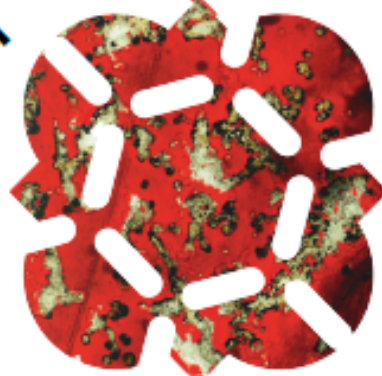


# SCIENCE and ENGINEERING in ARTS HERITAGE and ARCHEOLOGY SEAHA



4-6 June  
Woburn House  
WC1H 9HQ  
London, UK

On 6 June 2018 SEAHA will  
collaborate with ICOM-CC  
in the organizing of a  
roundtable for emerging professionals

## INVITED SPEAKERS

May Cassar  
Matthew Collins  
Edonis Jesus  
Chris Jones  
Grant Miller  
Nicola Masini  
Baroness Margaret Sharp  
Luca Pezzati  
Sofia Olhede

## ICOM-CC International CONFERENCE



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# BOOK OF ABSTRACTS

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## COMMITTEE

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*Conference Co-Chair*

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*Sponsorship and exhibitor liaison*

## PROGRAMME OVERVIEW

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### Speaker Sessions at-a-glance

Monday 4<sup>th</sup> June

Morning Session 1                      Novel technologies for monitoring Cultural Heritage   10.15-  
10.55

**Monitoring moisture content in historic timber-frame buildings with replacement infill panels**

*Mr Christopher Whitman*                      *Welsh School of Architecture, Cardiff University*

**Preventive Conservation and 3D - A photogrammetry protocol for deformation monitoring**

*Ms Armandine Colson*                      *German Maritime Museum*

Morning Session 2                      Building information research in Heritage Science   11.55-  
12.35

**Tracing back architectural spaces using the 3D laser scanning of ruins**

*Ms Bernadette Devilat*                      *University College London*

**Interdisciplinary study of hidden and invisible polychromies of the Basel Cathedral**

*Dr Tiziana Lombardo*                      *Swiss National Museum, Collection Centre*

Afternoon Session 1                      Developing Research Infrastructure                      14.10-  
14.50

**A gel electrochemical cell for in situ assessment of patinas and protective coatings for metals**

*Dr Emilio Cano*                      *CENIM-CSIC*

**Mobile Nuclear Magnetic Resonance as a Tool for Cultural Heritage Research**

*Prof Maria Baias*                      *New York University Abu Dhabi*

Afternoon Session 2                      Evidence Supported Policy Making                      16.00-  
17.00

**Emissions from PU insulation products- discovering the known unknowns**

*Mr Dzhordzhio Naldzhiev*

*SEAHA CDT, University College London*

**Engaging with industry to characterize volatile emissions from museum display case materials**

*Dr Elyse Canosa*

*Swedish National Heritage Board*

**Tuesday 5<sup>th</sup> June**

Morning Session 1

Analysis of Challenging Materials and Collections

9.55-11.00

**Violin varnishes: nanomechanics and advanced chemical analysis**

*Dr Marianne Odlyha*

*Birkbeck, University of London*

**Compatibility between traditional ground layers and 3D printing materials**

*Dr Bartolo Megna*

*DICAM, University of Palermo*

**Custom made gecko-inspired dry adhesives for heritage conservation**

*Mr Jacek Olender*

*Courtauld Institute of Art*

Morning Session 2

Bio/Chemo-Archaeology in Heritage Science

11.55-

12.35

**The metagenome of the York Gospels**

*Dr Matthew Teasdale*

*University of York*

**Characterisation of excavated Napoleonic artefacts from the Berezina and Waterloo battlefield using neutron and x-ray techniques**

*Mr Duncan Atkins*

*Institute Laue Langevin*

Afternoon Session 1

Dealing with big data in Heritage Science

14.10-

14.50

**Understanding Original Materials through Shared Scientific Reference Sample Collections**

*Dr Fenella France*

*Library of Congress*

**Crowd-sourced data in preventive conservation of large library collections**

*Miss Natalie Brown*

*SEAHA CDT, University College London*

Afternoon Session 2  
17.00

Crowd-Sourcing and Participatory Research

16.00-

**Crowdsourcing conservation: using visitors photographs to help manage and conserve heritage sites**

*Ms Rosie Brigham*

*SEAHA CDT, University College London*

**Use of 3D Printing in the Exhibition Hall: Museum Visitor Preferences**

*Mr Paul Wilson*

*University of Warwick*

**Mapping the Resilience of the York Historic Centre to Enhance the Community Local Flood Culture**

*Ms Alessandra Sprega*

*University of York*

## EXHIBITORS & SPONSORS

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We are delighted to announce the support of the following exhibitors:

**Analytik Ltd: A leading provider of Innovative Analytical Solutions**

Analytik provides cutting-edge scientific instrumentation to leading organisations throughout the UK and Ireland. We specialise in NIR, FTIR and Raman Spectroscopy Solutions, Multi and Hyper-spectral Imaging, and Light Measurement Solutions for the Conservation and Heritage sector.

Our advanced instrumentation offers academics and conservators alike an unprecedented opportunity to analyse precious and fragile artefacts, artwork and exhibits using non-invasive and non-destructive techniques. We've helped researchers across the UK and Ireland analyse colour in ancient sculptures, characterise pigments in manuscripts and improve monitoring of cultural heritage objects.

As a SEAHA partner, we are proud to support the SEAHA 2018 Conference. You can find out more about our products and solutions at [analytik.co.uk](http://analytik.co.uk).



## Heritage Science

Heritage Science is a fully open-access journal from Springer Nature, publishing original peer-reviewed research covering scientific, mathematical and computational methods and analysis of objects, materials, artefacts and artworks of cultural and historical significance in the context of heritage and conservation studies. Launched in 2013, Heritage Science aims to be the premier forum for the communication of quality research from the heritage science community, keeping the ethos of open science, open data and public engagement as its mission.

Springer Nature advances discovery by publishing robust and insightful research, supporting the development of new areas of knowledge and making ideas and information accessible around the world. We provide the best possible service to the whole research community.





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Headwall is the leading producer of spectral instrumentation for OEMs and end users worldwide. The Company's focus is on diffractive optics, in the form of very precise holographic diffraction gratings. These components and the spectral modules/spectrometers they enable are available to OEMs in industries such as color measurement and bio-medicine.

Headwall also produces imaging sensors that cover spectral ranges from UV-VIS to SWIR, as well as completely integrated solutions for airborne, medical/biotech, and advanced machine vision applications.



Moreover, we would like to thank our supporting sponsor:



## INVITED SPEAKERS

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### Nicola Masini

*CNR – Institute for Archaeological and Monumental Heritage (IBAM)*

Nicola Masini is Senior Researcher and Responsible of seat of Potenza of Institute of Archaeological and Monumental Heritage of National Research Council (IBAM-CNR). He is also Professor of Architectural Restoration in the School of Architecture in Matera, Director of the Italian Archaeogeophysics Mission in Peru. His scientific activity has been developing along two main lines of research: Earth observation sciences for Archaeological research, and non-invasive sensing technologies for Architectural and Archaeological heritage conservation and management.

He authored and co-authored over 320 publications.

Currently, he is responsible for two H2020 Projects: ATHENA (H2020-TWINN-2015) aimed at creating a Remote Sensing Science Center for Cultural Heritage in Cyprus and GeoMOP (H2020-MSCA-IF-2016)

For additional information see [his curriculum vitae](#).

Presenting:

**Earth Observation for archaeological research and cultural heritage management and monitoring. Approaches, case studies and new perspectives**

In the last two decades, the improvement of device performance and resolution of sensors as well as the increasing availability of user-friendly softwares for data analysis and processing have led to an increasing interest in the use of Earth Observation (EO) sciences and technologies for the study of human past, cultural heritage (CH) risk assessment and monitoring. The usefulness EO technologies in the CH domain depends also on the quality of the feedback between scientists and professionals/end-users (archaeologists/conservators/historians). This gap is due to the difficulty to interpret EO products for the diverse issues related to Cultural heritage interpretation, conservation and monitoring. Some experiences suggest different ways to facilitate the interpretation of EO results/products such as the data integration, the development of ad hoc data processing and feature extraction methods, the use of direct data for the validation of remote sensing-based results, the augmented reality and holistic approaches. The lecture deals with an overview of remote sensing based approaches for archaeological research and cultural heritage conservation. A number of case studies in Europe (Pompeii, Apulia), Southern America (Nasca, Macchu Picchu) and China (Silk Road and Luoyang) will be showed and discussed. The lecture conclude with a look at the future of Heritage Science and in particular CH remote sensing, also in view of the Copernicus Program and promising opportunities for scientific cooperation deriving from European Research Infrastructure for Heritage Science.

## Edonis Jesus

*Architect, Founder and chairwoman of BIM4Heritage*

Edonis Jesus leads and supervises the delivery of Building Information Modelling (BIM) operations for the Lendlease Consulting business unit.

She is a highly experienced architect with BIM and project management experience, with a deep understanding of integrated design approaches to the delivery of buildings with improved financial, environmental and social performance throughout their whole lifecycle.

Edonis founded and chairs BIM4Heritage, which is a special interest group established to champion Building Information Modelling (BIM) within the Historic Environment. She also sits on the UK BIM Alliance, and several other industry BIM committees.

Presenting:

**How can BIM help to the understanding and preservation of the historic environment?**

Using Building Information Modelling (BIM) within the historic environment is a developing concept that can potentially transform the way we understand and preserve structures.

As defined in the British government industrial strategy (2012), “BIM is a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets. BIM embeds key product and asset data and a three-dimensional computer model that can be used for effective management of information throughout a project lifecycle – from earliest concept through to operation.”

BIM is often associated with the construction of new build, but what of the refurbishment of existing buildings and in particular, heritage assets - How can BIM help us understand and preserve the historic environment?

This presentation looks at the concepts of Building Information Modelling (BIM); challenges and benefits of its implementation within the historic environment and the work being led by the BIM4Heritage committee.

## Luca Pezzati

*The National Research Council of Italy (CNR), European Research Infrastructure for Heritage Science*

Luca Pezzati is a physicist and an optics specialist. Since 1995 he is with INO-CNR (the [National Institute for Optics of the National Research Council](#) of Italy) where he is currently Senior Researcher. He started the Gruppo Beni Culturali (Art Diagnostic Group) of INO in 1998 and coordinated it for 14 years. He managed many research projects for CNR in the field of optical technologies applied to Cultural Heritage. He managed many research projects for CNR in the field of optical technologies applied to Cultural Heritage. He is a coordinator of E-RIHS, the [European Research Infrastructure for Heritage Science](#) (H2020- INFRADEV02-2016) and of the integrating activity project [IPERION CH](#) (H2020-INFRAIA-2014). He coordinated the National Node of DARIAH ERIC, [DARIAH IT](#) from 2013 to Nov.2016.

Presenting:

### European Research Infrastructure for Heritage Science

The European Research Infrastructure for Heritage Science (E-RIHS, [ˈɪrɪs]) – a Project in the ESFRI Roadmap ([www.esfri.eu](http://www.esfri.eu)) – supports research on heritage interpretation, preservation, documentation and management. E-RIHS is a distributed research infrastructure organized in a star structure: facilities from more than 20 Countries join national networks, coordinated by independent National Hubs, and the E-RIHS Central Hub in Italy, Florence, provides the unique access point to all E-RIHS services. E-RIHS will provide state-of-the-art tools and services to cross-disciplinary research communities of users through its four platforms: MOLAB: access to advanced mobile analytical instrumentation; FIXLAB: access to large-scale and laboratory facilities; ARCHLAB: physical access to archives and collections; DIGILAB: virtual access to tools and data hubs for heritage research – including measurement results, analytical data and documentation – from large academic as well as research and heritage institutions.

E-RIHS will help the preservation of the World's Heritage by enabling cutting-edge research in heritage science, liaising with governments and heritage institutions to promote its sustainable development and, finally, raising the appreciation of the large public for cultural and natural heritage and the recognition of its historic, social and economic significance.

E-RIHS started in February 2017 its preparatory phase supported by the EU project E-RIHS PP (H2020-INFRADEV-02-2016). Representatives of 23 Countries are now working together to prepare E-RIHS to be launched as a standalone research infrastructure consortium (ERIC) in 2021.

<http://www.e-rihs.eu/>

## **Baroness Margaret Sharp**

*Chairwoman of the House of Lords Select Committee inquiry into Science and Heritage*

Baroness Margaret Sharp chaired the House of Lords Select Committee inquiry into Science and Heritage which was seminal in stimulating renewed investment in research and training in Heritage Science in the UK.

Although the Committee reported over 10 years ago, she has remained involved in the area and is a member of the SEAHA Advisory Board.

Prior to entering the House of Lords in 1998, Baroness Sharp was for 20 years a fellow at the Science Policy Research Unit at the University of Sussex and wrote extensively about the development of science and innovation policy in both the UK and the EU.

Presenting:

**Austerity, Sustainability and Heritage Science**

## Chris Jones

*Head of Department, Core Research Laboratories at Natural History Museum London*

Chris Jones is Head of Core Research Laboratories at the Natural History Museum, London, incorporating the Imaging and Analysis Centre (IAC), Conservation Centre, Molecular Biology Labs and the more recently formed Collection Management Systems. Chris trained as an earth scientist and has specialised in the application of electron microscopy (standard high vacuum, variable pressure and field emission SEM) for the imaging and analysis (EDX) of specimens ranging from naturally occurring samples from the Museum's extensive collections through to materials and synthetics.

Prior to working at the Museum Chris worked in the Geology department at Oxford Brookes University and also spent eight years as an applications scientist in industry, working for Hitachi High Technologies, centred on the development of electron microscopy instruments and methods and their application in industry and academia.

Chris has published a number of peer reviewed papers ranging from ultrastructure in bryozoans through to the natural mineral pigments in works of art and contributed book chapters on the application of electron microscopy.

Presenting:

### **Natural History Museum – application of imaging and analysis to cultural and science heritage projects**

As a national museum and a scientific research organisation of international reputation, the Natural History Museum, London manages a programme of scientific, conservation and heritage challenges. The museum accommodates a registered collection of around 80 million naturally occurring objects ranging from insects and shells to dinosaurs, meteorites to plants and seeds and a library and archive of contemporary publications, rare manuscripts, drawings and paintings.

Research, curation and care and maintenance of the collection is required to fulfil the needs of the scientific research, care and conservation of the collection, presentation of specimens for public display and maintenance of a grade 1 listed building and the role it plays as a visitor attraction today.

This invited presentation will focus on three aspects of the museum's work, and its impact on science, public institutions, culture, heritage and global species conservation.

Three case studies will be presented:

#### **1. Blue whale skeleton**

The dismantling, conservation and remounting of a blue whale skeleton recovered from the Irish coast in the 1870's, and displayed in the museum's Mammals Hall since 1934, before removal in 2016 and forming the centre piece of a new exhibition in 2017. The conservation process included examination and analysis of bone and contaminants that have accumulated over the 80 plus year period of display. Various contaminants were identified and analysed using light, laser and electron imaging, x-ray elemental analysis and molecular techniques for DNA sequencing and identification. As an extension of the project the skeleton was 3D surface scanned, along with much of the museum's cetacean collection to form a digital surrogate collection.

#### **2. Diplodocus**

Forming the centre piece of the museum's Central Hall since 1979, Diplodocus has been dismantled, 3D surface scanned and a digitised, repaired and conserved and has embarked on a national tour of eight UK venues to add to the UK's national programme of museum and cultural heritage.

#### **3. Waterhouse building front entrance**

Reconfiguration and conservation of the museum's front ramp, developing step-free access in keeping with the building's heritage and aligning with grade 1 building planning and change regulations. An insight into how a Victorian building is as relevant today as a visitor attraction and benefit to society.



## Prof. Matthew Collins

*Niels Bohr Professor of Palaeoproteomics at the University of Copenhagen and Professor of Archaeology at the University of York*

Matthew Collins is Niels Bohr Professor of Palaeoproteomics at the University of Copenhagen and Professor of Archaeology at the University of York.

His research focuses on the persistence of proteins in ancient samples, using modelling to explore the racemization of amino acids and thermal history to predict the survival of DNA and other molecules. In particular, he is interested in developing technological solutions of direct practical application in the humanities.

Using a combination of approaches (including immunology and protein mass spectrometry) his research detects and interprets protein remnants in archaeological and fossil remains and he sees parchment as a most remarkable source of preserved animals skins documenting the history of a now lost craft.

Presenting:

### **Books and Beasts: Parchment manuscripts as a biological archive**

Skins of animals define the frontier between Western European history and prehistory. Turned into parchment they became the primary medium for our knowledge of pre-modern Western European culture. They were the most extensively used and best-preserved writing material in Europe before the piecemeal adoption of paper in the late Middle Ages and the early Modern Era. Digitisation campaigns are making more and more of the texts available as high-quality digital renders. However, the digital revolution, like earlier facsimiles, distances us from these objects. I will discuss a new project Beasts to Craft: (B2C) will exploit biomolecular and imaging methods, allied to craft knowledge, to document the first two stages in the story of the manuscript: (i) the livestock; (ii) the craft that turned skins into a writing medium.

