details of NODEM 2013 can be found in its website, as well as information about past and coming conferences: <a href="http://www.nodem.org/">http://www.nodem.org/</a> conferences/past/stockholm-2013/

Paper abstracts from all conferences are archived at the NODEM Digital Repository for open access, <a href="http://repo.nodem.org/">http://repo.nodem.org/</a>; on Youtube, please see: <a href="https://www.youtube.com/user/NodemNetwork">https://www.youtube.com/user/NodemNetwork</a>.

The next NODEM conference will take place on 1-3 December this year (2014). It will be held in Warsaw and hosted by Museum of King Jan III's Palace at Wilanów/Muzeum Pałacu Króla Jana III w Wilanowie, as well as by The Museum of the History of Polish Jews/Muzeum Historii Żydów Polskich. Please see the conference website for more information about NODEM 2014: <a href="http://www.nodem.org/">http://www.nodem.org/</a> conferences/nodem-2014/

#### **Paul Henningsson**

Digital Interpretation Consultant, <u>musedia</u> paul@musedia.net

# FAIL BETTER Decision Making in Conservation Practice of Modern and Contemporary Art

Review by Michelle Barger

December 6-8, 2013 Hamburg, Germany **Organised by**VDR Verband der Restauratoren

The opening of the symposium Fail Better coincided with the worst storm in Hamburg since 1962, yet international speakers and participants prevailed in a successful meeting at the Hamburger Kunsthalle. Interdisciplinary in nature, conservators, curators and other caretakers of modern and contemporary art gathered to address the challenges we face in caring for objects made from unorthodox materials and methods, and explore necessary shifts in our roles and decision-making models. Organized by Barbara Sommermeyer, conservator of contemporary art at Hamburger Kunsthalle, the symposium took place over two days, incorporating guided tours of the Eva Hesse, Gego and Santiago Sierra exhibitions, an evening reception on a touring barge down the Elbe in the thick of the storm, hearty local cuisine, and a hard-hat, behind-the-scenes tour of the ambitious Elbphilharmonie project.

Prof. Hubertus Gassner, director of the Hamburger Kunsthalle, provided opening remarks and charged the group with two directives to consider: what are the changing roles as caretakers of contemporary art, and how has decision-making changed. Sommermeyer introduced the themes for the conference, offering her goal to foster a more positive idea of failure. She shared examples of conservation treatments at the Hamburger Kunsthalle where replacement or replication of elements was a viable solution, followed by an example where this approach was deemed "going too far."

In the latter example, the artist shifted her opinion over time, ending with acceptance of disfiguring change in her work. The notions of changing opinions – whether it be artist's, curator's or conservator's – and of acceptance of ageing in art work were themes that continued to resonate throughout the symposium.

The symposium was divided into four moderated half-day sessions, beginning with Session 1: Failure. IJsbrand Hummelen (senior researcher/ conservator, RCE, Amsterdam) moderated this session which included presentations by Brigitte Kölle (curator, Hamburger Kunsthalle) and Silke Zeich (conservator, Museum Folkwang, Essen). Kölle curated an exhibition at the Hamburger Kunsthalle entitled "Fail Better" (1 March – 11 August 2013) inspired by Samuel Beckett's quote: Ever tried. Ever failed. No Matter. Try again. Fail again. Fail better. She offered examples of artists through time who have explored failure in both playful and tragic aspects. Zeich recounted historic examples of failure in art work that are revered objects in their respective cultures - inclusions in the glaze of a Korean vessel, rivets in the lid of a wooden Japanese tea jar, or the melding of an Etruscan body and a medieval head into a sculpture two centuries ago. She finished by sharing a recent conservation treatment of a Paul Thek experiential installation work in the Museum Folkwang collection. Due to fragility in the materials, visitors can no longer enter the meditative

space created by the artist, but must experience it from just outside the environment. Moderator Hummelen introduced a concept in the Netherlands where they talk about "curating of conservation" and posed this idea specifically to the issue of communicating failure to your audience. This opened the discussion into ways that we as curators and conservators use opportunities to inform visitors of failure, whether through physical space — a narrow hallway for Francis Alÿs' Sisyphean video of a Volkswagen Beetle repeatedly making its way up a hill only to roll back down — or with the use of labels and videos to convey experiences that are no longer possible.

In **Session 2: Replacements**, approaches in the conservation of minimal and serial art were shared by Eleonora Nagy (conservator, Whitney Museum of American Art, New York) and Elisabeth Bushart (head of conservation, Museum Brandhorst, Munich). Iris Winkelmeyer (head of conservation, Lenbachhaus, Munich) moderated the session. Nagy opened her presentation with examples from her extensive experience in treating Donald Judd's sculptures, sharing her deep knowledge in specific qualities of the artist's materials and fabrication details. She noted that Judd held a standard for the "highest quality" which is not the same as perfection - a quality we often project on his work. The notion of perfection in the 1960s/70s is different from what can be achieved today, given that fabrication methods are much more precise. Nagy also presented the treatment of *Ice Bag-Scale C*, a kinetic sculpture by Claes Oldenburg in the Whitney collection, which provided a good case study for exploring fine line between replacing elements in an art work vs. deeming the entire work a replica. This project also exemplified the new role of the conservator of contemporary art as facilitator and master documenter, and the importance of maintaining a network of specialists as dictated by the needs of complex works of contemporary art.

Bushart recounted a devastating example of accidental damage incurred on an art work by a visitor, resulting in a complicated journey of decision-making. Katharina Fritsch's Display Stand with Vases toppled over when a visitor backed into the work while taking a photograph. The aluminum trays in the stand dented and buckled, and numerous mass-produced plastic vases were chipped and fractured, with ink from the printed image transferring to other pristine surfaces on the sculpture. Challenges in decision-making ensued when the museum tried to reconcile the artist's approach which differed from what they had understood to be so intrinsic to her work. To complicate matters, the artist's opinion changed over the course of the long discussion, ultimately coming to a place of acceptance for the damage as part of the history of the work. Winkelmeyer moderated a lively discussion which highlighted the challenges in reconciling differing opinions by artists: one approach for market-driven treatments vs. another for works in an institution.

Lyndsey Morgan (Patina Art Collection Care Ltd., London) opened Session 3: Models for Decision **Making** with a thorough summary of the ambitious replication project of Naum Gabo's Circular Relief at Tate, where she was employed for many years. The original sculpture was made from cellulose acetate, an unstable plastic which quickly deteriorated during the course Morgan's tenure at Tate. The institution worked closely with Gabo's daughter and her spouse - Nina and Graham Williams - at every step of the multi-phased, process highly technical replication project, cautiously reviewing the results at each level before taking the next step. The resulting replica is very convincing, yet Morgan shared that she felt an emotion of sadness upon seeing it - "as if the work had died again." During her presentation, Morgan shared a quote by the Williamses: In making a replica, subjective judgment, personal task and individual skill are



Symposium participants.

*involved*. Perhaps they were suggesting that simply following a rigorous and exact replication ignores a need to work "in the spirit" of an artist for a more convincing replication.

Michelle Barger (deputy head of conservation, San Francisco Museum of Modern Art) highlighted her work with living artists as the starting point for informing decision-making. This approach grew out of challenges she experienced while preparing for an Eva Hesse retrospective and the difficulty in reaching decisions when the artist is no longer living. SFMOMA works with 30-40 artists each year, and is committed to developing relationships with them at the point of acquisition of their work in the collection. With an ambitious expansion project scheduled for completion in 2016, SFMOMA is in a position to design spaces that support this activity, and will have an area in their new conservation studio that can serve as an artist studio, interview space, or public program.

Derek Pullen (SculpCons Ltd., London) moderated the discussion which centered on the factors that go into making decisions about replicating a work. Examples shared by participants suggested that decisions are made on a case-by-case basis, citing examples where installation-based works could be successfully replicated, especially with assistants

who worked very closely with the artists. Pullen asked Barger her feelings on whether Hesse's work should be replicated. Although several of Hesse's assistants are living, Barger does not support replicas of the artist's deteriorated works, but has explored making mock-ups with an assistant – Doug Johns – as another point of access for understanding the artist's work. Other participants cautioned that it is not our role to be creators, and the danger in the uncertain status of replicated works was raised.

IJsbrand Hummelen and Matthew Gale (curator, Tate, London) presented for the final **Session 4:** Roles in Decision Making. Hummelen opened his presentation by reflecting on three case studies presented in the seminal conference Modern Art: Who Cares? (1997). He noted that artworks develop a biography that is shaped by the people, documents and photographs around them. Over time, these elements gain agency in telling the story of an object. Hummelen posited the idea that artworks become networks and move beyond their physical being; the artwork is the basis for the script, but the script is enlivened by all the agents/ actors. Gale recalled examples in history where replicas have achieved a level of authenticity: San Marco Campanile, which was restored in 1912; Marcel Duchamp's The Bride Stripped Bare by her



Moderated discussion, Session 1 (left to right): Brigitte Kölle, IJsbrand Hummelen, and Silke Zeich.

Bachelors, Even (The Large Glass) 1965 replica at Tate created because the original was too fragile to travel. He commented on authority that is transferred to a replica once exhibited, and questioned the authenticity of aura: is the passing of an aura into a replica "more of a hope than actuality" (Yves Alain Bois), or does the aura come from the viewer viewing? For example, most visitors to Tate do not realize that The Large Glass is a replica. In closing, Gale – who worked closely on the Tate's Sculpture Replica Project – shared a curatorial code of practice for replication, prompted by the experience in the project.

Barger offered closing remarks to the symposium, recalling the initial charge by Gassner. What are our changing roles as caretakers of contemporary art, and how has decision making changed? She noted that the shift from traditional art-making to more unconventional modes in contemporary art requires a parallel shift in how we as conservators approach our work. There is a new player on the field – the artist – and we need to more comfortably incorporate them into our practice. Similarly, our training is rooted in the materials of art, yet it was apparent during the symposium that we need to shift our skills sets to make room

for the immaterial in decision-making: the layers of meaning, the role of the biography that grows with an art work, reconciliation with changing opinions of artists (and conservators and curators), cultural perceptions of aging. Barger noted that the decision-making model continues to be based on an interdisciplinary group approach as it was defined in Modern Art: Who Cares, but artists are becoming more fundamentally integrated into this process. With respect to decision-making for replicas, there is a tendency to strive for quidelines and standards. She proposed that decisions would be better served by the approach outlined by philosopher Renee van de Vall in Modern Art: Who Cares?: an accumulation of thoughtful, case-based examples which will undergird and quide decisionmaking where every object requires a customized solution.

The recordings of symposium are available online.

#### Michelle Barger

Deputy Head of Conservation, SFMOMA mbarger@SFMOMA.org

# VIII National Congress of the Italian Association of Archaeometry Science and Cultural Heritage: state of the art and perspectives

Review by Ferruccio Petrucci

February 5-7, 2014 Bologna, Italy Organised by

AIAr - Associazione Italiana di Archeometria

AIAr, the Italian Association of Archaeometry, has been organizing since 1999 a biennial congress to promote the dialogue and exchange of ideas on research for the protection and conservation of Cultural Heritage. The 8<sup>th</sup> Congress of AIAr took place from 5<sup>th</sup> to 7<sup>th</sup> February 2014 at the Conference Center of the Italian National Research Council (CNR) in Bologna. The congress main aim is also that of AIAr: to enhance debate and collaboration among the many actors of scientific research in the Cultural Heritage field.

With more than 200 associates, most of them working in universities and research institutions, the association promotes an interdisciplinary approach to scientific research of Cultural Heritage, aimed at conserving, restoring or simply to advance on the knowledge of the remains of the past.

A national event is planned each year: a general purpose congress and a thematic workshop are organized, on alternate years.

The 8<sup>th</sup> Congress was intentionally focused on general issues and its 88 contributions, both oral presentations (48) and posters (40), were divided in six sessions: *Characterization and Diagnostics*; *Preventive Conservation and Restoration*; *Technological Innovation*, *New materials and* 

Nanotechnologies; Dating and Provenance; and Protection and Valorization. Due to the high number of communications and limited time, the congress was organized in parallel sessions. For the same reason, only some few presentations will be mentioned in this review.

As a curiosity for those who love statistics, taking a closer look at the content of presentations we find that the researches on specific works of art, from roman to contemporary art, are almost equalizing in number (22) the reports of archaeological interest (27) and that studies on stones and ceramics are by far more numerous (22) that investigations on any other art support material, including glass (6) and paper (5).

The works of the congress were introduced by invited speaker professor Peter Brimblecombe, Associate Dean and Chair Professor of Atmospheric Environment at the School of Energy and Environment in the City University of Hong Kong. His lecture, "Climate modelling and estimating damage to heritage", took stock of the situation of cultural heritage in the face of global warming and increasing urban pollution. The second day invited lecture was held by prof. Piero Baglioni of the Chemistry Department and CSGI Consortium of Florence University and was focused on the applications of "Nanoscience for cultural heritage".

At the end of the congress, a round table dedicated to the national and European aspects of funding was organized under the title "Perspectives and Tools for the funding of research applied to Cultural Heritage". Chaired by Maria Perla Colombini, President of AIAr and Director of the Institute for the Conservation and Promotion of Cultural Heritage (ICVBC) of CNR, Pisa University, the discussion took place among the speakers representing various institutions: Cristina Sabbioni, Director of the Institute of Atmospheric Sciences and Climate (ISAC) of CNR and on behalf of MIBACT, the Italian Ministry for Cultural Heritage, for the European Joint Programming Initiatives (JPI) calls on Cultural Heritage; Emilio Ribes Gómez, Coordinator of the European Project EC-SYDDARTA, from Instituto Tecnológico de Óptica, Color e Imagen, AIDO, Spain; and Marina Silverii, Deputydirector of ASTER, the Consortium for Innovation and Technology Transfer in the Emilia-Romagna region of Italy.

# Some highlights from the six sessions of the Congress

In this section some of the contributions that, in my opinion, best highlight the main features of the congress are presented. The extended abstracts of all contributions can be found in the congress' website at http://www.associazioneaiar.com/cms/content/extended-abstract.

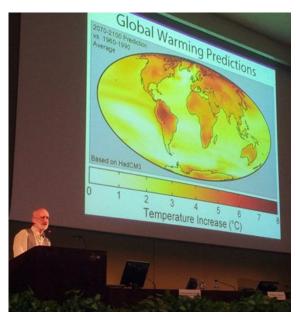
The session dedicated to *Characterization and Diagnostics* was the one with the most participants. For this reason it was extended throughout the entire duration of the congress, in parallel with the others remained sessions. It included presentations covering a wide spectrum of diagnostics of degradation processes, from biological degradation of underwater archaeological artifacts to the different sources of air pollution on carbonate substrates in monuments.

M. Ricca, from the University of Calabria, presented "The effect of biological activity on archaeological marbles in marine environment" which focused in the most destructive alteration of marble pavement slabs from the Underwater Archaeological park of Baiae, Naples. The alteration was characterized by microscopy tools, and it was found to be mainly exerted by piercing endolithic organisms. Other organisms, on the other hand, while not causing structural damage, induce disfigurement and illegibility.

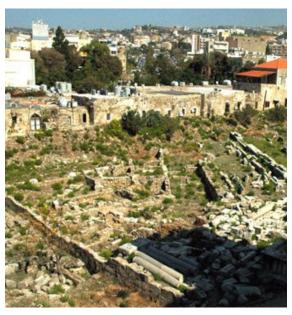
Dedicated to a very actual issue, strongly felt in areas affected by the earthquake that hit the Emilia Romagna region in May 2012, the analysis of building materials and of their degradation was conducted by researchers at the University of Modena and Reggio Emilia. On a presentation titled "Building materials and degradation phenomena of the Town Hall of Finale Emilia (Modena): a study for the restoration project after the 2012 earthquake", M. Caroselli spoke about the preparatory study to the drafting of the restoration project. The characterization of binders and aqgregates, present in mortars and plasters, has allowed to trace the evolution over time of the building itself and to make restoration materials compatible with original ones.

A large variety of studies on works of art were also presented, spanning from the metallurgical technology of Japanese swords to the composition of the paint tubes of Edvard Munch, from roman glass in Northern Tunisia to the "Gates of Paradise" in Florence Baptistery.

M. Aceto, from the University of Eastern Piedmont, presented "On the colouring of purple codices". The investigation of Middle Age codices, dating back to 6<sup>th</sup> to 8<sup>th</sup> centuries gave a deeper insight to the manufacturing of those parchments of admirable suggestion. Non-invasive spectroscopic



Prof. Brimblecombe during his introductory lecture.



The landscape shows how the archaeological remains merge in the living town of Byblos.

techniques like FORS and XRF have shown that the prestigious Tyrian purple was often replaced by purple dyes of vegetal origin, like orchil and folium, obtained by the lichen Roccella tinctoria and by the plant Chrozophora tinctoria.

On her presentation titled "The Herculaneum Conservation Project: characterisation of archaeological waterlogged wood by pyrolytic and mass spectrometric techniques", J.J. Łucejko from the University of Pisa, spoke about fragments of waterlogged wood from a Roman domus buried by the eruption of Vesuvius was analyzed by pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS). This method proved to be effective in characterizing the degradation state of the wood and identifying the binding media used in roman decorations.

The classical theme of environmental monitoring was discussed during the session *Preventive Conservation and Restoration* in an innovative approach, providing applicative perspectives in different topics to support the conservation of Cultural Heritage.

P. De Nuntiis, from the Institute of Atmospheric Sciences and Climate CNR-ISAC, presented "Beyond the environmental monitoring for the preservation of the Cultural Heritage: the frescoes of the monumental cemetery of Pisa" where an automated forecasting tool for the events of water condensation, based on the calculation in real time of the dew point temperature was applied in the Monumental Cemetery of Pisa. It is aimed at overcoming the concept of microclimatic monitoring, already fairly widespread in Italy as well as abroad, offering a practical tool - mainly based on an excellent knowledge of the degradation phenomena - as a real help to conservators. The system is rather original, even if the most innovative aspect concerns the activation of backheating panels to prevent water condensation.

Concerning the cleaning procedures, C. Pelosi, from the University of Tuscia, spoke about the "Study of the laser cleaning of wooden objects", where it was shown that laser cleaning applied to wood can be an effective procedure to remove surface deposits while preserving the original

patina, without negatively affecting the original support in terms of alterations of the surface morphology or possible color change.

Another well-suited cleaning procedure was presented in the session Technological Innovation by S. Voltolina, from Veneto Nanotech scpa. On his presentation titled "Assessment of a novel methodology for plasma cleaning, coating application and diagnostics and coating removal" it was explained about the introduction in the restoration field of plasma torches (Atmospheric Pressure Plasma Jets), formerly used only in industry for cutting and welding. This is accompanied by the awareness that protective coatings for stones, even with new synthetic polymers, are subject to aging and degradation. For this reason, a complete methodology focused on plasma torches, was proposed to clean, to coat and to remove inefficient coating from stone surfaces. This methodology is suitable to be easily extended to removal of graffiti from walls, among many other applications.

In the session dedicated to the *New materials and nanotechnologies*, A. Bernardi, from the Institute of Atmospheric Sciences and Climate CNR-ISAC, presented "Development of metal-alkoxides precursors for conservation nanomaterials: the EU Project NANOMATCH", where metal alkoxides were presented as new consolidants for stone, wood and glass. These products engender a nano-structured coating inside the pores of stone and wood, or in the internal cracks of a damaged glass, restoring mechanical stability. These very promising results have been the subject of several research projects, funded by European Community.

The *Dating and Provenance* session included the presentation of a rare application of the method of dendroprovenance given by 0. Pignatelli, from Dendrodata sas. Titled "L'alcova di Federico da

Montefeltro a Urbino: datazione e provenienza del legno", the lecture focused on the dendro-chronological sequence of the wood in the alcove of Federico da Montefeltro at Urbino, Italy. The wood was compared with master dendrochronologies of the same tree species (spruce, *Picea abies*) of other regions, finding significant correlations.

Finally, in the *Protection and Valorization* session, L. Bonati, from the University of Bologna, presented "A risk plan for Byblos' archaeological site". The assessment of the risk of armed conflicts and terrorism for the archaeological site of Byblos - the modern Jbail, Lebanon - was evaluated in the frame of the European Project CIUDAD: Cooperation in Urban Development and Dialogue. This work is aimed to produce documentation because the World Heritage urban sites of Byblos and Mtskheta, Georgia, subject to significant risk, may apply to a status of enhanced protection.

The conference, with its large variety of contributions and interventions, helped making the point of extensive research in archaeometry and also placed emphasis on new techniques, new topics and new problems that will be the subject of study and commitment of researchers in forthcoming years.

A selection of contributions will be peer-reviewed and published online at *Heritage Science Journal*.

In 2015 the AIAr workshop will be held in Palermo at the end of February, focusing the subject *Biology and Archaeobiology: from knowledge to preventive conservation*.

#### Ferruccio Petrucci

Physicist petrucci@fe.infn.it

# **MUSEUMPESTS 2014**

# Integrated Pest Management for Museums, Libraries, Archives and Historic Sites

Review by Pascal Querner

March 27-28, 2014 Williamsburg, USA **Organised by**MuseumPests.net

To celebrate the ten year anniversary of the IPM Working Group, an ad hoc group of museum and pest professionals who work together each year to create and share IPM resources, a two-day international conference was held earlier this year at Colonial Williamsburg, Virginia. The conference on *Integrated Pest Management (IPM)* in Museums, Libraries, Archives and Historic Sites inaugurated the newly revamped MuseumPests.net, one of the most important IPM resources on the web. MuseumPests.net covers the main issues faced when developing, implementing and managing an IPM, including prevention, monitoring, pest identification, solutions to solve infestations and additional resources like literature on IPM.

The active persons behind the website worked together with the Colonial Williamsburg Foundation Preservation Department to organise the conference, which took place south of Washington from 27<sup>th</sup> - 28<sup>th</sup> of March. Some 80 participants met to discuss new challenges in museum IPM from 19 states in the US and Canada as well as Israel, Germany and Austria. In addition to lively talks and poster presentations, the event included an intensive workshop program, visits to the Williamsburg open-air museum and a reception

held at the local museum. See the MuseumPests website at <a href="http://museumpests.net/museum">http://museumpests.net/museum</a>
<a href="pests-2014-conference/">pests-2014-conference/</a> for full information on the conference program.

Some visitors were invited to stay an extra day to participate in the US (East Coast) IPM Working Group meeting with reports on IPM in Europe and updates on the recently updated <u>MuseumPests.net</u> site.

Keynote talks were given by David Pinniger on *Past, Present and Future: The Origins and Spread of Museum Insect Pests* and Tom Strang *Pest Population Dynamics and Estimating Collection Risk.* David Pinniger is the leading IPM specialist in the UK and an independent consultant entomologist with over 30 year of experience on IPM in museums. His presentation described the development of IPM over time and the information we have today including, for example, the spread of pest species. Tom Strang is a senior conservation scientist at the Canadian Conservation Institute; he showed us exactly what can happen if objects are not protected from pests!

Other presentations, papers and posters centred around four main themes relevant to the



Termite bait for monitoring installed in the Collonial Williamsburg historic site.



Tom Strang during his presentation "Pest Population Dynamics and Estimating Collection Risk".



Conference participants.

implementation of IPM in cultural heritage institutions of all types:

- 1. Institutional Implementation of IPM
- 2. Monitoring & Control
- 3. Treatment & Remediation
- 4. IPM Policy, Health & Safety

Like always at IPM conferences, the UK was well represented with talks on Cost effective IPM initiatives in an existing gallery presented by Jane Hymas from the Natural History Museum and IPM Successes and Trials by Suzanne Ryder from the same museum in London. Posters were also presented on the IPM at the Bodleian Libraries of the Oxford University and the Oxford University Museum of Natural History. Contributions from US participants included ongoing work at the Andy Warhol Museum The Accidental IPM Program: A Case Study of Contemporary Art and Archives at The Andy Warhol Museum by Amber E. Morgan and John Samuel Jacobs. Ryan Jones, one of the few people in the world to hold a fulltime IPM position in the museum field (and with a commercial pest company background) presented on Subterranean Termite Prevention in Colonial Williamsburg. Even though the climate at this site is comparable to many central European cities, colleagues from Williamsburg have a tough job preventing damage by termites in the hundreds of wooden buildings that are located there.

Some of the most interesting contributions for me were on *IPM Policy, Health, and Safety,* moderated by Barbara Appelbaum, a conservator from New York. Investigation into contaminated collections appears to have progressed further in US museums than in European collections, especially concerning the safety of museum staff and policies on how to deal with problematic objects. During this session, there were several presentations by members of the American

Institute for Conservation's Health & Safety committee. Also, the director of the Smithsonian Museum Conservation Institute, Robert J. Koestler, presented an overview of the activity in this museum (which hosts one of the largest collections in the world) over the last 30 years!

The afternoon sessions allowed participants to choose between very diverse and interesting hands-on workshops and on-site tours including:

- Control Options for Termites, Wood Borers and Rodents
- Identification of Insect Pests by Pat Kelley (Vice President of Insects Limited)
- Risk Zone Mapping for IPM by Suzanne Ryder
- Introduction to Integrated Pest Management Principles and Practice
- Computerized Record Keeping for Pest Trapping Data
- Treatment and Remediation of Infestations and more...

The conference was organised by Patty Silence, conservator at the Colonial Williamsburg Foundation, Ryan Jones, Integrated Pest Management Specialist at the foundation and their helpers and colleagues. Many thanks to all of them for what was a great conference held in a unique location. Posters, presentations and most papers are already online at <a href="https://www.museumpests.net">www.museumpests.net</a>. The next big international conference will be in Paris in 2016.

#### **Pascal Querner**

Entomologist pascal.querner@boku.ac.at

# **Museum Lighting & LED Technology**

Review by Yngve Magnusson

April 18-20, 2014 Copenhagen , Denmark

#### Organised by

Department of Photonics Engineering, Danish Technical University

This review is for institutions and individuals that are planning, or are in the process, of changing parts or the entire museum lightning to LED. The main text present the event held in Copenhagen, mainly for Scandinavian Museums, but also highly relevant for institutions worldwide that are looking for good alternatives to the main actors on the market for museum lighting. The presentations and case studies stretched from the planning work of the architect, and insecurity from the trustees in the museums as well as the scientific covering of the subject. The references at the end of the review can also be used by institutions which not participated at the conference. The main purpose of the conference can be said to show how to approach LED with an open attitude and discover how to use the new possibilities which are offered with this young light source. If there are insecurity about which color temperature and color rendering to choose for your next project can it also be interesting reading.