## Prof. Sofia Olhede

*Professor of Statistics, Honorary Professor of Computer Science at University College London*

Sofia Olhede is a professor of Statistics, an honorary professor of Computer Science and a senior research associate of Mathematics at University College London. She joined UCL in 2007, before which she was a senior lecturer of statistics (associate professor) at Imperial College London (2006-2007), a lecturer of statistics (assistant professor) (2002-2006), where she also completed her PhD in 2003 and MSci in 2000. She has held three research fellowships while at UCL: UK Engineering and Physical Sciences Springboard fellowship as well as a five-year Leadership fellowship, and now holds a European Research Council Consolidator fellowship. Sofia has contributed to the study of stochastic processes; time series, random fields and networks. She is on the ICMS Programme Committee since September 2008, a member of the London Mathematical Society Research Meetings Committee, a member of the London Mathematical Society Research Policy Committee and an associate Editor for Transactions in Mathematics and its Applications. Sofia is also a member of the Royal Society and British Academy Data Governance Working Group, and the Royal Society working group on machine learning. Sofia is director of the UCL Centre for Data Science.

## Grant Miller

*Communications Lead, Zooniverse*

A former exoplanetary scientist, Grant is now responsible for communicating with our volunteers and researchers. He is also behind the Zooniverse's presence on social media and publishes the Daily Zooniverse blog.

Presenting:

### **Citizen Science and the Zooniverse**

Over the last decade citizen science has grown to become an integral part of many fields of research. Grant will introduce the Zooniverse, the world's largest platform for online citizen science, and discuss how it is working to tackle the crowd sourcing challenges of today and the future.

## Prof. May Cassar

*Director of UCL Institute for Sustainable Heritage at University College London*

Professor May Cassar is the Director of the UCL Institute for Sustainable Heritage and the Bartlett Vice Dean of Public Policy. May was appointed by the Department for Culture, Media and Sport as a member of its Science Advisory Council and recently to serve on the Department's Challenge Panel as part of its review of the National Heritage Memorial Fund and the Heritage Lottery Fund. May was appointed as only one of two external experts for Historic England's Science Review.

May currently directs the EPSRC Centre for Doctoral Training in Science and Engineering in Arts, Heritage and Archaeology, a multi-million pound UK Government investment to educate to doctoral level the next generation of heritage scientists. As the Director of the Arts and Humanities Research Council/Engineering and Physical Sciences Research Council's Science and Heritage Programme (2007-2014) and as Special Adviser to the House of Lords Science and Technology Committee Inquiry on Science and Heritage (2005-2006), May has led the resurgence of heritage science research activity in the UK over the last decade for which she has been recognised by the Royal Warrant Holders' Association with the award of the Plowden Gold Medal in 2012.

Presenting:

### **Heritage science economics: a social framework**

The economic environment is uncertain and business cycles are often driven by political and financial rather than social need. It would be wise therefore to expect as little as possible from Government under the current system. This is not to set the scene for a gloomy outlook but rather for a particular concept of heritage science economics. If we assume that newly fledged heritage scientists can expect little by way of traditional jobs, what opportunities and risk can self-reliance offer?

In this presentation, I will be taking a look at the present differently. Without imposing any political stance, I have chosen to look at the social elements of the Nordic economic model, to imagine the rewards that could arise from not waiting for the present system to provide solutions and what Government could do if it was fully engaged with the social agenda.

This means that structures which do not currently exist may need to be created and those that do exist may need to be developed in directions that support heritage science entrepreneurship. By joining the dots and adding a few more, a social framework may emerge that adds value to a new heritage science economics.

## SPEAKER PRESENTATION ABSTRACTS

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MONDAY 4<sup>TH</sup> JUNE

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MORNING SESSION 1

---

### **Monitoring moisture content in historic timber-frame buildings with replacement infill panels**

*Mr Christopher Whitman*

*Welsh School of Architecture, Cardiff University*

Co Authors:

*Prizeman, Oriol. Welsh School of Architecture, Cardiff University;*

*Gwilliam, Julie. Welsh School of Architecture, Cardiff University;*

*Walker, Pete. University of Bath;*

*Shea, Andy. University of Bath,*

**Keywords:** *Hygrothermal monitoring; Moisture content; Historic timber-framed buildings; Energy retrofit*

In an effort to reduce carbon emissions and improve energy efficiency and hygrothermal comfort, buildings across the UK are undergoing energy retrofits. For historic timber-frame buildings there exists the possibility that these modifications, undertaken with laudable intentions, could lead to elevated moisture content, exposing them to an increased risk of insect attack and fungal decay. This presentation will demonstrate the work that has been undertaken by the author to assess these risks through the use of in situ monitoring, laboratory testing and digital simulation. Electrical resistance measurements have been used to record both surface and interstitial moisture contents of oak frames with replacement infill panels in case study buildings and in laboratory conditions, mounted between two climate-controlled test chambers at the University of Bath's Building Research Park. In addition, digital simulations of a variety of replacement infill panel details have been undertaken with WUFI® Pro 5.3 and WUFI 2D developed by the Fraunhofer Institute. Coupled with temperature measurements, moisture contents have been cross-referenced with the hygrothermal conditions favourable to insect attack and fungal decay. The results of the digital simulation suggest that orientation, climatic conditions and infill material all significantly influence the moisture content, however, no prolonged periods of hygrothermal conditions favourable to biological decay agents were identified. Conversely, both in situ and laboratory measurements did detect some instances where hygrothermal conditions at the junction of the oak frame could facilitate insect and fungal attack. Further research is therefore proposed to investigate this discrepancy and to inform guidance that will enable the survival and continuing use of these historic buildings. This research has been made possible by the Association for Preservation Technology's Martin Weaver Scholarship.

### **Preventive Conservation and 3D - A photogrammetry protocol for deformation monitoring**

*Ms Armandine Colson*

*German Maritime Museum*

**Keywords:** *Photogrammetry, Deformation monitoring, Archaeological ship*

The discovery of well-preserved ship finds in archaeological context is rare. Large projects such as the Vasa (Sweden), the Mary-Rose (UK), the Bremen Cog (Germany) or the Viking ships in Roskilde (Denmark), showed the complexity of such excavations already in the 1960'. The archaeologists'

community is aware of the challenges occurring during field work and the different specialist needed on site. The conservation field has been dealing for more than 60 years with the development of treatments for waterlogged wood. The current consensus has been made around the use of Polyethylene Glycol (PEG), and such in different ways: combine with freeze drying or not, and using different molecular weight.

But what about after the treatment? How happens in the exhibition? Which kind of support is required?

Wood is a living entity and ships are not made to be stored on land. An archaeological ship is a combination of wood and conservation products making it a unique material. Which means that we know very little about the material properties of each ship and therefore foreseeing the ship's behaviour over time is not trivial.

Support systems are designed based on experience, but empirical information must be correlated with facts. Since 2014, the German Maritime Museum started to work on a digital three-dimensional acquisition protocol for the long-term monitoring of the Bremen Cog, 14th century vessel discovered in 1962 in the River Weser North of Bremen, Germany. The goal is to capture the displacement, which leads to the understanding of deformation processes. Along the way, the creation of a European working group on Monitoring of Preserved Ships (short MoPS) became a necessity and the first meeting was organised in 2017 in Bremerhaven.

The presentation will focus on the long-term monitoring issue based on the example of the Bremen Cog and the ongoing discussion within the MoPS working group.

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## MORNING SESSION 2

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### Tracing back architectural spaces using the 3D laser scanning of ruins

*Ms Bernadette Devilat*

*University College London*

**Keywords:** *3D laser scanning, built heritage, San Lorenzo de Tarapaca, Chile, earthquakes.*

Destroyed historic buildings can survive in the memory of future generations if records of them have been taken previously. That is not always the case. Sometimes, vestiges of buildings are the main source of information to speculate how they were. Measured architectural drawings could then be created from them — similar to archaeological methods. The accuracy of this process is challenged by the introduction of new surveying technologies such as 3D laser scanning.

A 3D laser scanning survey is a powerful and accurate recording method for the built environment as it combines high definition photos and a laser to build a measurable, coloured 3D model of the reality in a short period of time — in comparison with traditional surveying techniques such as hand-measured drawing.

This paper will show the 3D laser scan survey done in 2013 of the ruins of a series of dwellings in San Lorenzo de Tarapacá, Chile, partially destroyed after the 2005 earthquake, which had a magnitude of 7.9 (Mw).

3D laser scanning will be used as a basis to scale, adjust and create documentation of those buildings, in which previous records can be placed and measured, in an attempt to reconstruct how the

architectural spaces were. The result shows how scattered previous documents — mainly photographs — acquire new importance under the light of the 3D laser data.

This work allows for generating a virtual model of these buildings in their different stages of existence that can permanently exist in the digital realm, which is measurable and accurate, yet still partial due to the nature of previous documents. This would be relevant for diverting the potential need for a physical reconstruction, questioning the role of digital recording technologies of built heritage in post-earthquake situations. These aspects are further explored in author's PhD research: 'Reconstruction and record: exploring alternatives for heritage areas affected by earthquakes in Chile, supervised by Professors Stephen Gage and Camillo Boano at The Bartlett School of Architecture, University College London.

Keywords: 3D laser scanning, built heritage, San Lorenzo de Tarapacá, Chile, earthquakes.

### **Interdisciplinary study of hidden and invisible polychromies of the Basel Cathedral**

*Dr Tiziana Lombardo*

*Swiss National Museum, Collection Centre*

Co Authors:

*Marie Wörle, Swiss National Museum, Collection Centre*

*Bianca Burkhardt, Stiftung Basler, MÜNSTERBAUHÜTTE*

*Dorothea Schwinn Schürmann*

*Vera Hubert, Swiss National Museum, Collection Centre*

**Keywords:** *Polychromy, in situ XRF, Interdisciplinary*

The Cathedral of Basel, one of the outstanding late Roman/gothic cultural heritage buildings of Switzerland, appears generally as an aesthetic sandstone building. Nevertheless, historical evidences indicate the former presence of elaborated polychrome decoration on walls, tombs, bas-reliefs, statues etc. During the earthquake in 1356, the protestant reformation in 1524, and the 'purification' in 19th century, paintings have been destroyed, painted over or removed.

An interdisciplinary study, named PolyBasel, carried out by scientists, conservators and art historians was initiated to unveil the presence of rests and traces of original painted layers. Founded on historical and artistic bases a selection of several objects, all looking as made of naked stone was made. After a careful inspection, objects were then separated into two groups; one presenting tiny rests of possible polychromies in the hollow parts of the stone carving (hidden polychromies) and a second one where no evidence of former polychromies were found (invisible polychromies).

The first group was at first investigated in situ by XRF spectroscopy, then in the laboratory on designated samples in order to fully characterise the stratigraphy. In the case of the second one, a first screening was made using UV-light to highlight the presence of binder in the stone masonry; then in situ XRF spectroscopy was carried out.

Analyses show in both categories of objects the presence of former polychromies which could be original medieval ones. Proofs of later re-paints, very likely applied during two major renovation phases (in 1597 and 1772 or 1785/87) were also clearly identified in the case of hidden polychromies.

This study provides a totally new perception of the artistic value of the Basel Cathedral, especially for the 'invisible' pieces of mural painting, and brings a new highlight on the artistic and historical understanding of religious medieval buildings. Indeed, the findings could give new insights in the handling and interpretation of the "seen and unseen" polychromic decorations of other medieval European churches.

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## AFTERNOON SESSION 1

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### **A gel electrochemical cell for in situ assessment of patinas and protective coatings for metals**

*Dr Emilio Cano*

*CENIM-CSIC*

Co Author:

*Ramirez-Barat, Blanca; CENIM-CSIC*

**Keywords:** *Electrochemical Impedance Spectroscopy; metal conservation; coatings evaluation*

Over the past few years a big effort has been done in developing non-invasive techniques and portable instrumentation for cultural heritage studies. Besides classical analytical techniques, giving information on material's composition, other techniques assessing the conservation status of artefacts have acquired an increasingly important role in conservation science. Nevertheless, these techniques are less known and still far from being routinely, despite the relevance of having diagnostic tools in order to a better design of conservation treatments.

When speaking about metals, Electrochemical Impedance Spectroscopy (EIS) is a technique which provides information on electrochemical properties and behaviour of materials. EIS has been widely used in the study of corrosion mechanisms and coatings performance for industrial applications, and in the last two or three decades some researchers have been working in developing its application for cultural heritage. The application of EIS for in situ evaluation of the preservation status of metals sculptures and monuments is not an easy task. How to hold the electrolyte in contact with the irregular surface of the object, or how to interpret the results according to the complexity of the substrate and the often-limited quality of measurements due to low conductivity of the electrolyte or environmental noise- are the main constraints.

To overcome all these difficulties, we have been working in the development of a portable electrochemical cell with a gelled electrolyte (G-PE cell), especially designed for in situ measurements on cultural heritage. All design parameters such as influence of the gelled electrolyte, optimal concentration, selection of electrodes, cell geometry, etc. have been carefully studied to optimize the cell design. The design of the cell and a selection of case studies are presented to show the potential of this diagnostic tool for conservation assessment of metals and evaluation of coatings performance.

### **Mobile Nuclear Magnetic Resonance as a Tool for Cultural Heritage Research**

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**Keywords:** *Mobile nuclear magnetic resonance, Mummies, Violins, Paintings, Art forgeries*

Recent advancements in the field of non-destructive testing by nuclear magnetic resonance (NMR) were made possible by the development of single-sided mobile NMR sensors, capable of recording NMR signals from sample that are exterior to the magnet. The two main advantages of this method; its portability and non-invasiveness' fulfil the condition for analysis of precious objects that need to be kept safely in museums or archaeological sites and preserved intact during experiments. This makes mobile NMR an essential tool for studying objects and sites of high interest to the field of cultural heritage.

Here, we focus on the applications of the Profile NMR-MOUSE (MOBILE Universal Surface Explorer) sensor to cultural heritage research. We present how the NMR-MOUSE can be employed for the analysis and characterization of various objects of cultural heritage relevance, ranging from ancient mummies and bones to more recent artefacts, such as older and newer violins as well as modern paintings. We illustrate how this method can offer information related to the state of conservation of mummies, reveal insights into building a master violin and help identifying forgeries in the world of modern paintings.

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## AFTERNOON SESSION 2

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### **Emissions from PU insulation products- discovering the known unknowns**

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**Keywords:** *spray foam insulation; VOC emissions; contamination; indoor air quality*

The global polyurethane (PU) market is a multibillion pound industry. In 2015 the U.S., nearly 40% of the PU produced was used in the construction industry. The demand for PU insulation materials as a retrofitting measure for heritage buildings will grow even further considering the global drive of increasing energy efficiency. The potential for energy reduction is significant, but there is limited knowledge on a crucial unintended consequence of these retrofitting measures- the impact on indoor air quality from volatile organic compound (VOC) emissions. The current state of the academic research on such emissions is very limited taking into account the size of the market, wide range, application and availability of products. In order to fill this gap, we have conducted several experiments utilising SPME-GC-MS and TD-GC-MS to analyse VOCs emitted from three commercially obtained spray foam insulation (SPF) products. Passive sampling with SPME-GC-MS was used to undertake a broad analysis of the VOCs associated with the products and 1,2-dichloropropane (1,2-DCP) was found emitting from all three cured products. 1,2-DCP was found emitting from other SPF products in different studies, but its origins remained unknown. A TD-GC-MS analysis was later undertaken on only one of the closed cell foams and the raw material from which it was produced (B-side). Our results indicated that 1,2-DCP and 1,4-dioxane were present in the raw material and emitted from the cured product. Albeit the scale of the study is quite limited, the results do point to contamination of the raw products as a likely source of these VOCs.

This research could highlight that Class 1 and 2B carcinogenic VOCs were present in the raw ingredients of SPF products and that they should be averted at the source. These actions would negate the effort to control and mitigate the emissions to safe levels through natural and mechanical ventilation once they have potentially impacted the indoor air quality.

## Engaging with industry to characterize volatile emissions from museum display case materials

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**Keywords:** *Emissions, plastics, preventive, air quality*

Researchers at the Swedish National Heritage Board (RAÄ) are currently investigating emissions from museum construction, display, and storage materials. As part of the project, RAÄ collaborated with industry to analyse volatile compounds from medium density fibreboard (MDF) and Forex® rigid polyvinyl chloride (PVC) sheets. Rigid PVC sheets such as Forex® are gaining popularity in display case manufacture as replacements for MDF, but there is little research into their compatibility with cultural objects. The results from this study intend to elucidate the off-gassing properties of MDF and Forex®, providing museums with the knowledge to make informed material choices. As a case study, the National Museum in Stockholm incorporated MDF and Forex® into their newly-renovated galleries and display cases, giving RAÄ, the opportunity to monitor the materials in their synergistic environment.

RAÄ utilized a three-pronged investigative approach for the project through material characterization, laboratory emissions testing, and on-site air quality analysis at the National Museum. Material characterization via XRF, SEM-EDS, and FTIR was used to investigate the presence of Forex® additives such as sulphur-containing tin heat stabilizers. Laboratory emissions testing was performed in collaboration with Research Institutes of Sweden (RISE) and the German Federal Institute for Materials Research and Testing (BAM). During emissions analysis, volatile organic compounds and acidic gases from unaged and light-aged Forex® samples were quantified using GC-MS, HPLC, and ion chromatography. In addition, Oddy tests at RAÄ, were used to observe emissions from unaged and light-aged MDF and Forex®. On-site air quality analysis was performed in collaboration with the Swedish Environmental Research Institute (IVL). Using small passive air sampling devices, pollutants within closed display cases of the National Museum were collected over the course of four weeks and quantitatively measured.

### Violin varnishes: Nanomechanics and advanced chemical analysis

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**Keywords:** *Nanomechanics, atomic force microscopy, synchrotron radiation Fourier Transform Infra-Red Spectroscopy, varnished wood samples, pyrolysis-gas chromatography mass spectrometry*

This paper provides information on the depth of penetration of varnish layers in model violin varnish samples using synchrotron radiation micro-Fourier Transform Infra-red analysis. This information is then combined with a study of nanomechanics using Atomic Force Microscopy (AFM) of the same samples. The model samples were prepared according to traditional recipes from an Italian lutemaker family used in practice for the last 150 years. These varnishes consist of one or several layers of mixed organic and mineral materials prepared by the instrument maker (or a second craftsman) by grinding, mixing, solubilising and/or heating the raw materials. The mixtures are subsequently applied with a brush, a piece of cloth or the bare hand on the external surface of the wooden parts. In this paper the prepared model systems consist of several layers of varnish on top of a maple wood panel (6 x 1.2 x 2 cm). Layers of different varnish compositions, including both oil and spirit-based varnishes, were prepared and analysed after both natural and artificial ageing. The oil-based varnish showed higher penetration into the porous wooden structure (around 200 Åµm) than the spirit based one which remained on the surface with a clear separation from the wood. The unaged spirit-based sample was stiffer with a higher value for Young's modulus than the oil-based sample. In both oil and spirit-based samples there was a shift in the maximum of the distribution of Young's modulus to higher values on light ageing; the distribution of the spirit-based aged sample was broader than for the oil-based sample. Nanomechanical adhesion and deformation images obtained from Peak Force Quantitative Nanomechanics (PFQNM) also showed differences between oil-based and spirit-based varnish indicating that the oil-based sample had a more pliable surface. Py-GC/MS was used to establish the differential ageing and oxidation of the wood support on which the varnish was applied.

### Compatibility between traditional ground layers and 3D printing materials

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**Keywords:** *3D printing materials, compatibility, wooden frame*

Starting point of this work was the restoration of a Panel Painting depicting the Adoration of the Shepherds with a Saint Bishop, by an unknown author, stored in the Galleria Regionale della Sicilia di Palazzo Abatellis, in Palermo. It was decided to integrate a missing angular decorative element of the painting's frame in order to restore the integrity of the frame by reverse engineering and 3D printing. Reintegration was feasible as the frame has a modular decorative pattern and the remaining three corners were available.

Reverse engineering and 3D printing techniques have been used in order to find a solution according to the principles of recognition, reversibility and compatibility. Moreover, this method allowed to produce two substitutive corners with the very same shape but with different surface: the first one simulating wooden support and the second designed to illustrate the original stratigraphic technique of the frame.

In order to choose the proper material for 3D printing process a research has been performed to individuate a suitable 3D printing material compatible with the finishing materials used in the restoration field. Three different 3D printing materials have been chosen: two with a cellulosic filler and one characterized by a good resistance to various deterioration causes. Samples were prepared by applying two traditional ground layers, i.e. gypsum or calcium carbonate with rabbit glue, and a ground layer based on plectol adhesive. The samples underwent accelerated artificial ageing procedures, i.e. thermal, humidity and UV cycle, in order to evaluate the compatibility between 3D printing polymers and ground layers by microscopic observation of the samples, leading to the choice of coupled materials to be used to produce the substitutive frame corner reproducing the finishing technique.

### **Custom made gecko-inspired dry adhesives for heritage conservation**

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**Keywords:** *Adhesives; Gecko-inspired Dry Adhesives; New Materials, Photography Conservation*

The search for new materials for use in heritage conservation has recently met the attention of researchers after years of being left aside. However, the design for new adhesives, dedicated for conservation use is still in its infancy; our research hopes to add to a small but developing field.

Most of the lizards from the gekkonidae family have a unique ability to stick to any surface at any angle with a force significantly exceeding their own weight. Simultaneously, they can run at high speeds. This is because of the nanostructures on the undersides of their feet that use, predominantly, van der Waals forces to adhere to substrates. Gecko-inspired dry adhesives (GDAs) try to mimic this ability, using similar structures moulded in polymer films, resulting in strong adhesion and easy removal. This paper describes the more recent research that has developed out of a PhD project assessing the possibilities of using GDAs in conservation.

The first two years of assessment of commercially available GDAs, established a consistent testing methodology. Materials were tested on one substrate, contemporary photographic prints, at a range of temperatures and relative humidity. Macroscopic tests were supplemented by materials

characterisation (using FTIR, DMA and tensile testing) as well surface analysis in visible light and ESEM. Thus we have investigated the basic parameters affecting the adhesive force of the GDA's in shear and peel testing, as well as materials' properties. A new collaboration between Kelvin Nanotechnology Ltd, the James Watts Nanofabrication Centre at the University of Glasgow, and ourselves, has started in order to develop a technology for conservation needs. Manipulating the chemical composition GDAs and, as a result, their internal properties allows for more precise design for the discipline's particular needs and to better understand the mechanisms of artificial gecko adhesion. This paper reports on the preliminary results from this pilot project.

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## MORNING SESSION 2

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### **The metagenome of the York Gospels**

*Dr Matthew Teasdale*

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**Keywords:** *Biocodicology, Ancient DNA, Metagenomics*

Medieval illuminated manuscripts represent an irreplaceable historical record. The majority of these documents are written on parchment, the product of domestic animal skins (cattle, sheep and goat). However, the biological origin of parchment makes it a target for bacterial and fungal colonists, whose presence often impacts the legibility and in extreme cases even the long-term viability of the document.

Dry cleaning with PVC erasers is a common and widely used conservation technique that allows for the surfaces of parchments to be cleaned without causing damage to the objects themselves. We have developed a method to extract DNA from the waste material of this process, which would otherwise be discarded.

This approach was applied to document the vast array of biological information contained within the pages of the York Gospels. This manuscript produced 1,000 years ago, is one of only a small collection of pre-conquest Gospel books to have survived the Reformation and is still used in ecclesiastical ceremonies today. Shotgun metagenomic analyses of the sequences recovered from the York Gospels identified bacterial genre who are components of the human skin microbiome as well as those thought to be hazardous to parchment conservation."

### **Characterisation of excavated Napoleonic artefacts from the Berezina and Waterloo battlefield using neutron and x-ray techniques**

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**Keywords:** *Neutrons, Napoleonic Era, Tomography*

An important collection of artefacts has been unearthed during archaeological surveys from 2012 to 2017 around the village of Stoudienka in Belarus, the site of the Napoleonic army's passage during their retreat from their Russian campaign in November 1812. Recovered objects have resulted in the

historian's needs for further characterization to obtain otherwise hitherto unknown information, for example their mode of damage and chemical composition for provenance purposes.

Three different and completely non-destructive neutron techniques were principally put into practice in the study and examples of each these are presented here. Firstly, plastic deformation measurements using neutron diffraction strain analysis provided insights into the biography of a fragment of a cast bronze Imperial eagle, suggesting that it had undergone impact from projectiles, possibly lead musket balls. Elemental fingerprints of a collection of individual lead balls found at the Waterloo and Berezina battle sites were obtained by prompt gamma activation analysis, confirming their pre-industrial era fabrication from different localities, but also raising questions on environmental sample contamination. Lastly, neutron tomography coupled with laboratory xCT methods revealed hidden details in a cast eagle's talon and provided complimentary data essential in order to carry out a complete investigation.

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## AFTERNOON SESSION 1

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### Understanding Original Materials through Shared Scientific Reference Sample Collections

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**Keywords:** *Reference collections, materials degradation, collaborations*

One of the challenges in understanding and preserving heritage materials is determining the cause of degradation, and the impact of treatments and exhibit, while doing no harm. Reference materials that can be used as surrogates are needed for testing conservation treatments and assessing the impact of environmental parameters. Museums, libraries, archives and galleries contain a range of material types with diverse conservation needs. Being able to share material characterization is important for sharing resources and distributing information. This includes access to historical data, while leveraging this information for sharing heritage material issues. The Center for Library Analytical Scientific Samples - physical (CLASS), and Digital (CLASS-D), contains the physical collection of scientific material samples (Barrow books, fibres, pigments, papers, parchments, inks, storage media, audio-visual media, textiles, ceramics etc.) and CLASS-D all the digital data that pertain to the reference materials. Samples undergoing natural aging can be compared with accelerated aging to predict the impact of treatment and environment. The CLASS physical collection continues to expand, and the CLASS-D database highlights the importance of accessible research data on all material types. The database contains structured, linked metadata on each material with metadata for access and searchability, all data files are non-proprietary and sustainable. All material samples undergo a full characterization with multiple complimentary techniques, including but not limited to FTIR, XRF, XRD, Raman spectroscopy, MS, GC, UPLC, SEM ICP, SEC, TGA, fluorescence, PLM, microscopy, spectral imaging. This characterization allows baseline data with repeat testing for natural aging, critical for understanding degradation mechanisms. This scientific reference collection will ensure better understanding of material properties while assuring trend analysis for preservation of heritage materials.

## Crowd-sourced data in preventive conservation of large library collections

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**Keywords:** *citizen science; NIR; library preservation; spectroscopy*

This research presents a study into the quality of crowd-sourced data in the context of scientific research in libraries. Gathering collection 'health' data is an important element of preservation; however, the activity is often considered to be resource-intensive and surveys are not performed as routinely as might be useful. By introducing non-experts as surveyors within the daily operations of the library, we can progress beyond the current practice and at the same time engage a new segment of library users in scientific research and conservation.

A 4-month study of the general collections at the Bodleian Libraries, Oxford University has evaluated whether non-experts can collect valid, reproducible chemical data about collection items (pH, DP, TS and lignin content) using a near infrared spectroscopy instrument. Experiments were performed at 2 points of the document supply chain (the journey a book takes from repository to reader), where book fetchers and library users took part. Data for 510 reader-requested books were collected by participants and compared to data collected by a researcher. A framework of analysis included examining the reliability of the data and spectral differences, resource implications, required training, and how variables such as book size, weight and condition have affected the ability to measure a book and the obtained results.

Preliminary analysis has shown that tools can be implemented at different sites of the document supply chain with varying accuracies and cost implications:

- To hire an expert who is able to perform measurements and interpret the results is the most accurate but expensive option.
- A book fetcher is able to obtain accurate measurements but will need to be trained how to use the tool and would not be able to interpret the results.
- Readers can measure books they have taken out of the library. The results are accurate enough to use, and there is little cost implication however the failure rate is high. " This experiment has successfully shown that non-users can be integrated into the process of data collection for preservation activities within libraries.



### **Crowdsourcing conservation: using visitors photographs to help manage and conserve heritage sites**

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**Keywords:** *crowdsourcing, citizen science, metrology, smartphones*

Citizen science has the potential to change the way heritage is managed. The use of data contributed by members of the public could improve the monitoring of isolated heritage sites. This study set out to establish the usefulness of crowdsourced image data as a tool to monitor built heritage at two Scottish sites Holyrood Castle and Machrie Moor.

The feasibility and quality of data collection was first determined using controlled lab experiments. The ability of various consumer grade digital cameras to accurately capture colour, particularly shades of red, brown and green, (colours implicated in important facets of heritage conservation, such as salt efflorescence or biological growth), was assessed following the sequential imaging of test colour swatches. Cameras tested included those found in popular mobile phones such as the Apple iPhone and Samsung Galaxy. By measuring LAB colour values, we established that all cameras tested were able to accurately record levels of colour without prior calibration. Furthermore, by measuring the total area of colour captured, we were able to determine that these cameras could survey colour variations in areas as small as 600 mm<sup>2</sup>.

Images submitted by the general public via Twitter and Instagram and email. While social media was an effective tool for engaging audiences, images submitted through such sites were compressed to an extent that made them unsuitable for accurate monitoring of colour, as determined by comparative LAB measurements. It was also established that without methods of calibration between images, it is not possible to obtain reliable quantitative measurements of colour. However, the collected data was useful to track changes to the heritage sites in a qualitative fashion, with regards to plant growth and waterlogging. Future developments of crowdsourced heritage monitoring should address an effective way to calibrate images, that does not detract from the heritage sites themselves.

### **Use of 3D Printing in the Exhibition Hall: Museum Visitor Preferences**

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**Keywords:** *3D Printing; User Experience; Cultural Heritage; Preference; Factor Analysis*

The subject of touch is one of great concern in the modern museum and the past few decades have seen the re-establishment of the senses back into the museum in an effort to create more personal experiences for all visitors, regardless of disability. As a result, museums now provide a multitude of ways for visitors to get involved with collections including touch tours, handling sessions and interactive exhibits.

However, for many museums, particularly those with extremely precious and fragile objects, the access granted to visitors is still tightly controlled, typically utilizing inessential but robust items with little historical or cultural significance in restrictive settings that limit the freedom of the few visitors who are given the chance to interact with the collections.

One way of circumventing this issue is through the use of touchable, faithful replicas manufactured through 3D printing. Many museums are beginning to make use of such replicas for engaging their audiences but as of yet very best practice guidelines have emerged for how to utilize 3D prints within displays, creating an impending need for museum professionals to better understand the needs of their audiences.

Here we describe a study looking into the preferences of the museum visitor with regard to touchable 3D printed replicas carried out at the Oxford University Museum of Natural History (OUMNH). We utilize a slew of methods commonly used in user experience studies, including semantic differentials, factor analysis and content analysis to understand the preferences of museum visitors with regard to material properties of 3D printed replicas.

Analysis shows that there are three major factors are involved in visitor preference for 3D printed replicas; 1) the verisimilitude of the replica, 2) its robustness and 3) its quality, the first of these being by far the most significant factor for visitor preference. The implications of this research for museum practice is also discussed.

## **Mapping the Resilience of the York Historic Centre to Enhance the Community Local Flood Culture**

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Co Author:

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**Keywords:** *Community, Resilience, PGIS, Conservation, Dissemination*

Historic built heritage is the tangible expression of the culture of a place. Natural disasters, such as flooding, constitute a violent interruption to the continuity of these tangible and intangible values. In this context of exceptional cultural emergency, community participation and the understanding of a local risk culture are considered key in the promotion of preventive measures and in reducing disaster vulnerability.

Over the last few decades, the cultural assets of the historic city of York (UK) have been threatened by an increasing frequency of flood episodes due to climate change. In order to mitigate the impact of the flooding and to preserve vulnerable heritage, it is necessary to enhance the notion of 'living with risk' within the community affected. This project explores ways in which digital resources can be used to engage and increase community awareness and to integrate local 'flood culture', how people understand, respond and adapt to flooding - in long-term planning and mitigation measures.

The study conducted in York's historic centre, aims to enhance community resilience to flood through digital techniques and participatory planning. This research explores the potential of Participatory Geographic Information Systems (PGIS) online as a method able to record tangible and intangible elements of the York local flood culture in relation to the historic buildings affected by flooding. The data base created by GIS software will inform citizens and conservation practitioners about the vulnerability of historic buildings and it will suggest possible measures to adopt in accordance with

principles of sustainability and compatibility with traditional materials, providing the basis for future best-practice guidelines. A web-based method is proposed that supports social learning and draws on the existing knowledge and capacities of the community.

## POSTER PRESENTATION ABSTRACTS

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### Finding common ground in earthen heritage conservation: Chinese and Western approaches to conservation

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*Professor Heather Viles, University of Oxford*

**Keywords:** *Cross-cultural collaboration, Silk Road, Earthen Heritage,*

Earthen heritage makes up 10% of World Heritage Sites but also 33% of sites on the World Heritage in Danger list. Current conservation strategies have generally been ineffective over long time periods and so collaboration between countries and cultures is needed to help develop novel conservation strategies. However, collaboration across cultures, such as between Chinese and Western conservation experts, can be difficult due to differences in: how earthen heritage is valued; requirements for authenticity of earthen sites; extent of intervention which is seen as acceptable at the site; who participates in site management; and how sites are used.

A workshop with 13 Chinese earthen heritage experts and 13 Western heritage researchers investigated the extent to which there are significant differences between how Chinese and Western heritage experts value earthen sites and what is considered as a good conservation strategy. The workshop was translated in English and Mandarin and consisted of three discussion sessions and a co-created questionnaire. We found that there are many similarities in the valuation and approach to conservation between Western and Chinese heritage experts. This suggests a bilingual approach could be used as a basis to encourage discussion and develop future collaborations with earthen heritage experts.

### Scientific Understanding of 19-20C Tibetan Manuscript Culture in the Context of Asian Papermaking

*Miss Yujia Luo*

*SEAHA CDT, UCL*

**Keywords:** *Tibetan paper, characterization, conservation, heritage*

So far, there have been lots of published studies on European paper, a little research on Islamic paper and Chinese paper; however, scientific evidence of Tibetan paper, including physical and chemical properties, is almost completely lacking. These valuable Tibetan artefacts and inks are complex objects to characterise and analyse due to their chemical inhomogeneity, as well as often unknown raw materials, production processes and storage conditions. This research will conduct reliable, detailed and diverse experiments to analyse from the scientific views. Non-destructive methods including pH measurement, DP identification and fibre analysis, and destructive methods with FTIR and NIR will be used to explore a deep understanding of Tibetan paper for better preservation and promoting Tibetan culture.

Tibetan manuscripts represent a unique, important and significantly understudied typology of heritage. Scientific research into the technology of paper- and ink-making in this region is almost

entirely lacking, and yet it is of great significance for cultural heritage of China and Tibet. With the scientific understanding about this heritage, it is possible to narrow the scientific gap and lay foundation for long-term preservation in this field.