It was around 30 years ago that LED became more common in art installations, a good reason for conservators to learn more about the use of this technology. For many years, LED has also been an important topic when it comes to saving energy. In the beginning the technique was expensive and the payback period was, in many cases, so long that it was not possible for institutions to change. Hence, the current strategy was to postpone the adoption for later. In 2009, when the

clear incandescent light bulb was phased out in the European Union, the discussion about LED in museums resurfaced. The producers of museum lightning also became more active at this time. An early discussion of this technology had caused an insecurity concerning the use of LED in museums because of a large part of harmful wavelengths. The development of LED continued and UV and IR radiation was removed from the light sources recommended for museums. Nevertheless, the concerns of harmful wavelengths are still persisting. During this time it became clear that it is possible to make LEDs that are suitable as light sources in museums, reaching the high standards of curators and conservators, without having to make big investments and have to change the complete lightning system. "Retrofit", or keeping the old light fittings and changing only the light source, became a term often used when discussing light.

With time, the price kept dropping, and we are now aware that there are "good" and "bad" LEDs. The new issue is, then, how do we recognize the "good" LEDs? This conference covered the subject of "light quality" with the discussion of "Solid State Light" (SSL), meaning the light source, color rendering index (CRI), correlated color temperature (CCT) and light output (Lumen/Watt). It was also shown how UV and IR radiation have been removed and that it is possible to reduce the most harmful wavelengths, and even to almost

eliminate them. The possible drawbacks by doing this were also discussed. The more obviously advantages with LED, the dimming properties and enormous life span, also by heavy use, are now common knowledge and was less discussed. The recommendation of CCT deviated between the presentation, and it was also one of the issues which the conference organizers gave to the audience. Do we need other recommendation for CCT in Scandinavia?

The payback period has also been significantly reduced. The conference showed examples from two up to six years of use before the investment is paid of. In some cases, under certain circumstances such as retrofitting, a payback period of six months can be reached!

All presentations can be downloaded from the conference website.

#### The Presentations

The latest of Scandinavian conferences that cover the topic of LEDs was held in Copenhagen during 18<sup>th</sup>-20<sup>th</sup> of April this year. The conference "Museum Lighting and LED Technology" was organised by the unbiased Department of Photonics

Engineering at the Danish Technical University (DTU) which has been evaluating the development of LED for several years, but also has taken active part in developing LED technology specifically for museums. During the conference, participants were offered practical demonstrations and theoretical background as well as a workshop to tie up the questions from the participants at the end of the event. Several professions connected to light in museums got the opportunity to share their experiences with LEDs.

The conference started with the presentation of the meeting's main topic, to share the knowledge obtained by DTU in their research with LED. Scientific views and experiences by other institutions were also presented. Different case studies from different countries and continents showed the possibilities LED offers, both in scientific and amusing ways.

In my opinion, the most important, with the highest impact and relevant contributions to the conference, were the two first presentations. Dr. Carsten Dam-Hansen, senior researcher at DTU Photonic presented the fundaments of light in an understandable way. The red line was the development of a LED for the treasury at the Royal Danish



Conference Participants. Photo by Anders Thorseth.

Castle. In this project, DTU and its partners developed a LED which gives a CRI > 93 by CCT 2200-2400 K. This LED gives a better visitor experience, and protects the objects from damaging radiation. Dr. Dam-Hansen finished his presentation to stress the importance of always test the light sources for: spectral power distribution; luminous flux; efficiency; CCT; CRI; luminous flux and color maintenance; intensity distribution; and illuminance and irradiance. This final recommendation is in my opinion the essence of how to proceed when converting to LED. I would also recommend following the work of Dr. Dam-Hansen on developing international test standards for LED light.

The next speaker was Mr. Jacob Munkgaard Andersen from CSO of DOLL, one of eight so-called Green labs that the Danish government supports for a rapid implementation of energy efficient technology. The Danish Green Labs work on testing and demonstration of energy savings in close cooperation between research institutes and private companies. Museums can also use these facilities for testing light which is, in my experience, unique in the world. In practice, a museum can send the lamps (retrofits) to DOLL's Quality Lab to test their usability and obtain the values of the criteria that Dr. Dam-Hansen listed previously. This service is supported by the Danish government with 40% of the actual costs. Mr. Munkgaard Andersen stated that museums in other countries can also use this service. Mr. Yngve Magnusson from KODE, in Bergen, Norway showed in his presentation that KODE has used the data delivered by DTU Photonik, which are identical with the services from DOLL, for the planning of two LED projects where savings between 50% and 80% were reached by retrofitting instead of changing the complete lighting system. In the future KODE will use the services of DOLL.

Dr. János Schanda, Professor Emeritus at the University of Pannonia, Hungary where he taught colorimetric and visual ergonomics, gave an excellent presentation of choosing LED spectrum for frescos giving the example of the Sistine Chapel. Dr. Schanda promoted a CCT of 3000-3500 K as "warm white", where Dr. Dam-Hansen used CCT 2200-2400 K as "warm white". The difference in CCT was announced with a question mark in the invitation to the conference: does Scandinavian museum needs another light than Museums in other parts of the world? Is a higher CCT required in the Mediterranean region? This question was also indirectly asked on the field trip that took place the evening before the conference. The participants were put on test by Giancarlo Castoldi, Director of Targetti Poulsen, Italy in an experiment where seven different light sources and technologies were evaluated by the participants. The result will later be presented on the homepage of the conference. Dr. Schanda contributed in many ways to the conference through illustrative answers of questions and contribution to the workshop. His long experience of the work of CIE could have added an extra dimension to this conference if only one extra day could have been added.

For the conservators in the audience, the contribution from Bent Eshøj, from the Danish School of Conservation, was not new but was still very informative. Mr Eshøj has worked with light in museums for two decades and is well oriented in the issues concerning the employees responsible for the museum objects safe keeping and the dilemma of "saving" vs. "showing". Bent Eshøj not only converted the information presented in the first presentation to the language of conservators, but also prepared the audience for the later presentations by putting LED in the context of conservation. What might contribute to confusion about the LED properties is the graphs of



Intervention of Dr. János Schanda, Professor Emeritus, University of Pannonia. Photo by Anders Thorseth.

"damaging ratio", "relative photon energy" and "relative sensitivity" used in several presentations, not only by Bent Eshøj, but also avoided by others. In my opinion should we wait to use it until we have some kind of standard to rely on? I will not use it again until then.

Four contributions to the conference were mainly case studies: Giulio Antonutto, Light designer from ARUP, London; Johan Carlsson, Creative Director, JAC Studios, Stockholm; Eric Hagan, Conservation Scientist from the Canadian Conservation Institute, Ottawa; and Yngve Magnusson, Head of Conservation, KODE, Bergen. The two first combined their case studies with a philosophical view of light and its use. Mr. Antonutto also contributed with plenty information about light and the issues of choosing light. As a light designer it may be his normal activity although

I'm afraid that for the audience there was, in my opinion, too much information and too fast in the time frame of 40 minutes. In the future, I would like to hear a day lecture of Mr. Antonutto. The presentation of Mr. Carlsson was focused on the exhibitions he has supervised in Denmark and Sweden. He did not go deeper into the technique of LED.

Both Dr. Hagan and Mr. Magnusson showed case studies tied to changing light in a museum. Dr. Hagan's case is located in Yellowknife, Canada, which is approximately equivalent in terms of daylight hours per year with mid-Sweden. This makes his presentation relevant for the participants, even if Yellowknife is far from Europe. The presentation from Dr. Hagan showed the practical considerations as well as the theory in the decision project. The information given can also very well be used in Scandinavian settings, and I consider the presentation very relevant for the audience, although it did not presented so much direct hands-on information as the contribution from Dr. Dam-Hansen. The presentation from Dr. Hagan can very well be used to argue for the benefits of retrofitting the museum instead of changing the whole light system. The same can be said for the last of the case studies presentations. Mr. Yngve Magnusson used the criteria of Garry Thomson, as published in 1986, to show that they are still valid in the process of planning light for exhibitions. These contributions went further to show the new possibilities that LED technology offers to protect the objects and to save energy. The term "visitor controlled lightning" was used to show the work of KODE to reduce the exposure (in lxhrs) for objects. The average exposure in the galleries with LED is today ca. 50% less than the limits recommended by ICOM. Also, the energy consumption is reduced to 95% with the use of dimmable LED connected to a system of sensors and controllers, which are

systems available today even for private households.

The two most eye-catching presentations were done by Mr Giancarlo Castoldi, director of Targetti Poulsen, Florence and Dr. Marc Fontoynont, Professor of Lightning Technology and Design in Aarhus. Mr. Castoldi's presentation was both funny and serious, the most interesting part being his work with designing light for the Exhibition "The Greek from Toledo". Mr. Castoldi has contributed with the light to this exhibition and the examples shown in the presentation were very convincing for the high pay-off connected to focus on the light for the art. The same as DTU and Dr. Dam-Hansen's team has done with increasing the visitor experience at the Danish Royal Treasure has been done with El Greco's paintings by Mr. Castoldi. While the first is a permanent exhibition, the later can only be seen until 14 of June, 2014. I recommend the readers of this review to go to the homepage of the conference and look through Mr. Castoldi's presentation since it contains many good examples of how to use light to give the most to the visitors, in terms of contrast use.

Mr. Fontoynont's presentation gave a very good insight in the planning process for museum lighting. One would wish that more museums applied this kind of professionalism. The presentation contained plenty information for institutions that are planning to change to LED, although the work presented is not for the institutions to do themselves. Professionals, like Mr. Fontoynont will always be required in seriously lighting projects. The final conclusion from Mr. Fontoynont also showed a degree of integrity in recommending light for museums. His conclusion to use "volume lighting behind diffusing glazing" is, in my opinion, the best way to light galleries and also the most economical one. The

use of "visitor controlled light" can improve the experience. In the presentation of designing a new LED for Mona Lisa in the Louvre I reacted on the specification to use a CCT of 3200 K. This is higher than the recommendation from Dr. Dam-Hansen (2200-2400 K.) and the average of what Dr Schanda recommended as warm white (3000-3500 K.). Copenhagen's latitude position, where Dr. Dam-Hansen works, is 55°41'N while Paris is located on 48°51'N and Rome is 41°54'N. The question from the conference organizers to the participants seems to be valid: do we need another CCT in Scandinavia than the rest of Europe? Of course the result would also be applicable to many other regions on the same latitude. If we planned an imaginary exhibition in the Norwegian city of Honningsvåg, one of the most northern cities on the European mainland positioned at latitude 70°59'N, would we, according to what the presentations showed us, go lower than 2200 K? This is, in my opinion a valid question for DTU to continue researching.

The last contribution was made by Nigel Sylvester from ERCO Lightning, London the only commercial one. This was the first presentation that showed the participants how a LED illumination is actually built. This was done in an understandable and non-technical way. His presentation also explained the energy savings context in the UK and the collaboration with well-known Galleries in several countries. This presentation was the only one indicating that a high CRI is not essential to museum lightning, citing a Swedish gallery where a CRI of 80+ was the wish from the gallery director. ERCO also goes another way than those recommended by Dr. Dam-Hansen and Dr Schanda. ERCO offers two different CCT for LED: 3000K / CRI 90+ and 4000K/ CRI 80. The later has a higher light output (125 lumen/W), almost 30% more than the first (90 lumen/W). This means that galleries with long distance between lamp fittings



Giancarlo Castoldi, director of Targetti Poulsen, during his presentation. Photo by Anders Thorseth.



During the field trip to Thorwaldsen Museum. Photo by Anders Thorseth.

and objects will always have to stay with the lower CRI. The future will show if ERCO can keep up this policy.

### The Day After the Conference - The Workshop

Almost half the participants chose to stay for the workshop which was held the consecutive day on the same location. The workshop was intended to clarify the demand for a guide or similar tool for the selection of LED for museums in the regional context of northern Europe. The goal was to identify challenges for lighting that are more pronounced or specific for Scandinavia. During the presentation there were some challenges that were presented: opening hours beyond the normal daylight period during a long time of the year, high cost of energy and special preferences for CCT among the population mentioned. The organizers also wanted to summarize the state-of-the-art within museum lighting quidance.

Yngve Magnusson opened up the day with a short introduction before Dr Hagan continued introducing the "Guidelines for selecting Solid State Lighting for Museums" a joint project between the Getty Conservation Institute (GCI) and the Canadian Conservation Institute (CCI). The quideline is already known by museum professionals since 2011 but Dr Hagan provided further and more detailed information that is valuable for museums such as how can the criteria of other organizations like "Energy Star", "Gateway" and "Lighting Facts" be useful for institutions that are planning lighting systems. After this presentation, the participants should know how to find out more about third-party testing and certification of LED products. The presentation is also available on the conference homepage.

Afterwards, Dr. János Schanda picked up the thread and gave two small presentations to clarify some issues and to show us more about color rendering in the internet.



Field trip at Tøjhus Museum. Photo by Anders Thorseth.

Before the participants got active in the workshop tasks, Mr Hanz Nyström spoke about the ongoing process of a European standard for museum lighting. He could only talk in general terms about this project due to the ongoing process. The standard will be published later in 2014.

The workshop was managed by Mr Jesper Wolff, from DTU Photonic. The first workshop task was to point out and to prioritize the most urging issues for museum professionals in the transition to LED lighting with regards to conservation, technical aspects, aesthetics and economics.

The work was performed in groups and presented verbally by each group. A short summary was that the participants wish to learn more about "bad" and "good" LED to be sure that they are not harmful for the objects. The technical understanding needs to be improved in order to know

that the right choices are taken. The aesthetics is an issue, but not one that needs much guiding. The economy is of concern, mostly in case of how to finance and calculate the transition to LED. The result from the workshop will later be presented on the conference homepage.

The second workshop task was to identify the best possible tool to facilitate the transition in museums in the areas mentioned in previous task. The groups seemed to agree on that it should be a web-based solution, but if it should be an interactive system, like social media or a passive tool to calculate costs, etc., was not clear. Both seem to have its supporter. The groups in favour of social media meant that it must be a closed forum so it can stay focused on the subject. It was proposed that the people from the conference should be able to stay in touch after the workshop and so a closed discussion group in LinkedIn was proposed. Another



Poul Kattler addressing the audience during the field trip to the Experimentarium City. Photo by Anders Thorseth.

proposed tool was a procurement tool for museum to avoid mistakes in the process of buying LED through a bidding process, something that is mandatory if the project is big enough.

The workshop finished with a discussion round, and the participants wished to stay in contact for further arrangement to continue to discuss lighting.

### The Evening Before the Conference: The Field Trip

The first part of the conference consisted of a field trip to institutions in Copenhagen that have been using LED in new and old presentations. The key employees spoke about their experiences and the challenges with the LED lighting and what concerns they have had in the change to LED.

At the first institution, The Tøjhus Museum, lighting designers Jørgen Kjer and Johan Carlsson

presented the new installed permanent exhibition. It was outspoken that the project's economy directed the fitting and light source choices. The main emphasize was not on a high CRI or an awareness of color temperature but an innovative use of retrofit and standard fittings.

William Gelius, curator at the Thorvaldsen Museum, showed us the ongoing process of changing to LED. Being a museum built for daylight, the Museum had the challenge to install a new lighting system without drilling new holes in the walls. The participants got an idea of how important it is to consider the positions of the light sources to avoid disturbing glare and strong contrasts. The museum is in the process to achieve great energy savings but must still work on the placement of the light sources. In 3-4 months the visitors of the Thorwaldsen Museum will get a better impression of how the light will work!

In the trip to the third stop, Poul Kattler from Experimentarium City, not a museum but a science center, presented the institution and explained his experience using a track mounted LED system from ERCO. Mr Kattler did not hide away that they are a private financed science center, not depending on public financing. One main reason for choosing a track system was the flexibility and adaptability in changing exhibitions. He also stressed the usability of the three phase system: one phase for common lightning, other for the direct spots, and the third for running the installations.

At the National Gallery of Denmark (SMK), Jørgen Wadum and Niels Borring did not show so much about LED but explained more in detail why they have waited so long to start using LED at the museum, a project that is still undergoing. The actual demonstration at SMK was conducted by DTU, showing their new test boxes and references for testing light sources. Giancarlo Castoldi, together with DTU, tested the participants by conducting a survey on how they responded on seven different light sources on similar art pieces. The result will later be presented on the conference homepage.

To finish, some interesting statistics:

- In total, there were 124 participants, from which 90 men and 34 women, from 11 countries;
- There were no female presentations;
- Denmark, Sweden and Norway were best represented.

If one had worked with light in museums 30 years ago, one had to be concerned about testing the UV and IR filters that was required to obtain a suitable museum light. CRI was known but not considered to be a big issue. It was possible to get light sources with CRI higher than 96 as they were already in use in industry. However, since the price for purchasing and maintaining the lights

were too high for the museums, they settled with CRI 80. Nevertheless, already in 1978, in the first issue of *Museums Environment*, Garry Thomson recommended to use CRI >90!

Back then, the UV filters that were tested almost never fulfilled what the manufacturer's fact sheet said: 99% absorption of UV showed to be 70% at the very best. We had to keep on testing until we found something that worked. And the next time someone would buy the same filter it had to be tested again. This was the work done by museums professionals around the world.

Today, the light sources (LED) are free from UV and IR radiation. The damaging wavelengths in the blue and green fields are also treated more seriously. Thirty years ago most museum professionals did not know how they could be controlled.

The recommendation of CCT 30 years ago spanned from 3500 K. to 6500 K., depending on literature, but also from which country it was being discussed. Back then, this was also connected to the photographer's work since different films where calibrated to different light sources. Much has changed in the last 30 years but some things remain the same.

The conference shows that we still need to test our light although nowadays we can get the light that we wish for without external filters. We can get a higher CRI if we think that we need it or if it improves the visitor experience. The conference in Copenhagen also showed that we should start thinking seriously about the CCT of our light source, and to adapt it to where we live.

### Yngve Magnusson

Conservator













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# FLUORESCENCE IN SITU HYBRIDIZATION: A POTENTIALLY USEFUL TECHNIQUE FOR DETECTION OF MICROORGANISMS ON MORTARS

Marina González, Ricardo Vieira, Patricia Nunes, Tânia Rosado, Sergio Martins, António Candeias, Antonio Pereira and Ana Teresa Caldeira

### Fluorescence *In Situ* Hybridization: a potentially useful technique for detection of microorganisms on mortars

Marina González, Ricardo Vieira, Patrícia Nunes, Tânia Rosado, Sérgio Martins, António Candeias, António Pereira and Ana Teresa Caldeira

### **ABSTRACT**

This paper discusses the possibilities of applying Fluorescence In Situ Hybridization (FISH) to detect microorganisms on mortars, as this analytical technique has been used in different fields for the detection and identification of individual microbial cells in situ. FISH technique was applied for microbial detection on test and real mortars inoculated with fungal suspensions of S. cerevisae 396 and Nectria sp. A universal eukaryotic probe (EUK516) labelled with fluorescent dye (Cy3) was tested with different cell fixation procedures (4% (w/v) paraformaldehyde or 50% (v/v) ethanol in PBS). Positive results were obtained with FISH detection of Nectria on testing/artificial as well as authentic/historical mortars, which confirms successful application of FISH technique to a new on mortars.

### 1. Introduction

Microbial activity plays an important role in the deterioration of built heritage. Although the influence of microorganisms on deterioration processes is undisputable, the role of individual microbial species that form the communities is not yet fully understood. The development of new microbial detection and identification techniques is crucial for furthering our knowledge of microbial influence on heritage deterioration and designing appropriate preservation strategies.

Detection and identification of microbial communities present on artwork can be achieved using various complementary methods, with new approaches being continuously developed. The traditional culture-based techniques are time-consuming and are limited by the microorganisms'

ability to grow under standard laboratory cultivation conditions [1, 2]. To overcome this drawback, culture-independent techniques based on molecular approaches, that are more sensitive and need smaller quantities of sample than those previously mentioned, have been applied. The use of molecular techniques based on expensive Polymerase Chain Reaction (PCR) present an important limitation, i.e. the impossibility of studying the microorganisms in situ [1, 2]. Nevertheless, a "non-PCR"-based technique is available that combines the precision of molecular techniques with providing information on the number and spatial distribution of microorganisms: Fluorescence In Situ Hybridization (FISH) [3]. As well as being inexpensive and informative, this analytical technique is also very powerful, rapid and straightforward [4]. Surprisingly, only a few studies in the field of cultural heritage

conservation and restoration have exploited the potentials of using FISH method [5-8], despite it being the most commonly applied non-PCR-based method in other fields [1, 2, 9]. FISH allows the detection of microorganisms by a fluorescently labelled oligonucleotide target probe that hybridizes specifically to its complementary target sequence within the cell [2]. The selection of rRNA probes enables phylogenetic specificity to be varied from universal to subspecies level [9].

This study applied FISH technique for direct detection of microorganisms on mortars, using a rRNA probe, as a complementary technique used for characterization of the microbiological community. FISH was applied to a series of test and real mortars, which were inoculated with cell suspensions of Saccharomyces cerevisiae 396 (yeast) and Nectria sp. (filamentous fungi), from a laboratory collection. *Nectria* sp. was selected because its involvement in deterioration of mortars of historical Alentejo buildings (Évora, Portugal) has been previously confirmed. On the other hand, S. cerevisiae, although not biodeteriogenic, has been selected, because its detection by FISH in suspension using EUK516 labelled with a fluorophore has been used successfully in the past [10].

This preliminary study was undertaken to evaluate the applicability of this technique, using specific probes, as a simple, rapid and efficient tool to identify biodeteriogenic agents in mortars.

### 2. Material and Methods

FISH technique was performed on a series of test and real mortars, which were inoculated with fungal suspensions. The FISH results were compared to data obtained from techniques that evaluate presence of microorganisms, their proliferation and metabolic activity.

### 2.1. Sample Preparation

### **2.1.1.** Mortars

Both test and real mortars were used to investigate the applicability of FISH technique for the detection of microorganisms. Real mortars were collected from damaged frescoes of the abandoned church of Santo Aleixo (Montemor-o-Novo, Évora, Portugal). Mortars microfragments (50 mg), were sampled with sterile scalpels and microtubes using micro-invasive methods and then sterilized.

### 2.1.2. Preparation of Microbial Suspension

Two fungal suspensions were prepared using *Saccharomyces cerevisiae* 396 (SC396) and *Nectria* sp. microorganisms belonging to laboratory collection (HERCULES-Biotech Laboratory, University of Évora). The strains were grown in Malt Extract Agar (MEA) slants at 28°C for 1 day (yeast) or 5 days (filamentous fungi). Cells were harvested from the agar surface and then suspended in NaCl 0.85% (w/v) aqueous solution.

### 2.1.3. Inoculation of Mortars

Mortars (1.5 g) were inoculated with 1.0 mL of each fungal suspension at room temperature for 24 h.

### 2.2. Detection and Evaluation of Microbial Contamination

### 2.2.1. Fluorescence In Situ Hybridization

Each sample (0.1 g of mortars) was washed once with 0.5 mL phosphate buffered saline solution (PBS; 130 mM NaCl, 8 mM NaH<sub>2</sub>PO<sub>4</sub>, 2.7 mM KCl, 1.5 mM KH<sub>2</sub>PO<sub>4</sub>, pH 7.2) and fixed for 4 h with 1 mL of fresh fixation buffer solution (4% w/v paraformaldehyde in PBS at 4°C or 1:1 (v/v) PBS/ethanol at 20°C). To avoid cellular aggregation the fixatives were added drop by drop. Following centrifuging for 5 min at 4500 g, the supernatant was discarded. Cells fixed with paraformaldehyde

were washed three times and those fixed with ethanol were washed once. For hybridization, 80 µl of hybridization buffer (0.9 M NaCl, 20 mM Tris-HCl, 0.1% SDS) and 1  $\mu$ l (120 ng/ $\mu$ l) of the probe EUK516 (5'-ACCAGACTTGCCCTCC-3') rRNA labelled with indocarbocianine (Cy3) were added. Then, samples were incubated at 46°C for 2 h and centrifuged for 5 min at 4500 g. The supernatant was discarded and the mortars were washed with 100 μl of pre-warmed hybridization buffer for 30 min at 46°C. The samples were then centrifuged 5 min at 4500 q and the supernatant discarded. The mortars were spotted onto microscope slides and observed with a Leica DM 2500M darkfield microscope. Image caption was carried out with a Leica DFC290HD camera.

### 2.2.2. Biological Activity Assay

The colorimetric 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay was used to estimate the cell viability in mortars as previously described by Rosado *et al* [11]. It is based on the ability of living cells to reduce metabolically the pale yellow MTT to a purple formazan salt. Mortar samples (0.1 g) were incubated with 0.5 mL of MTT solution (0.5 mg/mL in PBS) for 4 h at room temperature in the dark. After that, the mixture was centrifuged for 10 min at 8000 g and the supernatant discarded. The resulting purple formazan crystals were dissolved in 1 mL of DMSO/ethanol (1:1) and absorbance intensity at 570 nm was then measured with a spectrophotometer (Hitachi, U-3010).

### 2.2.3. DNA Extraction and Amplification

Metagenomic DNA was directly extracted from the mortar microfragment (0.1 g) collected with NucleoSpin740945 DNA Extraction kit (Macherey-Nagel, Düren, Germany). The extracted DNA was used as template for PCR amplification. A partial sequence of 18S rDNA gene was amplified using primer pair NS1 (5'-GTAGTCATATGCTTGTCTC-3') / PCR reactions were carried out in a Robocycler (MJ Mini Bio-Rad). The PCR mixture (25 µL) contained reaction buffer 10x supplied with MqCl<sub>2</sub> 25 mM, dNTPs 2 mM, primer sets 0.4 μM, Taq DNA polymerase 5 U and 1 µL of the extracted DNA. The PCR program consisted of an initial denaturising step for 1 min at 95°C, followed by 40 cycles with a denaturising step at 94°C for 1 min, an annealing step at 50°C for 1 min, an extension step at 72°C for 2 min and a final elongation cycle at 72°C for 6 min. The PCR products, the molecular-weight size marker Generuler 100 bp (Fermentas, Lithuania) and a control sample were run on a 1.2% agarose gel containing ethidium bromide 10 mg/ mL, at 90 V and at room temperature. The amplification products were visualized under UV light (Bio-Rad system).

### 2.2.4. Microbiological Proliferation Assessment

Microanalysis of the selected fragments of mortars was performed using a HITACHI 3700N scanning electron microscope (SEM) coupled with a Bruker AXS X-ray energy dispersive (EDX). The accelerating voltage was 18–20 kV. This technique allowed the observation of mortars' microstructure and morphology, as well as microbial contaminations and elemental composition (point analysis and 2D mapping).

### 3. Results and Discussion

Positive results were obtained from FISH experiments using an universal probe EUK516-Cy3 on test sterile mortars inoculated with *Nectria* and SC396 using both paraformaldehyde (4%) and ethanol (50%) as fixing agents. FISH results of a sample inoculated with *Nectria*, shown in Figure 1, reveal that it is possible to detect the microorganism

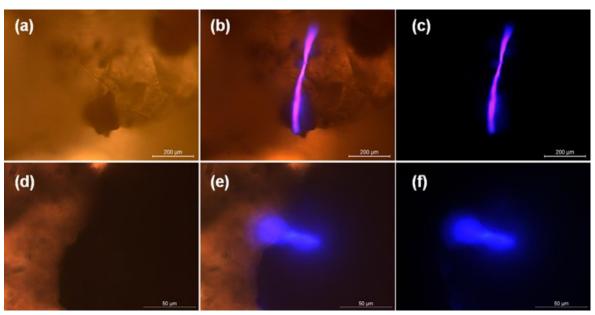


Figure 1. Microscopic images of test mortars inoculated with Nectria fixed with paraformal dehyde (a-c) and ethanol (d-f). The same area is shown in the bright-field (a, d), a combination of dark- and bright-field (b, e) and dark-field (c, f) observation.

on a mortar sample. Hybridization of SC396 was not observed. A control test was carried out by adding NaCl 0.85% (w/v) aqueous solution to a mortar sample instead of a microbial suspension. The results for the paraformaldehyde control reveal that paraformaldehyde residues remained detectable but did not interfere with microorganism detection. However, as no differences in fluorescence intensity were observed for paraformaldehyde and ethanol, the latter is initially preferred to avoid interferences of residue detection.

Once it was confirmed that FISH technique could be successfully applied for detection of microorganisms (at least filamentous fungi in the first instance) on test mortars, the FISH technique was then applied to samples of real mortars. Both fixing agents, 50% ethanol and 4% paraformal-dehyde, were tested in order to evaluate them, to develop a protocol for detection of microbial communities on real mortars. In situ hybridization signals were not obtained for SC396 in real mortars. However, positive results were obtained for *Nectria* 

with the universal probe EUK516-Cy3 (Figure 2) which confirmed good cell permeability conditions of Nectria with the fixing agents and revealed the possibility of applying FISH technique to real mortar samples. Complementary techniques were also used for the following purposes: i) to evaluate microbial contamination in mortars inoculated with SC396 and to confirm their presence in investigated samples; and ii) to compare the results obtained by FISH technique for Nectria. In order to fulfill these considerations, the following techniques were used: i) SEM analysis and MTT assay, useful for the evaluation of microflora proliferation and their biological activity [11]; and ii) molecular techniques, that allowed the recog-nition of the type of microorganisms present in the samples.

Evidence of biological contamination was observed in mortar microfragments analyzed by SEM. The image obtained by SEM allows the observation of fungal hyphae belonging to filamentous fungi penetrating the microstructure of the mortars inoculated with *Nectria* (Figure 3a). The images obtained from mortars, inoculated with SC396,

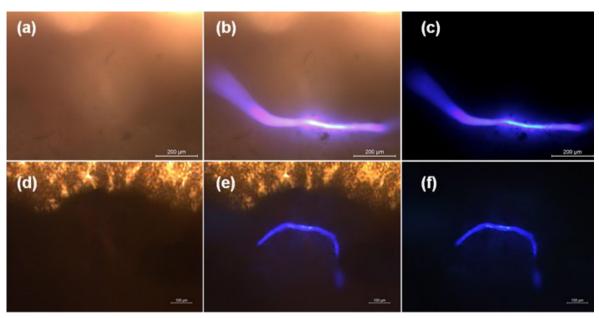


Figure 2. Visualization by FISH of Nectria in real mortars fixed with paraformal dehyde (a-c) and ethanol (d-f). The same area is shown in the bright-field (a, d), a combination of dark- and bright-field (b, e) and dark-field (c, f) observation.

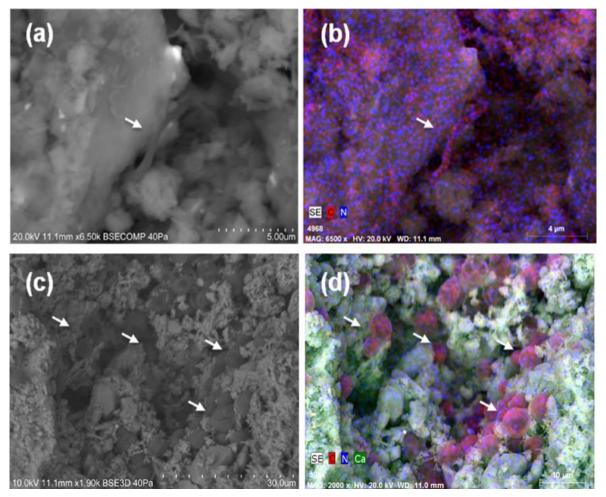


Figure 3. SEM micrograph and EDX elemental composition map of mortars inoculated with fungi.

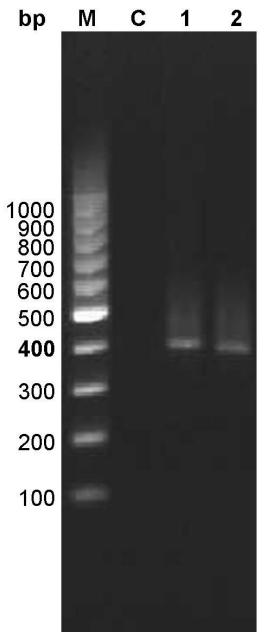


Figure 4. Gel electrophoresis of PCR products amplified from DNA extracted from mortars inoculated with SC396 and Nectria (1 and 2, respectively). Lane M corresponds to the 100 bp DNA molecular-weight size marker and lane C to the control.

reveal the presence of yeast cells (Figure 3c). Furthermore, EDX analyses (Figures 3b, 3d) of the structures of both samples confirm the presence of elements characteristics of organic material such as carbon and nitrogen, which points to the presence of microbial contamination. Thus, SEM-EDX results confirm the presence of fungi in the mortar samples.

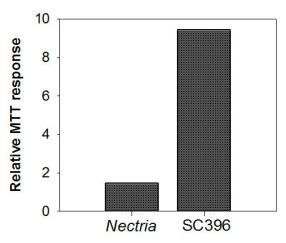


Figure 5. Relative MTT response for the mortars inoculated with SC396 and Nectria. The relative responses were calculated using the absorbance at 570 nm for 107 living cells of SC396 as a reference.

### 4. Molecular Evidence of Fungi

The presence of fungi cells in mortar samples was also investigated by molecular techniques. The metagenomic DNA was extracted and amplified by PCR. The amplified products were run on an agarose gel. DNA from the mortar samples showed positive amplifications of 18S rDNA fungal primers NS1/ Fung-GC (Figure 4). The size of the PCR products of approximately 400 bp suggested the presence of fungi on mortar samples.

Metabolic activity was also investigated on mortar samples inoculated with fungal suspensions using the MTT assay, as the appearance of purple formazan crystals, proportional to the living cells in the sample, can be a useful and fast marker. A more intense colour is associated with a higher cell viability in a sample. Thus, the more intense coloured solution obtained for SC396 sample, (associated to a higher relative MTT response), in comparison with that correspondent to the *Nectria* sample, points to a higher metabolic activity in the mortar inoculated with SC396 rather than in the *Nectria* sample as it is shown in Figure 5.

The results obtained by complementary techniques for the analysis of real mortars inoculated with *Nectria*, confirmed the presence of fungi contamination, which are in agreement with the results obtained by FISH technique. This positive correlation of results obtained by various analytical techniques shows that FISH technique could be applied to detect at least filamentous fungi. However, none FISH signals can be visualized for mortars inoculated with yeast, despite the fact that complementary approaches used (SEM-EDX, PCR-based and MTT,) showed the presence of yeast cells and their high metabolic activity.

The absence of FISH signals could be due to the problems that have been previously reported for FISH technique [3]: a low cellular ribosome content, the impermeability of cell walls or the accessibility of probe target sites. Further investigations should be carried out to improve the analytical method for SC396 detection in mortars.

Future work should involve testing various fixing agents, fixation times and the design of specific probes for specific biodeteriorating agents to improve their detection as well as identification in mortars.

### 5. Conclusions

This preliminary investigation demonstrates that a simple, rapid and cheap FISH analytical technique could be applied for the detection of at least filamentous fungi on mortars, with further need to test the analytical protocol for each probe. The results obtained by FISH were confirmed by SEM-EDX and PCR-based techniques, that revealed fungi contamination, together with the use of MTT assay, which revealed the presence of active metabolic cells in mortar samples.

### 6. Acknowledgments

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### MARINA GONZÁLEZ

Physical Chemist, Postdoc in Biochemistry marinagonpe@qmail.com

### RICARDO VIEIRA

Biochemist, Master student in Biochemistry ricardo.o.vieira89@qmail.com

### **PATRÍCIA NUNES**

Biochemist, Bachelor in Biochemistry patricia\_nunes77@hotmail.com

### TÂNIA ROSADO

Biochemist, PhD candidate in Biochemistry tania.s.rosado@gmail.com

### **SÉRGIO MARTINS**

Chemist, PhD candidate in Organic Chemistry smam@uevora.pt

### **ANTÓNIO CANDEIAS**

PhD in Chemistry, specialization in Surface Chemistry and Heritage Sciences candeias@uevora.pt

### ANTÓNIO PEREIRA

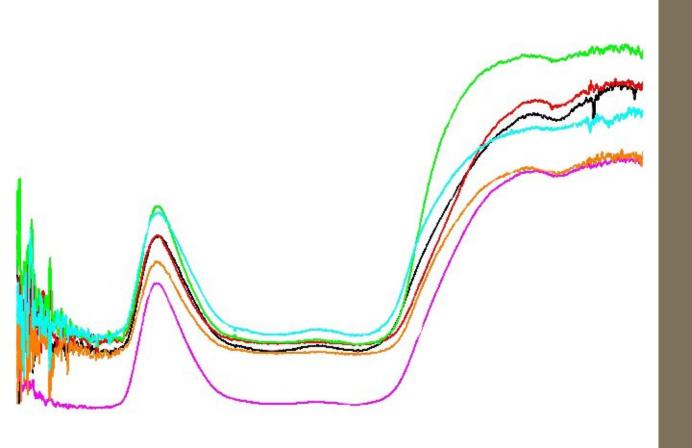
PhD in Chemistry, specialization in Organic Chemistry amlp@uevora.pt

### Ana Teresa Caldeira

PhD in Chemistry, specialization in Biochemistry/ Biotechnology atc@uevora.pt

## FORS SPECTRAL DATABASE OF HISTORICAL PIGMENTS IN DIFFERENT BINDERS

### Antonino Cosentino



### FORS spectral database of historical pigments in different binders

### **Antonino Cosentino**

### **ABSTRACT**

This paper presents the development of a Fiber Optics Reflectance Spectra (FORS) database of 54 historical pigments commonly used in art work. The database is available on-line and stores a large collection of spectroscopic data that can be freely downloaded. The database was built by collecting the reflectance spectra of the pigments both in pure powder and applied with gum Arabic, egg tempera, linseed oil and fresco, aiming to provide a knowledge base for the evaluation of the effect of different binders on the pigments' spectral features. The obtained results confirmed the effectiveness of the FORS system used for the non-invasive identification of pigments in different binders. Its small dimensions, low cost and other significant features such as instrument mobility and rapid data collection make it well adapted to the specific needs of professional art examination in the field. The paper highlights the great potential of this database for pigment identification purposes, and its usefulness to provide, for the first time, the additional possibility to freely download all spectroscopic data that would be of significant value as a reference for other FORS researchers in this field.

### 1. Introduction

The identification of pigments in polychrome artworks is of great interest to obtain a deep knowledge of the raw materials and the painting technique applied, as well as to provide useful information to art historians and conservators to select the proper conservation procedures and correctly define restoration plans. In many cases, however, sampling cultural artifacts is not permitted and, therefore, the application of non-invasive techniques is the only diagnostic tool. In the analysis of polychrome artworks, among the techniques available in portable version, Fiber Optics Reflectance Spectroscopy (FORS) has been established as a powerful one for the identification of pigments. A FORS spectrum shows for each wavelength, the ratio between the intensity of the reflected light and the incident light, measured

with respect to a standard white reference. This ratio is called reflectance and is given in percentage (%). The FORS spectra can provide information useful for the characterisation of pigments since the light that is not reflected is absorbed or transmitted depending on the chemical composition of the material tested. Pigments' identification procedures using reflectance spectroscopy involve a spectral database and can be achieved by comparing the spectral features (characteristic wavelengths) of the investigated unknown spectrum with the ones available in the database.

The peculiar advantage of this method with respect to the other spectroscopies most commonly used, such as XRF and Raman, is that the FORS equipment can be assembled with relatively low cost components: a light source; a spectrometer; a probe; and two fiber optics, one to illuminate the sample and

the other to collect the diffused light (Figure 1). If the FORS system is limited to the visible spectrum, including just a small portion of the near infrared and the near ultraviolet, between 360 nm and 1000 nm, then the cost of the equipment is considerably low. However, if a wider spectral range is desired, more sophisticated and, thus, expensive equipment is required, in order to achieve greater accuracy and sensitivity in the far infrared. Specific advantages of the assembled system presented in this paper are its low weight and small dimensions, which are very important features for art diagnostics professionals. Indeed, on site art examination is extremely valuable and so the equipment portability is of the highest importance such as, for example, examination of mural paintings on high scaffoldings. Portability is also extremely valuable for traveling professionals who must bring the equipment to the site.

Other advantages are the speed in data collection and the modularity of the system. The same spectrometer could be used to set up other type of experiments simply by providing it with the right probes and sources (such as transmittance and fluorescence spectroscopies and colorimetry).

FORS has been widely employed by scientists for art diagnostics for almost three decades. In 1987, a research article introducing the application of FORS technique to the analysis of artworks was published [1], and in 1997 the application of this method for the identification of pigments and the monitoring of color changes on the Brancacci Chapel Frescoes in Florence was reported [2]. Later on, the IFAC (Institute of Applied Physics NelloCarrara) online database of FORS spectra of pigments was published [3]. This was the first and is still currently the most complete database in existence; however, their spectra are not downloadable. IFAC's database provides FORS spectra in the 270-1700 nm range for pure pigments or

mixed with different binding media (egg tempera, mastic varnish and linseed oil). Some of the pigments were also applied as glazes over paint layers or metal leaf. In the recent literature a great number of research works have been reported demonstrating the use of FORS technique for the identification of pigments and natural dyes on a great variety of art works such as paintings and mural paintings [4-8], as well as on other polychrome artworks such as illuminated manuscripts [9]. Furthermore, the method proved effective to identify natural dyes in historical textiles [10] and was recently applied for the evaluation of plastics degradation in modern artworks [11].

This paper presents the development of an online database of downloadable FORS spectra of 54 historical pigments in powder and mixed with gum Arabic, egg tempera, linseed oil and fresco. The database covers the 360–1000 nm spectral range and it is accessible as CSV files downloadable from <a href="http://e-conservation.org/issue-2/36-FORS-spectral-database">http://e-conservation.org/issue-2/36-FORS-spectral-database</a>. An extract from the spectra database is presented and discussed in this paper, aiming to provide a knowledge base for the assessment of the effect of different binders on the pigments' spectral features, as well as to evaluate the capabilities of the miniaturized and low cost FORS system used.

### 2. Experimental

### 2.1. Instrumentation

For the collection of the reflectance spectra, a portable Ocean Optics USB4000 spectrometer with a 3648-element Toshiba linear CCD array, a diffraction grating with a working range of 360-1000 nm and resolution of 1,5-2,3 nm (FWHM) was used. The instrument is equipped with an HL-2000-FHSA halogen lamp, a reflection probe R400-7-UV/VIS and an integrating sphere ISP-R



Figure 1. Miniaturised FORS system (from left to right): halogen lamp, USB4000 spectrometer and integrating sphere.

(Figure 1). The R400-7-UV/VIS consists of a tight bundle of 7 optical fibers (400 µm in diameter) in a stainless steel ferrule - 6 illumination fibers around one read fiber. The diffuse light is collected at the same angle of the incident light, but the probe can be tilted by the operator to get readings at 0/0, 45/45, decreasing the reflected component, or any arbitrary angle. The integrating sphere averages the diffused and the reflected components, providing a spectrum which is characteristic of the material analyzed and does not depend on the specific measuring angle. Spectra have been acquired with the following parameters: integration time: 5 sec (integrating sphere); 5 msec (reflection probe); scans to average: 4; boxcar width: 5. The integrating sphere ISP-R has been used to acquire all the spectra stored in the database while the reflection probe has been used only on the set of pigments laid with gum Arabic. Spectra have been collected at 45/45.

### 2.2. Pigments

Fifty-four historical pigments have been tested, all commercially available from Kremer Pigments

(Germany). Information regarding their composition and manufacturing processes is available on the company website. Table I shows the name and product code of each pigment. These were analyzed as powder and when grinded using a glass muller with gum Arabic, egg tempera and linseed oil as binders. They were applied with a brush on watercolor paper made of cellulose and cotton, acids and lignin free, commercialized by "Fabriano", 270 gr/m<sup>2</sup>. These test plates are called "pigment checkers" and are visible in Figure 1. The reflectance spectrum of the paper was tested and it is flat without relevant features (Figure 2). The pigments were also applied with fresco technique, on a preparation of marble powder and lime plaster  $(Ca(OH)_2)$ in ratio 2:1. FORS spectra of all the binders and the watercolor paper are shown in Figure 2.

### 3. Results and Discussion

An extract of the developed database is presented below and the spectra acquired are discussed in groups of color. This database aims to complement

the IFAC one by providing the FORS spectra of some additional pigments: Egyptian blue, Maya blue, phthalo blue, cobalt violet, cadmium green, cobalt green, phthalo green, lithopone, cobalt yellow and gamboge. Furthermore, to the best of the author's knowledge, the FORS spectra of the following pigments are also here reported for the first time: cobalt violet, cadmium green, cobalt yellow and gamboge.

### 3.1. White Pigments

Among the whites, titanium white and zinc white are known for their strong UV absorbance [12] which is evident in the FORS spectra and remains unchanged regardless of the binder (Figure 3). Lithopone is a mixture of barium sulfate, a good flat reflector [13, 14], and zinc sulfide, which is responsible for absorption bands in the 650-800 nm region [15] (Figure 4). Lead white, as well as gypsum, has a flat spectrum [16] but it appears to be strongly modified by the absorbance in the blue and UV region when mixed with egg tempera and linseed oil (Figure 5).

### 3.2. Blue Pigments

The database presents the FORS spectra of 11 blue pigments. Azurite shows the characteristic and well documented reflectance maximum at about 450 nm [2] and its FORS spectra are not affected by the binders (Figure 6). On the other hand, egg tempera and linseed oil shift the position of the 480 nm peak for blue bice, the synthetic form of azurite (Figure 7), in higher wavelengths as a consequence of their absorbance bands.

Smalt is characterized by an absorbance band that is divided in three sub-bands [6] with minima at 540 nm, 590 nm and 640 nm (Figure 8). The above mentioned three minima are well defined only in the spectrum of powder smalt, while when any type of binder is added the minima at 590 nm and 640 nm cannot be distinguished.

Cobalt violet has an absorbance band divided into two sub-bands with minima centered near 490 nm and 580 nm which are well defined in any binder (Figure 9). Applied as fresco, the spectrum is strongly modified and this could be attributed to an actual reaction of the pigment with the lime. Indeed, only few pigments are inert enough to be actually useful for fresco.

Egyptian blue shows two absorption bands near 800 nm and 630 nm, and is also characterized by the presence of a peak at 950 nm which could be assigned to its infrared fluorescence [17], and is visible with every binder (Figure 10). Phthalo blue has a minimum at 920 nm [18] which is visible in all binders, except fresco (Figure 11).

FORS can easily differentiate between indigo and Maya blue pigments; the first one is characterized by the presence of a broad absorption band in the 420-730 nm range, while Maya blue shows a more narrow absorption band between 540 nm and 730 nm followed also by a stronger and sharper positive slope [19] (Figure 12).

### 3.3. Green Pigments

The reflectance spectra of eight green pigments were recorded. Green earth shows two broad reflectance maxima near 560 nm and 810 nm attributed to celadonite [7] and even if weak, they are evident with each binder used (Figure 13). The spectrum of malachite is recognizable by its large absorbance band between 600 nm and 900 nm [4] and is barely affected by the binder (Figure 14). Figure 15 demonstrates the FORS spectra of malachite mixed with an increasing amount (by weight) of lead white (0%, 20%, 40%, 60%) and the pigment is still identifiable. Cadmium green shows two characteristic minima at 620 nm, 710 nm and a stronger one at 920 nm, which can be observed in every binder (Figure 16). Cobalt green also exhibits a characteristic

Table I. Distribution b	v color c	of the 54 historical	piaments	(Kremer Piaments	) studied in this paper an	d respective piament code.

White	Yellow	Red	Green	Blue	Brown	Black
Lead white, 46000	Cadmium yellow, 21010	Alizarin, 23600	Cadmium green, 44510	Azurite, 10200	Burnt Sienna, 40430	Ivory black, 12000
Zinc white, 46300	Cobalt yellow, 43500	Cadmium red, 21120	Chrome green, 44200	Blue bice, 10184	Burnt umber, 40710	Vine black, 47000
Lithopone, 46100	Lead Tin yellow I, 10100	Red lead, 42500	Cobalt green, 44100	Cobalt blue,45730	Van Dyke , 41000	Bone black, 47100
Titanium white, 46200	Lead Tin y. II, 10120	Red ochre, 11574	Green earth, 11000	Egyptian blue, 10060	Raw Sienna, 17050	Lamp black, 47250
Gypsum, 58300	Massicot, 43010	Vermilion, 10610	Malachite, 10300	Indigo, 36005	Raw umber, 40610	
Chalk, 58000	Naples yellow, 10130	Madder lake, 372051	Phthalo green, 23000	Maya blue, 36007		
	Orpiment, 10700	Lac dye, 36020	Verdigris, 44450	Prussian blue, 45202		
	Saffron, 36300	Carmine lake, 42100	Viridian, 44250	Smalt, 10000		
	Yellow ochre, 40010	Realgar, 10800		Ultramarine, 10510		
	Yellow Lake, 36262			Phthalo blue, 23050		
	Gamboge, 37050			Cobalt violet, 45800		

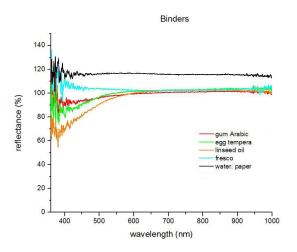


Figure 2. FORS spectra of the binders and the support watercolor paper.

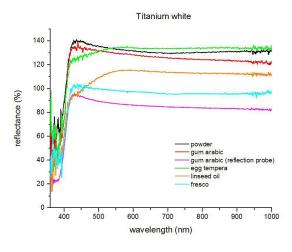


Figure 3. FORS spectra of titanium white.

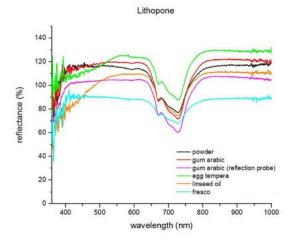


Figure 4. FORS spectra of lithopone.

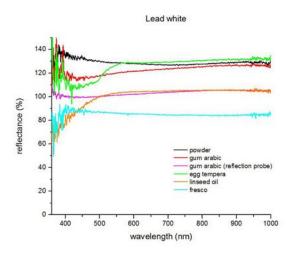


Figure 5. FORS spectra of lead white.

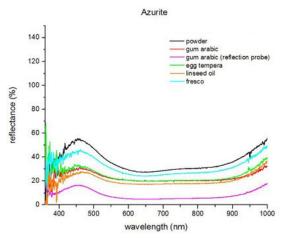


Figure 6. FORS spectra of azurite.

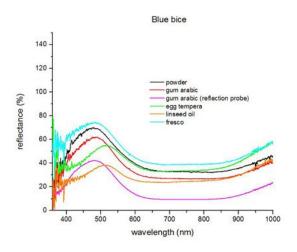


Figure 7. FORS spectra of blue bice.

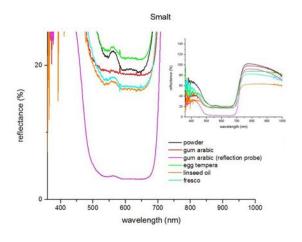


Figure 8. FORS spectra of smalt: full scale spectrum (right); zoomed in on the structured absorbance band (left).

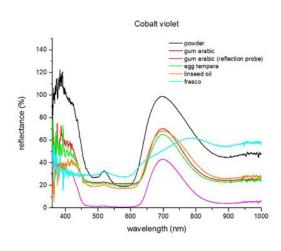


Figure 9. FORS spectra of cobalt violet.

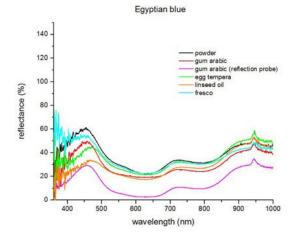


Figure 10. FORS spectra of Egyptian blue.

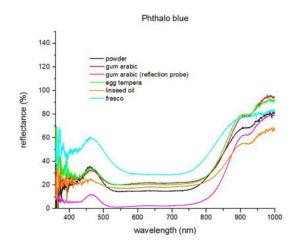
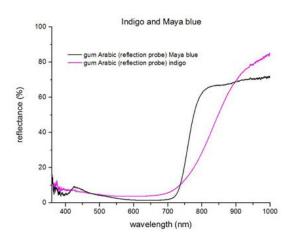


Figure 11. FORS spectra of p blue.



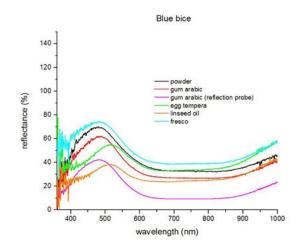
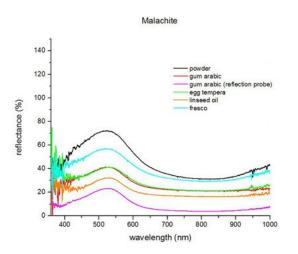


Figure 12. FORS spectra of indigo and Maya blue.

Figure 13. FORS spectra of green earth.



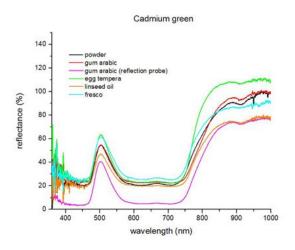


Figure 14. FORS spectra of malachite.

Figure 16. FORS spectra of cadmium green.

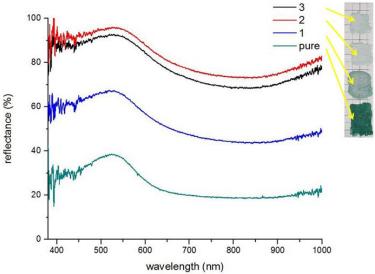


Figure 15. FORS spectra of malachite mixed with lead white in gum Arabic.