### **Cast in a new light: the surface coatings of nineteenth century plaster casts and their conservation**

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**Keywords:** *Plaster casts, Cast Courts, V&A museum, Northumbria University, AHRC research*

The Art and Humanities Research Council supports this PhD research as part of a Collaborative Doctoral Partnership (CDP) between Northumbria University's Department of Art and Department of Applied Science and the Victoria and Albert Museum's Departments of Conservation and Sculpture. The study aims to investigate the iconic Victoria and Albert Museum (V&A) collection of the 19th century plaster casts through the analysis of their coatings, as means to ensure a desired appearance and durability, and to compare the efficacy of conservation treatments in order to propose a safe and effective methodology for the removal of soils from their surface. The understanding of the materials and the techniques of the 19th century makers and a glance at the coeval plaster casts' collections, in Europe and in the world, are fundamental to achieve these objectives. The analytical study of historical reproductions and testing of specific cleaning techniques will ensure the achievement of the project's aim.

The wide range of original and later surface finishes, including pigmented coatings, certainly reflect the change in function of plaster casts along the 19th century. " "By generating novel knowledge on the production of the 19th plaster casts, the research will contribute to greater accessibility of information for specialists and the public. It will highlight the relevance of the historic collection, and encourage a broader audience through contribution to current discussions on replication and the exploration of the copy, stimulated by digital applications.

The research will have immediate impact on the condition of the V&A plaster casts through close communication with the V&A Cast Court Project at regular stages.

### **Sustaining Scotland's clay-rich sandstone buildings**

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Co Authors:

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*Maureen Young, Historic Environment Scotland, Conservation Scientist.*

**Keywords:** *sandstone, weathering, clays, mineralogy*

The built heritage of Scotland is both a cultural, and economic asset for the country. Within the built heritage, sandstone is the most common rock type used as building stone, known for its pleasing aesthetics and durability as a construction material. However, some sandstone derived heritage sites have recently shown rapid signs of weathering and subsequent decay. We hypothesise that the mineralogy of a sandstone plays a more important role in weathering patterns and decay than has been appreciated previously. The presence of swelling clays (e.g., montmorillonite) within stone is

often associated with enhanced weathering and is therefore, an important group of minerals to be considered when assessing nature and causes of stone decay. Factors such as the type, amount and distribution of clays will affect how the stone naturally deteriorates. Moreover, analysing the crystallographic properties of common minerals within weathered sandstone, such as muscovite, may provide insight into stone decay mechanisms and decay rates. Comparing sandstone from a number of heritage sites will aid in the understanding of how mineralogy, amongst other factors, influences stone decay. Techniques being used to thoroughly evaluate the mineralogy and physical properties of particularly clay-rich sandstones include optical microscopy, scanning electron microscopy (SEM), Raman spectroscopy and X-ray diffraction (XRD).

### **Assessment of antimicrobial ability and environmental applicability of polymeric materials for the wall paintings conservation**

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**Keywords:** *wall paintings; polymeric materials; environmental simulation; antimicrobial property; heritage conservation*

Detachment, flaking, and efflorescence are major challenge for murals conservation, thus synthetic polymeric materials being widely employed for the mural restoration, but the repaired areas are prone to mildew in humid conditions; it is still limited to evaluate the microbial susceptibility and environmental applicability of commercial polymeric materials. In this project, polyvinyl acetate emulsion, polyvinyl alcohol, pure acrylic emulsion, silicone acrylic emulsion, acrylic resin, Paraloid B-72 and industrial gelatin were selected for anti-microbial assessment, complied with weighing, SEM-EDX, FTIR and GC-MS methods to determine the quality loss, morphology, structure properties of polymers. Through the gradient relative humidity (RH) simulation, environmental applicability of polymers was assessed accordingly. The results showed that gelatin was a material most easily attacked by microorganisms, even the RH was at 75%; polyvinyl acetate, acrylic and silicone acrylic films act as growth substrates to microorganisms at high humidity (98.7%) environment. Antimicrobial ability of different polymers varied according to microbial species, *Aspergillus funigatus* was the most invasive fungi that causing serious biodeterioration in this study; some of gelatin films have been liquefied after 3 months aging test inoculated with *Penicillium ruber*, partly attributed to biodegradation process. To prevent the biodeterioration of polymeric materials used in heritage conservation, it is suggested to check microbial pollution (indigenous or deposited airborne microorganisms) and clean operate conditions (avoiding high humidity weather), improve antimicrobial property or use a broad-spectrum biocide.

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## The microbial deterioration and occurrence mechanism of relocated wall paintings of the Tiantishan Grottoes

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**Keywords:** *Tiantishan Grottoes, Cultural heritage, Microbial community, Biodeterioration mechanism*

Tiantishan Grottoes, a famous site for its historical status in the spread of Buddhism art in ancient China. Unfortunately, most of murals were stripped and removed to museum due to reservoir construction project in 1960s, most of them were experienced a severe deterioration caused by microbial activities. To understand the occurrence mechanism, samples were collected from two wall paintings for a systematic survey. SEM technology was employed and shows us abundant filaments and spores occupy the surface and even permeate into superficial layer of the wall paintings. Illumina MiSeq method were used for disclosure the microbial community information, 16/18S rRNA gene-based sequences revealed a high bacterial diversity but a relative low fungal abundance, including bacterial groups Firmicutes, Actinobacteria, Proteobacteria, Bacteroidetes, Cyanobacteria, Acidobacteria, Deinococcus-Thermus and Fusobacteria; and fungal groups Ascomycota and Basidiomycota. Among them, two bacterial genera of the Promicromonospora and Planomicrobium and fungal order of the Sordariales and the family of Trichocomaceae were dominant in the samples. Review historical records, we believed three main factors may be responsible for microbial deterioration of the wall paintings: Firstly, Rough early intervention measures: animal gelatin and wet gypsum emulsion were widely used for reinforcement measures of stripped wall paintings, importation of C/N sources and available water; Secondly, unreasonable package model: several pieces undried wall paintings were put in a hermetic wooden case, formed a humid environment with poor air-exchange. Thirdly, absence of the museum management: wall paintings were put in museum warehouse more than half a century with non-ideal conservation conditions.

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## A pin through the skin can wear thin within the specimen (sic)

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**Keywords:** *museum collection, Entomology, pin corrosion, chemical analysis, collection care*

When insects are collected they are usually pinned using stainless steel pins. In the past, pins made from different metals were often used to pin insects, most frequently brass. The use of such copper-based alloys has resulted in much damage to entomological collections. Copper, and other metals, corrode more easily than stainless steel, typically forming green or blue long, curly crystals of what, in the absence of detailed analysis, is described by the collective term 'verdigris'. Verdigris itself may be attractive (it is what gives copper roofs their lovely patina), but when it forms from a corroding pin inside an insect kept in a museum collection, it may cause considerable damage to the specimen. The secondary minerals forming during the corrosion of copper include copper carbonate, copper chloride and copper acetate. All of these have a lower density than the original pin material, their formation is therefore accompanied by a volume expansion. The result may be the complete destruction of an insect, which 'explodes' in slow motion. While the phenomenon is documented widely, the corrosion products and precise causes are rarely examined. Using a combination of surface and bulk sensitive techniques (XPS, XRD and EDX), we have characterised the corrosion products and conclude that the results of previous assessments were incomplete. Brass pins predispose insects to corrosion-related damage and corrosion of brass in different contexts may be caused by humidity fluctuations and/or the presence of air pollutants such as organic acids. In entomological collections, however, corrosion appears on directly pinned specimens most likely triggered on pins in those insects having large fat bodies, the insects' main energy storage organ. We are grateful that this project was enabled through support by the Nuffield Foundation.

### Simulation modelling in preservation management: Moving from single measures to complex systems models

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*SEAHA CDT, UCL*

**Keywords:** *Preservation management, Archive and library collections, Simulation modelling, System dynamics, Agent based simulation*

This project explores the use of System Dynamics and related computational modelling to evaluate the effect of preservation actions during the lifetime of archive and library collections. The novelty of this research lies on its approach to preservation management not as single, independent measures but as a process that is part of a complex system: preservation management is not seen in isolation, but in relation to the other archive and library functions in the broader context of collections management. This approach will enable us to explore whether decisions made in one part of the system might affect the output of another part of the system. The model seeks to find the potential synergies as well as counter-intuitive results of decisions which otherwise might have not been identified.

This poster will focus on the methodology used to elaborate the model.

First, a casual loop diagram was elaborated in collaboration with professionals working in archives and libraries. During participatory workshops the key variables as well as the dynamic complexity of the system were identified. The causal loop diagram provided a qualitative approach to the model and it was used as the starting point for the formulation of the mathematical model. For the mathematical model, two simulation paradigms are combined in an hybrid model: whereas preservation management decisions are modelled using System Dynamics (SD), the heterogeneity of the archive records and their behaviour are captured using agent based simulation (ABS). This poster is an introduction to the architecture of the model, the mathematical formulation, and the challenges of developing complex systems models based on data from disparate data sources.



## **Books with synthetic covers in contemporary library collections**

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**Keywords:** *Plastics, book, library, conservation, non-destructive research*

Modern books represent system of functionally interconnected book bindings elements from different materials. Mechanisms of degradation are different by natural and synthetic plastic materials, lifetime depends on the degree of sensitivity to damaging factors like gaseous pollutants, light, climatic conditions etc. Book covers from synthetic materials, like a polyvinyl chloride, cellulose acetate, cellulose nitrate, polyurethane and others, represent specific problems of conservation. Within the frame of a NAKI grant (Program of the applied research and development of national and cultural identity) called 'Synthetic materials in the library collections', currently is carrying out a survey of types of plastic used for book covers and decorative elements. Research of synthetic materials was carried out by instrumental non-destructive methods such as FTIR and spectral analysis in NIR in combination with chemometry. The purpose of the presentation is better protection of cultural heritage preserved in libraries. The information of synthetic materials in library collections is important for the planning of restoration interventions, climatic conditions and storage options. Some plastics can emit dangerous vapours, which could be dangerous for readers and library employee. Therefore, the problem with unstable plastics in the libraries is also applies to health protection and the environmental protection.

## **The Bloomberg Stylus Tablets and Advances in Computational Imaging: Capture, Processing, Public Engagement, and Collaborative Scholarship**

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**Keywords:** *web-based viewer; RTI; collaborative scholarship; crowd sourcing*

Over 400 Roman wooden stylus tablets were discovered during excavations in 2010-2013 for the new Bloomberg LP headquarters in London. Known as the Bloomberg tablets and dating from approximately 50 to 80 A.D., they are the earliest handwritten records of daily life in the first-century Roman settlement of Londinium (modern London). Bloomberg LP has collaborated closely with Museum of London Archaeology (MoLA) and the University of Oxford's Centre for the Study of Ancient Documents (CSAD) at the Ioannou Centre for Classical and Byzantine Studies, to conserve and study the tablets. The tablets were originally coated with blackened beeswax, which is now lost, and a stylus was used to incise messages through the wax, leaving small scratches in the underlying wood. The tablets could be reused, complicating the epigraphers' task of reading them. As an aid to epigraphy of the tablets, CSAD has recently deployed a specially designed 128-LED light array dome for capturing digital surrogates of the tablets using Reflectance Transformation Imaging (RTI). The new dome places 96 of the light positions in three rows at low angles around its perimeter to provide better resolution of fine surface features. CSAD is exploring methods of combining 3D imaging and

machine learning with RTI to improve the recovery of messages from the tablets. In collaboration with the departments of Archaeological Science and Computer Science, a web-based viewer is being developed that provides a variety of rendering enhancements with annotation and drawing layers, and the ability to record the state of the viewer, annotations, and metadata, so that researchers can easily view and share data and collaborate across the internet. With this new web-based RTI viewer, we are creating a platform for crowd-sourcing of epigraphy, opening a new path for collaborative digital scholarship and direct public engagement with the material artefacts of Roman history in the United Kingdom.

### **Assessment of lead oxides suitability as a material for monitoring acetic acid in museums**

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**Keywords:** *Acetic acid, Sensors, Preventative conservation, Material analysis, Chemistry*

Acetic acid is a well-known museum pollutant which can cause damage to a wide range of artefact materials. Museum guidelines recommend that acetic acid is maintained at parts per billion (ppb) concentrations, however, it is currently difficult for museums to measure such low values. Current methods either require expensive scientific equipment and expertise, have long sampling times, and/or have high uncertainties. Piezoelectric quartz crystals (PQCs) have the potential to overcome these issues. They are small electrical components whose oscillation frequency varies linearly with the mass on the surface of the crystal and is sensitive to changes of a few nanograms. Previous studies have coated PQCs in a thin lead layer and used the device as a dosimeter. As the lead corrodes, its mass changes which can be monitored by the PQC, therefore acting as an early warning sign for lead damage. Since lead is very sensitive to organic acids, this dosimeter can be used to predict their presence. However, as lead will form lead oxide when exposed only to air and water, it is hard to quantify and isolate the response to acetic acid.

This poster outlines methods to evaluate if lead oxide particles are sensitive to acetic acid, without having a cross interference from water vapour. The response of lead oxide particles, lead coupons and lead powder were exposed to acetic acid vapour under three relative humidity environments. The mass changes of the samples were monitored in real time.

The results show that lead oxide had a linear response with acetic acid, with no evidence of interference from moisture content. In addition, the increase in mass was an order of magnitude larger than that of lead powder, which is attributed to its smaller particle size. In contrast the lead samples exhibit an undesirable interference from water vapour. Hence, this is strong justification that lead oxide coated PQCs could be used to quantify acetic acid vapour, which will be tested in future work. " This research project aims to deliver low concentration acetic acid sensors for museum applications. In addition to providing the tools for museums to assess display and storage environments, it will also provide researchers with affordable technology to measure acetic acid concentrations during material interaction experiments, enabling research driven guidelines for this compound to be developed further. This will contribute to the sustainable display and storage of

artefacts, which will ensure the longevity of the economically important Heritage Tourism Industry and our cultural assets.

### Development of custom-built equipment to study mediaeval manuscripts

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**Keywords:** *Portable instrumentation; Raman spectroscopy; Multispectral Imaging; Manuscripts; Pigments identification*

Portability is one of the qualities that enables analytical instruments to be used in the heritage field. However, commercially available devices are not designed to study art-historical items but rather find their market in areas such as geoscience and drugs investigations, which have different requirements (particularly for the power of radiation used). We aim to develop and implement our instrument prototypes designed to study mediaeval books and to cope with the challenges that working in situ with such unique items implicates, providing enough sensitivity despite the portability and conservation requirements of the objects.

The equipment consists of a modular Raman spectroscopy setup, VIS-NIR fibre optics reflectance spectroscopy (FORS) kit and a multispectral imaging system (MIS). The Raman equipment includes a custom-built super head probe whose design is considerably smaller than commercial devices and that makes areas difficult to access reachable. The wavelength laser source and its maximum power density value are set to identify the highest number of pigments possible with a good signal:noise ratio but maintaining the safe operating conditions for photosensitive pigments.

Complementary to the Raman data, the MIS has a small number of filters (9) selected to achieve the best image contrast possible. It reduces the processing time compared to the more complex (often redundant) large dataset gathered by hyperspectral imaging systems, but it still allows to map the pigments and to recover the reflectance spectra from the images.

The whole equipment was tested in the lab and in situ for measurement campaigns in several sites. Traveling with two suitcases, it was possible to acquire Raman spectra, identify pigments from their spectral fingerprint and map them thanks to the MIS. The palettes used on manuscripts from different periods and provenance were reconstructed to enrich the knowledge of British manuscripts lineage in a completely non-invasive manner.

### What lies beneath? High resolution imaging and analysis of lichen covered surfaces at Stonehenge

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**Keywords:** *Stonehenge, machine vision, machine learning, lichen, terahertz imaging*

Stonehenge has an abundance of axe-head carvings that give a picture of 5000-year old burial traditions in England. However, archaeologists who have surveyed the monument suspect that the

shrubby fruticose lichen that covers 23% of the monument is obscuring an additional bounty of such carvings. Prior attempts to see below the lichen using digital techniques have not yet been successful. This work will develop machine learning, machine vision, pulsed terahertz imaging and other techniques to noninvasively uncover Stonehenge's surface, and potentially reveal hidden archaeological carvings beneath the lichen. Currently, axe head carvings on bare stone surfaces have been identified using image analysis from the Point Cloud Library using c++, MATLAB and OriginLab. Work on incorporating this into the machine learning algorithms for finding carvings under lichen is ongoing.

### **Assessing the impact of vibrations on Rubens' ceiling**

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**Keywords:** *Vibration analysis; Multispectral imaging; Vibration monitoring*

The painted ceiling by Rubens at Banqueting House in London is of immeasurable value and reflects the power of Stuart dynasty in the world. With a history of over 380 years the painted panels have been subjected to at least nine conservation treatments and removed at least five times. The most significant treatment took place in 1906-08 when due to sagging the original canvases were removed, marouflaged on timber frame plywood panels, which were suspended to the roof trusses by hooks and eyes.

Recent condition surveys show signs of damage on the original painted layer and canvas at the joints between the supporting plywood boards. The current research project is investigating if vibrations generated by activities inside or outside of the building play an active role in the crack propagation process associated to the relative movement between the boards. The research is also exploring best ways of analysing and presenting vibration data (collected using MSR 145 data loggers) as well as methods available for quantifying displacement and strain (such as Digital Image Correlation) used in order to characterise the vibration behaviour of the painted panels. Furthermore, an analysis of the collected data can inform about best tools to be chosen in future monitoring and accuracy requirements needed for this case study.