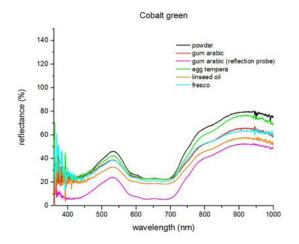
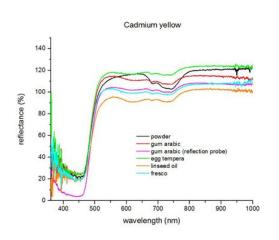


Figure 17. FORS spectra of cobalt green.

Figure 18. FORS spectra of phthalo green.



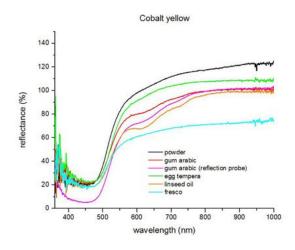
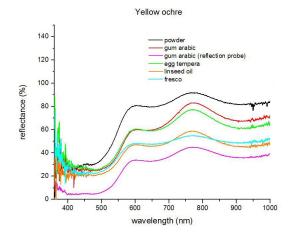


Figure 19. FORS spectra of cadmium yellow.

 ${\it Figure~20.~FORS~spectra~of~cobalt~yellow}.$ 



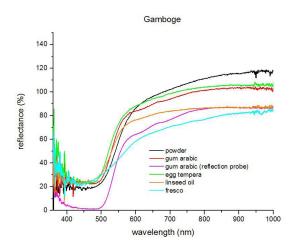


Figure 21. FORS spectra of yellow ochre.

Figure 22. FORS spectra of gamboge.

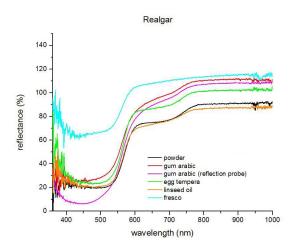


Figure 23. FORS spectra of realgar.

absorbance in the infrared at 820 nm [3], which even weak is still detectable in all binders (Figure 17). Phthalo green is reported to present a weak secondary peak at 700 nm [13] but this peak was not observed in our sample (Figure 18).

### 3.4. Yellow Pigments

Cadmium yellow contains zinc sulfide and therefore its reflectance curve presents similar spectral features between 650 nm and 800 nm with the respective ones observed in lithopone as expected (Figure 19).

Cobalt yellow is characterized by two absorbance bands at 620 nm and 700 nm (Figure 20), which are visible only with the gum Arabic and linseed oil binders. Iron-containing pigments such as yellow ochre are identified by their characteristic S-shape and the presence of two broad absorption bands near 660 nm and 930 nm which could be attributed to goethite [7] and are detectable in every binder (Figure 21). Gamboge shows two very weak absorbance bands at 620 nm and 670 nm, which are visible only with the gum Arabic binder (Figure 22).

### 3.5. Red Pigments

Realgar has a characteristic inflection point at 740 nm [3], visible in all binders but fresco, due to a reaction with lime (Figure 23). FORS is very sensitive to the presence of lakes and dyes [20, 21] and it is very useful for the identification of glazes. Figure 24 shows the FORS spectra of 4 red lakes

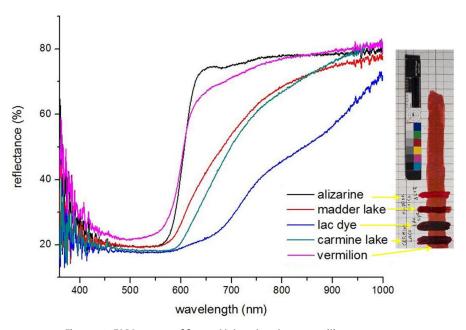


Figure 24. FORS spectra of four red lakes glazed over vermilion.

glazed over vermilion. As expected, their FORS spectra are not modified by the vermilion painted underneath.

### 3.6 Black and Brown Pigments

The four black pigments could not be differentiated. Among the browns only raw Sienna and burnt Sienna are identified by their characteristic S -shape [7].

### 3.7. System Performance

The signal obtained using the integrating sphere exhibited a fair amount of noise in the UV and blue regions, as well in the near-IR end of the spectral range. The reflection probe provided much better spectra across the entire investigated range, and due to its lighter weight and better handling, it seems to be the better solution for on-site examination. Both probes allowed the detection of the strong UV absorbance band of titanium white and zinc white, while the weak absorbance bands present in cobalt blue at 480 nm and 495 nm were identified only with the reflection probe. The performance in the visible range was good with both probes; the characteristic S-shape of ironcontaining pigments such as red and yellow ochre and sienna was detected with high accuracy. In some cases, the weak sub-bands present in the spectra of the pigments in powder were still recognizable in the spectra of the pigments laid with the binders, as shown for cobalt violet. In other cases, the very weak sub-bands could be lost in the spectra of the pigments after being laid with a binder, as shown for smalt. This example highlights the limits of this low-cost FORS system compared to the more sophisticated one used for the construction of the IFAC database which allowed the detection of the sub-bands of smalt even in the cases where it has been mixed with binders or other pigments.

In the near-infrared region up to 1000 nm, the reflection probe performance was still good. For example, the absorption bands of zinc sulfide present in lithopone and cadmium yellow from 650-800 nm, and the cadmium green minima at 620 nm and 710 nm, were well defined in every binder. The absorbance band of phthalo blue at 920 nm and the weak absorbance of cobalt green at 820 nm were visible in all binders, as well.

### 4. Conclusions

This new and available on line FORS spectral database of 54 historical pigments in powder and mixed with different binders is a very useful and helpful addition to the already created databases of reflectance spectra existing on line. FORS researchers working in the field of Cultural Heritage Science can significantly benefit from the added possibility to freely download all spectroscopic data that is provided for the first time, and use it as a powerful tool for pigments identification purposes as well as to evaluate how different binders influence the spectral features of the pigments.

The database shows that this system can produce spectra comparable with those of the referenced literature and it is an effective FORS system for the non-invasive identification of pigments in different binders in the 360-1000 nm spectral range.

Other additional value is that the spectra were acquired with a miniaturized and low cost FORS system designed for portable field use. Its small dimensions and speed in data collection make this system valuable for professionals involved in art examination in the field.

### **Acknowledgments**

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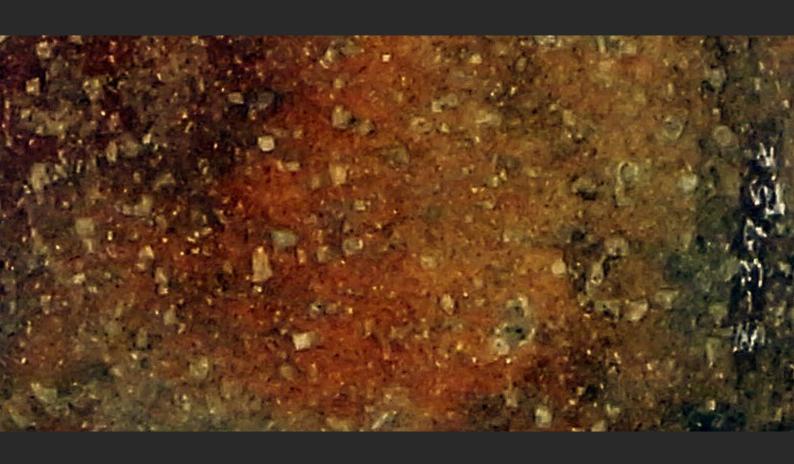
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### ANTONINO COSENTINO

Cultural Heritage Scientist antoninocosentino@gmail.com

Antonino Cosentino is a PhD Physicist specialized in Cultural Heritage Science and he works on his private practice service providing art examination, training and consulting for private professionals, institutions and private collectors. He promotes and disseminate innovative and low-cost solutions for technical and scientific examination of Art on his blog "Cultural Heritage Science Open Source" chsopensoource.org.

# A MULTI-ANALYTICAL APPROACH FOR THE STUDY OF NEOLITHIC POTTERY FROM THE GREAT DOLMEN OF ZAMBUJEIRO (ÉVORA, PORTUGAL) – A PRELIMINARY STUDY



Ana Manhita, Sérgio Martins, Joana Costa, Cátia Prazeres, Leonor Rocha, Cristina Dias, José Mirão, Dora Teixeira

### A Multi-analytical Approach for the Study of Neolithic Pottery from the Great Dolmen of Zambujeiro (Évora, Portugal) – a Preliminary Study

Ana Manhita, Sérgio Martins, Joana Costa, Cátia Prazeres, Leonor Rocha, Cristina Dias, José Mirão, Dora Teixeira

### **ABSTRACT**

The chemical and mineralogical composition of the Zambujeiro Dolmen ceramics was analysed using stereomicroscopy (SM), X-ray diffraction (XRD), in-situ X-ray fluorescence spectroscopy (XRF) and scanning electron microscopy with X-Ray energy dispersive spectroscopy detection (SEM-EDS). Analyses have shown that quartz is the most abundant mineral in the ceramics, with feldspars, especially alkali feldspars (Na, K), being also present in the majority of the samples. Titanium-iron oxide minerals, like ilmenite, were also detected in some samples. The nature of the clay minerals varies among the samples, but it was possible to identify illite/smectite which can help approximate the firing temperature of the ceramics. Overall, the ceramics' composition is consistent with the geology of the area, confirming the local provenance of the materials used for its production. Analysis of the organic content was done using gas chromatography coupled with mass spectrometry (GC-MS). The ceramic's organic content is likely from vegetable origin, which can be inferred from the presence of a high content of unsaturated fatty acids, various steroids of vegetable origin (campesterol, stigmasterol and beta-sitosterol), absence of cholesterol (steroid of animal origin) and a ratio of fatty acids C16:C18 > 1. Biomarkers for the presence of resins from the genus Pinus, the diterpenoid derivatives such as dihydroabietic and isopimaric acids, were identified in some samples. The reason for the use of resinous materials can be attributed to their sealing or qluing properties, but they could also bring a characteristic flavour to the materials stored in the ceramic vessels.

### 1. Introduction

The Great Dolmen of Zambujeiro (GDZ), built between the 4<sup>th</sup> and mid-3<sup>rd</sup> millennium BC, between the late Neolithic and Chalcolithic periods, is located on the right bank of Peramanca riverside, in Valverde, municipality of Évora (Portugal), and is one of the largest megalithic monuments on the Iberian Peninsula. The Zambujeiro Dolmen was identified and excavated between 1964 and 1968 and is classified as a National Monument since 1974. During the 1980s, due to the monument degradation, some conservation works and

archaeological research were carried out [1]. The Zambujeiro Dolmen still preserves the grave (burial chamber and hall), much of the tomb hill, and on its periphery two large stelae-menhirs can be found. Collective inhumation was practiced there, accompanied by the deposit of articles of great quality, indicating that they were most likely a group of distinguished individuals. The collection of materials found in GDZ is large and includes several lithics such as arrows, axes and schist plates, as well as a large collection of pottery. Despite the lack of important information that should have been collected during the initial



Figure 1. The Great Dolmen of Zambujeiro. Photo by Ken & Nyetta.

excavations in this archaeological site, the architectural monumentality of GDZ and the extent and variety of its spoil are sufficient reasons to try new types of studies that can bring more information about the life of people who were buried in this location (Figure 1).

The study of ceramics in archaeology is mostly concerned with the vessels' provenance, manufacture and usage. The recent development of very sensitive and non-destructive analytical techniques can provide information at the microscopic level that can elucidate and complement the archaeological inventory of the spoil. Through the use of different physical and chemical techniques, it is possible to identify the mineralogical and chemical composition of the ceramics, and thus to obtain information on its provenance (eg., to distinguish the local ceramic from imported) and the production technology used (eg., identify kiln temperature) [2-4].

The chemical and mineralogical composition of the paste is partially inherited from the clay raw material. Clay is a secondary earth material and the clay deposit geochemistry depends on its parent rock, and the degree of physical and chemical weathering [5]. Thus, its composition reproduces the composition of the initial rock, modulated by climate that controls the weathering processes. The chemical and mineralogical data, therefore, can be used as fingerprints for provenance studies [6].

The precise identification of the mineralogical composition of the ceramic requires X-Ray Diffraction (XRD) and thermoanalytical experiments [7]. Chemical composition can be obtained by Scanning Electron Microscopy coupled with Energy Dispersion X-ray Spectrometry (SEM-EDS), X-ray fluorescence (XRF) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS). The interpretation of data must be careful because mineralogical

and elemental composition of clay from a singular source and the pottery made from it can differ considerably. For instance, because the stability field of the minerals is dependent of the firing temperature, the pottery mineralogical composition might not correspond directly to the clay mineralogy since clay is a low temperature mineral.

Temper is added to a clay material in order to change its properties and improve its workability. Raw materials like sands, shell, micas, crushed rocks or grog can be used as temper. The mineralogical composition of temper can be assessed by stereomicroscopy and polarizing microscopy with data acquisition. The size of each temper unit is adequate to microscope analysis [8].

SEM-EDS analysis allows a further insight on the paste texture and the textural interrelationships of the mineral phases present that are too small to observe by optical microscopy. EDS spectra can provide elemental analysis of the paste and temper components, complemented with in-situ XRF. Although the major element composition stays constant during the firing, the possibility of chemical element inward or outward diffusion during the firing or the buried, inducing also mineralogical and textural transformations, must be considered. The analysis of the inner part of ceramics by XRF can provide information about this aspect.

With XRD it is possible to distinguish the minerals within the clay group [9]. Also, since it is known that the original clay components alter its original structure when subjected to certain intensity and heating rate [10, 11], it is possible to infer the approximate temperature ranges [12].

The preservation of organic molecules inside the porous structure of the ceramic, which can serve as biomarkers, allows the identification of certain

food products or others that can provide information on the type of the ceramics' use.

The study of vessel usage using the recovered organic compounds from the porous ceramic is based on the archaeological biomarker concept which relies upon matching the chemical structures of the organic materials and their distribution on the archaeological samples, the 'chemical fingerprinting', with the presence of chemicals in organisms known to have been exploited in the past. The archaeological biomarker concept can be applied to any class of biomolecules, such as ancient DNA, proteins, carbohydrates, and fats, even if, in most cases, these are only present in a degraded form [14]. In fact, the application of the archaeological biomarker concept requires not only knowledge of the biochemical compositions of the organic commodities exploited by humans in the past but also information on how these materials can be altered by processing and/or burial. Many of the mechanisms and pathways of molecular structural change resulting from degradation and decay are predictable and, thus, can enhance the interpretative framework [13].

Fats are one of the most stable biomarkers, and both animal and plant fats are composed mainly by triglycerides in which three fatty acids are attached to a glycerol by ester bonds. Triglycerides (TGA) from plant and fish origin are richer in unsaturated fatty acids, while saturated fatty acids are predominant in TGAs from animal origin. During burial, the ester bonds in the triglycerides can be broken by hydrolysis with the release of the fatty acids. TAGs can degrade forming diacylglycerols (DAGs), when only one fatty acid hydrolyses, or monoacylglycerols (MAGs), when two fatty acids hydrolyse. Only the most well preserved archaeological fats still contain TAGs, while MAGs are most often detected.

Once released from the triglyceride, the shortchain fatty acids are more water-soluble and volatile than the long-chain fatty acids. The released unsaturated fatty acids are also more susceptible for degradation (the double C-C bond is more reactive) when compared to the saturated fatty acids. Usually, archaeological degraded fats have a larger amount of long chain saturated fatty acids like the palmitic and stearic acids, when compared to all other fatty acids. The presence of unsaturated fatty acids can be related to fish or plant origin, being the presence of long chain alcohols and alkanes a further confirmation for the plant origin of the fat residues. Sometimes the unsaturated fatty acids are no longer present, but their degradation products can provide further insight into the nature and the ways fats were processed.

Steroids can further assist in the identification of the fat origin since the presence of cholesterol in the organic residue extracted from ceramics indicate possible animal origin, while plant origin can be attributed when plant sterols, like campesterol or stigmasterol, are identified.

The application of the archaeological biomarker concept requires that the total extract recovered from the ceramic be separated into individual compounds, and that these compounds be identified. This requires that the analytical techniques employed be able to provide molecular-level resolution, achievable by the combination of chromatographic techniques (gas or liquid chromatography, GC or LC) with mass spectrometry detection (GC-MS or LC-MS).

In 1997, Evershed *et al*. [14] showed that the stable carbon isotopic composition of the main fatty acids preserved in the pottery appeared unaffected by diagenetic alteration during burial. Thus, by using on-line gas chromatography—

combustion—isotope ratio mass spectrometry (GC–C–IRMS) and by comparison with modern reference fats, researchers can now distinguish different animal fats (dairy and several ruminant and non-ruminant species) by plotting the  $\delta^{13}$ C value for palmitic acid against that for stearic acid [15,16]. Using the available analytical methodologies, researchers have identified several commodities used during the Neolithic period in different parts of the world, including milk [17–23], animal fat [24, 25], fish [26], and resins [27, 28].

### 2. Methods

Seven ceramic samples recovered from GDZ were selected from the Évora Museum's collection, and the study was divided in two parts: chemical and mineralogical composition of the ceramic paste, which can be used as a fingerprint for provenance and production studies; and organic residue analysis, which can provide data on the containers usage.

### 2.1. Ceramics' Chemical and Mineralogical Composition

The chemical and mineralogical composition of the ceramics paste was obtained using different analytical techniques that provide complementary information about the samples.

The samples were observed in a binocular microscope Leica M205C using magnifications between x65 and x110. The stereomicroscope (SM) was equipped with a Leica DFC 205 camera allowing image acquisition of resin mounted samples for the subsequent analysis by SEM-EDS.

Using SEM-EDS analysis, a high resolution image can be obtained and it can provide rapid qualitative or quantitative analysis of elemental composition with a sampling depth of 1-2 microns.

Characteristic X-rays may also be used to form maps or line profiles, showing the elemental distribution in a sample surface. An Hitachi S3700N SEM coupled to a Bruker Xflash 5010 SDD energy dispersive spectrophotometer was used in variable pressure mode, using a voltage of 20 KeV for spectra acquisition and image acquisition in backscattered electron mode.

In-situ XRF provides information about the elemental composition of the samples. The information obtained can be used complementary with SEM-EDS data. A portable XRF spectrophotometer Bruker Tracer III-IV SD was used for in-situ analysis. Spectra were recorded using a voltage of 40.0 kV and current intensity of  $30.0 \mu A$ .

XRD can be used to determine the mineral composition of the ceramic paste. XRD patterns were recorded with a Bruker D8 Discover, using Cu K radiation, operating at a 20 angular range of 3-75°, step size of 0.05° and a step time of 1 sec.

### 2.2. Organic Residue Analysis

The organic residues analysis was performed by gas chromatography coupled to mass spectrometry (GC-MS). GC-MS is a separation technique that allows the identification of the organic compounds present in the ceramic samples. The sample preparation included the previous cleaning of the ceramic to eliminate handling contamination, sample collection, extraction with a chloroform/methanol mixture, derivatization with N,O-Bis(trimethylsilyl) trifluoroacetamide + 1% trimethylchlorosilane (BSTFA) [28] and further injection in the GC-MS system.

A Shimadzu GC2010 gas chromatographer coupled to a GCMS-QP2010 Plus Mass Spectrometer was used with a Phenomenex Zebron ZB-5HT capillary column (15m length, 0.25mm I.D., 0.10  $\mu$ m film thickness) to perform the analysis.

### 3. Results and Discussion

Traditional methods of pottery analysis by archaeologists rely on typological or stylistic criteria/ features to provide information relating to the means and place of manufacture of individual vessels, their relative dates, and possible functions. Nowadays, advanced analytical techniques enable more detailed information on provenance and technology of fabrication and possible usages of the pottery materials.

The studies that have been published on the organic content of Neolithic ceramics have been done on materials excavated in settlement sites [17-28], while the Zambujeiro ceramics come from a funerary context.

Three methods were used to assess the composition of the ceramics: XRD for mineralogical composition, XRF for chemical composition, and SEM-EDS for chemical composition and spatial distribution of the elements, through elemental mapping. Optical microscopy was used to evaluate the size, form and orientation of clasts or minerals (Figure 2).

Figure 3 presents the X-Ray diffractograms for two of the studied samples. Quartz is the most common non-clay mineral found in ceramics, and it was found in all samples. Muscovite, a type of mica, was found in some samples. Amphibole, an inossilicate, was also found in some samples. Feldspars, especially alkali feldspars (Na, K) were also found in the majority of the samples.

The nature of the clay minerals varies from sample to sample and it was possible to identify

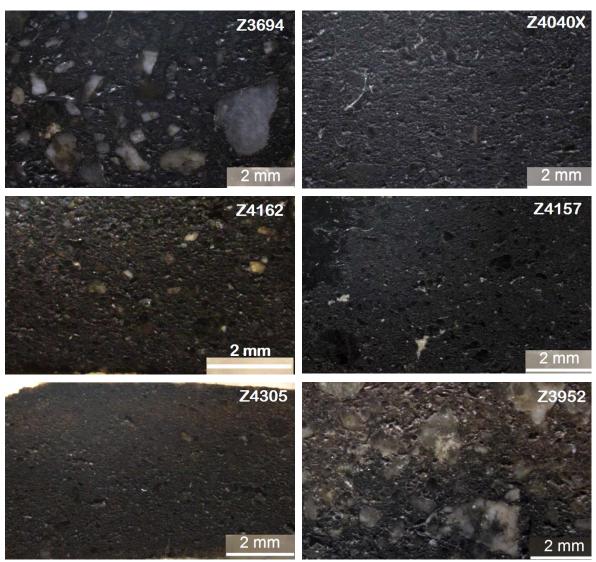


Figure 2. Optical microscopy images of the studied samples.

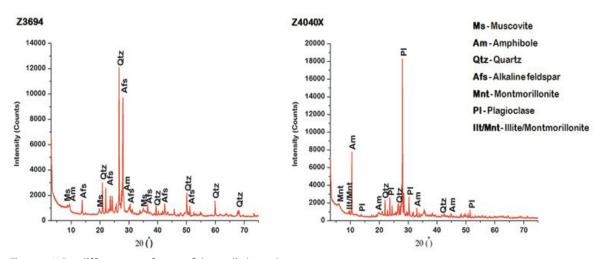


Figure 3. X-Ray diffractograms for two of the studied samples..

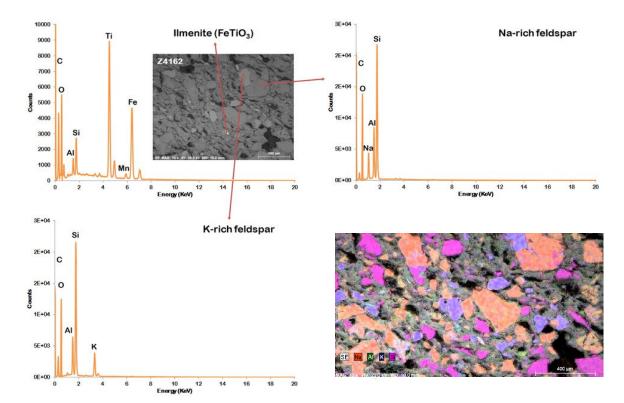


Figure 4. SEM-EDS results for sample Z4162.

illite/smectite. Clay minerals crystallize to other minerals, starting at 600 °C, so their presence in ceramics gives an estimate of the temperature used for firing.

The results for SEM-EDS (Figure 4) and XRF (Figure 5) complement the information given by XRD, confirming the presence of alkali feldspars and titanium-iron oxide minerals, like ilmenite. Figures 4 and 5 show examples of the SEM-EDS and XRF results for one of the samples (Z4162).

In Figure 6 two chromatograms are presented that are illustrative for the studied samples and in table I the corresponding peak identification are shown.

Overall, the samples exhibit good preservation as several unsaturated fatty acids (C18:1 and C18:2) and mono-acyl-glycerols (MAGs) were detected

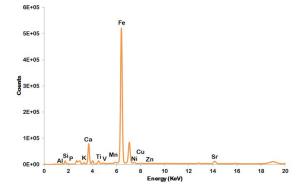


Figure 5. XRF results for sample Z41624.

in most samples. The presence of unsaturated fatty acids in the original content of the vessels was further confirmed by the detection of azelaic acid, a degradation product of unsaturated fatty acids. The presence of polyunsaturated fatty acids, and in particular C18:2, is surprising in samples from this period. In archaeological environments, polyunsaturated fatty acids easily undergo oxidation processes localized at the double bonds via radical reactions with the inclusion of oxygen in

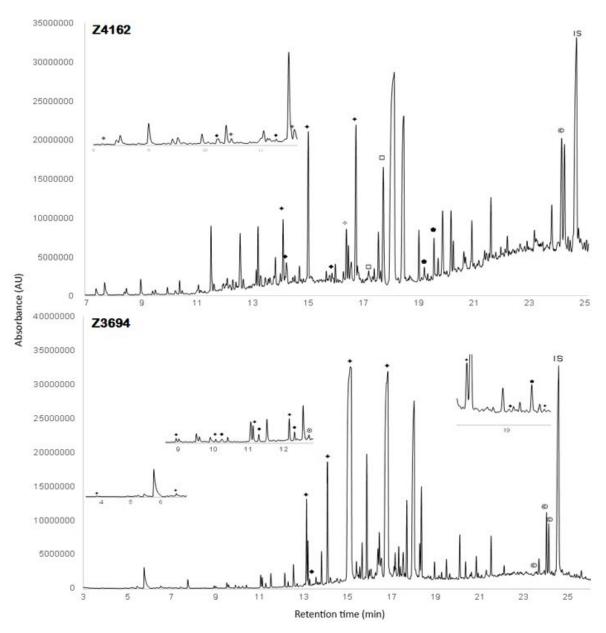


Figure 6. GC-MS chromatograms of samples Z4162 and Z3694. Peak identification is shown in table I.

the carbon chain, carbon–carbon bond cleavage, and formation of lower molecular weight species, such as azelaic acid (also detected in the samples) [13].

The chromatographic profiles suggest that the ceramics were previously used for materials of vegetable origin: high content of unsaturated fatty acids, presence of various steroids of vegetable

origin (campesterol, stigmasterol and beta-sitosterol), absence of cholesterol (steroid of animal origin) and a ratio of fatty acids C16:C18 > 1 [13]. Despite the evidence for a vegetable origin of the fats stored in the studied fragments it is not possible to establish its botanical origin.

Another information gathered from the chemical analysis of the lipid extract is the absence of

Table I. Peak identification of the compounds present in the GC-MS chromatograms of samples Z4162 and Z3694.