Although visual analysis of GigaPan multispectral and other historical images reveal that no important change can be identified on the studied panel, vibration data suggests that cracks may open within the elastic domain. At the same time vibration data analysis (of amplitude in time and frequency domain) shows limitations that need to be addressed in further research.

A correlation of the research methods used in the project can validate the results obtained and also help establish potential guide vibration values that may be associated with risks for the paintings.

## Pilot Project for the creation of new engaging models of CH storytelling

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**Keywords:** *Cultural Heritage, engagement, ICT platforms*

The Cultural Heritage (CH) System characterizing the Eastern Sicily owns a high quantitative consistency and qualitative variety of cultural resources to be promoted with innovative and engaging strategies. Within the 'NEPTIS' project, the multidisciplinary research team of the Institute of Archaeological and Monumental Heritage of the National Research Council (IBAM-CNR) in synergy with Engineering Ingegneria Informatica SpA, has been able to create services and applications supporting new cultural experience-oriented tours, such as the integrated system prototype 'Conceptouring'.

New ways of storytelling of tangible and intangible cultural heritage and new models of adopting a collaborative approach to support the co-creation of contents and services have been tested in Catania urban historic centre and the archaeological site of Santa Venera al Pozzo, involving students and territorial associations, offering a qualitative feedback on the construction of the interactive cultural experience.

## Strain distribution in historic tapestries: Testing Methodology

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**Keywords:** *Tapestries, Strain, DIC, Tensile Tests*

Considering their structure and manufacturing process, historical tapestries are some of the most complex European works of art. Tapestries have a structure made of interweaved weft and warp yarns usually made from different materials. This with the fact that a tapestry with its design, repairs and ageing makes it a unique object in terms of physical and mechanical properties.

This collaborative research between the EPICentre at University College London, Historical Royal Palaces (HRP) and IBM aims to understand the variability of stress-strain states in tapestry structures caused by displaying techniques and environmental factors, advising on the best conservation techniques to prevent further degradation.

Since samples of historic tapestries are rare, previous research on tensile behaviour and strain distribution considered new woven aged samples (1) and results on behaviour of real historic tapestry structures are limited (2, 3).

This poster presents the initial phase of the research where a method to characterize and explain the mechanical behaviour in tapestry structures was formulated. This methodology is based on physical characterization, tensile testing and digital image correlation (DIC) of different historic tapestry samples that were tested under a tensile load in the weft direction. This poster presents the holistic methodology that is being followed to inform and interpret the tensile behaviour, showing that without considering all properties of an historic tapestry, solid conclusions on its tensile behaviour would not be possible. Initial tests showed that to a heterogeneous structure, heterogeneous strain distribution is expected. Furthermore this distribution is dependent on the different materials used as well as the existence of slits and conservation repairs.

1. *Duffus Thesis U. Manchester; 2013.*
2. *Bratasz et al. Strain. 2014;51:78-88.*
3. *Khennouf et al. Strain. 2010;46(1):19-32.*

### **Drying Out Masonry - Comparing the Performance of Lime-Mortar Joints and Test Walls under Driving Rain.**

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**Keywords:** *lime mortar, driving rain, test walls, non-destructive techniques*

When exposed to intense rainfall, lime mortar in the joint, by having a higher porosity, should absorb moisture from the surrounding stones and therefore help the masonry to dry out. It is therefore essential to assess the performance of repair mortar in a masonry system in order to draw practical implications and guidance. This study was done in collaboration with practitioners from Historic England.

Five single layer test walls were built using Cornish granite, which can be found on many of the historic buildings in South-West England, each with a different lime mortar to enable comparison of their response to driving rain. Natural hydraulic lime 3.5 (NHL, St Astier), non-hydraulic quicklime (Cornish Lime), quartz, calcitic aggregate (Moreton Cullimore sand) and additives of biomass wood ash at 30% of the aggregates, were used in different combinations.

After three months of curing in a sheltered laboratory area under relatively constant conditions (15-20°C, 75-90% RH) and with no recorded wind, each wall was sprayed simulating a short intense rain spell in Devon in Summer. The sides of the walls were sealed with vapour proof membrane to force evaporation through the main faces. Evaporation was monitored for one week using a microwave moisture meter (MOIST35B) for depth measurements, a high-resolution radar (Malå) for surface readings and constant gravimetric measurements.

Data collected show a difference in behaviour from each lime mortar composition, especially a higher capacity of absorption from mortars made with NHL slacked with quicklime and using wood ash. There is also evidence of wetter surface joints after 24 hrs, showing the movement of moisture out of the joints during the evaporation process. These results enable a better understanding of the impact

of specific materials in lime mortar performance that can make recommendations to practitioners and conservation specialists for repair of masonry facing damp environmental conditions.

### **Moisture content determination in cellulose nitrate-based museum artefacts by using dielectric thermal analysis**

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**Keywords:** *polymer degradation; cellulose nitrate; moisture uptake; dielectric thermal analysis*

Cellulose nitrate (CN) constitutes the basic raw-material found in several museum artefacts, besides being in the formulation of paints, adhesives, lacquers, and coatings. Due to the susceptibility towards hydrolysis of the material in the presence of moisture, CN objects may suffer decomposition, which may be further accelerated depending -among several other factors - on the environment conditions and the polymer properties.

The study of moisture sorption into CN has been investigated by a few authors, mainly by measuring the kinetics of sorption at isothermal conditions and neglecting the presence of hydrolysis reaction. There has been an agreement about the importance of the sample thickness on the moisture diffusion rate. On the other hand, contrasting opinions arise about the importance of the environmental relative humidity (RH) on the moisture diffusion rate. Whereas some authors have concluded that RH does not impact on the moisture diffusion rate through CN, others have suggested that the diffusion coefficient presents a reduction tendency towards the increase of RH. Understanding the relationship between environmental RH, moisture sorption and moisture content, is therefore important to develop strategies for preserving CN-based heritage objects.

In this context, the evaluation of moisture uptake by using dielectric thermal analysis (DETA) represents a new approach able to bring deeper insights into the water sorption behaviour of CN. This work presents initial findings on the development of a method for determining the moisture content of CN objects. Samples were analysed in a DS6000 DETA (Lacerta Technology Ltd.) at different frequencies and temperatures. Results indicate that distinct CN artefacts may present different polymer chain arrangements, resulting in distinct permittivity behaviour when submitted to an alternating current. The next steps will involve the analysis of objects containing different moisture contents for the method calibration.

## Modelling the diffusion of Diethyl Phthalate Plasticiser from Cellulose Acetate artefacts in museums and collections

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**Keywords:** *Modelling, Diffusion, Plasticiser, Cellulose Acetate, Cellulose Nitrate*

Plastics constitute one of the major inventions of the 19th and the 20th century having affected people's lives significantly. Plastics consist of many components and their instability is one of the main conservation challenges. Plasticisers are compounds used to change polymer properties such as decreasing the glass transition temperature and making the material more flexible. Diethyl Phthalate (DEP) has been used in Cellulose Acetate (CA) and Camphor in Cellulose Nitrate (CN) as major plasticisers. Plasticisers start migrating from the surface of the material within a timescale of 10-30 years, causing gradual degradation of the object interpreted as brittleness and colour change. It is of immense importance, therefore, to understand the mechanism and provide conservators with practical advice deriving from a scientific approach.

Migration of plasticisers from polymers has been of an interest in different fields such as packaging in food industry and medicine. Regarding heritage artefacts, plasticiser migration has been studied experimentally before. CA motion picture films plasticized with DEP have been subjected to artificial aging to monitor plasticizer loss. However, it has not been modelled before from first-principles using Partial Differential Equations (PDEs). The proposed model seeks to understand and simulate the diffusivity of different plasticisers leaching from CA and CN plastic heritage objects. Diffusion is described by Fick's second law for a system of variable diffusivity as:

$$\frac{\partial C}{\partial t} = \chi \frac{\partial^2 C}{\partial x^2}$$

where C is the concentration and d is the effective diffusivity of the diffusing plasticiser through the polymer. The diffusion PDE is solved numerically, by defining a mesh grid within the dimensions of the object and by using a finite differences discretisation scheme. The model is able to simulate different diffusion scenarios counting for variable contents of plasticiser through the polymer over time and variable types of plasticiser including mixed compounds.

## Using instrumental methods in the investigation of glass deterioration in English Heritage collections

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**Keywords:** *Glass deterioration; Non-invasive; Collection survey; Polymerisation*

Our understanding of the fundamental processes occurring at the interface of glass and its respective environment, is still far from complete. The manifestation of deterioration symptoms in vitreous materials depends not only on their chemical composition and storage or display conditions, but also on the conditions they exposed to before their accession into a heritage collection. An understanding



of each of these parameters is especially crucial in collection surveys, since the condition evaluation is frequently based on the appearance of the corrosion layer, which is of importance in itself as it frequently carries the original surface of the object. This project aims to develop fast, reliable, and measurement-based survey methodologies for robust evaluation of the stability of archaeological glass and its corrosion layers. This research executes a broad survey of a variety of artefacts from different periods in selected assemblages in English Heritage collections.

Potentially at-risk objects are identified based on appearance, their archaeological background and previous observations by conservators. Selected objects which can be sampled are taken for analysis using optical microscopy and electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS) as well as portable X-Ray Fluorescence Spectroscopy (pXRF). The bulk chemical composition of the pristine glass is then related to the composition and morphology of its corrosion layer in order to establish a dataset in which corrosion characteristics may be related to the history of the object. Polymerisation indices (Ip) of the selected glasses, obtained non-invasively by Raman spectroscopy will be compared with theoretical polymerisation values based upon chemical composition (e.g. NBO/T) to determine their relative effectiveness in predicting durability.

### **Monitoring and modelling of microenvironment inside storage boxes**

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**Keywords:** *box, modelling, monitoring, paper*

In the heritage field, storage boxes are a traditional tool used for protection of artefacts against environmental factors that accelerate degradation, such as temperature and relative humidity. However, the microenvironment inside a box can also cause deterioration of the objects it contains, such that it is as important to monitor conditions inside boxes as it is outside; a practice not currently universal in museums and archives.

In this research, environmental monitoring was used to measure temperature and relative humidity inside the boxes. Measurement in various external environments were made on collection of home-made archival boxes made of different materials and of different shapes and sizes to see if and how these parameters influence Temp/RH levels. Monitoring was used on both empty boxes and boxes filled with paper and humidity buffers to see if they influence microenvironment. In addition to monitoring, calculation of air exchange rates and modelling studies for each box were applied to get deeper insight on environmental conditions in the boxes and which processes affect these conditions, i.e. air exchange and/or water absorption.

## Water vapour in Cellulose nitrate and cellulose acetate; a study of the sorption and diffusion mechanism.

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**Keywords:** *cellulose nitrate; cellulose acetate; hydrolysis; water sorption; water diffusion*

Our understanding of the decay processes and stability of plastics is rudimentary. We know how some decay mechanisms such as hydrolysis, the role of acids, plasticizer migration and chain scission modify chemical, physical and mechanical properties in cellulose acetate (CA) and nitrate (CN). Others, such as the influence of water vapour sorption and diffusion are not well-studied.

As part of the European funded project H-2020, COMPLEX: The Degradation of Complex Modern Polymeric Objects in Heritage Collections: A System Dynamics Approach, this work will focus on analytical methods to study sorption and diffusion of water vapour into CN and CA, and the correlation between sorption and diffusion and material properties such as chemical composition, molecular weight, glass transition temperature and crystallinity. Techniques such as NIR spectroscopy, FTIR, NMR, XPS, BET, DMA, DSC, DETA will be used to analyse material properties (such as chemical composition, glass transition temperature, crystallinity and porosity) and water vapour content and its behaviour (sorption, diffusion and desorption). Moreover, the study will investigate how this correlation is influenced by environmental parameters, e.g. temperature and relative humidity.

This poster details the interaction between plastics and water vapour to illustrate the degradation processes in CN and CA and how it depends on the type of additives and their amount.

## The effect of relative humidity fluctuations on library materials: measuring displacements using Digital Image Correlation

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**Keywords:** *Humidity fluctuations; Digital Image Correlation; Displacements*

Library and archival collections are very sensitive to moisture. They are even influenced by negligible variations in relative humidity. Substantial humidity fluctuations may cause dimensional changes leading them to lose mechanical stability. The study aims to investigate how relative humidity fluctuations cause mechanical changes on library and archival collections. As the first step for investigating displacement, the elaborate scientific measurement method is needed to provide accurate numerical figures of how much they deform. The way of measuring a displacement of library

objects has been conducted by few methods but the measurement method has not been fully established. This study focuses on using Digital Image Correlation (DIC) to look at the displacement of library objects. The main research question of this study is whether DIC is an appropriate method for measuring displacements of library objects or not. This research explores the type of DIC technique (2D and 3D measurement) and which technique is useful to measure the deformation of library objects.

The result shows the disparity, measuring the deformation of a sheet of parchment, between 2D and 3D deformation measurement in their length [mm]. The 3D deformation has higher deformation values (less than 3%), which implies that there were some possibilities of data loss of out-of-plane in 2D deformation (less than 1%).

### **Novel interactive technologies and the use of Augmented Reality for situated heritage experience: the Whitechapel case study**

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**Keywords:** *Augmented Reality, Digital archive, Situated experience, Immersion, Interdisciplinary*

In this paper we report on studies conducted as part of the Augmented Reality in Whitechapel project (<https://www.youtube.com/watch?v=zi0vYMbQcE0>). This is an interdisciplinary study on novel technologies initiated by researchers from the Bartlett School of Architecture, Dept. of Computer Science and UCL Interaction Centre in collaboration with the AHRC “Histories of Whitechapel project” (Survey of London and the Centre of Advanced Spatial Analysis at UCL). Using archival material, such as images and text that has been collected and documented by the “Histories of Whitechapel project” for the area, this study focuses on engagement with the archival digital content through situated and immersive technologies. In an iterative design process, we created an experience through a viewing Augmented Reality interface, using a tablet and its embedded camera that reads façade patterns to reveal digital content on its screen. In this piece of research we argue on the importance of situating heritage experience in real public spaces and outline its implications on the use of the archive-content and the built environment-interface when designing for heritage. A pilot study of user journeys carried out in the actual site using immersive mixed reality to reveal relevant digital content in situ (Whitechapel). A full day workshop with key stakeholders from all involved disciplines further took place in the same locations. This paper reports on the discursive practice of involving experts and end users during the iterative design process, with the ultimate scope to inform design and enhance experience of physical-digital cultural content in the actual places of the historic instances the digital material represents. It further raises questions around the type of technology to better support the content and the level of immersion that such technologies may allow, aspects we need to work with when we design digital interfaces for heritage.

## Hyperspectral and Multispectral Imaging of Historic Building Materials

Mr Andy Wade

Hutton and Rostron

**Keywords:** *Hyperspectral, Historic Building*

Multispectral and hyperspectral imaging are non-invasive analytical techniques which combine spectroscopic and spatial information. Spectral imaging has been used for over 50 years, and as time has progressed, so has its applications. Initially used in remote sensing and satellite imaging, the popularity of the technique built momentum within applications such as medicine, food science, pharmacology and agriculture. Its ability to provide accurate and substantial spectroscopic information, while having no physical impact on an object, made it desirable to conservation and its delicate and treasured artefacts. Used for the isolation and determination of inks, paints and dyes on different types of media, spectral imaging became a quick and valuable tool to assess a samples' chemical composition as well as its condition, previous repairs, and the types of materials used. This type of data can be used to assess the best path for conservation to take, as well as dating an object and confirming its provenance. As equipment advanced, spectral imaging was able to be taken out to the field, and research began to be focused on building materials and their defects. It has been shown that it can provide useful information in the characterisation of mould growth, timber decay and timber species identification, presence of liquid water within porous building materials, and also salt and mineral contents within masonry and concrete. As well as providing millions of spectra on chemical composition, the data from spectral imaging is multivariate by nature, and through manipulation by data analyses can be displayed visually. This gives the viewer either a glimpse of what was not previously visible to the naked eye, or make features more apparent to the less-trained eye

## Identification of Pigments important in the Art History - using three techniques are available at the scientific lab in Qatar National Library (Raman spectrometer, XR-F, Reflectance Spectrometer)

Mr Maxim Nasra

Qatar National Library

**Keywords:** *Pigment Identification - Spectrometers*

The studies and the research of pigments identification used in the art history especially in the manuscripts are very rare in the Arab world, most of the studies on the Arabic and Islamic manuscripts (identification of pigments) are done in the western institutes.

The purpose of the research:

We start doing Pigment identification analyses in the scientific laboratory at Qatar National Library using three kind of complementary techniques:

- Raman Spectrometer
- X-Ray Fluorescence Spectrometer
- Fiber Optic Reflectance Spectrometer (FORS)

Our collection: includes manuscripts, maps, printed books, paintings, etc.

When we start using these machines to identify the pigments and other dyes stuff materials we faced a problem - that to interpret the results we need a reference data to compare our results with it.

There are some data libraries are available to buy it and use it as reference, but these libraries were created using different machines with different features - as these kinds of results are very precise and many factors are affect the results

In addition, the data are not available for all historic pigments.

From this point i decide to start with this research project (identify the most important pigments used in the art history) using our machines and create our database libraries- and at the end of the project try to publish some of results in Arabic.