Peak #	Rt (min.)	Possible identification	MW	Peak #	Rt (min.)	Possible identification	MW
	3,856	Caproic acid, TMS ester (C6:0)	188		14,203	1-Hexadecanol, O-TMS (C16)	314
	6,514	Caprylic acid, TMS ester (C8:0)	216		15,040	Palmitic acid, TMS ester (C16:0)	328
	8,162	Tetradecane (C14)	198		15,609	Margaric acid, TMS ester (C17:0)	342
	8,933	Capric acid, TMS ester (C10:0)	244		15,957	1-Octadecanol, O-TMS (C18)	342
	10,057	Undecylic acid TMS ester (C11:0)	258		16,366	Linoleic acid, TMS ester (C18:2)	352
	10,222	1-Dodecanol, O-TMS (C12)	258		16,727	Stearic acid, TMS ester (C18:0)	356
	10,475	Hexadecane (C16)	226		17,222	Dehydroabietic acid, methyl ester	314
	11,117	Lauric acid, TMS ester (C12)	272		17,669	Dehydroabietic acid, TMS acid	372
	11,278	1-Tridecanol, O-TMS (C13)	272		18,261	Arachidic acid, TMS ester (C20:0)	384
	11,547	Heptadecane (C17)	240		19,071	1-Docosanol, O-TMS (C22)	398
	12,141	Tridecylic acid, TMS ester (C13:0)	286		19,258	2-Monopalmitin,TMS ether	474
	12,293	1-Tetradecanol, 0-TMS (C14)	286		19,473	1-Monopalmitin, TMS ether	474
	12,701	Azelaic acid, di-TMS (C9)	332		19,707	Behenic acid, TMS ester (C22:0)	412
	13,128	Myristic acid, TMS ester (C14:0)	300	©	23,476	Campesterol, TMS ether	472
	13,268	1-Pentadecanol, 0-TMS (C15)	300	©	24,014	β-sitoesterol, TMS ether	482
	14,066	Pentadecylic acid, TMS ester (C15:0)	314	©	24,116	Stigmasterol, TMS ether	484

long-chain ketones; these compounds are usually present when animal or vegetable fats are heated above 300 °C [13], suggesting that the pots were not used for frying, but used for boiling foodstuffs of vegetable origin cannot be excluded. However, food materials of plant origin (except the oils) have a small content of fats, leaving few residues in the ceramics when just boiled in water [13]. The large fat residue content of some of the analysed samples suggests that the ceramic vessels were likely used for storage of materials based on a vegetable fat.

One of the most interesting results of these analyses was the identification of diterpenoid derivatives such as dihidroabietic and isopimaric acids, in some samples. These compounds are known to be biomarkers for the presence of resins from *Pinaceae* family, and in particular from genus *Pinus*. So far, the use of pine resins in the Neolithic

period is rare, being more common the detection of resins derived from birch bark (genus *Betula*) [29]. The reason for the use of resinous materials can be attributed to their sealing or gluing properties. Resins can also impart a characteristic flavour to any material storage inside the vessels. The studied ceramics had no visual signs of the resin and it is not obvious why they were used in the first place. *Pinaceae* resins were widely used by the Romans to seal their amphorae, used to transport different food products throughout their empire [30].

#### 4. Conclusions

Mineralogical composition of the ceramics, determined by XRD, showed quartz as the most abundant mineral in most samples. Feldspars, especially alkali feldspars (Na, K) were also found in the

majority of the samples. The nature of the clay minerals varies from sample to sample and it was possible to identify illite/smectite. This gives an approximation to the firing temperature of the ceramics, since illite decomposes above 950/ 1000 °C, and smectite decomposes at lower temperatures However, this is not enough to determine the firing temperature of the ceramics, and further examination of the sherds using thermal analysis will be performed in a near future. SEM-EDS and XRF results corroborate the information given by XRD, confirming the presence of alkali feldspars and titanium-iron oxide minerals, like ilmenite. Results for the ceramics' composition are consistent with the geology of the area and confirm the local provenance of the materials used for the ceramics' production. The presence of a high content of unsaturated fatty acids, various steroids of vegetable origin (campesterol, stigmasterol and beta-sitosterol), absence of cholesterol (sterol of animal origin) and a ratio of fatty acids C16:C18 > 1, suggests that the fat content on the ceramics is likely from a vegetable source. Biomarkers for the presence of resins from the Pinus genus, dihydroabietic and isopimaric acids, were identified in some samples. Pinus resin could have been used for their sealing or adhesive properties, but they would also bring a characteristic flavour to the materials stored in the ceramic vessels.

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#### **ANA MANHITA**

Chemist anaccm@uevora.pt

#### **SÉRGIO MARTINS**

Chemist smam@uevora.pt

#### **JOANA COSTA**

Biochemist joana.c.costa89@gmail.com

#### CÁTIA PRAZERES

Geologist catiaprazeres@uevora.pt

#### **LEONOR ROCHA**

Archaeologist lrocha@uevora.pt

#### **CRISTINA DIAS**

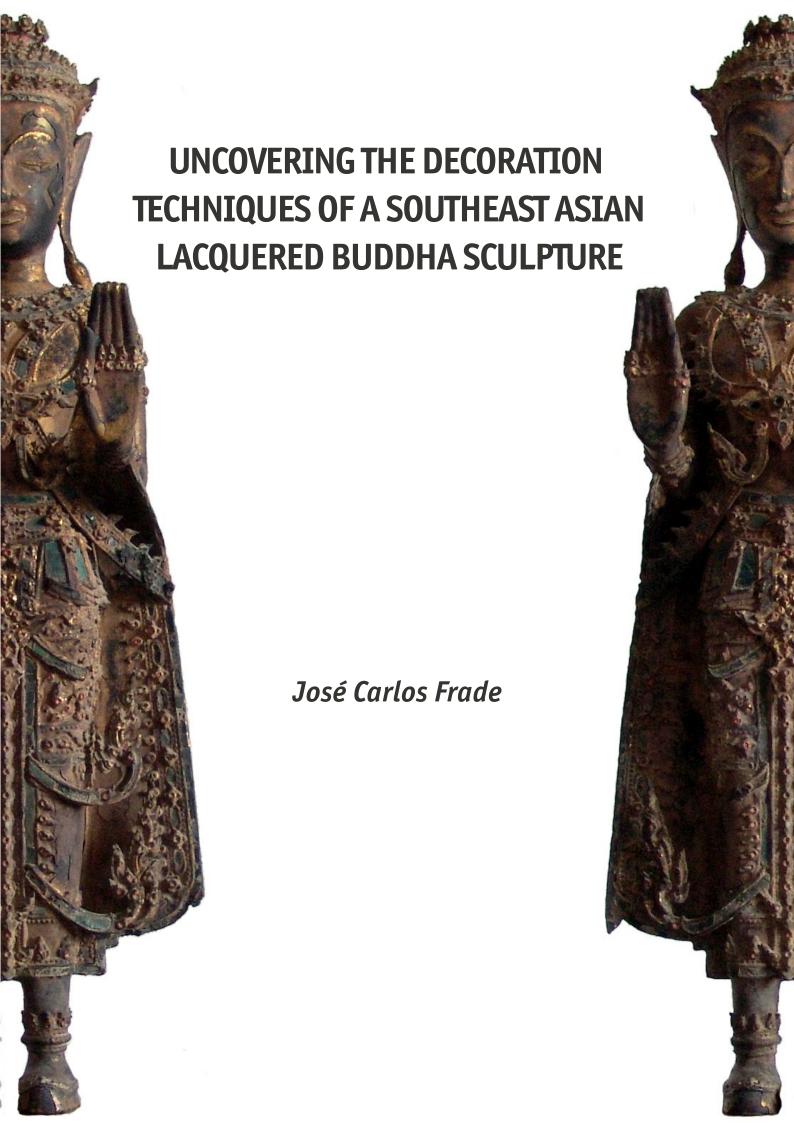
Chemist cmbd@uevora.pt

#### **JOSÉ MIRÃO**

Geologist
jmirao@uevora.pt

#### **DORA TEIXEIRA**

Chemist dmt@uevora.pt



# Uncovering the Decoration Techniques of a Southeast Asian Lacquered Buddha Sculpture

#### José Carlos Frade

#### **ABSTRACT**

In this work, a Southeast Asian lacquered Buddha sculpture attributed to the 19<sup>th</sup> century was studied using different micro-analytical tools, namely optical microscopy, micro-FTIR, Py-GC/MS and micro-XRD. The several analyses carried out permitted the identification of the materials applied in the sculpture as well as to determine the alloy that constitutes the sculpture's support. The sculpture is made of a copperzinc alloy substrate that was lacquered and decorated. The two major decoration techniques in this artefact are gold leaf application and glass mirror inlay, and the different examinations performed revealed how they were executed. Also, the lacquering technique was assessed through the identification of the materials applied in the different layers of the lacquer coating, and the type of lacquer applied in the sculpture was identified by Py-GC/MS as being obtained from the Melanorrhoea usitate tree.

#### 1. Introduction

The first evidences on the use of lacquer in Southeast Asia are Chinese documents dated from the 9<sup>th</sup> century where lacquer is mentioned as being used as coating material for monasteries and palaces in Burma [1]. Nevertheless, it is possible that its use is somewhat earlier, dating from the time of the introduction of Buddhism, as it seems that there have been a more or less close relation between the Buddhist religious practice and the use of that material [1, 2]. It is known that Buddhism was introduced in Burma around the 5<sup>th</sup> century [1], and probably the art of lacquering soon followed.

Many are the substrates on which Asian lacquer has been applied as a protective and decorative coating, being wood and bamboo the most common materials [3-9]. Usually, the production of a lacquered object involves a great number of work sequences of applying lacquer and polishing

[8, 9]: the first layers of lacquer – ground layers – are commonly constituted by clay, raw lacquer and another material that improves the adhesive power of the mixture to the substrate (eg. starch glue made from rice); the middle and final layers are, in general, only made of lacquer (usually lacquer that has undergone some kind of refining or processing) [8-10].

Concerning the decoration techniques of lacquered objects, it is believed that they all had their origins in China and that some techniques were more practiced than others in certain periods and/or regions [8, 9, 11]. In Southeast Asia, along with others, two of the most frequent decoration techniques are the application of gold leaf (*lai rot nam*, in Thailand; *shwei-zawa*, in Burma) and the inlay of coloured glass mirrors which may be combined with the inlay of mother-of-pearl or other materials (*kruang muk kam bua*, Thailand; and *hman-zi shwei-cha*, Burma) [1].

Asian lacquer is a very durable coating material that can be obtained from various species of trees: Rhus vernicifera (China, Japan and Korea), Rhus succedanea (Vietnam and Taiwan) and Melanorrhoea usitate (Burma and Thailand) [2, 4, 6, 7, 9, 12]. Composed of a complex mixture of compounds that includes a series of catechol derivatives and the enzyme laccase, Asian lacquer hardens through a polymerization process catalyzed by this enzyme [6, 7, 9]. After curing, lacquer films are very hard and insoluble, being extremely difficult to analyse with many of the conventional analytical techniques [6, 7, 13-17]. Actually, the only technique capable of distinguishing the lacquer produced by each species is pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS), though Fourier transform infrared spectroscopy allows an easy distinction from other coating materials [12, 17-19]. Using Py-GC/MS, the distinction of Asian lacquers can be attained through the detection of specific pyrolysis products, which may be difficult when using a filament-type pyrolyser, or by means of the extraction of mass chromatograms and comparison of their profile with those from lacquer references. The mass chromatograms of the ions m/z 108 and m/z 104, corresponding respectively to a series of alkylphenols and alkenylbenzenes, are particularly suitable for this purpose [2, 12, 19].

In this work, a Southeast Asian lacquered Buddha sculpture (figures 1 and 2) was studied with the purpose of uncovering the decoration and lacquering techniques employed during its production. The sculpture is attributed to the 19<sup>th</sup> century (or first half of the 20<sup>th</sup> century), and belongs to a private collection. It has about 50 cm high and is made of a metal substrate that was lacquered and decorated mainly with gold and coloured glass mirrors. Analytically, little is known about the materials and procedures used in the production of this type objects, and this



Figure 1. Southeast Asian lacquered Buddha sculpture.

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Figure 2. Upper part of Buddha's crown, which is separated from the rest of the sculpture.

study was a fine opportunity to access them. The actual knowledge about these lacquered artefacts is described in generic terms in the literature, frequently referring to Chinese or Japanese artefacts, and in many exhibition catalogues [2, 4, 5, 8, 9, 20].

In order to characterize the sculpture in terms of its execution techniques, it was necessary to analyse the sculpture materials and to understand how they were applied through the use of several microanalytical tools, namely by optical microscopy (OM), Fourier transform infrared micro-spectroscopy (micro-FTIR), pyrolysis—gas chromatography/mass spectrometry (Py-GC/MS) and X-ray micro-diffraction (micro-XRD). Results gave relevant information on the nature of the materials, and permitted to have a glance on the complexity of what is to make an artefact like this.

#### 2. Experimental

This study began with the collection of microsamples from the lacquer coating for cross-section examination by optical microscopy and for analysis by micro-FTIR and Py-GC/MS. Sampling was carried out using a surgical scalpel on fissures or detachment areas. The results obtained by these techniques were complemented by micro-XRD non-destructive analyses to the metallic support of the sculpture, to corrosion/degradation products on the surface, and to the decorative elements of the sculpture.

Cross-sections from the lacquer coating were prepared for optical microscopy examinations, through the inclusion of the sample in epoxy resin (Epofix, Struers). OM observation of the cross-sections was carried out under visible light using a Leitz WETZLAR optical microscope coupled to a Leica DC500 digital camera.

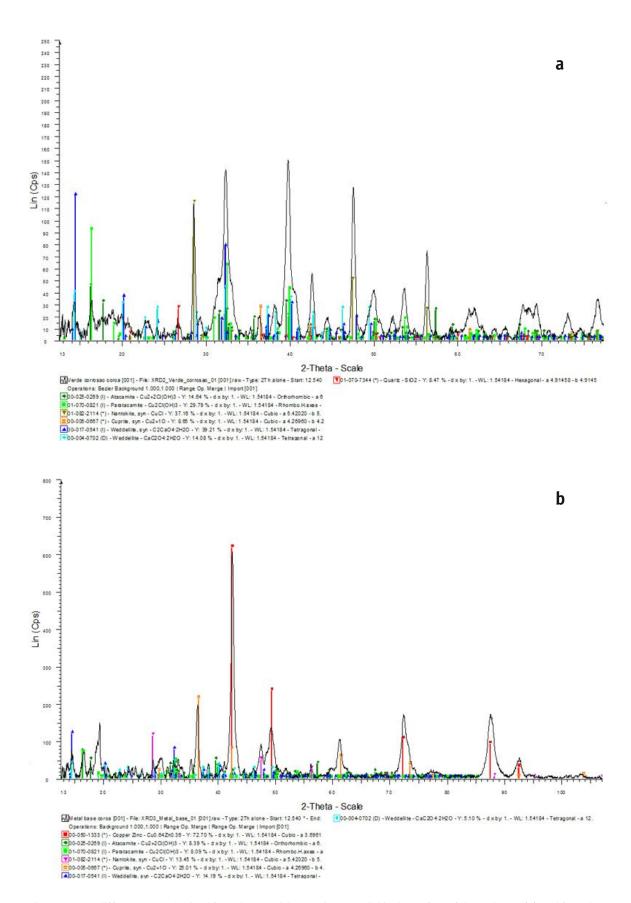


Figure 3. X-ray diffractograms obtained from the greenish corrosion material in the surface of the sculpture (a) and from the metal that constitutes the substrate of the sculpture (b).

Table I. Description of t	he points of th	he Buddha's crown analy	used by micro-XRD	and corresponding	a identified materials.

Analysis sites	Materials identified		
Reddish polychromy	Vermillion, weddellite		
Greenish corrosion material	Atacamite, paratacamite, nantokite, cuprite, weddellite, quartz		
Crown metal substrate	Copper-zinc alloy, atacamite, paratacamite, nantokite, cuprite, weddellite		
Golden lacquer surface	Gold, Copper-zinc alloy, weddellite		
Brownish material on the crown's surface	Gold, Copper-zinc alloy, weddellite, gypsum, quartz		
Reflecting material of a green glass mirror	Lead, lead and sodium basic carbonate, hydrocerussite, lead oxide sulphate		
Reflecting material of a colourless glass mirror	Lead, lead and sodium basic carbonate		

Micro-FTIR analyses were performed using a Thermo Nicolet Nexus 670 FTIR spectrometer coupled to a Continuµm IR microscope. Samples were compressed in a micro-compression diamond cell and analysed in transmission mode. Each spectrum is the result of 254 scans acquired at 4 cm<sup>-1</sup> resolution over the region 4000 cm<sup>-1</sup> to 650 cm<sup>-1</sup>.

Micro-XRD analyses were made in a Bruker D8 Discover diffractometer with Cu K radiation and a GADDS detector. The EVA code was used for phase identification.

Py-GC/MS experiments were carried out with a CDS Pyroprobe 2000 coil filament pyrolyser, attached to an Agilent 6890N gas chromatographer equipped with a 5975N mass spectrometer. Analytical conditions were as described elsewhere [12]. Pyrolysis products were identified by interpretation of mass spectra and by comparison with NIST and Wiley libraries.

#### 3. Results

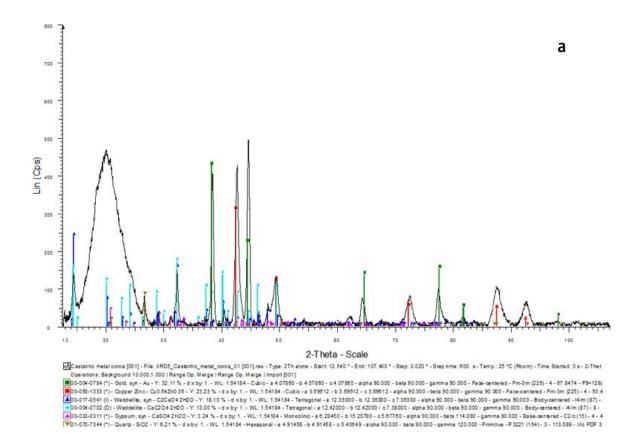
The combined use of micro-FTIR, micro-XRD and Py-GC/MS in the study of this lacquered Buddha

sculpture allowed not only to identify the materials applied during its execution, and those formed as a consequence of their deterioration, but also permitted to understand how the sculpture was lacquered and decorated. The crown in the head of Buddha was damaged and its upper part was physically separated from the rest of the sculpture (figure 2) so it was possible to perform all micro-XRD analyses in a non-destructive way in this part of the crown since it was small enough to be placed inside the diffractometer's chamber.

#### 3.1. Support and Corrosion/Deterioration Products

In the superior part of the crown, the metal support of the sculpture was exposed in some areas due to the lacquer detachment allowing thus its direct analysis by micro-XRD without the interference of other materials such as lacquer itself or the gold leaf covering most of the sculpture's surface.

Micro-XRD analysis allowed to verify that the metal support of the Buddha sculpture is a copper and zinc alloy, as well as to identify some corrosion products present on its surface (table I and figure 3). Peaks in the diffractograms of figure 3 show copper chlorides and oxides as being the major corrosion



b 80-70-60 50 30 -20-10-0 -10 4000 3500 3000 2000 1500 1000 Wavenumbers (cm-1)

Figure 4. X-ray diffractogram (a) and FTIR spectrum (b) of the brownish material deposited in the surface of the sculpture.

products: atacamite ( $Cu_2(OH)3Cl$ ), paratacamite ( $Cu_3(Cu,Zn)(OH)_6Cl_2$ ), nantokite (CuCl) and cuprite ( $Cu_2O$ ). These compounds were also detected in the greenish material deposited in some areas of the sculpture's surface.

Weddellite (calcium oxalate) was also identified in the surface of the object, which may be related with some biological activity as a consequence of the conservation conditions to which the sculpture was submitted over time. This material was detected in most of the points analysed by micro-XRD (table I).

In fact, almost all the sculpture's surface was covered by a brownish material deposit that was analysed by micro-FTIR and micro-XRD (figure 4). FTIR spectrum reveals the presence of calcium oxalate (1647, 1323 and 780 cm<sup>-1</sup>), silicates (1028, 952 and 780 cm<sup>-1</sup>), traces of calcium carbonate (1419 and 874 cm<sup>-1</sup>) and a sulphate (1114 cm<sup>-1</sup>) [21-24]. Micro-XRD confirmed these results, except for calcium carbonate, and allowed to determine that the sulphate was gypsum.

#### 3.2. Gold Lacquer Coating

Samples collected from the gold lacquer coating were examined by OM and analysed by micro-FTIR and Py-GC/MS. Cross-sections (figure 5) reveal that the lacquer coating is constituted by three layers, the first and the third being made of lacquer and the second is a mixture of lacquer and clay.

FTIR spectra of layers 1 and 3 (figure 6) show the characteristic absorptions of Asian lacquer: 3370 cm<sup>-1</sup> (0-H stretching), 2928 and 2856 cm<sup>-1</sup> (C-H stretching), 1713 cm<sup>-1</sup> (C=O stretching), 1628 cm<sup>-1</sup> (C=C stretching in aromatics and alkenes + COO-asymmetric stretching in polysaccharides), 1449 cm<sup>-1</sup> (C-H deformation + COO-symmetric

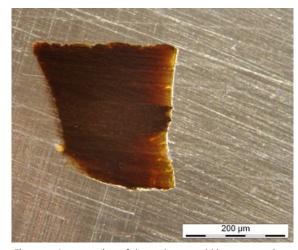


Figure 5. Cross-section of the sculpture gold lacquer coating.

stretching in polysaccharides), 1275 cm<sup>-1</sup> (C-0 stretching in phenol groups), 1080 cm<sup>-1</sup> (C-0 stret-ching), 780 cm<sup>-1</sup> (out-of-plane C-H deformations in aromatics), 755 cm<sup>-1</sup> (out-of-plane C-H defor-mations in aromatics), 726 cm<sup>-1</sup> (out-of-plane C-H deformations in aromatics + CH<sub>2</sub> rocking), and 693 cm<sup>-1</sup> (out-of-plane C-H deformations in aromatics) [12, 18, 21, 22].

FTIR spectrum of layer 2 (figure 6) exhibits some additional bands (some superimposed with those of lacquer) that correspond to the presence of kaolin: 3699 cm<sup>-1</sup> (0-H stretching), 3634 cm<sup>-1</sup> (0-H stretching), 1034 cm<sup>-1</sup> (Si-0-Si stretching), 914 cm<sup>-1</sup> (0-H deformation in Al-OH groups), 799 cm<sup>-1</sup> (Si-0 stretching) and 699 cm<sup>-1</sup> (Si-0 stretching) [24].

The lacquer of the sculpture was analysed by Py-GC/MS with the purpose to identify the type of lacquer that was applied during its execution. The pyrogram and correspondent mass chromatogram of ion 104 are depicted in figure 7. The alkenylbenzenes profile presented by the mass chromatogram shows that the most abundant benzene derivative is undecenylbenzene (eluting at 32.18 min) and is very similar to the profile presented by reference lacquer obtained from *Melanorrhoea usitate* species [12].

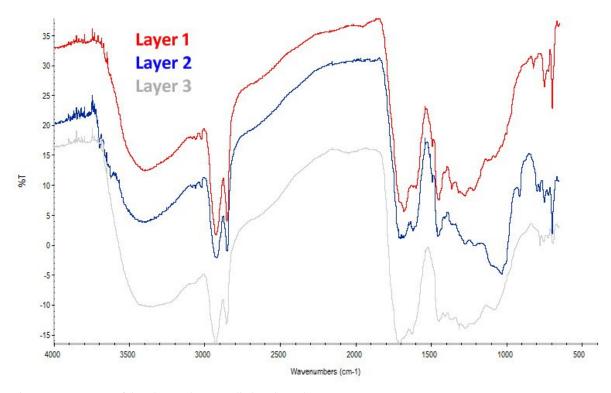


Figure 6. FTIR spectra of the 3 lacquer layers applied on the sculpture.

When examining cross-sections, it is not quite perceptible a golden layer corresponding to the gold leaf applied on top of the final lacquer layer. Nevertheless, the direct examination of the sculpture surface using magnifying lenses allowed understanding that gold leaf was applied directly on the last layer of lacquer, without the previous application of a bole layer which might be constituted by vermillion or orpiment mixed with lacquer [9]. The analysis of the golden lacquer coating by micro-XRD confirms this observation since no traces of those materials were detected. Actually, the diffractogram obtained (figure 8 and table 1) reveals peaks due to the presence of gold, a copper-zinc alloy and weddellite. In this case, the analysis was sensitive enough that the metal support of the sculpture was detected. Then, in case a bole layer would have been applied, its inorganic materials would have also been detected.

#### 3.3. Sculpture Decoration

Besides the gold that covers almost entirely this lacquered Buddha sculpture, it presents some other decorative elements: green and transparent mirrors and a reddish polychromy.

Figure 9 depicts a detail of the reddish polychromy, and the FTIR spectrum and diffractogram obtained in its analysis. Micro-XRD analysis reveals that the red colour is due to the use of vermillion, and FTIR spectrum shows the characteristic absorptions of beeswax [22].

In what concerns to the green and transparent mirrors, it is easy to appreciate that these mirrors were inlayed in the lacquer coating (figure 10) when visually examining the sculpture. The inlay was made through the use of an adhesive material (a black paste) to which the mirror would first

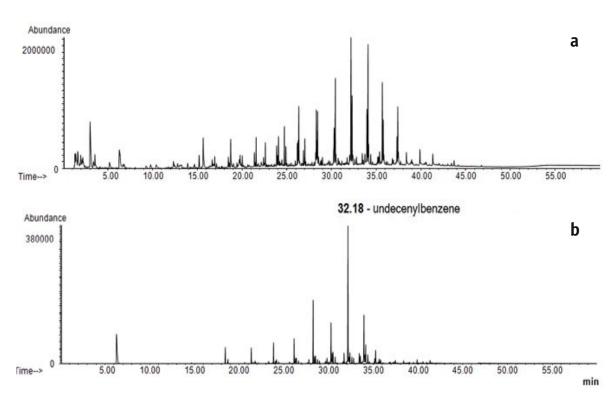


Figure 7. Pyrogram (a) and extracted mass chromatogram of ion 104 (b) obtained in the analyses of the lacquer by Py-GC/MS.

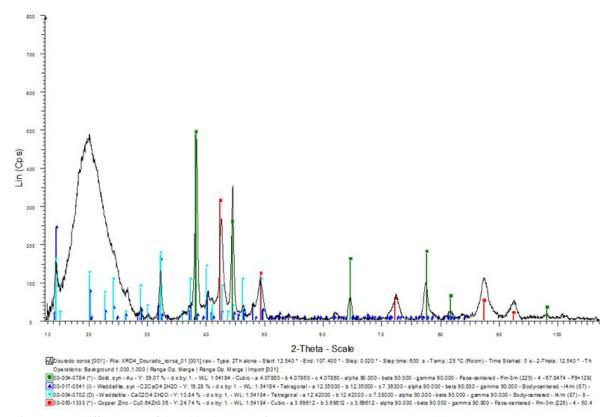


Figure 8. X-ray diffractogram of the golden lacquer surface.



adhere and then lacquer was applied covering the mirror completely. Finally, a polishing step would be made until the surface of the mirror appears underneath the lacquer [4].

The material used as adhesive for the mirrors could be analysed with no problems by micro-FTIR, as in many cases the mirrors have already been detached from its place, leaving the black paste

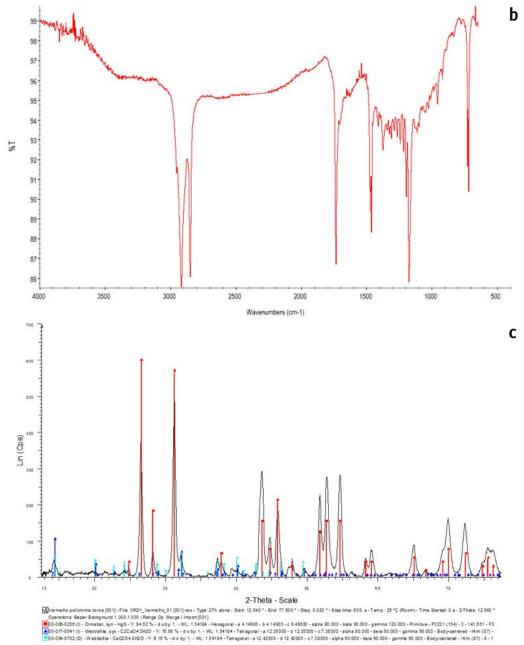


Figure 9. Detail of the reddish polychromy in Buddha's crown (a), and respective FTIR spectrum (b) and x-ray diffractogram (c).

exposed (figure 10). It is important to mention that the black paste surface presented a silver coloured material on its surface corresponding to some remains of the mirrors' reflecting material. The bands in the black paste FTIR spectrum (figure 11) are due to the presence of lacquer and kaolin, meaning that the black paste is a mixture of clay and lacquer. The mirrors' reflecting material was analysed by micro-XRD in two of the detached

Figure 10. Detail of the inlayed glass mirrors.

mirrors (table I and figure 12), and it was possible to comprehend that the reflecting material of the mirror consists of lead. Also, some lead corrosion products were detected in the XRD analyses, namely lead and sodium basic carbonate (NaPb<sub>2</sub>(CO<sub>3</sub>)<sub>2</sub>(OH)), hydrocerussite (Pb<sub>3</sub>(CO<sub>3</sub>)<sub>2</sub>(OH)<sub>2</sub>), lead oxide sulphate (PbSO<sub>4</sub>.PbO). The detection of lead and some of its corrosion products is rather unusual since the most common material used for the production of flat glass mirrors between the 16<sup>th</sup> and 20<sup>th</sup> centuries was a tin-mercury amalgam, although there are some accounts on the use of lead, tin and "marcasite" mixed with mercury [25].

#### 4. Conclusions

The combination of several micro-analytical tools allowed the characterization of the lacquer and decoration techniques (gold leaf application and mirror inlay) from a lacquered Buddha sculpture.

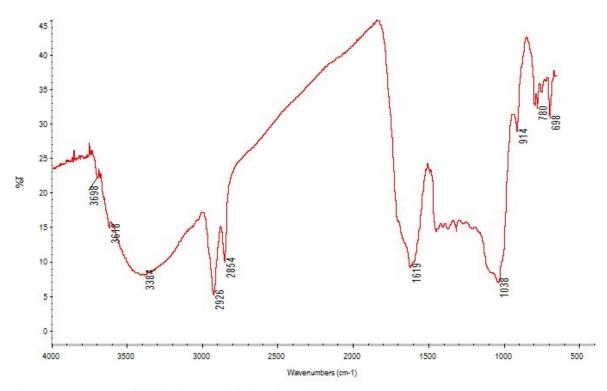


Figure 11. FTIR spectrum of the black paste used for the mirrors inlay.

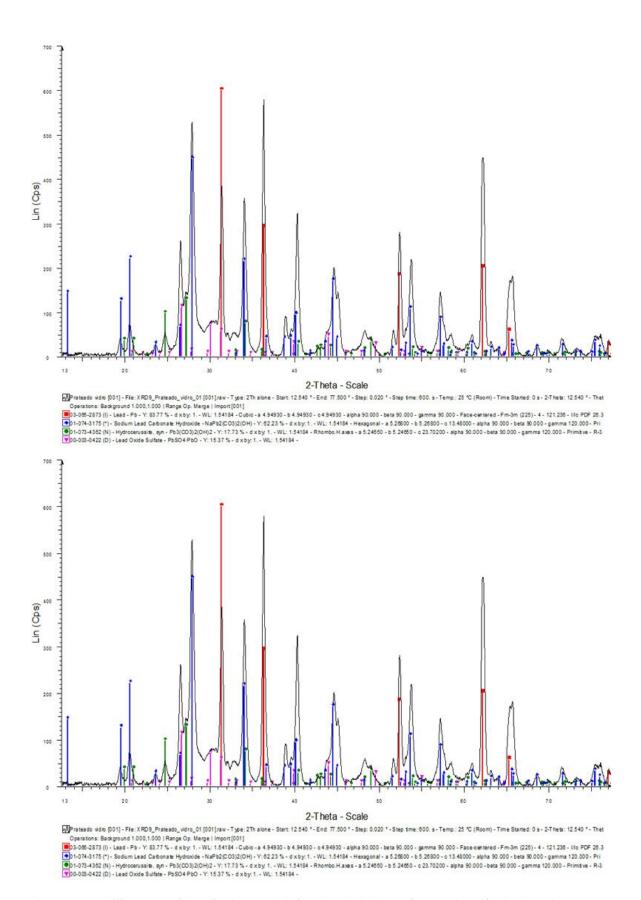


Figure 12. X-ray diffractogram of the reflecting material of two detached mirrors: a) green mirror; b) colourless mirror.

The sculpture's support, an alloy of copper and zinc, was finished with lacguer produced by the Southeast Asian species Melanorrhoea usitate. The lacquering technique employed is slightly different from that usually applied in the production of bamboo or wooden artefacts. In this case, probably due to the metallic nature of the substrate, the first layer applied on it was composed just of lacquer instead of the more common mixture of clay and lacquer. This mixture was found to be applied only after this first layer, which was then covered by another coat of lacquer that was simultaneously used as an "adhesive" for the gold leaf decorating the most part of the sculpture's surface. The mirror inlay found in the sculpture was made through the use of a paste composed by a mixture of clay and lacquer to which colourless and green mirrors were glued.

#### 5. Acknowledgments

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#### JOSÉ CARLOS FRADE Chemist

jfrade@porto.ucp.pt

José Frade, PhD, is Professor at the Portuguese Catholic University and vice-director of CITAR - Research Centre for Science and Technology of the Arts.

# TRAVELLING BENEATH THE GOLD SURFACE – PART I: STUDY AND CHARACTERIZATION OF LABORATORY RECONSTRUCTIONS OF PORTUGUESE SEVENTEENTH AND EIGHTEENTH CENTURIES GROUND AND BOLE LAYERS



Irina Sandu, Fancesca Paba, Elsa Murta, Manuel Pereira, Conceição Ribeiro

# Travelling Beneath the Gold Surface – Part I: study and characterization of laboratory reconstructions of Portuguese seventeenth and eighteenth centuries ground and bole layers

Irina Sandu, Fancesca Paba, Elsa Murta, Manuel Pereira, Conceição Ribeiro

#### **ABSTRACT**

This paper is the first part from an experimental study on documented reconstructions of gilded composites performed within a research project on gilding materials and techniques in Portugal between 1500 and 1800 (PTDC/EAT-EAT/116700/2010). This study deals with the various aspects related with the choice and preparation of raw materials used to produce gesso and bole layers, the imprecise terminology that the historical recipes and treatises provide, the different steps to be followed in the laboratory experiments and their validation with analytical techniques. The results refer solely to the water gilding technique reconstructions on flat wooden samples, focusing on the preparation and application of ground and bole layers. This is important to show how the practical work performed in the laboratory can be complemented with analytical evidences obtained from different analytical techniques such as optical microscopy, scanning electron microscopy and X-ray diffraction. This can be a starting point for further studies of technical and technological procedures, relevant to conservation studies. Correlating the terminology and literature information with the practical data and critically approaching the different sources, both historical and analytical, is the basic rule for the correct reproduction of ancient recipes with modern materials and techniques.

#### 1. Introduction

Gilding technical procedures and materials were described since early times in the arts and crafts literature and they were used quite extensively until today in the decorative arts that involved carving and sculpting in different materials such as wood, ceramic, glass, and metal [1].

Between history and conservation practice, the art technological sources field proposes many recipes, reconstruction procedures and the criteria that should guide the laboratorial work [2]. In most cases, analytical expertise is required to assess whether the reconstructions are faithful to the original, and if the indicated parameters in terms of materials, procedures and steps to be followed were respected [2-3].

The main questions that often arise when someone wishes to put into practice the ancient gilding recipes are whether the materials we have access to in modern times have the same quality, properties and behavior as the ancient ones, and to which extent we are able to really interpret and reproduce the old recipes when terms and procedures are not always clearly explained. Are we sure to use the same glue and gesso as the ancient craftsmen to prepare the gesso grounds? Is the animal glue (and which kind: sheep, goat or rabbit?) we will use of the same quality as the ancient one? Is the gesso grosso or gesso mate properly prepared and the layers clearly distinquishable in the stratigraphic composite? Which kind of leaf should we use considering that literature confirms the general use of 23 and 24 karats of ternary alloys of gold with other metals (silver

and copper)? Which kind of surface (protective and/or decorative) treatment is more appropriate: varnishing with shellac or other type of varnish; fosco (mate) effect obtained by the application of an animal glue layer, or sgrafito or estofado decoration using tempera paint?

Without aiming to answer all these questions, this paper presents the initial results of experimental procedures conducted during the research project GILT-Teller: um estudo interdisciplinar multi-escala das técnicas e dos materiais de douramento em Portugal, 1500-1800 (PTDC/EAT-EAT/116700/2010) funded by the Portuguese Foundation for Science and Technology [4].

One of the tasks developed within this project is to characterize with documented reconstructions gilded wood carved altarpieces and sculptures from the Portuguese baroque epoch. Among an important number of historical and contractual documents consulted in parish archives and in regional and the National Library in Portugal [5] two treatises, one written by Philippe Nunes (1615) [6] and other by José Lopes de Baptista Almada (1749) [7], were chosen for their gilding recipes (Table I). Two recipes were chosen from each treatise as being representative from the 17<sup>th</sup> and 18<sup>th</sup> centuries, both in water and mordant gilding techniques.

The reproduction in the laboratory of these recipes was focused on obtaining the raw materials for the gesso grounds, bole and animal glue layers and on their application on wooden samples.

Digital photography and video recording documented the procedures.

The main criteria for the choice of wood species was the shape and number of reconstructions, the number of recipes to be reproduced and the more relevant literature for the timespan considered

as the most productive and representative for the Portuguese gilded wood carved decoration (talha dourada). The final choices were pine and oak wood. The other criterion was the availability, behavior and characteristics of the raw materials for the aimed reconstructions and for the further accelerated ageing. The choice was gesso and two different animal glues. The added value of this study was the behavior information of the different gilding layers/materials when applied on flat and 3D surfaces. The results here presented refer only to the water gilding technique reconstructions on flat wooden surface samples (Figure 1), focusing mainly on the ground and bole layers preparation and its application.

It should be underlined that all procedures are very subjective and depend on the artist experience. Although subjected to previous known recipes, it is the experience and sensibility of the artist that controls all procedure of glue, *gesso grosso* and *fino* making and the exact ratio of solubility of glue in the water or of gypsum on the diluted glue.

#### 2. Recipes and Materials

#### 2.1. The Recipes and Their Terminology

Table I presents the two water gilding recipes recommended by Philippe Nunes and José Lopes Baptista de Almada.

The gesso terminology is quite confusing because many ancient publications use it as a generic term for grounds and do not indicate its precise composition, whether is an anhydrite, a dihydrated calcium sulfate (gypsum), hemihydrated calcium sulfate (known also as plaster/gesso of Paris, made of bassanite) or calcium carbonate. In the latter case, we found the Portuguese term cré,





Figure 1. Wooden supports typologies: flat (left) 4x8x2 cm and three-dimensional (right) 8x12x4 cm.

which is different from gesso. The term gesso-cré, although without reference to its composition, was found in the account book Livros de contas do Mosteiro de Tibães, dated after 1760, from a Monastery in northern Portugal that kept most of its coeval documentation [8]. What is obvious from the literature is that in the southern European countries the tradition of plaster panels or wooden sculptures made use of qypsum/anhydrite while the northern countries made use of calcium carbonate ground [9]. The analytical results obtained from a series of Baroque altarpieces in Portugal showed that sometimes calcium carbonate can be found mixed with the gypsum in the ground layer [10]. Another interesting data on the composition of the gesso grounds is the identification of celestite (strontium sulfate) in Portuguese retables [11] and the fact that the gypsum source was traced back to the mines of Óbidos (Leiria) and Soure (Coimbra). Other provenances for the gesso used in Portugal are also mentioned such as Morocco, Spain and France [12-13].

The distinction between *gesso grosso* and *gesso fino*, *mate* or *sottile* is common to different countries and periods both for painting and sculpture making [14-16]. Translations sometimes introduced errors in denominating the materials or layers.

The analytical research made by several authors [9-10, 17-19] confirmed that gesso grosso is mainly made of anhydrite. Other studies show that a mixture of anhydrite with hemihydrate or even dihydrate sulfate can be found in grounds from paintings and sculptures [20]. The use of analytical techniques is required as to provide a precise composition of the different layers of *gesso*. Optical microscopy and scanning electron microscopy coupled with energy dispersive spectrometry (SEM-EDS), which is able to map the elements on each layer of a stratigraphy, are often used in these studies but it is not enough to assess which of the types of gesso is present. Figure 2 shows a ground made of calcium, sulfur and oxygen which means that a calcium sulfate is present but other techniques, such as X-ray diffraction or micro-Raman, are needed to assess if anhydrite, hemihydrate or dihydrate calcium sulfate.

The gesso fino denomination is linked to the material characteristics and its production, much more expensive than gesso grosso, is mainly constituted of fine lamellar crystals of dihydrated calcium sulfate. The gesso grosso, made of coarse, heterogeneous crystals, is applied on several layers on top of the wood to reduce the irregularities of the support and is sanded with sandpaper sheets

Table I. The two water gilding and alum thawing recipes in their original language and translated into English.

Author Year	Short description according the original text	Main steps to be reproduced		
Philippe Nunes, 1615	Pera assentar ouro em pedra, pao e vidro, e couro  Pera asentar ouro em pedra, se ha de guardar a ordem seguinte.  Primeiramente se ha de imprimar, e depois de seca a imprimadura se lhe ha de pôr o mordente e como estiver em cezão, dourar.  O pao se doura de dous modos: a hum delles chamão ouro mate, como he o que fica assima dito, e que assi serve também no pao como na pedra, e o outro se chama ouro burnido. O ouro mate se acenta sobre o pao aparelhado como dizemos na pintura até ser imprimada, e depois se lhe põe o mordente, e quando está já quasi seco se lhe acenta o ouro com algodão. E se quiserdes fazer hum ouro muito fermoso que pareça ouro burnido, fazey que o mordente seja pulimento de Ocre claro, ou escuro, e depois de estar muito polido e lizo (que nisto está sayr o ouro bom) depois de enxuto lhe acentay o ouro que ficará muito fermoso, e tão bom como se fora burnido.  O ouro burnido se faz assi. Depois de estar o pao encolado lhe day uma mão de gesso comum, e seja ao modo de lavadura delgado, e se na cola lhe botardes huma cabeça de alhos serve para que não falte, depois lhe day tres ou quatro mãos de gesso mate, o qual se faz assi. Tomase o gesso comum, e depois de moydo e peneirado se bota em huma panella chea de agoa clara, e cada dia se lhe muda e se bate duas ou três vezes, e aos dez dias fica gesso mate então o tiray e sequay, e uzay delle. Depois de dardes estas mãos que digo, lhe dareis duas de bollo comum, e depois outras duas de bollo fino, e sejão todas estas mãos dadas com cola quente, depois de enxuto quando quereis dourar molhareis muito bem, e sobre o molhado com agoa clara acentay o ouro, e depois de seco burni com o bornidor, que se faz de pederneira muito lizo e ficará o ouro muito fermoso. ()	- 2 hands of "baldreu" glue (to be added with a head of garlic); - 1 hand of "aguarelha" (diluted animal size); - 3 or 4 layers of gesso mate (fine) (without gesso grosso); - 2 layers of common bole; - 2 layers of fine bole; - apply the gold leaf in water gilding.		
José Lopes de Baptista Almada, 1749	Do modo de dourar brunido em madeyra  Em primeyro lugar se tomará huma vazilha, ou panella nova de barro, e se encherá de retalhos de pelles de luvas, e logo se tirarão para fora, e se lançarão em hum alguidar, no qual se hão de lavar em tres agoas, tirando-lhe huma, e lançando-lhe outra: estando muyto bem lavadas, se tornarão a lançar dentro da mesma panella, e se encherá de agoa, pondo-se a ferver, até se desfazerem todos os retalhos, mexendo-os para isso muyto bem, e depois tirada para fóra, se coará por hum peneyro em huma vazilha limpa, onde se deyxará até que se coalhe. Desta colha coalhada, depois de fria, se tirará a que estiver por cima, e se guardará em huma vazilha para a tempera do bolo armenio, e a seguinte, antes de chegar ao fundo, em outra vazilha tambem para se fazer o gesso mate, de que abayxo trataremos; e da ultima se fará o Gesso grosso. Lançando huma pouca em huma panella (conforme a obra que se houver de dourar) e se porá ao fogo a aquecer muyto bem, e então se lhe lançará hum pouco de gesso, desorte que a agoa, ou colla fique muyto delgada, e com huma brocha, molhada nesta colla quente, se dará huma mão sobre a madeira, que se quizer dourar, toda por igual, e depois de estar muyto bem enxuta, se porá outra vez a panella ao lume, e se lhe lançará mais gesso, desorte que fique mays grossa a agoa, ou colla, que a primeyra, e estando quente, della com a mesma brocha se dará segunda mão sobre a pimeyra. Estando enxuta a segunda, se lhe dará terceyra na mesma fórma, pondo terceyra vez a panella ao lume, misturando-lhe mais gesso, ou colla, se for necessario, advertindo que estas collas hão de dar-se sobre a madeyra de tal sorte estendidas, e puxadas com a brocha, que não fiquem mais grossas em humas partes do que em outras; porque sendo assim ficarão encobrindo o mais miudo do entalhado, ou outra qualquer cousa. Dadas estas sobreditas mãos de colla, se continuará com o Gesso mate. Preparando-o na forma seguinte. Tomar-se-ha huma pouca de segunda colla, que acima mandamos guardar, e posta em hu	"preparation" of glue (sizing of the wooden support)  - 3 layers of gesso grosso (1st one of "aguada"); - 3 layers of gesso fino; - 4 layers of Armenian bole; - apply the watergilding technique.		

(cont.)

# Unkown author, ca 1400

#### Concia p(er) una pelle

Hawe alume de rocho i(n) polvere onc(e) 2. doi ova b(e)n(e) dibatutj poi tollj uno bono pugno de farina cio e el fiore et tanto sale q(uan)to bastasse p(er) i(n)salare una libra de carne et tanto olio q(uan)to condisse una menestra et una bona foglieta daq(ua) calda et mecti i(n) la dic(t)a q(ua) p(ri)ma lo alu q(ua) e calda mecti dentro la pelle depilata et manegiala p(ua)0 et strocila p(ua)1 et remene la p(ua)2 et remitendola p(ua)3 et remitendola p(ua)4 et remitendola p(ua)5 calda p(ua)6 calda p(ua)6 et remitendola et remitendola p(ua)6 calda p(ua)7 calda p(ua)8 et remitendola et remitendola p(ua)9 calda p(ua

- -two ounces of alum in powder;
- two eggs;
- a handfull of flour;
- salt as much as the neces-sary to salt a Libra of meat and the quantity of olive oil enough to spice a soup;
- half liter of boiled and hot water;
- alum very well grinded;
- -flour:

- mix well and add the eggs and oil. When the water is hot immerge the skins without the fur, mix well and then remove them and put into hot water. The skins should stay immersed at least 1 night or four hours. At the end remove it and leave them dry on a stick. Polish using pumice stone on both sides.

of different grading between each application. The *gesso fino*, made of finer and more homogenous crystals, is applied over the layers of *gesso grosso*, and is also sandpapered between each application. This smoother layers improve the surface over which the bole and gold leaf has to be applied [9, 18, 21]. Figure 3 shows an example of ground layers made of *gesso grosso/gesso fino* sequence.

The bole (or bollus) is the red or yellow ochre layer applied over the ground and sometimes burnished with agate stone, to receive the gold leaf. Originally, the ancient gilders made use of Armenian Bole, named as such according to its provenience although more recently local iron oxide mixed with argillous/clay minerals (iron, aluminum and silicon are usually detected in the bole layers, Figure 2) were used to obtain the bole, even though the ancient denomination was maintained, as it is the case of the recipe given by Almada. Dark bole is also mentioned, mainly for applying the silver leaf.

The animal glue terminology is also imprecise and confusing regarding the raw material used to

prepare the sizing for the panel and the binder solution for the gesso ground. Parchment and glove leather glues were used since ancient times until their production ceased in the 20<sup>th</sup> century. Nunes (1615) recommend the exclusive use of gloves leather for sizing, priming and gilding [6]. Many other European treatises mention the term "skin glue" obtained from thawed animal skins (qoat, sheep/lamb, cow or piq), parchment or "qlove clippings" [8, 22-23]. It is very probable that scraps of different thawed skins, used to make gloves, were recycled for this purpose. Nowadays, it is common to consider that animal skin is obtained from rabbit skin or parchment but these cannot be considered the only probable raw materials for the production of animal glue in ancient times.

A recent research [8] shows the different terminology used by 17<sup>th</sup>-18<sup>th</sup> century documents (treatises and work contracts or daily account books) in Portugal for different types of glues and qualities. The cheapest glue was probably made by carpenters and cabinet makers from cheaper cuts, cartilage, bone and nerves, while the higher quality glue was named "gloves glue" or

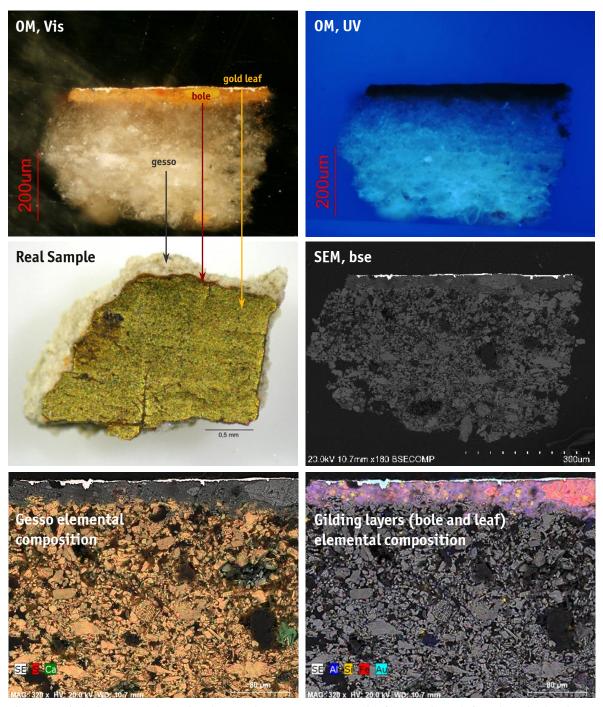


Figure 2. Optical microscopy and scanning electron microscopy on a cross-section from a real sample from the main altarpiece of the S. Francis Church in Castelo de Vide, Portalegre.

"parchment glue". Clippings (retalhos, meaning leftovers discarded by glove makers) and gloves glue (colla de luvas) were identified as base of a binder material for gilded altarpieces, polychrome statues and carved ornaments. The facts regarding the use of animal skins that are relevant for the

reconstructions are: the use of young animal skins; process of tanning the skin; the need to let the animal skin boil in water during the glue preparation (probably the alteration of the adhesive properties of glues subjected to temperatures above 60° C was not well known) and the possibility

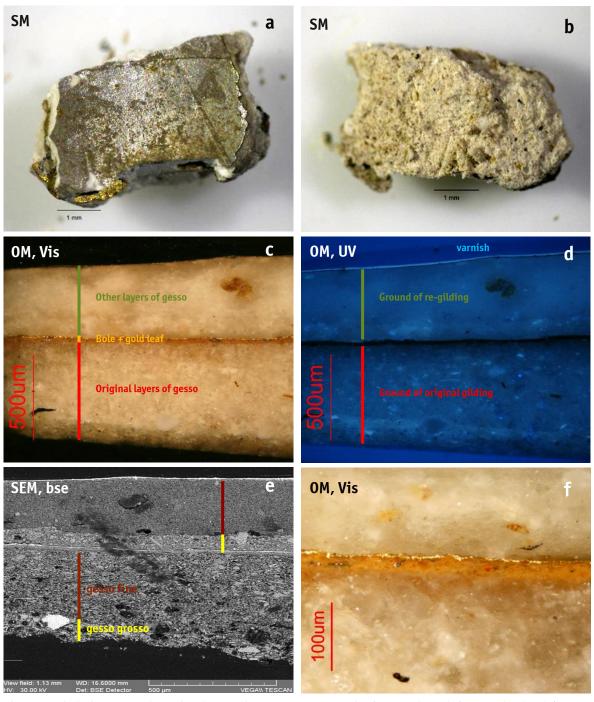


Figure 3. Optical microscopy and scanning electron microscopy on a cross-section from a real sample from Bucelas church (Loures, Lisbon) showing two phases of gilding. Image f shows the detail of the gilding layers at the interface between the two grounds.

to strain the glue before use [8]. The use of garlic is also mentioned as component of the mixture made of gesso and animal glue [6] or added to the glue size and then called "alhada" [24]. This practice was common to other gilding traditions and not only in Portugal [25].

Ouro burnido (burnished gold) and ouro mate/ fosco (mate gold) is another distinction made by the two treatises regarding the type of gilding technique and the surface treatment of the leaf after its application [26]. Only the gold leaf applied by water gilding technique can be burnished, the

mordant technique does not allow this treatment. The published researches on the purity of ancient gold leaf mentions pure gold (24 karats) and ouro de lei, ouro subido, or ouro fino (between 20 and 24 karats); values of 23.25 and 22 karat are quite common, 16 karats leaf is also in use after the second half of the 18<sup>th</sup> century [1, 27-31]. A recent study [10] shows the use of silver leaf with a varnish (the most common the shellac, or goma-laca) in order to imitate the appearance of the real gold leaf. Figure 3 gives the case of a real sample from the main altarpiece of Bucelas church (Loures, Lisbon, 18<sup>th</sup> century) where two phases of gilding were identified, the more ancient (original) having a gold leaf applied over bole and gesso layers, while the more recent is silver leaf with a thin layer of varnish with a bluish fluorescence.