Materials:

I contacted with an Italian company and bought one of their products (it's called pigment checker) is a collection of pigments important in art history. Among all the pigments and their varieties ever used in art, this collection selects the most used from antiquity to early 1950's.

The total number of historic pigments are 70

The results:

At the end of this project we will have for each pigment one reference data at least (spectral) which can be used as a reference data to do the comparison when we do analysis for the pigments in the heritage collection.

### **Characterising the environmental and mechanical properties of BEVA 317 adhesive for the lining of canvas painting**

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Co Authors:

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**Keywords:** *Canvas, lining, BEVA, moisture, mechanical analysis*

The movement of canvas paintings due to fluctuations in relative humidity (RH) is a common cause of mechanical damage to paintings, which can be significantly reduced by tight climate control within museums and galleries. However, tightly restricting the environment in historic house properties is problematic on two fronts

- i) they host a large range of objects with different environmental requirements and
- ii) the historic buildings are often listed and therefore have limitations in terms of architectural building modifications.

Given these limitations it is critical to understand how an artwork, and associated treatments, will behave on open display in varying relative humidity conditions and to consider means of reducing local fluctuations.

Historically, paintings were lined as a matter of routine, but concerns regarding the integrity of the artwork and irreversible alterations in the painting structure have resulted in many conservators avoiding these interventions where possible. There are various studies regarding the selection of lining material and their response to the environment, but little research has been undertaken into the mechanical behaviour of BEVA 317 adhesive.

Standard methods to assess the mechanical response of canvas paintings and lining toward environment fluctuations couple tensile testing instrumentation with environmentally controlled sample chamber. This provides essential data to analyse the material response of the test samples, providing information on breaking strength in addition to the elastic response to small strains.

#### Research Questions

- What is the impact of concentration and temperature of application on the diffusion of the adhesive and mechanical properties of canvas lining treatments using BEVA 317.
- How do these variables influence the mechanics of the adhesive bond between canvas and sailcloth lining treatments?
- What is the impact of RH cycling on the bond?"

#### **Keep it together - adhesives and consolidants for wax seals**

*Dr Lora Angelova*

*The National Archives*

**Keywords:** *consolidation, adhesives, wax, wax conservation, wax seals*

The National Archives (TNA) house thousands of medieval pendant seals composed primarily from beeswax. Used by royalty and laypeople to officiate documents and imprint identity, seals offer an insight into social history and form a valuable part of our heritage.

Depending on its initial state, processing, admixture components or colorants, and storage conditions, historic beeswax can display surprising stability or severe embrittlement and porosity. The latter is commonly encountered in seals, especially those made without pigments (aka white seals). Decades ago, TNA's Collection Care Department suspended historical restoration methods of wax seals involving invasive and non-reversible re-adhesion of broken pieces and the vacuum-induced consolidation of flaky, brittle seals with natural and synthetic resins. Newly discovered damages are resolved through re-housing the seals in custom-built cases with maximum support. Because our collection can be handled by the public, it is essential that a method for stabilising and repairing seals be established.

Considering its prevalence throughout human history there is surprisingly little consensus on appropriate conservation methods for beeswax. We have collated a list of adhesive and consolidant candidates through a review of the conservation literature. Now, we are aiming to create artificially degraded wax samples for systematic mechanical testing of adhesives. Gas and liquid chromatography/mass spectrometry and infrared spectroscopy have been used to study the chemical composition of our model and historical samples. X-ray tomography has helped to compare

the porosity of the model samples to naturally aged wax seals; we can also trace the penetration of adhesives into the joints using this technique. This research has opened new questions into historical methods of seal production and the physical and chemical causes of wax degradation which will be discussed.

### **Interdisciplinary study on medieval caskets of the Swiss National Museum**

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**Keywords:** *spectroscopy, radiocarbon dating, medieval caskets, authenticity*

The collection of the Swiss National Museum (SNM) contains a large number of medieval wooden caskets (ca. 450). These are furniture items, the majority of which were most likely wedding gifts or holders for personal items such as jewellery, letters or documents. Many of them were transferred to the SNM at the time of its founding (1889) from medieval collections, and little is known about their precise provenance.

Stylistically these items could be attributed to the medieval time; nevertheless, some of them, due to discrepancies in their decorations, are suspected to be copies elaborated during the historicism era (1850-1920). At this time, in the German speaking part of Europe, there was a big interest on this special kind of items.

A pilot project was started on a choice of 10 caskets in order to characterise their pigments, binders and coatings with the aim of identifying 'probable modern' from 'clearly medieval' materials. Because of the high historical value of these objects, the respect to their integrity is a major concern; therefore exclusively non-destructive techniques such as XRF, Raman and FTIR spectroscopy were used. This would help to discern if the objects are originals or copies in order to avoid sampling for 14C dating.

These first analyses could indicate a medieval facture only for two caskets based on the presence of lead tin yellow, a pigment used from 13th until the beginning of 18th century then dismissed, and the use of tin foil decoration; a technique very common in medieval times. For the other eight caskets no clear hints were found as the determined materials have been used since the middle age until today. Therefore, five of them were chosen to be dated by the radiocarbon method using accelerator mass spectrometry AMS. The resulting radiocarbon ages of the caskets correspond to 1320-1440 AD (3 caskets) and 1480-1650 AD (2 caskets). These 5 examples illustrate the potential of 14C analysis in support of the interdisciplinary studies.

### **Microfading tester round robin test**

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**Keywords:** *microfading, MFT, light damage, round robin test, light sensitivity*

Microfading is a virtually non-destructive technique to directly assess the light sensitivity of collection items: A submillimetre area of an object is exposed to light of very high intensity, whilst the change of reflectance is measured simultaneously by a spectrophotometer. The data is conventionally converted into colour change  $\Delta E$  and expressed in ISO Blue Wool equivalents.

Diverse collections are assessed by microfading tests, covering materials such as graphic media, textiles or photographs. However, the technique has not been standardized and there are no generally agreed test protocols to ensure reproducibility and comparability. In addition, different instruments have been developed in recent years, which can differ significantly in their design; examples are retro-reflective and 0°/45° measuring geometries, the use of LED instead of xenon as the light source, contact vs contactless measurement etc. This abundance of instrument types has led to the initiation an interlaboratory trial of “a round robin test” to assess the comparability of light sensitivity data obtained with different instruments at institutions worldwide. The outline of the microfading tester round robin test, which is currently in the implementation phase, is presented in this poster.

### **Deterioration and conservation of sandstone grottoes in Northwest China**

*Ms Yinghong Wang*

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**Keywords:** *sandstone grottoes; the Silk Road; deterioration; multi-method research*

Grottoes, also known as cave-temples, are an important example of cultural heritage, displaying unique artistic styles based on Buddhist doctrines, and reflecting the importance of Buddhism in ancient China. Sandstone is one of the most common rocks among the grottoes complex that have been found in China. The most quantity of grottoes distributes in the region of NW China because of its geographic advantages, adjacent to Middle East, and unique geological condition, consisting of large area of Gobi desert and loess plateau. Gansu province, NW China, possesses many grottoes, in approximately 170 sites. The North Grottoes Temple, Qingyang, Gansu Province, China, represent the highest standard of grottoes art in Longdong region (east part of Gansu Province), however, due to the long-term exposure to the environment, erosion and deterioration have been produced in the site. It is necessary to carry out studies for understanding the nature and deterioration of the North Grottoes Temple to inform future conservation and management strategies. A series of laboratory-based techniques and in-situ equipment were involved to evaluate the condition of the North Grottoes Temple. Karsten tube was used to measure the water absorption coefficient of the sandstone in the site. Equotip hardness tester was used to test the surface hardness of the sandstone. Infrared thermal imaging camera was used to monitor surface temperature change on sandstone. Besides, polarizing microscope and X-ray diffraction analysis were conducted on small samples obtained from the site in order to characterize the mineralogy and petrology of the sandstone.



## Characterisation of trophic interactions in the biodiversity literature: a lexicographic perspective

Miss Sandra Young

University of Brighton

**Keywords:** *information extraction; biodiversity; corpus linguistics*

Living in the data age, the question of how data can be analysed and used is central to its worth. The corpus query tool Sketch Engine has a Word Sketch feature which was developed to look at word usage to identify concepts for use in lexicography. This feature has helped in the push to evaluate language usage objectively, based on the evidence in corpora, instead of relying on our notions of what we expect to find. This research looks at adapting the Word Sketch feature to produce an evidence-based view of species interactions in biodiversity research papers, to make it possible to get an overview of vast quantities of data, to compare it with the conceptual structure traditionally accepted to exist in this domain. Currently in its pilot phase, this research has identified that traditional Word Sketches can be used to form groups of simple species interactions. By adding annotations, the relationships between different levels of references to species become more apparent, as does the link between these mentions to simple subject verb object interactions. Extensions to the traditional Sketch Grammar (the rule-based file used to identify relationships) have been used to identify the potential for identifying hierarchical relationships between species through pattern matching. The research is now focussing on using parsed data in the Sketch Engine to support the identification of more complex relations, using NER to identify species mentions to further enhance this process. The results from this phase will then be used to develop a tailored annotation system that will focus on species interactions within a corpus and compared with hand-crafted ontological approaches to biodiversity annotation.

## The determination, quantification and visualisation of movement during the drying of waterlogged archaeological wood

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**Keywords:** *Waterlogged archaeological wood, laser scanning, moisture content*

The Mary Rose is a 16th century warship of Henry VIII's which is currently on display in Portsmouth Historic Dockyard, UK. After a consolidation treatment of spraying with polyethylene glycol (PEG) for 19 years, the ship has been air drying in environmentally controlled conditions since 2013. Drying has incurred some displacement, deformation and cracking, and modifications have had to be made to the structural support structure to maintain the ships integrity. When fully dry and therefore when it is expected the majority of movement will have occurred, a new support system will need to be developed in order to fully support the ship in an aesthetically pleasing way. In order to determine the

most effective support system, it is necessary for us to understand more thoroughly the changes that have occurred and why.

Throughout the conservation process photogrammetry and laser scans have been taken, which correlate to the different stages of conservation e.g. spraying with PEG and drying. Interrogation of these scans has enabled global patterns of movement to be determined, alongside local areas such as crack development and the shrinkage of timbers. The ability to link this information to the stage of conservation allows a greater understanding of the behaviour of PEG treated waterlogged archaeological wood. In addition, during the drying phase of conservation, moisture content analysis has been conducted, to identify the drying rates and patterns around the hull. Preliminary findings from this analysis will be discussed.

This information combined gives an unprecedented insight into how the Mary Rose hull has changed throughout the course of conservation, which will be relevant to projects around the world where a similar conservation treatment has been employed.

### **A hyperspectral scanning system for large heritage surfaces.**

*Mr Charles Willard*

*SEAHA CDT, UCL*

Co Authors:

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*John Gilchrist, Camlin Photonics*

*Robert van Langh, Rijksmuseum;*

*Adam Gibson, UCL*

**Keywords:** *Hyperspectral, Stitching, Mosaicking*

Many hyperspectral imaging systems have a limited spatial resolution, making it challenging to capture the details of large heritage surfaces. To create a detailed high-resolution image, multiple images can be stitched together using image mosaicking techniques. This work will implement an automated mosaicking technique for hyperspectral images to ensure accurate alignment and stitching of images. Image blending techniques will also be applied over the image boundaries where seam line cutting will be investigated as an approach to preserve the accuracy of spectral reflectance data. The imaging pipeline will be calibrated to ensure the scientific accuracy, both spatially and spectrally, of the resulting high-resolution image. A case study will be conducted on a genealogical roll held at UCL Special Collections, the roll is 6m long and constructed from joined parchment sections. The roll traces the lineage of England's Plantagenet rulers back to Adam and Eve. It is suspected that the roll was completed in different sections, spectral analysis of the inks may help to determine distinct segments within the roll. The method developed will be implemented on a new hyperspectral scanning platform capable of scanning large heritage surfaces up to 2m x 2m. This work will be completed in collaboration with Camlin Photonics and this research will potentially lead to improved products and services within Camlin. This research is supervised by Adam Gibson from UCL Medical Physics and this project may prove to be useful for medical imaging techniques. The image processing techniques may also find uses in adjacent domains such as remote sensing and environmental monitoring. The results of this work could help improve the understanding of the genealogical roll which will increase public engagement with this collection.

## Review and evaluation of building materials emissions testing schemes as tools for the control of emissions of volatile organic compounds (VOCs) in indoor air.

*Ms Chrysoula Thoua*

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**Keywords:** *Indoor air quality, volatile organic compounds, building materials*

Indoor concentrations of pollutants have a significant effect on personal exposure, as a result of the high percentage of time spent in indoor environments (about 90% of the workday in the UK). Recent guidelines and standards recognise source elimination to be the first consideration in strategies for indoor air quality, followed by ventilation design which takes into account emission characteristics of identified sources. Building materials which cover large surface areas of the internal space can be persistent sources of a wide range of VOCs. Part F of the building regulations requires that low emission materials to be used to limit the required ventilation rates to reasonable levels. The characterisation of products as sources of VOCs is achieved through different voluntary and regulatory schemes with a range of testing methods, criteria and certification. However, current guidelines and labelling schemes do not account for a number of factors which can influence emission rates, such as age of product, temperature, air flow and secondary generation of compounds. The presented paper aims at evaluating whether manufacturers provide sufficient information to designers for the assessment of building materials as emission sources of VOCs in indoor environments. Results from a literature review suggest that existing testing methods fail to provide adequate information such as the decay rate of emissions and emission characteristics in different environmental conditions, but also the combined effect of construction layers, resulting in uncertainties which can lead to indoor air quality performance gaps. It is concluded that, in order to assess the contribution of building materials to indoor air quality, there is a need for adaptation of mandatory emission testing to ensure that databases of emission characteristics of different products are populated and up to date. This study addresses the lack of information on building materials as significant and persistent emission sources in indoor air. A regulatory change is required in order to acquire sufficient evidence from manufacturers and certifiers of building products. This will enable the material-palette tailored assessment of indoor air concentrations of VOCs and the determination of relevant epidemiological correlations. Urgently addressing this evidence gap, on a policy level can have benefits for public health and prevent carbon-intensive retrofit measures.

## Mathematical modelling of hydrolytic degradation in cellulose acetate artefacts

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*Joyce Townsend, Tate*

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**Keywords:** *mathematical modelling, plastics, polymers, system dynamics, degradation*

Cellulose acetate is a plastic found in many modern museum collections. Degradation of this polymer is unpredictable and often by the time a problem is apparent it is too late to save the object. Artefacts may appear stable for years, then undergo rapid deterioration in only months. Objects which appear similar at first can degrade at very different rates, even if they are kept in the same storage conditions. While various mechanisms of degradation in cellulose acetate have been researched, the underlying explanation for this strange behaviour is unknown.

This research project aims to develop mathematical models for understanding degradation in cellulose acetate. Based on a review of the literature, hydrolysis reactions (deacetylation and glycoside bond cleavage) play a major role. Water vapour in the storage environment is taken up by the polymer making it possible for hydrolysis to occur. The deacetylation reaction produces acetic acid, which can further catalyse hydrolysis reactions. Emission of acetic acid into the environment yields a characteristic smell which has led to the degradation phenomenon itself being nicknamed “vinegar syndrome”. The research will attempt to model several of the fundamental physical and chemical processes going on, developing a system of equations which describe how chemical composition varies in time and space. Hence, the model may be used to predict how different factors due to the object or the environment contribute to material changes over varying timescales from days to decades.

The poster will present the concept for modelling the object and its environment as a single system subjected to multiple processes, the basis for the mathematical model. It will discuss how the model will be developed, what kind of results and conclusions the model may deliver, and the value of the research to the conservation community and to other scientific domains.

### **Multi-disciplinary investigation of causes of damp and mitigation measures in a 16th century Brick manor house, Hellens Manor, Herefordshire**

*Ms Susan Wolff*

*SEAHA CDT, UCL*

Richard Grove, SEAHA CDT, University of Oxford;

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Frida Vonstad, SEAHA CDT, UCL,

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**Keywords:** *Conservation historic brick buildings preservation of art work*

Helens Manor, Herefordshire, is a brick-built manor house based around a 16th century brick manor hall and successive additions over 4 centuries. Two ground floor rooms: the original hall and an early twentieth century addition used to house paintings and furniture presented with a problem of excess humidity and consequent mould growth. A combined hydrological study and building survey was carried out to investigate sources of surface water. Temperature and relative humidity data logging had been carried out over the previous 3 years during which time dehumidifiers had been introduced. Moisture content of the walls, floor and ceiling was carried out at different depths using an innovative microwave meter the Moist 350 by RF, Leipzig, together with IR photography. This showed extensive water penetration through the depth of the wall at low level together with penetration through the floor. Together with preventative measures to reduce water ingress suggested by the survey, short term tests and modelling was carried out to assess the impact of increasing temperature by heating,

or increasing ventilation. The impact of the dehumidifiers was analysed in relation to National Trust Guidelines for conservation of artwork. Practical and pragmatic solutions are needed for the protection of works of art in historic houses which have a limited budget for remedial measures. This study suggests a methodology which can be replicated for similar buildings.

### **A holistic approach to diagnosing the deterioration of rock-hewn churches in Lalibela, Ethiopia**

*Miss Blen Taye Gameda*

*SEAHA CDT, University of Oxford*

**Keyword:** *Lalibela; Rock-hewn; Basaltic scoria; Non-destructive analysis; Swelling clay*

Rock-hewn churches are made using the existing setting of the stone outcrop and adopting the natural morphology of a site to create new spaces. One of the most famous churches built in this style are the eleven rock-hewn churches of Lalibela which were built in medieval times. These churches are carved into the slope of a basaltic scoria hill and are found at an elevation of 2430-2550m a.s.l. Its unique architectural style has earned this site a place in the UNESCO world heritage list. There is an urgency to understand the vulnerability of the churches to environmental and manmade agents to maintain the use of these churches as holy places of worship and an important cultural heritage site. The overall aim of the project will be to develop an improved deterioration assessment methodology for non-masonry, rock carved and excavated cultural heritage sites. This research will focus on diagnosing the prevalent causes that threatens the church and how to understand the way these mechanisms operate. This will be achieved with a combination of laboratory and field-based experiments to determine the deterioration at different scales. Laboratory analysis and experiments will be carried out to investigate the physical properties of the basaltic scoria. Water absorption capacity and the stresses caused due to swelling clay minerals will be measured to determine how these properties will affect deterioration. On site assessment of the churches will be done using non-destructive methods to determine the role moisture distribution and wetting and drying cycles have on weathering processes. Microclimate will also be assessed to investigate the effect of protective shelters placed on site to protect the shelters from water infiltration. Such an approach will give a better understanding of how weathering operates in rock-cut cultural heritage sites.

### **The robustness and expected generalisation errors of NIR spectroscopy for modelling the degree of polymerisation of cellulose**

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Co Author:

*Professor Matija Strlic, UCL*

**Keywords:** *NIR spectroscopy, PLS regression, degree of polymerisation, error assessment, non-destructive measurement*

There is no doubt that non-destructive methods are of great significance for analysing cultural heritage materials. These methods not only eliminate the physical consumption of materials, which relieves a big concern of the stakeholders, but also minimise the time needed for data acquisition, which provides the potential for developing insights into collections based on large data sets covering wide range of sample varieties. For successful qualitative and quantitative applications, such as the prediction of lifetime expectancy and cost-benefit of preventive conservation, a good understanding

of the expected error of non-destructive methods deserves more attention. However, rarely have the sources that contribute to the expected generalisation error of the applications been assessed.

In this research, we looked at the use of near infrared (NIR) spectroscopy coupled with partial least squares (PLS) regression to model the degree of polymerisation (DP) of paper. Taking a comparative approach between model and historical paper samples, we validated that there is a fundamental relationship between NIR reflectance and DP which can be modelled using PLS regression. We examined the three sources that contribute to the expected generalisation error of prediction, among which the variance of predicted DP seems to contribute most to the total variance estimated by mean squared error of prediction (MSEP) for both model and historical paper samples. Furthermore, we evaluated the robustness of the model application in varying environmental conditions. For model paper, the PLS model for DP prediction is largely affected by the moisture content of paper. However, for historical paper, fluctuating moisture content within  $\hat{\pm}3\%$  ( $\sim\hat{\pm}20\%$  RH) does not lead to prediction of DP out of the range of root mean squared error of prediction (RMSEP).

### **Vibration and museum collections: a cause for concern? A method to investigate damage occurring during object transport.**

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**Keywords:** *vibration, transport, museum, object, damage*

There are many situations in which objects get exposed to vibration in museums. A review of the currently available literature on the topic revealed that research in this area has so far mainly focused on paintings, leaving the impact of vibration on 3D objects largely unexplored. However, there is evidence that shock and vibration do cause damage to objects.

This conference contribution (poster) will present a methodology to detect and quantify the damage on organic museum objects caused by shock and vibration during transport. The development of this methodology is part of a MRes research project at the UCL Institute of Sustainable Heritage in collaboration with the British Museum. The eventual aim of this research is to investigate the long-term effects of vibration on museum objects and seeks to explore whether low-level continuous vibrations are as harmful as discrete shocks of high magnitude.

Guiding principle for designing the research methodology was for it to be as closely related to museum practice as possible: exposing objects with unknown history of exposure to vibration during various journeys within London and the wider UK using a 3.5t van. Methods selected for measuring vibration and documenting the damage on objects need to be easily applied in a busy museum environment.

The poster describes and evaluates the methodology: For this research sacrificial test objects are used and mounted in a crate without vibration absorbent materials. The vibration on the object as well as on the transport crate is recorded with tri-axial MSR 165 accelerometers. The vibration is sampled at a rate of 1600Hz over 15+ hours in the course of various van journeys.

A quantitative damage assessment of each object is carried out before and after transport using photographic and descriptive techniques. The statistic software MATLAB and a bespoke code are required to process and analyse the large amount of data gathered. Recording the object condition efficiently in terms of time and resources but with adequate precision posed a major challenge, due to the three-dimensionality of the objects and the minor scale of damage detected.

My research will support some of the core aims of the heritage sector: the preservation of collections for future generations and the increase of access to collections. Better understanding of the effects of vibration on objects can prompt efforts to improve transport packaging, allowing fragile objects to travel more safely. The ability to lend more generously even fragile objects from indigenous collections to source communities, for example, will allow community members to reconnect with their heritage, increasing social cohesion and wellbeing.

### **Building Information Models for monitoring and simulation data in heritage buildings**

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**Keywords:** *HBIM, Dynamo, façade weathering, heritage buildings, environmental modelling*

This research aims to both analyse the current use of Building Information Modelling (BIM) in heritage buildings and how to improve it. BIM has been extensively analysed, specifically focussing on its employment with existing buildings. BIM is defined as a collaborative process that supports the management of the life-cycle of a building, going from its conceptual phase until its realisation, its maintenance or even its demolition.

Through a preliminary case study, the applicability of BIM process on heritage buildings has been studied, specifically concentrating on non-expert users. For this task, we chose to use Autodesk Revit as the BIM software, and the Jewel Tower in Westminster, London as the case study. The preliminary case study allowed to detect important gaps in BIM when used for heritage buildings. One of the most striking is the absence of a dedicated tool for condition reports. Hence, the aim of this project is the development of a heritage-specific tool that will enable stakeholder to make informed decisions in maintenance planning, supported by BIM.

Given that humidity is a major factor in the weathering of façades, being able to forecast and monitor humidity presence is one of the main ways in which predictions of weathering/degradation can be introduced in BIM. To achieve this, a weathering forecasting model will be produced, and then integrated into BIM. Specifically, working with Revit, the integration will be obtained using Dynamo. Dynamo is a tool that enables visual programming, through the organisation into nodes and wires. Nodes represent parameters and actions, whilst wires represent the relationships between them. Dynamo also supports the creation of nodes through Python coding, which gives full flexibility. The

above-mentioned forecasting model is created through the numerical solution of damage functions, the rainwater runoff model and the sharp front theory.

### Cellulose acetate degradation; assessing the influence of ventilation and relative humidity

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**Keywords:** *Cellulose acetate, Degradation, Environmental control, Ventilation*

Cellulose acetate (CA) was used throughout the 20th century as a modern art material and photographic film. Today it is a problem plastic for heritage collections and shows olfactory and visual signs of degradation. The chemical processes which account for these are known;

- plasticiser migration from the bulk phase causes visible deposits to appear on the surface.
- polymer hydrolysis releases the characteristic scent of acetic acid. In turn a build-up of acetic acid may catalyse polymer hydrolysis, thereby creating an auto-catalytic mechanism.???

The relationship between these processes and temperature is known, but the impact of relative humidity (RH) and ventilation is not established. We aim to systematically study how RH and ventilation affects the rate of plasticiser loss and the polymer's molecular structure during an environmentally controlled aging process.

Specifically, we wish to conclude

- If venting storage boxes to reduce polymer hydrolysis is at the cost of retaining high plasticiser concentrations
- If humidity control can affect the rate of plasticiser loss and polymer hydrolysis
- How physical properties of CA change due to degradation.

Samples of CA plasticised with 32% diethyl phthalate will be thermally aged to induce accelerated degradation of the sample at 70°C and 0% RH. Comparison of three ventilation regimes will be achieved by restriction of air flow over a sample. Comparing samples aged in open, sealed, and partially enclosed vessels will allow us to measure the effect of air velocity on plasticiser loss and the polymer. The experiment will also be repeated at 50% RH to replicate museum storage conditions.

Sample analysis will be undertaken after 1, 2, 6, 14 and 28 days of aging. Plasticiser concentration will be measured by ATR-IR with calibration by <sup>1</sup>H NMR. To monitor polymer hydrolysis, changes to polymer's acetyl substituents will be measured by <sup>13</sup>C NMR. Post aging, emissions from samples will be measured by SPME-GC/MS. Finally, elasticity and glass transition temperature changes will be measured by AFM and DSC.

Ultimately, we aim to evaluate how a controlled storage environment can limit physical change to cellulose acetate-based objects.



## Air movement: impact on spore germination and hyphal growth

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**Keywords:** *Mould, Historic buildings, Preventive conservation, Air movement*

The presence of mould on historic materials is an environmental issue for many historic properties. It causes deterioration of historic materials and is a health hazard for everyone in contact with contaminated materials. Anecdotally, in the literature, it has been mentioned that the presence of air movement has an impact on mould development, reducing its development and therefore working as a preventive conservation measure.

For its development mould is extremely dependent on the presence of water, among other limiting factors. Previous results have shown that the presence of air movement increases the drying rate of wood and paper samples. Therefore, undergoing research is looking at the relationship between mould development and air movement.

This research aims at isolating and determining the impact of air movement on mould development by assessing spore germination rates and hyphal growth under controlled environmental conditions.

Previously, a drying situation was explored where samples acclimatized at 85% RH were placed in a controlled environment of approx. 17% RH, and four air velocities were tested for their effect on changes in water activity. However, in order to isolate the impact of air movement, an environment where substrate and environment are in equilibrium (RH and T) needs to be created, and in this condition no drying of the substrate should occur.

Under optimal environmental conditions, 70% RH and 20 °C, on an agar substrate, spore germination time and hyphal growth rate will be assessed in two stages.

Firstly, without air movement, and secondly with an air velocity of 0.75 m/s. Mould development will be assessed at intervals of 12 hours, over seven days.

Moulds spores from the genus *Cladosporium* will be used.

Results from this research will give a better understanding of the current theory that has been hypothesised in the literature but for which there is a lack of scientific evidence.

## Influence of application method on the use of ammonium phosphate as preservative

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**Keywords:** *Ammonium phosphate, marble preservatives, reman spectroscopy, artificial ageing*

This work deals with the application of the Ammonium Hydrogen Phosphate as preservative and consolidant during the restoration and consolidation intervention on a twin columns group in the east side of the Santa Maria La Nova Cloister in Monreale, UNESCO Heritage from 2016. The Superintendency for Fine Arts in Palermo prescribes the use of ammonium phosphate as the only acceptable material for the consolidation of the Cloister, so this work deals with the influence of application method and solution concentration on the results achievable with this material.

Particularly as the treatment have to be done on vertical surfaces the use of a supporting material is mandatory so the focus is on the use of pure cellulose pulp or a mixture of cellulose pulp and sepiolite.

The experimental work started with the artificial decay of Carrara marble samples, as the columns consist of this marble. The artificially decayed samples have been treated using different concentration, i.e. 0,5, 1, 2 and 3M of di-ammonium-hydrogen-phosphate. All the solutions have been applied by means of both pure cellulose pulp and a mixture between cellulose pulp and sepiolite in one to one ratio.

The sample have been characterized before and after treatment, and before and after ageing procedure, by means of optical microscopy and Raman microscopy in order to evaluate the nature and distribution of new phases appearing on the surfaces.

Finally the samples underwent accelerated wash out tests in order to verify the effectiveness of the treatment. The achieved results led to choose of the treatment to be used on the columns and these data can be used for the treatment on the whole cloister and similar cases.

### **Handheld Raman Spectroscopy for Non-Invasive Investigation of Chemical Content in Acrylonitrile Butadiene Styrene (ABS) Historical Objects**

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**Keywords:** *ABS, Raman spectroscopy, LEGO, non-invasive*

Handheld Raman spectroscopy was applied to the characterization of acrylonitrile butadiene styrene (ABS) LEGO bricks with the aim of assessing the capability of handheld instrumentation for non-invasive analysis of plastic design objects. New pieces and comprising twelve different colorations were analysed and results compared with data collected from naturally aged pieces dated 1970's. Illumination at 785 nm with handheld Raman spectroscopy confirmed the presence of ABS and provided clear signatures of the presence of pigments, which were successfully identified as phthalocyanines (blue and green bricks) and azo-pigments (yellow and brown) and quinacridones (pink and violet). Raman analysis showed effective in distinguishing different colorants used to achieve slight changes in coloration, such as light and dark green and blue pieces. In addition, colorant mixtures were successfully identified as well as the presence of inorganic oxides, such TiO<sub>2</sub>, commonly used in plastic formulations. Interestingly, it was also found that other polymers such as polycarbonate (PB) and acrylic resins were used instead or in combination with ABS to achieve different mechanical properties or transparency. High fluorescence background was observed in aged pieces, due to the formation of superficial degradation products. This work showed the high potential of handheld Raman spectroscopy for analysis of coloured plastics. Due to the low cost of instrumentation, easiness of use, non-invasiveness and in situ quality of analysis, handheld Raman

spectroscopy could be easily implemented by museums as characterization tool of collection objects where could provide support for the development of historical plastic object preservation protocols.

### **Displaying future heritage? The museum work of Jason Bruges Studio and United Visual Artists**

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**Keywords:** *future heritage; digital sensory environments; immersive experience; museums; interaction design studios*

Through the collaboration of museums with business, novel ways of presenting and interpreting heritage are being developed. The paper investigates the relationship between heritage, audience and technology, by focusing on the integration in museum displays of digital sensory environments created by two established, London-based creative studios, Jason Bruges Studio and United Visual Artists. Their works, or immersive installations, bridge the boundaries between science and art, combining architecture, interaction design, projection, light and sound in a total experience made to function in time and space. They were commissioned by museums as material expressions in their own right, and as key experiences in themselves for presenting heritage themes and concerns, rather than simply as interpretative aids. Against the background of embodiment theories, and based on interviews with the designers and first-hand study of cases, the paper analyses how the works define a physical environment which has the capacity to visualise and communicate heritage through interactive, immersive, sensorial and affective experiences. These new modalities of display produce, through their different degrees of immersiveness and their multimodal interactions, different norms of object-body relations. By looking in parallel at the work of the two studios, from their first commissions in 2005 until now, the paper unravels the way they become integrated in museum space, and critical shifts in their significance and nature. By creating singular experiences that must be lived at that time and space, they have the “aura” of works of art and “the authenticity of experience”. More importantly, they are transformed over time from temporary installations to installations that become part of the permanent collections of the museums and so part of future cultural heritage. This digital, time-based and immersive heritage is then raising new challenges in terms of management, preservation and curation.

### **The effect of temperature on emission of carboxylic acids from cultural heritage collections - will low temperature storage reduce air filtration requirements?**

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**Keywords:** *Emission rate; volatile carboxylic acid; air quality; passive climate control; cultural heritage.*

Preservation of cultural heritage collections for future generations place a large demand on air quality in exhibitions, repositories and display cases. Emission of harmful contaminants inside enclosures can be largely avoided by selecting suitable construction materials; however, the emission of contaminants from chemical decay process within the collections cannot be removed. Museum objects made of wood, paper and cellulose acetate emits carboxylic acids causing deterioration e.g. tarnishing of metals, salt efflorescence on calcareous structures, and acid hydrolysis of organic materials. The emission of formic and acetic from four naturally aged cultural heritage objects was determined using emission chambers with active sampling on silica gel and ion chromatography analysis. The results confirm that the emission depend on temperature. For example, the emission of carboxylic acids from a newspaper from 1914 decreases at 10°C to 68% of the emission rate at 23°C.

Growing concern for global climate changes together with budget restrains have led to an increasing replacement of energy consuming ventilation systems with repositories using a larger degree of passive control e.g. unheated repositories. The low temperature in unheated repositories will reduce the chemical deterioration and the emission of harmful contaminants from the collection. In this presentation, we will, by using a simple mass balance model compare the effect of temperature on the concentration of formic and acetic acid in air inside repositories. Based on the results the decrease in concentration when reducing the temperature from 23°C to 10°C will be estimated.

The results will be linked to existing guidelines for climate conditions and air quality in repositories. Reducing the emission of carboxylic acids from the collections with decreasing temperature will potentially reduce the requirement for air filtration and increase energy efficiency.

### **Mapping pigments on the Shrine of King Taharqa**

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**Keywords:** *Hyperspectral imaging, pigment analysis, Egyptology*

The Shrine of King Taharqa, currently housed in The Ashmolean Museum, Oxford, is the largest intact Egyptian building in England. It was originally constructed around 680 BCE and excavated in 1930 CE in Kawa (Sudan). Once in Oxford efforts were made to preserve its sandstone façade which has an array of carved figures that were once richly decorated. Today though, not much can be seen of the pigmentation and the question of how it was originally meant to look remains unanswered.

Microscopy was carried out in 1990 on samples from the shrine prior to conservation treatment, and a photo-induced-luminescence study was carried out in 2015 to ascertain the location of Egyptian blue. These investigations provided some information but not a complete picture. The current project is to ascertain whether reflectance imaging can be used to determine the original look of the shrine?

In this study hyperspectral imaging has been carried out across the west wall of the shrine in order to produce a complete reference of the current state of the surface which might assist in reproducing the original 'colours' of the shrine.