## 2.2. Raw Materials: Gesso Powders and Alum Thawed Animal Skins

#### 2.2.1. The Gesso Reproduction

Considering the difficult interpretation of the historical documents on the making of *gesso grosso*, we approached the process using analytical characterization to prove the composition of three typologies of commercially available gesso. To reproduce technical recipes described by Nunes and Almada, gypsum products were analysed in order to understand its composition and compare its quality with the ground layers from the cases we are studying. The procedure consisted in monitoring: the operational conditions and the materials' behavior of raw materials' times and temperature of burning the gypsum; the quantity of the material used and the grain size; and the weight loss after the burning process.

To analyze the commercial products X-Ray fluorescence (XRF) (Philips 1480 X-Ray spectrometer,

4 internal routine programs) was used. To confirm the data we also used a XRD Difractometer PANA-LYTICAL X´PERT PRO with the following parameters: Cu K radiation, I= 35mA, V= 45kV Scan 5-70° 2, step 0.033, t= 100s, I= 35mA, V= 45kV.

The analysed materials, namely two rocks, were brought from Óbidos. Their crystals were differentiated as fine gypsum and very fine gypsum according to their grain size. Figure 4 shows the XRD of the fine gypsum and very fine gypsum composition.

The initial results showed that the fine gypsum is pure di-hydrated calcium sulfate while the very fine gypsum is made of insoluble anhydrite and a little percentage of dolomite. Only the upper one was considered adequate as raw material for our experiments. The fine gypsum was fragmented in small pieces and then divided in four groups of the same weight (38 g) heated in the oven (Nabertherm L 9/11/SKM Model) in variable conditions of temperature and exposure (Table II).

The resulting powder was immersed in water for four days to obtain dihydrated gesso (gesso mate) and after each hydration step a further XRD analysis was performed (Figure 5). The experiments were useful to answer several of our questions: which is the temperature when the transformation of gypsum into hemihydrated gesso happens; which is the range of temperature where the hemihydrated gesso and anhydrite are obtained; which is the temperature where only anhydrite is obtained and if is still soluble in water at 600°C or more temperature is necessary.

However, despite the clear appearance of the samples from fine gypsum selected for this study, it was found that there were impurities that contaminated the gypsum's final product. Only by visual identification we cannot be sure if a fine

Table II. Parameters o	f the hydrai	tion procedure	forthe	four groups of fine gypsur	m.

Fine gypsum	Initial Temperature (°C)	Final Temperature (°C)	Time (h)	Initial Weight (gr)	Final Weight (gr)	XRD Result	Still able to be hydrated
Group 1	130	160	1h15	38	37	Hemi- hydrated gesso	Yes
Group 2	130	160	2	38	35,6	Hemi- hydrated gesso	Yes
Group 3	300	25	8	38	*	Hemi- hydrated – soluble anhydrite	Yes
Group 4	500	600	1h30	38	25,5	Soluble anhydrite	Yes

<sup>\*</sup> Tampered result.

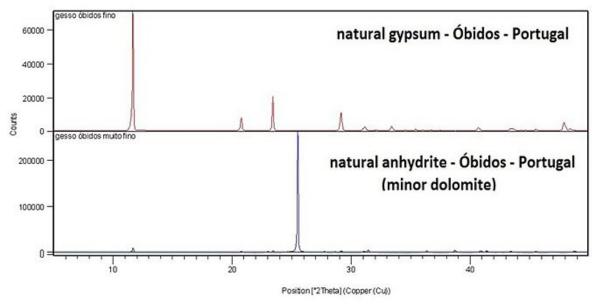


Figure 4. XRD difractograms of fine gypsum (natural gypsum) and very fine gypsum (natural anhydrite).

grained gypsum rock is pure or not. The first piece of rock analyzed indicated only the presence of gypsum but a second one, from the same location and having the same appearance, presents a very complex composition with impurities. Indeed, the XRD results from the second sample indicated the presence of anhydrite, carbonates and minor pyrite in the starting material. After the small fragments were heated at 160° C many harder particles of carbonate and anhydrite were found.

The carbonate particles also presented a darker color. Therefore, that material was considered not adequate for obtaining the pure gesso grosso and gesso mate. Considering the difficulty of recognizing the purity of the raw materials, selenite type, a very pure transparent variety of gypsum, pure fibrous crystals originating from Morocco, were then used to prepare the gesso mate for our model samples (Figure 6) and not the gypsum originally from Óbidos.

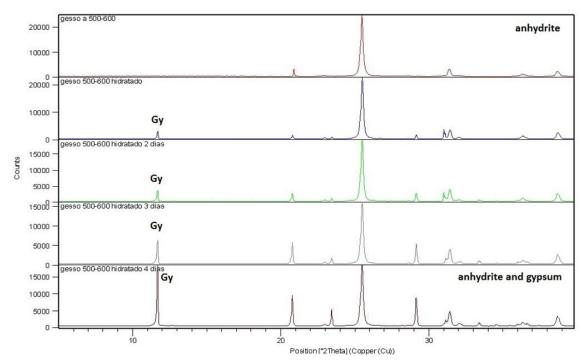


Figure 5. XRD diffractograms of hydrated anhydrite after four days where an increase of the peaks intensity of gypsum (Gy) can be observed.

The Moroccan gesso was characterized by XRD and resulted to be very pure. The probability of the gesso being imported in ancient times from other countries like Morocco is also confirmed by literature [11] which states that at the time there were very few gesso mines in Portugal and therefore foreign sources had to be found to supply the necessary quantity for retabular production.

#### 2.2.2. Animal Glue Production

The thawing procedure of animal skin is very old and aims to render the leather more resistant to the atmospheric and biological agents. The thawing materials were more or less the same during the history: calcium hydroxide, vegetal tannins, animal fats and alum.

In the absence of Portuguese recipes, we decided to follow an Italian manuscript known as *Manuscritto Bolognese* (ms 2861, Table I). Although

referenced by many authors, this particular recipe from the Italian Bologna province was first translated to English by M. Merrifield in 1849 [23]. It refers to the historical use of materials in Italian oil painting over a broad period of time. This translation was not always well succeeded because the Bologna vulgar dialect can sometimes be of difficult understanding so they all lack a complete description of all the necessary materials. Professor Pietro Baraldi, from the Università di Modena e Reggio Emilia, made a very useful translation and critical review of the recipe [32].

Our thawing experience procedure in fresh animal skins from young lamb (sheep) and goat was made manually and with tools according to the recipe. The fresh skins were salted with NaCl to prevent the rapid process of deterioration of tissues (putrefaction). The salt penetrates into the skin, which still has around 65% of water, and produces its partial elimination by an osmotic effect. After

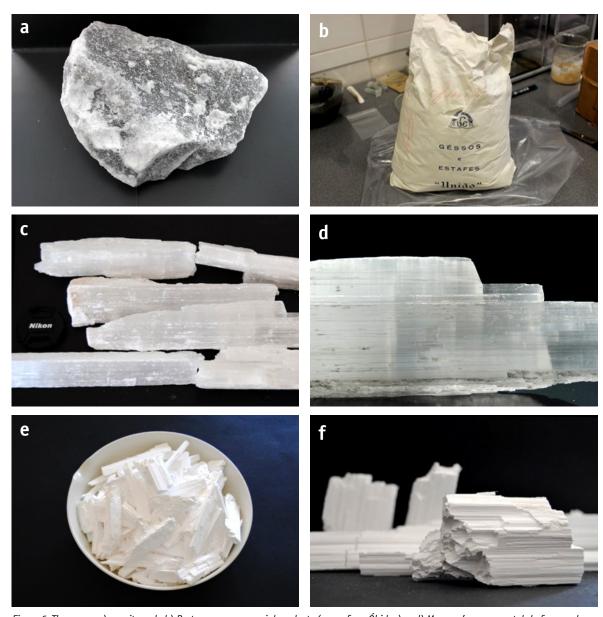


Figure 6. The gesso: a) gypsite rock; b) Portuguese commercial products (gesso from Óbidos); c-d) Morocco's gesso crystals before; and e-f) after burning in the oven.

abundant washing in water, the skin is re-hydrated and the salt and dirt removed. The skins are then exposed to open air in vertical position to lose the excess water.

The following process is the elimination of the fur by the application on the skins inside for three hours of a saturated solution of sodium sulphide (Na<sub>2</sub>S) and calcium hydroxide, Ca(OH)<sub>2</sub>, obtained from hydrating the calcium oxide,

known as *pedra de cal*. The chemical reactions that occur during this process are complex but essentially are based on the solubilisation of the keratin by breaking the disulphide bond (-S-S-) contained in the cistine molecule. The presence of calcium hydroxide stabilizes the pH of the washing bath around 12.5, optimal for the depilation and for the reduction action of sulphide and sulfhydrate. The chemical reagents penetrate into the skin until the follicular level and attack the radix



Figure 7. Main steps of the thawing procedure of two animal skins: a) sheep (white) and goat (black) skins; b) chemical reagents used for depilating the skins (sodium sulphide ( $Na_2S$ ) and calcium hydroxide,  $Ca(OH)_2$ ); c) preparation of the mixture for the depilation; d) immersion of the skins into the mixture; e) mechanical removal of the hair; f) ingredients of the Bolognese manuscript recipe; g) mixing the products for the thawing process; and h) heating the mixture before the treatment of the skins..

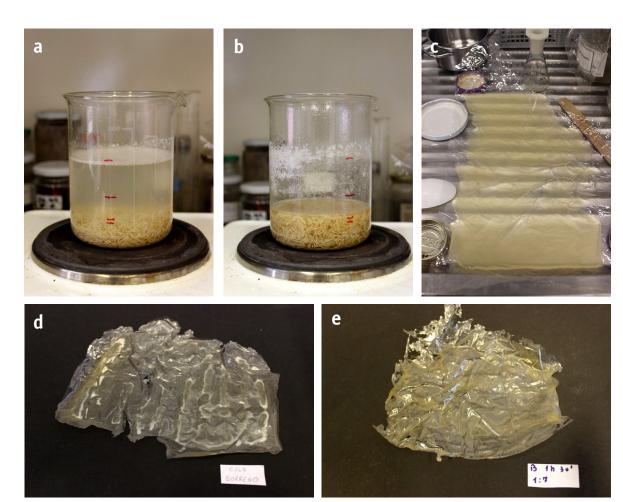


Figure 8. Main steps to obtain sheep skin glue: a) hydrated small fragments of sheep skin to be dissolved on a heating plate; b) monitoring of the water level; c) drying the glue solution on a melinex sheet; d) dried foil of sheep gelatine; and e) dried foil of sheep gelatine, ratio 1:7 in water boiled for 1h30.

of the fur that is then removed mechanically with a big blade, especially made for this task.

The depilated skins were left overnight in water and washed to remove all the residual fur. The following day the removal of the residual tissues that connect the skin to the bones was performed mechanically. The final process was the exposure to the air of the skins after stretching on wooden sticks in order to eliminate the water for complete drying. The skins were then ready to be thawed using potash alum according to the Bolognese Manuscript recipe.

Figure 7 shows the steps of the thawing procedure executed at the LIFER leather factory located in

the village of Nossa Senhora de Machede, Évora with the help of the Mr. Lidório Fernandes.

The preliminary tests led to: a protocol for both the skins as well as temperature and time for boiling the skins in water in order to obtain a gelatinous composition; the drying technique; and the procedure to obtain the sizing material (glue) from the animal gelatin.

The dried thawed skin was then cut in small fragments and left stand in water overnight. Once hydrated, it was put into a Becker with water in ratio of 1:7 (1 of skin and 7 of water) and then heated on a heating plate. After different trials to understand which is the ideal water temperature,

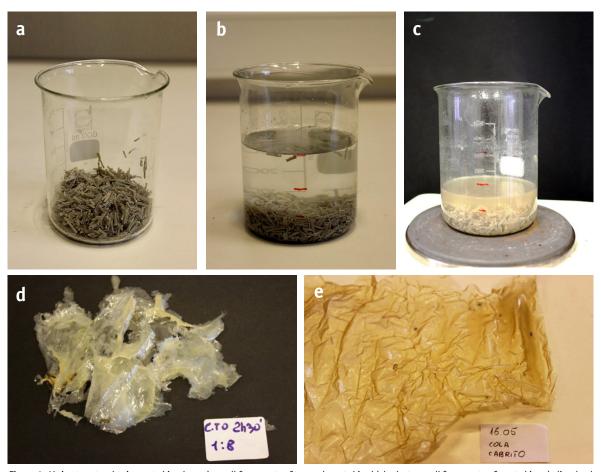


Figure 9. Main steps to obtain goat skin glue: a) small fragments of tanned goat skin; b) hydrate small fragments of goat skin; c) dissolved on a heating plate and monitoring the water level; d) experiment of dried foil of goat gelatine in a 1:8 ratio in water for 2h30; and e) dried foil of goat gelatine.

considering that the terminology in the treatises speak of "boiling water", this means reaching 100°C, it became obvious that the gelatin can be obtained by maintaining the heating temperature around 60-70°C. The procedure is considered finished when, after one day of heating, one third of the initial product is obtained. A careful monitoring of the water level is therefore recommended.

During heating, the skin fragments were not completely transformed into gelatin by which filtration using a sieve was necessary to separate the residues from the final product. The gelatin was then applied on a melinex sheet in a thin layer that once dried formed a rigid and transparent film that could easily be broken in small pieces or scales. This product can be conserved

in a dried environment and re-used by hydration to obtain the liquid animal glue/size.

Figures 8 and 9 shows the main steps to obtain the glue solutions or gelatin from the alum thawed animal skins. A slight difference in color and appearance is observed between the sheep and goat glues, both during the preparation in water solution and as film after the drying of the solution on a melinex sheet.

## 2.3. Application of Animal Glue Sizing and Gesso Grounds

Figure 10 illustrates the application on the wooden model sample of a layer of sizing, prepared from the animal glues and water in ratio of 1:7.



Figure 10. Main steps to the application of ground layers: a) Heating in "warm water bath" the goat gelatine; b) keeping the gelatine solution warm; c) first application of animal size with brush in flat sample; d) first application of animal size with brush in three-dimensional sample; e) mixing gesso with the gelatine; and f) application of first layer of ground on the flat sample.

According to the two Portuguese recipes, the gesso grounds must be obtained by mixing gesso powder with the binder, animal glue solutions obtained from the gelatin originated from thawed animal skins. Some authors mention the use of a piece of garlic boiled together with the gesso mixture that in the eighteen century was called *alhada* [24]. The astringent properties of garlic and the various sulfur compounds favor the adhesion of the several layers of *gesso grosso* and subsequently the ones of *gesso fino* that is applied

on top and sanded with abrasive papers between the different applications.

In this phase, several trials were done to understand which would be the proper quantity of water needed to obtain the glue hide, with good adhesive and cohesive properties for the gesso powder. The dried film scales were put overnight in water; after the hydration the excess water was eliminated and the resulting gelatin was heated in "warm water bath" at around 60 °C,

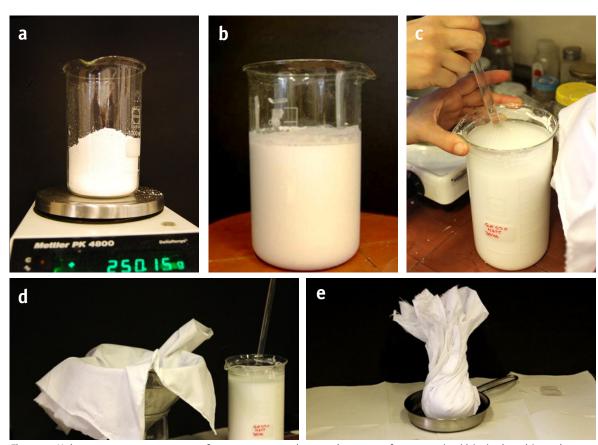


Figure 11. Main steps to prepare gesso mate from gesso grosso: a) measuring 150 gr of gesso powder; b) hydration with continuous changes of water; c) stir once a day preventing gypsum from setting; d) pouring the hydrated gesso into a cloth; and e) the water is squeezed off to obtain a loaf of gesso.

in order not to alter its properties. Then, the necessary quantity of gesso was added considering the density of the mixture, its color and viscosity. This is the part where experience and sensibility is more required because the result depends much from both the material and the artist's hand. It is necessary to obtain a homogenous mixture, with a good hiding power and easily sanded, without lumps.

The preparation of the *gesso mate* from the *gesso grosso* (previously calcinated gypsum) includes the hydration with continuous changes of water and shaking of the suspension during several days to prevent the gypsum setting. This procedure assures a good quality of *gesso fino* particles, dispersed and separated into water. Then, the slaked gesso is poured into a cloth and the water

squeezed off, a loaf being formed from the damp thixotropic *gesso fino*. This loaf will be mixed with the animal glue solution and will form a liquid mixture to be applied by brush.

Figure 11 shows the main steps for the obtaining of gesso fino by hydrating the gesso grosso and removing the excess water and the application of different layers of ground (Figure 12) followed by sanding the surface with an abrasive paper.

#### 2.4 The Bole Layers

For the preparation of the bole we used the loaves made of a red argillous material, immersed for five days into water. In the first days the mixture was agitated to promote the disaggregation of the mineral and its hydration. Once a suspension



Figure 12. Main steps to prepare ground and its application: a) sieving the loaf of gesso; b) grind the gesso in mortar to obtain gesso fine powder; c) mixing it with animal glue solution in a "warm water bath"; d) application with brush of several gesso fino layers; e) sanding the surface with an abrasive paper; and f) final sanding with fine abrasive paper.

without lumps was obtained, the argillous material was left to sediment on the bottom of the bucket and the excess water was eliminated. For obtaining the bole paste, 100 g of the sedimented material was mixed with 40 g of animal glue in a aqueous solution of 10 %. The number of layers varies according to the recipe and the application of the bole and glue mixture was made overlapping vertical and horizontal layers.

Figure 13 illustrates the main steps of bole obtained from powdering the natural mineral material and mixing it with animal glue solution (10% w/w) followed by its application procedure in perpendicular layers and by final polishing with a burnisher.

#### 3. Conclusions

Although limited to the description of ground and bole layers preparation and application, the

present paper shows the complexity of the documented reconstructions criteria and procedures for gilding techniques. These preliminary results of the task developed within the Gilt-Teller project are important to show how we can complement the practical work done in the laboratory with analytical evidences obtained by using complementary analytical tools and can be a precious source for further studies on gilding recipes, materials and techniques. Correlating the terminology and literature information with the practical data and critically approaching the different sources (historical and analytical) is the basic rule for correct reproduction of ancient recipes with nowadays means and materials.

According to our results, the quality control of the materials used is one of the most important aspects of the whole process of reconstruction. This control takes into account the rational choice of the most pure lots, obtained from the raw materials of high purity or from certified foreign

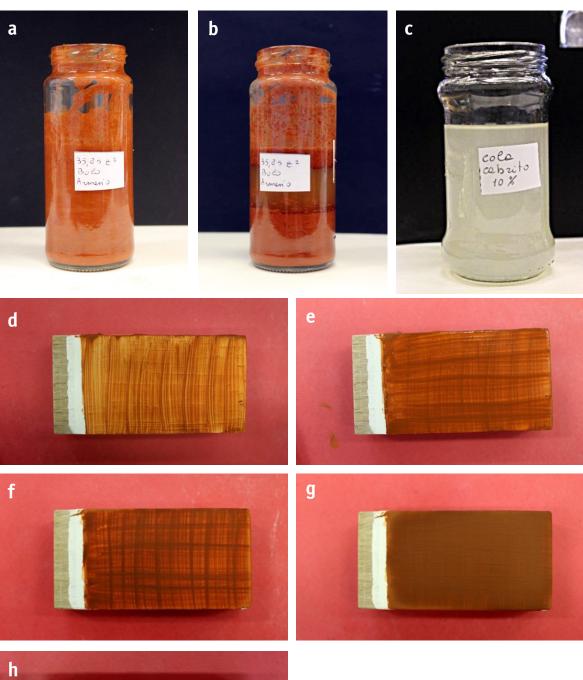




Figure 13. Preparation of red argillous material: a) loaf of bole immersed in water; b) material was left to sediment on the bottom of the bucket; c) lamb glue solution dissolved 10% (w/w) in water; d) first application of bole in the upwards position; e) transversal application of second layer; f) succeeding applications of bole layers in perpendicular layers; g) four layers of bole; and h) final polishing with a burnisher.

providers. In the case of gesso, taking into consideration the heterogeneity of some granular rocks the selenitic varieties should be preferred. On another hand, the presence of impurities can be useful for detecting the sources/localization of these raw materials, although not interesting to the present work.

The second part of this study will bring into attention the procedure for gold leaf application and

surface treatments and the analytical results on the reconstructions for the whole gilded composite.

#### 4. Acknowledgments

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# IRINA SANDU Conservation Scientist

irinasandu@uevora.pt

# FRANCESCA PABA Conservator-restorer

francescapaba@hotmail.com

## ELSA MURTA Conservator-restorer

elsa.murta@gmail.com

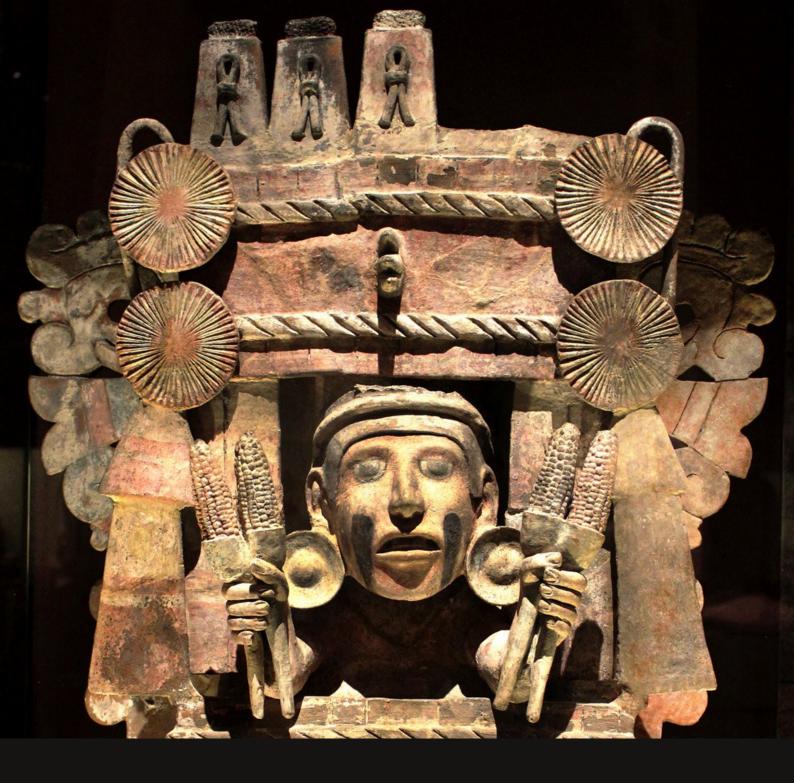
#### MANUEL COSTA PEREIRA Geologist

mfcp@ist.utl.pt

# CONCEIÇÃO RIBEIRO

**Conservator-restorer** 

sao.ccrestauro@gmail.com



# SYMBOLISM AND USE OF MAIZE IN PRE-HISPANIC AND COLONIAL RELIGIOUS IMAGERY IN MEXICO

Eva Leticia Brito Benítez

# Symbolism and Use of Maize in Pre-Hispanic and Colonial Religious Imagery in Mexico

#### Eva Leticia Brito Benítez

#### **ABSTRACT**

Maize was a sacred element and the central point of the religiosity for pre-Columbian civilizations in Mexico. The Tarascos, an ancient culture that settled in the western region of Michoacán, manufactured images using parts of the maize plant to represent their gods. After the Spanish conquest in the early 16<sup>th</sup> century and the beginning of the evangelization of native people, the first bishop of Michoacán Vasco de Quiroga, promoted the birth of an inedited art creating Christian sculptures with the ancient manufacturing technique. This article presents an historical review of symbolism and use of maize in religious imagery in Mexico, during pre-Hispanic era and Colonial period. It emphasizes on the Mesoamerican cultural signification of the plant and on the meaning of syncretism, understood it as the amalgamation of the native religion and Catholic beliefs. It is important that the world is aware of the existence of a Mexican inedited art that represents a tangible example of the fusion between two distant cultures.

#### 1. Introduction

Maize is a plant originally from America that belongs to the *Phocaea* family and the *Zea* genus which includes five species from Mexico and Central America. The Zea Mays species corresponds to the cultivated form, which is distributed nowadays on almost the entire Mexican soil. They are perennial, herbaceous, and robust plants that measure between one and four metres high, presenting a root from which a stalk springs in a cylindrical form and upright position, where long leaves are born. The fruits are edible, known as corn cobs or *elotes*, and consist of a core covered with rows of grains that can be yellow, purple, blue or white [1] (Figure 1).

The earliest evidence for domesticated maize was recovered from Guilá Naquitz Cave, in the southern Mexican State of Oaxaca, date to 4280 BC [2]. In

Tehuacán, State of Puebla, remains of the cultivated plant dating from 3000 BC were also found [3]. These discoveries were made in the area known as Mesoamerica (Figure 2), which covers part of the actual Mexican and Central American territories (from Guatemala to Nicaragua), where groups with similar cultural characteristics inhabited before the Spanish conquest in the early 16<sup>th</sup> century. Maize was the basic product of the Mesoamerican food, together with squash, bean and chili [4]. Until today, it is still the central product of the diet of the majority of Mexican people.

Maize was not only the economic base of Mesoamerica but it also represented a fundamental point in its religiosity. It was treated with respect and humbleness because it was the sacred element with which the gods had created the "real man" after various failed attempts with other materials. The Earth was seen as a plain object with four



Figure 1. Com cobs or elotes. Photo by Eva Chaire.

MESOAMERICA

PACIFIC OCEAN

Figure 2. Mesoamerica region.

corners oriented to the cardinal directions in a similar way to a corn field or *milpa*. Each of the agricultural calendar cycles implied a religious celebration related with fertility rituals. The gods of maize were represented in codex, mural paintings, ceramic vessels, stelas, and sculptures of different materials [5].

The pre-Hispanic Tarascan culture settled in Michoacán (AD 1200-1521), western region of Mexico, used parts of the maize plant to manufacture lightweight sculptures representing their deities, which could easily be transported by their priests to the battle fields [6]. It was the Mesoamerican symbolism of the plant and the technique invented by the Tarascan, the two factors that permitted the tangible production of gods with maize sacred essence.

After the discovery of America and the arrival of the Spaniards at the beginning of the 16<sup>th</sup> century, a new religion was imposed to the Mesoamerican cultures, although it did not have any significance to them. The missioners looked for symbolic elements in the pre-Hispanic iconography that could converge with the Catholic faith, so that the Indians could identify themselves with it. It was the first bishop of Michoacán, Don Vasco de Quiroga,

who promoted the birth of an inedited art of Christian religious imagery applying the Tarascan manufacturing technique [7]. In a similar form as the ancient effigies were carried by the priests during wars, their lightness resulted ideal to load the new sculptures during the processions of the Holy Week and other festivities of the liturgical calendar. Although pre-Columbian images of this kind did not survive, Christian sculptures from the 16<sup>th</sup> to the 18<sup>th</sup> centuries still exist in Mexico.

This article presents an historical review of symbolism and use of maize in religious imagery in Mexico, during pre-Hispanic era and Colonial period. It begins with the topic of sculptural and pictorial representations of maize deities of some Mesoamerican cultural groups; the second point discusses the creation of Catholic effigies employing parts of the maize plant; later, the iconography of Christian images is treated; and finally the manufacturing techniques are briefly explained, since they have already been studied in depth. This works emphasizes the Mesoamerican cultural signification of the plant and on the meaning of syncretism, understood it as the amalgamation of the native religion and Catholic beliefs, and not only as the application of Indian procedures to create Christian images.

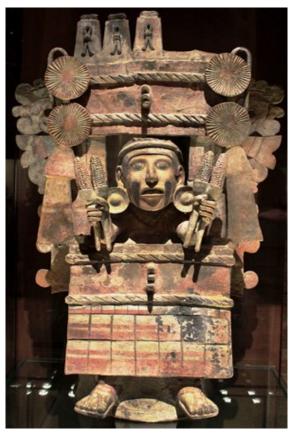


Figure 3. Mexican masculine god of maize. National Museum of Anthropology, Mexico. Photo by Eva Chaire.



Figure 4. Coatlicue. National Museum of Anthropology, Mexico. Photo by Eva Chaire.

#### 2. Pre-Hispanic Deities of Maize

The Mexicas or Aztecs, settled in the Central Altiplane of Mexican territory (AD 1325–1521), had a conjunction of feminine and masculine deities associated to maize (Figure 3). *Coatlicue* (coatl: serpent; cue: skirt) was the Náhuatl¹ name of the goddess of the sustainment in general (of all that was eaten and drunk), and of maize in particular (Figure 4). Furthermore, there were specific manifestations for each one of the ages of the

The ancient Mayas of the peninsula of Yucatán, settled in southern region of Mexico (2000 BC – AD 1521), represented the deity of maize as an individual with human traits, masculine, young, and with an accentuated cranial deformation<sup>2</sup>. In some cases, leaves and grains of maize with the figure of the affix *bil* (growth), emanated from his head. In codex, the hieroglyphic that accompanies him is *nal* (maize) [5]. A polychrome ceramic plate found in the archeological zone of Calakmul, State of Campeche, from the Early Classic period (AD 250-600), shows the god with winged arms and

plant: Xilonen was "the one who lives like a tender corn cob"; Centeotl represented the deity of the ripe corn cobs; and Ilamatecihuatl was "the lady with the old skirt, old dry corn cob covered by yellow and wrinkled leaves" [8].

<sup>&</sup>lt;sup>1</sup> Náhuatl is the native tongue that was spoken by the Mexicas or Aztecs and it still continues to be spoken in several regions of Mexico.

<sup>&</sup>lt;sup>2</sup> Cultural practice of intentional skull deformation performed by the Mayan and other Mesoamerican groups such as the Mexicas.

dressed in underwear of jaguar skin (Figure 5). Although archaeological objects with representations of the god have been preserved, he is often identified by specialists as "God E" since it is unknown with precision his Mayan name.

Tarascan culture (AD 1200-1521) worshiped a goddess named *Xaratanga*, lunar deity with feminine attributes tied to the agriculture fertility. Her name means "the one that shows something" or "the one that bears plants" which has been interpreted as "the supreme mother of nature". She is identified as the wife of the god of the underworld, which demonstrates her relation with the subterranean world, a place where the seed germinates and life emanates from [9].

Besides the representations of the divinities related with maize, the Tarascan also recreated those using constitutive materials of the same plant. The chronicle of the Franciscan friar Alonso de la Rea (1639), narrates that "[...] they are the inventors. Because they take the corn stalk and they take out the heart [...] and grinding it, a paste is made with a genus of glue that they call tatzingueni" [10]. They named tatzingueni to the mixture of orchid bulbs with a paste that was elaborated using the medulla of the corn stalk, to form a spongy mass with which they molded the body of the effigies.

The Relación de las Ceremonias y Ritos y Población y Gobierno de los Indios de la Provincia de Michoacán [6], a book written in 1541, shows that the Tarascan had lightweight sculptures elaborated with corn stalk that represented their gods and were taken to battles by priests called Tiuimencha (Figure 6). This way, the warriors would receive protection and motivation to triumph and, in case of defeated, they could flee carrying on their backs their deities so that they would not fall into enemy hands.



Figure 5. Mayan plate with the god of maize. Exposition "Faces of the Divinity", Fort of San Jose el Alto Museum, San Francisco de Campeche, State of Campeche. Photo by Eva Chaire.



Figure 6. Tiuimencha loading on his back a sculpture of maize stack (originally published by M. Toussaint, La Relación de Michoacán, su importancia artística, Imprenta Universitaria, 1937, p. 9).

During the military formation at the battle, the priests responsible for the gods *Caricaueri* and *Xaratanga* were placed in front of a squadron of 400 men [11]. Caricaueri was the lord of the war who identified the enemy, and benefited his people with



Figure 7. Virgin of the Health, Basilica of Pátzcuaro, State of Michoacán. Photo used with permission.

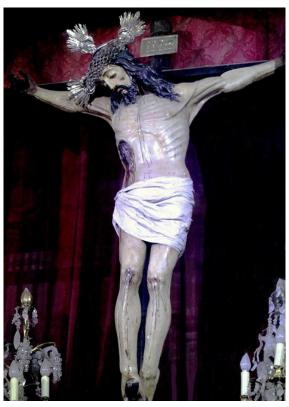


Figure 8. "Sleeping Christ" with "clean" body (16<sup>th</sup> century), Metropolitan Cathedral of Mexico. Photo by Eva Chaire.

material bonanza and a place for women and their children. The material reward was related to food and this, at the same time, with *Xaratanga*, the goddess of vegetation and maize. The name *Caricaueri* can also be translated as "the one who comes out making fire" or "the fire that comes out burning", alluding to the sun and giver of energy [9].

This couple, formed by a solar god from heaven and a lunar divinity that represented the underworld, symbolized the indispensable duality to guarantee the Cosmos dynamics: life and death, in order to achieve rebirth. It can be inferred that, even in defeat, the gods with maize heart guaranteed the rebirth of the warriors in a new life.

The images of Tarascan deities of maize stalk later disappeared. This was principally due to the fact that Spanish missioners destroyed and replaced them with new Christian figures. Another cause could be attributed to the biodegradation of its plant materials.

#### 3. The Birth of an Inedited Art

In 1523, the friars of the Order of Saint Francis of Assisi arrived; in 1565 they organized the territories under their jurisdiction and Michoacán passed to form part of the Providence of the Apostles of Saint Peter and Saint Paul. In 1538, Vasco de Quiroga was named the first bishop of Michoacán and became the principal promoter of the creation of Christian imagery applying the Tarascan technique.

It is believed that the first work of this kind is a Marian figure created around 1540, representing

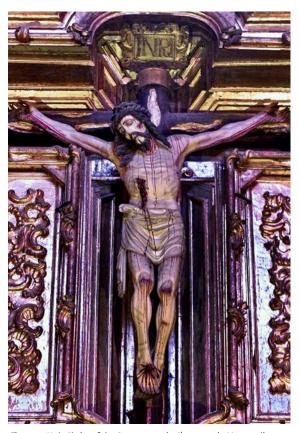


Figure 9. Holy Christ of the Conquerors (17<sup>th</sup> century), Metropolitan Cathedral of Mexico. Photo by Eva Chaire.

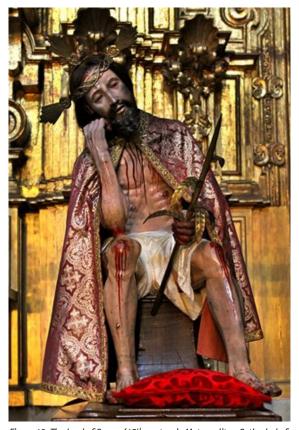


Figure 10. The Lord of Cocoa (18<sup>th</sup> century), Metropolitan Cathedral of Mexico. Photo by Eva Chaire.

the Immaculate Conception of Holy Virgin Mary, and whose author is considered to be an Indian named John, helped by a friar known as "the Italian". The image was baptized as Health of the Sick and located in the Hospital of Saint Mary in the town of Pátzcuaro, the capital of the ancient Bishopric of Michoacán [12]. Great devotion surged among the natives for her, whom they related to *Xaratanga*, in accordance with an ancient legend that narrates the Virgin converted herself into a mermaid who lived at the bottom of the lakes as the pre-Hispanic goddess did. In 1750, the sculpture was mutilated for dressing, and it is still kept in the Basilica of Pátzcuaro and known as the Virgin of the Health [13] (Figure 7).

According to friar Alonso de la Rea [10], the bishop Vasco de Quiroga brought from Spain the artist Matias de la Cerda especially to manufacture Christian images according to the Tarascan procedure. It is believed that he installed his workshop at Pátzcuaro, that he married a native woman and gave birth to a son named Luis de la Cerda, who later took on his father craft.

Some authors, such as Xavier Moyssén [14], sustain that there were other regions such as Querétaro and the Valley of Mexico where this type of effigies were produced. An example is the sculpture titled Virgin of the *Pueblito* (small town), dated 1632 and located in the convent of Querétaro, attributed to the Franciscan friar Sebastian Gallegos, who proceeded from the Province of the Apostles Saint Peter and Saint Paul of Michoacán.

The Catholic sculptures of maize stalk principally incarnated Jesus, central figure of the Christian doctrine that confirms to the believers the existence



Figure 11. Jesus Christ (17<sup>th</sup> century), Museum of Ex-Convent of Acolman, State of Mexico. Photo by Eva Chaire.



Figure 12. Lord of Collateral (probably 16th century), Parish of Assumption of Virgin Mary, Acaxochitlán, State of Hidalgo. Photo by L.F. López Monroy.

of a supreme being, and serves as the intermediary between his father and men. Other personalities were also represented, such as the Virgin Mary and the Wise Men, although in less proportion [15].

#### 4. Iconography of Christian Sculptures

The Renaissance predominant features of the images of Jesus Christ on the 16<sup>th</sup> century, such as the expressions of serenity, calm and nobility, dignified the pain that is manifested as a simple insinuation of their wounds. The bodies are known as "clean" since they lack blood because the evangelizers could not show a god crucified by men while they demanded the natives to abandon their human sacrifice practices. They commonly have eyes closed, for which they are also known as "sleeping Christs" [16]. An anonymous image of Jesus Christ with these characteristics is located in the Metropolitan Cathedral of Mexico (Figure 8).

The 17<sup>th</sup> century had as their maximum exponent Luis de la Cerda who, unlike his father, lived in a society in which cross-breeding proliferated and

the Baroque style was in heyday, giving birth to the "mexicanization" of the Christian figures. Their primordial objective was to show the torment of the crucified with an exaggerated realism that reached the point of cruelty; they were characterized by a corporal disproportion that exalted his suffering. The facial features lose the expression of calm and serenity to give way to a torturous agony. The skin is overwhelmed with scars and bruises from which qush forth abundant blood, reason of why they are usually named "bloody Christs" [17]. An example of this is the Holy Christ of the Conquerors, an anonymous piece from early 17<sup>th</sup> century, elaborated with maize stalk paste, polychrome and with shell incrustations (Figure 9), located at the Chapel of the Holy Christ and the Relics of the Metropolitan Cathedral of Mexico.

In the 18<sup>th</sup> century, the elaboration of Christian figures decreased but examples from this period have been preserved, such as the Lord of Cocoa, anonymous image realized with maize stalk paste, polychrome (now repainted), with natural hair and eyebrows. It is possible to appreciate it as an exempt sculpture (Figure 10), located at the

Chapel of Saint Joseph of the Metropolitan Cathedral of Mexico. Since the last century, the technique was retaken to elaborate small pieces with tourist sale goals.

#### 5. Manufacturing Techniques

None of the Colonial chronicles that mentioned the existence of Christian sculptures of maize stalk described with precision its making procedure. The images analysis were initiated by the Mexican specialists Julian Bonavit (1947) [17] and Abelardo Carrillo y Gariel (1949) [18], and followed by Salvador Cruz (1967) [19], Luis E. Orozco (1970) [20] and Enrique Luft (1972) [21]. Their results showed that there were different manufacturing techniques and a variety of materials employed besides parts of the maize plant. In 1975 also Andrés Estrada made an important contribution with the first national inventory of this kind of images [16]. Research in historical topics, manufacturing techniques, degradation processes and restoration treatments have been developed by several specialists [22-30].

The results allow us to classify and understand the characteristics of the principal making procedures which are briefly explained as follows.

#### 5.1. Sculptures with Core

From the waist up the skeleton was made with long fibers of maize stalk with a genus of glue that Tarascan called *tatzingue*. The bottom part was elaborated with a fragment of floral stems of *pita*<sup>3</sup>, to which other portions of the same material destined to form the core of the base were added. Over the frame, a coat of medulla of the same stalk was extended that served to give the complete body of the figure. The finishing consisted of a coat of chalk colored on the surface. It is believed

that the image named Lord of Collateral (Figure 12) of Acaxochitlán, State of Hidalgo, was made with this technique. The sculpture is located at the collateral altar of the Parish of Assumption of Virgin Mary of the town; its exact date is unknown but it is considered to belong to the 16<sup>th</sup> century [31].

#### 5.2. Images without Core

These are images constructed with stalks that are accommodated vertically, forming a great analogous bunch, glued together to a piece of wood without gaps. The cutting and the final molding were done coating and pressing the stalks until the desired form was attained, and finally the embodiment and the pictorial coat were applied.

#### 5.3. Effigies with Core of Maize Leaves

Firstly a core of dry leaves of the plant was formed, and then they were tied together by means of a string of *pita*, giving the approximated form of a human skeleton. For the extremities, the feathers of *guajolotes*<sup>4</sup> were used, which were twisted to mold the palms of the hands; the articulations were reinforced using thin strips of cotton cloth or *pita*. Over this skeleton, a coat of maize stalk paste was applied and with which the human body was sculptured, and on top, as a sort of stucco layer, a rough coat of chalk known as *ticatlali* was applied. The skin color was achieved with a tint and a final shine was given with some drying

<sup>&</sup>lt;sup>3</sup> Pita is a perennial plant with a light green colour that belongs to the Amaryllidaceae family, and it is native from Mexico. It has radical leaves, fleshy stalks and spines on the edge and tip; 15 to 20 centimetres wide at the base and up to 3 metres in length.

<sup>&</sup>lt;sup>4</sup> Word of Indian descent assigned to a specific category of turkey belonging to the Phasianidae family.

<sup>&</sup>lt;sup>5</sup> Amate is a tree of the Moraceae family, abundant in warm regions of Mexico. It was used to make a kind of paper commonly employed in pre-Hispanic codices.

vegetable oil. To simulate blood, retouchings were given with cochineal and carbon black pigments, as for the hair and beard, although in occasions natural hair was also applied.

As an example of the use of maize leaves, there is an anonymous Christian image of the early 17<sup>th</sup> century (Figure 11) kept in one of the museum cellars of the Ex-Convent of Acolman, State of Mexico. It was restored in 1990 by Calderón and Monteforte [24] who detected maize leaves in one broken arm.

#### 5.4. Sculptures Exempted

These correspond to the "hallow Christs". The frames are made with one or several glued sheets of paper, which can be of European (cotton or linen) or Mexican (amate<sup>5</sup>) origin. The sheets were manipulated fresh in order to form the thoracic cavity, legs, arms and head. Over the skeleton, a paste of maize stalk was applied to model the figure and over it the final polychrome was applied.

Independently of the applied technique there can be variations: the internal gaps increase or decrease in the images, the extremities and head can be made of stalk or wood, and the gauze of the same paste or textile superimposed, and it can be presence or absence of paper. Some images were also complemented with crystal eyes and tears, porcelain or ebony teeth, human nails, lashes and hair, and metallic ornaments.

#### 6. Conclusions

Maize had a very important cultural significance in Mesoamerica: it was the central point of religiosity and a sacred plant used to create sculptural representations of the gods. The Catholic religion was imposed by the Spanish conquerors

and the ancient deities of maize stalk were replaced with unknown images. However, the essence of the heathen divinities did not disappear, it survived through the maize employed to sculpt the heart and corps of Jesus, the son of a new god, who was made as a human being the same way the Mesoamerican man was modeled by his creators with the sacred plant.

The devotional images of maize stalk that have been preserved in Mexico are a clear expression of religious syncretism, something that should not be simply interpreted as the result of the union of a pre-Hispanic manufacturing technique with Christian symbols. Beyond that, it must be understood as the amalgamation of different religious beliefs as a consequence of a particular historical process and the cultural dynamics.

It is important that the world is aware of the existence of a Mexican inedited art that represents a tangible example of the fusion between two distant cultures, art that have survived for almost 500 years and continue to do so until today.

#### 7. Acknowledgements

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### EVA LETICIA BRITO BENÍTEZ Cultural Heritage Researcher

eva brito@inah.gob.mx

Eva received degrees in Restoration of Movable Cultural Heritage from Escuela Nacional de Conservación, Restauración y Museografía "Manuel del Castillo Negrete" and from Instituto Nacional de Antropología e Historia (INAH), Mexico. She also holds a doctorate in Mesoamerican Studies from Universidad Nacional Autónoma de México (UNAM), Mexico. She has been a teacher at INAH, Escuela Nacional de Conservación, Restauración y Museografía, and Diocesan Seminary of Campeche, in Mexico, as well as at the Universidad de la Laguna, Tenerife, Canary Islands, Spain.

# **Historical Perspectives on Preventive Conservation**



#### **Review by Daniel Cull**

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Preventive restoration is also more imperative if not more necessary, than an extremely urgent restoration, because it is intended precisely to avoid the latter.

(Brandi, p. 11)

This is the sixth volume in the "Readings in Conservation" series by the Getty Conservation Institute, the series began with Historical and Philosophical Issues in the Conservation of Cultural Heritage a timely contribution to the field, the series has proceeded through various conservation specialisms covering; Paintings, Photographs, Textiles, and Archaeological Sites, and now the sixth book covers Preventive Conservation. The book contains 65 texts, narrowed down from an initial selection of over a thousand possible texts in the editor's original shortlist. I shall endeavour to give an overview of the types of texts

included, to illustrate why this is a necessary addition to the bookshelf of anyone interested in preventive conservation, and particularly those interested in teaching its historical development.

The book contains a vast array of well written informative texts, forming almost certainly the broadest single collection of readings on Preventive Conservation available in English; moreover it is beautifully illustrated with full page colour images throughout, including a full page engraving of a bookworm; a scary sight when flicking through the book! The texts are arranged by theme, and chronologically within each theme, allowing the reader to get a sense of the historical development

of the field. One of the core narratives of the book is the attempt to show the circular nature of thinking about preventive conservation, and the ways in which current discourses surrounding sustainability are looking back to our pre-"professional" days for inspiration and ideas, to my mind this shows the begin-nings of a level of maturity in our field. The core of the book is divided into nine sections, the first three could be considered background sections, namely: 'Philosophies of Preventive Conservation', 'Keeping Things', 'Early Years of Conser-vation in Museums', the following five sections could constitute what would today be known as the core work of the preventive conservator, specifically; 'Relative Humidity and Temperature', 'Light', 'Pests', 'Pollution' and 'The Museum Environment and Risk Management', while the final chapter quite sensibly focuses on looking at 'Future Trends'.

The background section starts with 'Philosophies of Preventive Conservation', taking its lead from the first of the book series, situating Preventive Conservation within the theoretical conservation tradition, and includes seminal figures such as John Ruskin, William Morris, Cesare Brandi, and David Lowenthal. Interestingly Mariam Clavir is included introducing the concepts of intangible cultural heritage and significance; and hinting at the possibilities of a non-western (or non-Eurocentric) conservation tradition. In part 2, 'Keeping Things', we find eleven readings that consider traditions of saving and looking after objects; whether religious, artistic, or family heirlooms. Although this section goes on to show the development of cabinets of curiosities widely agreed to be the origin of the museum concept, the texts I found to be the most fascinating related to 18<sup>th</sup> century housekeeping practices, and traditional Indian techniques for protection from insects and mitigating the effects of climate. The final historical section is 'Early Years of Conservation

in Museums', in which the book considers the role of Preventive Conservation in early museology. The editor admits that although the first official museum was founded in 1683, the Ashmolean Museum at the University of Oxford, there is a dearth of literature until the mid-19<sup>th</sup> century concerned with Preventive Conservation in the museum environment. I was amused to read a line referring to "architects of eminence" (p. 94) showing that starchitects have always been drawn to museums. It is clear to see in this section a growing appreciation, and need for knowledge of Preventive Conservation.

The next sections, and the bulk of the contents, broadly define what has become the core work of the Preventive Conservator; we are introduced to the agents of deterioration, and the growth of a scientific understanding of how and why objects change. In Part 4 there are ten texts that consider 'Relative Humidity and Temperature', one of which covers the famous, almost mythical, storage of objects from the National Gallery in Welsh caves during the Second World War. Deemed such a successful decision that the airconditioning installed post war at the National Gallery was designed to try to simulate the conditions of the Manod Quarry! The book includes a few of those fabulous photographs of priceless art packed perilously on the back of old trucks. Part 4 concludes with the essential Applying Science to the Question of Museum Climate that illustrates the many reasons for historical inflexible quidelines and how greater scientific understanding has allowed more flexible guidelines to be adopted, ultimately improving the care of collections. "While entrenched thinking (or lack of it) has persisted, the new guidelines have gained wide acceptance" (p. 177). Part 5 is a shorter section with only six texts discussing 'Light'. The first by Brommelle summarizes the influential 1886 Russell and Abney Report that

discussed the effects of light on watercolours, for a long time this report was difficult to find, unfortunately although it is now available online [1] no links are cited in the book. The rest of the texts discuss a variety of aspects of light, and our increasing understanding of different types of light. Although a solid overview I could not help but think that this part of the book cut off chronologically too early and in so doing missed opportunities to consider more recent discussions in the field around micro-fading and/or the implications of LED lighting.

If preventive conservators have nemesis, in Part 6 we get to meet them: 'Pests', the section begins with extracts from servant instructions in insect prevention in the 18<sup>th</sup> and 19<sup>th</sup> century, as time goes on we see the introduction of highly toxic chemicals as scientists gain a foothold, and then we are introduced to the concept of Integrated Pest Management and methods of prevention as widely practiced in museums today. I particularly appreciated the inclusion of an extract from Rachel Carson's ground-breaking environmental book 'Silent Spring', the inclusion of texts that are not from the profession, but have been highly influential, is exactly the contextualising function I believe a 'reader in conservation' should have. In the next part we move on to discussion 'Pollution'; amusingly for a book written in LA all the texts discuss the smog of London. These discussions begin in 1661 with the publication 'Fumifugium', decrying the air quality created by burning coal, and suggesting a remedy of removing coal based industry and planting sweet smelling flowers. It will surprise no one that this advice was ignored at the time. I was really pleased to see included Loftus St. George Byne's article about the corrosion of shells at the British Museum, and article I've seen quoted and referenced numerous times but never had the opportunity to read before. It's great to see

such classics included as they truly add to the importance of this publication. The final part of this section considers the application of the knowledge developed so far in 'The Museum Environment and Risk Management'. This part includes the Preface to both the first and second edition of Garry Thomson's 'The Museum Environment', probably still most significant, how-to quide for preventive conservation. The choice to include the prefaces is important as they are often overlooked, although they form one of the most important sections of the book in that that they lay out the limitations of the information therein; "No one who reads this book will fail to end with a realisation of our general ignorance" (p. 303), the failure to take heed of these words led to the book mistakenly being turned into unchallengeable rules to be strictly adhered to, a realisation that has been significant in recent discourse in the field.

The book concludes by considering 'Future Trends', and is packed with 12 texts covering economics, sustainability and management of change. The chapter begins with a set of predictions by Garry Thomson, editorially suggesting the prescient abilities of this great-man of the field; I'm more sceptical and would put forward the suggestion that many of the developments were made by people who took his words as challenges and qoals to be achieved. I thought it was an excellent choice to include Kate Clark's 'Informed Conservation' to stress the dynamic nature, and facilitated-use role, of conservation, I think this article really speaks to a future I would like to see in saying "Conservation is becoming increasingly positive and proactive, rather than negative and re-active" (p. 353). There follows a whole series of articles discussing various aspects of sustainability, and the final two texts are interesting in that one, by Roberto Nardi, develops the idea that conservation should take place in the public

view, if the field wants public support, and the final paper is by the editor Sarah Staniforth and utilizing a writing style I really appreciate with that draws upon another field, in this case the slow food movement, as a source of inspiration. To my mind the major hole in, and ultimately the missed opportunity with, this final collection of writings is that there is nothing from outside the western academic/conservation canon, and although there was earlier in the book an indication of alternative ways of thinking about conservation with for example the inclusion of Lowenthal, Clavir, Itoh, and Agrawal, by failing to include similar thoughts in the future trends section these earlier texts take on the role of indicating missed opportunities and roads less travelled. I personally feel that it would have been great to include something written about sustainability from outside of the West, and my vote for essential text would have been something to do with the Malian idea of Culture Banks [2], truly bridging the idea of sustainable cultural and economic development and a great model for social utility of the conservation profession.

Ultimately this book will I believe quite rightly become a classic in the preventive canon; with its vast array of texts and even more extensive additional readings bibliography. This book will likely become an essential reading for students and professional alike, and will likely garner significant interest in the lay public too. As Timothy P. Whalen notes in his Foreword, "In order to advance conservation practice, it is important that we understand previous practices and rationales, consider how they have evolved, and think critically about the challenges ahead", this volume is a great step along such a road, and all concerned with its creation, especially its editor Sarah Staniforth, should be congratulated for their work.

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#### **Daniel Cull**

Preventive Conservator Historic Royal Palaces Daniel.Cull@hrp.org.uk

Daniel Cull is interested in Preventive Conservation. Ethnographic Conservation, and Conservation Theory. Daniel has worked at institutions in the UK and USA, he currently supervises Preventive Conservation activities at Kensington Palace, the Tower of London, and Banqueting House, Whitehall. Daniel trained at the Institute of Archaeology, University College London. He has served as a board member of e-conservation magazine and on the board of the Western Association for Art Conservation. His recent research interests have focused around Web 2.0, Wikipedia, and the ethical implications of the emerging social media landscape for conservators. He has also published on post-colonial ethics, Native American contemporary art, and collaborative or consultation-led conservation.

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