Here we present the results of hyperspectral imaging, Raman spectroscopy, XRF and photogrammetry to provide a map of visible pigmentation. Using computational techniques we attempt to digitally recreate the original appearance of the west wall. The results will be used by the Ashmolean Museum to enhance the visitor experience.

### In situ condition assessment of 18th century British heritage building located in Shimla using nondestructive tests : A case study of Barnes court

### Identifying Ways to Save Energy in Conservation by Understanding User Habits - Energy Saving Challenge Survey

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**Keywords:** *Energy, Energy Usage and Savings, Environment, Sustainability, Green Labs, Sustainability in Conservation*

Finding achievable ways to save energy in our profession is one of the goals that Sustainability in Conservation (SiC) is working towards. Changing habits and raising awareness are key to reaching this goal. Understanding workplace conditions and habits is essential to the provision of information that might induce changes towards a greener conservation industry. Hence, our survey (composed of ten questions, both in open and closed format) investigates the use of appliances, energy consumption habits and energy saving initiatives by country, specialisation and industry sector. The ongoing survey, advertised via social media and conservation platforms, has been completed by 42 respondents to date. 60% of respondents are unsure whether their buildings use clean energy, if their appliances are certified as energy efficient (59%) or whether there are any appliances that should be unplugged when not in use (due to dead energy), (49%). While many respondents confirm they have appliances which must stay on (54%), the majority (83%) report that some appliances, for example lights, heaters, fans and computers, can be turned off when not in use. The exceptions include appliances such as fume hoods, refrigerators, freezers, Fourier Transform Infrared (FTIR), emergency lights and air-conditioning systems. 68% of respondents state that they have energy saving initiatives in their building ranging from recycling initiatives to encourage the switching off of PCs and lights, solar heating for water, motion sensors for lights as well as good insulation. 80% of respondents however, do NOT have energy saving stickers on their appliances. Suggestions of respondents regarding ideas for energy savings include reducing use of lighting via motion sensors or reminder-stickers, reducing overheating and overcooling, monitoring storage and exhibition areas for heat loss by means of infrared imaging, holding workshops and information days.

## Developing a Traditional Spar Varnish for Conservation use for Marine Conservation

*Mr Matthew Hancock*

*Royal Armouries*

**Keyword:** *Challenges, Varnish, Opportunities, Interdisciplinary, Research*

This paper focuses on the challenges and opportunities of developing of a traditional spar varnish (aka. long varnish) for historic boats using organic resin formulas that were used on boats built before the use of phenolic resin, or around of the time of WW2 when phenolic resin was in short supply before alkyd resins became popular.

Recipes and methods of the resin varnishes used before phenolic are rare and there remains an amount of experience in making varnish, in order to develop a varnish experimentation is required. Although rosin was often used for spar varnishes, it was decided that this project would use copal resin also used in spar varnishes to develop a traditional spar varnish that would be suitable for use in conservation and on historic objects still in service, while aiming to give a performance close to a modern spar varnish. This paper will present this process as a work in progress with the results to date.

To be able measure the performance difference between the modern reversible Tung oil marine varnishes used on classic boats testing is required, on this project this is achieved by coating marine ply panels and testing them in the field. (The dinghy park) Monitoring is normally over 2 years, the expected life of a marine varnish.

This project will demonstrate the challenges of developing a product using scientific research for a conservation use that is effectively a niche market, using low cost technology and optimising resources with the support of professional associations. These professional associations supported the project with grants and access to published research material. This intense development research is required before it is possible to engage industry in such a specialist project, however, when the research stage is in progress it is possible to collaborate with industry to ensure the benefits of the project are accomplished.

## Presenting a Marine Salvage Conservation Project to the Public (Giving Public Engagement Quantitative and Qualitative Values)

*Mr Matthew Hancock*

*Royal Armouries*

**Keywords:** *public engagement, challenge, Scientist, Marine Salvage*

This paper will focus on the challenges and opportunities that arise when heritage science is presented to the public. The 17th Century Marine salvage project is one of Royal Armouries larger projects as it is externally funded, a condition of this funding was that the Conservator would develop a public engagement programme as part of the project.

The project is the conservation of three 17th Century gun recovered from the sea; two were recovered from the wreck of the HMS London a Peter Gill Gun and a Commonwealth Gun. The final gun is a Dutch composite gun, possibly the most interesting of the three guns. The guns are also linked to the Anglo-Dutch war and the East India trading companies.

The challenge of this project was to engage the public into the project, what might be an exciting project to a Conservation Scientist might appear to very dull to some members of the public. The public engagement was to consist of regular blogs and monthly 20 minute talk by the conservator. The history helped tell the story but the science was still difficult to make exciting but the composite gun with its engineering from 4 different types metal combined with the legal arguments over patents, gave the opportunity to present part of the talk with a comparison to a John Grisham novel helps to make the engineering element more exciting to the public. This comparison technique was also used in other parts of talk for example using second hand gun on a refit of the HMS London to modern austerity.

The research element of this project is about opportunity, the public engagement element gives the Royal Armouries. This opportunity to collect quantitative and qualitative data to establish if there is a value in having the conservator giving these talks and understand better the amount of attendees required to achieve this value, also data will give an indication of economic cost but also the benefits of improved public participation to the museum.

### **Conservator versus or along with artist? Case studies of collaboration of restorer with David Lynch, Natalia LL and Massimo Bartolini**

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**Keywords:** *conservation of contemporary art, David Lynch, artist's intention, context of the work of art, conservation standards*

Conservation - restoration of modern and contemporary art is shaped by factors absent during treatment of 'traditional' art like use of new materials and techniques, great significance of the context of the work and artist able to take part while decision making.

Diverse examples of cooperation between conservator and artist illustrate various ways of their mutual interaction.

David Lynch wanted to conduct the treatment him-self and needed restorer just as support. The treatment not 'proper' concerning restoration standards, but assisted by conservator, was opportunity to discuss other possible methods opening artist to more 'appropriate' solutions. Personal info on studio practice and access to original materials were gained and the aesthetic expectations of artist expressed.

Natalia LL wished her pastel *Shivers* to be treated in areas of faded coloured paper support. It did not disturb the composition significantly. Safety reasons suggested not to reconstruct faded part but artist insisted on returning full integrity. During discussion she agreed to make reconstructed parts distinguishable.

In *The soul of the tree* she used sawdust, remnants of real tree that inspired the work. In damaged areas sawdust was missing and after decision to reconstruct them, surprisingly use of original material was of no importance for artist, even though they were still preserved.

Massimo Bartolini contemporary *Organ* was changed by diminishing metal and wooden elements in order to achieve proper tones. The final effect was consulted via mobile talk with the artist instructing on loudness and especially the tempo of the movement of the bell producing sounds.

Case studies present diverse attitudes of artist and conservator concerning extent, ways, reasons and goals of restoration and interaction of both sides modifying the attitude and broadening understanding during and by conducted treatment redefining accepted borderlines of common standards.

### **Development of a new neutron technique for the analysis of gold alloys: validation through standards and a pilot study on Byzantine gold coins**

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**Keywords:** *gold, non-invasive, neutrons, provenance*

A recent paper has argued, based on archaeological and historical information, that trans-Saharan gold trade in Africa began before Islamic control, and that gold from West Africa could have been used to strike Byzantine coins in Carthage (Phillipson 2017). Seeking to investigate this hypothesis, this work presents the analysis of gold standards and coins minted in Carthage during the 7th century AD. The samples were analysed using newly developed Time Resolved Prompt Gamma Activation Analysis (T-PGAA) for quantitative elemental analysis. The presented results show the potential of the technique, identifying the isotopes in both the standards and coins and attempting a first approach to a quantitative analysis. Using this innovative technique, we also show an increase in the sensitivity to detect trace elements in bulk analyses of metals through which it will be possible to characterize and identify the provenance of the gold used to make them. T-PGAA consists of the measurement of gamma energy spectrum induced by the radioactive capture as a function of incident neutron Time of Flight, directly related with the energy of incident neutrons. The campaign of measurements has been conducted in VESUVIO beamline at ISIS Spallation Neutron Source.

### **Toxic collections: understanding organic volatile pesticide emissions from artefacts in museum collections**

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**Keywords:** *Hazards, Pesticides, Museum, Contamination*

Over the past three decades, there has been an increased awareness of the implications of handling and working with museum collections contaminated with hazardous pesticides. This has motivated the heritage sector to undertake research regarding characterisation of the chemical residues present in their collections to inform safe working practices. However, there are still many questions to be answered. Organic pesticides have been identified as a group that would particularly benefit from further research, with the aim to improve health and safety standards.



This project is an interdisciplinary scheme that involves conservation, heritage science and analytical chemistry to increase the understanding of British Museum artefacts with organic pesticide contamination. The research focuses on the feasibility of calculating emission rates of volatile pesticides from specific objects.

A group of objects with suspected pesticide contamination were chosen following an established set of criteria. Existing British Museum documentation mentions previous use of persistent organic pesticides such as lindane and chloronaphthalene. In order to identify the specific organic pesticide residues present in the chosen objects, the air surrounding the artefacts was sampled using solid phase micro-extraction (SPME) fibres. Following this, the results are analysed using gas chromatography coupled with mass spectrometry (GC-MS). Once the presence of pesticides has been confirmed, quantitative data of the emissions is obtained by placing objects in a bespoke aluminium emission chamber fitted with a pump and a desorption tube filled with TENAX TAA. The analytes are subsequently thermally desorbed and analysed with GC-MS.

This research aims to improve practice by providing tangible data about the residues present and their rates of emission at various environmental conditions. The information obtained improves the planning of safe access to collections.

### **Studying the effect of light on the experience of the museum environment in situ: towards a novel and interdisciplinary methodological framework**

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**Keywords:** *light visitor experience physiology psychology*

Recent discoveries in circadian research demonstrate the multifaceted effect of light on humans yielding psychological responses elicited by its influence on shaping the visual scene and physiological non-visual responses associated with circadian effects. Moreover, a great part of lighting research has focused on valence laboratory studies. Indeed, there are very limited studies on the effect of light on human experience of space which have taken place outside the lab. This can partly be explained by the great need of resources to undertake such work. And hence, in situ studies are extremely useful if the research findings are meant to apply in real world and inform real practice.

To understand all aspects of light in the context of space user relationship, we propose a novel methodological framework for in situ studies, combining physiological markers and behavioural observations, and qualitative insights. For our research project, we use novel technologies such as mobile Electroencephalography (EEG), and Galvanic Skin Response (GSR) combined with participant observations of behavioural parameters, closed, structured questionnaires and semi-structured interviews, to document both visual and non-visual responses in museum environments. Although the field of focus is that of light, the methodology can be widely applied in visitor experience studies.

**Conserving collections on display while combating climate change: developing air pressurisation methods with museums & showcase makers to quickly gauge airtightness & spot leaks in passive showcases**

*Mr James Crawford*

*Sustainable Microclimates*

Co Author:

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**Keywords:** *display case; microclimate; airtightness; pressure testing; leak detection*

No furniture is arguably as vital to the economic and ecological sustainability of museums as display cases with unpowered climate control. These passive showcases have long been crucial for aiding up-close visitor viewing of exhibits, while shielding against misdeeds and environmental decay. And now, showcase microclimates are advocated for cutting carbon emissions and operating costs of museums using powered climate conditioning. But showcases are often the costliest and most time-squeezed part of opening exhibitions, and their ability to slow exhibit decay and save building energy is not routinely tested during their life cycle: from manufacture and installation, to their decades in use. Worsening matters, future more variable gallery environments mean passive showcases, and any sorbents, will be less able to sustain their microclimates.

Most air lost by showcases is driven by differences and changes in air pressure. Diagnosing showcase airtightness by pressurisation methods entails compressing (or decompressing) showcase air by ~0.001-0.01%. To measure the airtightness of a showcase with gaps, air is pumped into (or from) it at adjustable rates so allotted differential pressures ( $\pm 5-50$  Pa) can be held steady: the constant pressurisation method. To measure a tightly built showcase, air is pumped until a standard pressure is reached. Then the duration taken for the showcase pressure to fall towards room pressure is timed: the pressure decay method. To detect leaks, carbon dioxide (CO<sub>2</sub>) is added to a slightly pressurised showcase and expelled CO<sub>2</sub> is sniffed with a handheld non-dispersive infrared (NDIR) sensor.

Air pressure testing of showcases takes 10-30 minutes. This complements the 1 or more days to obtain the air exchange rate (AER) using the established method: tracer gas decay. And leak detection under pressure with NDIR sensing is ~1,000 times more sensitive than ultrasound sensing used by museums and showcase makers

**The modern, innovative ICT platform as dedicated Intelligent System for Environmental Parameters Management - challenges and achievements in museum practice.**

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**Keywords:** *ICT platform, environment, prevention, museum, WSN architecture*

The changing role of museums in the world poses new challenges to these institutions. The IT solutions supporting the archiving of collections, sharing digital copies of monuments, management of tourist traffic, finances or safety of objects are elements that allow to overcome these challenges.

In the Museum of King Jan III's Palace in Wilanów, the Intelligent System for Environmental Parameters Measurement/Management together with built-in prediction models is currently being tested. It is innovative technological solutions to ensure control of environmental parameters inside the museum and provide the highest level of monitoring and control in which collections of monuments are located. The results presented today included: microbiome analyzes, catalog of biodeterioration threats, air PM analysis, RH/T fluctuations, the number of visitors and the development of a model predicting the occurrence of threats based on changing environmental parameters.

The technical basis for the research is created by an innovative ICT platform, integrated with a network of measurement devices, stabilizing environmental and microbiological parameters. The sensor's network based on the WSN architecture is scalable, self-configuring and self-organizing. Development of innovative solutions for self-organization of networks, methods of contextual addressing, algorithms and protocols of hierarchical contextual routing, methods of data transfer based on context identifiers will enable more effective implementation of the large-scale Internet of Things network. The development of network and sensors will be possible using the laboratory facilities of the project partners, in particular the PL-LAB 2020 test network, the Wireless Network Laboratory, the Internet of Things Laboratory.

The final result of the conducted experiments and measurements - the platform prototype operating in conditions close to real, will correspond to the VII level of technological readiness of TRL VII.

### **A Comparative study of Porosity between Zinc Phosphate Alkyd based and Solvent based Epoxy Paints. Is Porosity A Necessity or a Problem?**

*Mr Matthew Hancock*

*Royal Armouries*

**Keywords:** *Zinc, corrosion protection, coatings, electrode*

Most solvent based coatings are porous; some coatings are manufactured to be porous. For example, micro porous paints for wood. Papers have been published that suggest that increases porosity in metal coatings have little effect on corrosion. Also, research has been undertaken on under coating corrosion and how the difference size zinc particles can let moisture through the coating. Porosity creates advantages and disadvantages in organic and polymer coatings; the biggest advantage is that it lets the electrode through to assist corrosion protection. The problem is if the electrode can get in so can moisture as is known only a small amount of moisture is required to start the corrosion process, allowing the zinc particles to join up could affect the efficiency of the electrode.

The aim of this research project is to gain a more in-depth understanding of how much and the effect of porosity with different coatings in the title of this project for corrosion protection and if greater or smaller porosity makes a difference and to start investigating the best level of porosity for corrosion protection. The data collected about the best level of porosity in required for corrosion protection will then be used to attempt to develop a coating that will have similar properties to Gore-Tex but in the case of protective coating for metallic objects the coating will need to let the electrode in and keep moisture out.

The first part of study will experiment with the amount of porosity of different types of paints by measuring the amount of water absorbed in to porous and steel substrates. The second part of this project is to create different amounts of porosity in the different types of paint and then test for corrosion using a similar method to ASTM G50. The data collected from the experiments should give

information on the ideal level of porosity for corrosion protection in zinc phosphate alkyd based and solvent based epoxy paints and could be used to develop coatings.

### Lithium silicate admixture in mortars to be used as putty for limestone

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**Keywords:** *Lithium silicate, marble, putties, mechanical tests*

Marble is a very common material in artworks for its softness, relative isotropy and homogeneity and its characteristic waxy look that gives "life" to sculptures. Even if in geology the term "marble" refers to metamorphosed limestone, commonly the term 'marble' is used more broadly encompassing hard unmetamorphosed limestone that can be polished assuming a glossy aspect. In the restoration field when marble artworks have cracks that alter the smoothness of their surface, a putty is used to fill them, for both aesthetic and conservative reasons. Putties usually consist of epoxy resin mixed with marble powder. The use of a synthetic resin raises some doubts on compatibility and durability of such putties, on the other side an inorganic binder, such as natural hydraulic or slaked lime, lead to a mortar that can't be polished and doesn't fit the aesthetic purpose of the putty. In this work, it's studied the use of lithium silicate as admixture to improve the characteristic of inorganic mortars, particularly mechanical resistance and surface hardness in order achieve a good workability of the mortar surface.

The mortars underwent compression and three-point bending tests to measure the influence of lithium silicate on mechanical properties, capillarity test and equilibrium water content to verify modification on the interaction with environment, abrasion resistance tests to study surface hardness modification.

The results clearly indicate that lithium silicate in low percentage allowed to obtain a more resistant mortar, characterized by a harder and more compact surface that can be polished in order to resemble marble smoothness. Moreover capillarity rate decreases while equilibrium water content increases slightly, indicating that the treatment affect only a little the interaction with environment. Finally the mortars can be painted using lithium silicate as binder for watercolour so that these mortars can be used not only on white marble but also on coloured limestones.