

BROMECC 35

Bulletin of Research on Metal Conservation

December
2014

Editorial

BROMECC 35 summarizes ten recent research projects about improving the documentation, analysis, restoration and preventive and interventive conservation of metallic cultural heritage. The abstracts come from projects devised within the frameworks of individual master's and doctoral studies and multi-partner projects – mainly within continental Europe.

Research into advancing artefact documentation is presented in an abstract from a pan-European consortium which develops optical measurement techniques for the cultural heritage sector. Preventive conservation research is outlined by two abstracts concerned with evaluating indoor air quality in real time. They come following this year's landmark declaration by the IIC and the ICOM-CC for more sustainable and flexible environmental guidelines. The first is a new project aiming to develop an air quality monitoring kit which combines multiple environmental parameters to alert against air pollution. The second outlines a new data-logger for monitoring air corrosivity by electrical resistance. This commercially available device represents the culmination of European Union funded activities in museums around the world. With respect to research into new interventive conservation methods, a description is given of the complementary analyses for optimizing the use of subcritical fluids to remove chlorides from ferrous archaeological artefacts. In order to advance the evaluation of coatings and patinas *in situ* on artefacts, a novel thixotropic electrolyte for electrochemical impedance spectroscopy is outlined in a further abstract. To assist the development of compatible treatment interventions on gilded silver from the Middle Ages, non-destructive and non-invasive material characterizations of artefacts and contemporary models were pursued by another researcher. Also, research into the removal of rust stains using organically-derived chelating agents for restoring painted ferrous artefacts is explored. Meanwhile, to aid the restoration of archaeological bronzes and the uncovering of original surfaces encrusted with corrosion products, research from Iran has developed a decision-making process and practically tested corrosion product removal methods on various corrosion morphologies. An image from this last project is used in the title for this edition of BROMECC. Output from another European Union project is demonstrated with a new commercially available tool – using atmospheric plasma – for surface-cleaning, and for depositing and removing protective coatings. Lastly, investigations into the susceptibility of antimony-rich lead alloys by organic vapour corrosion and their stabilization and protection by advanced methods are outlined in another abstract.

These abstracts and new announcements published in BROMECC 35 were revised and translated by the BROMECC editorial team which has recently seen some changes. I welcome three new members: Ana Pastor and Ana Crespo, the Hispanophone Translators; and Julie Masson-MacLean who augments the team of Francophone translators. Many thanks to Emilio Cano for his prior contributions as the Hispanophone Coeditor and welcome to Diana Lafuente who now fulfils this role.

Wishing you enjoyable and informative reading!

James Crawford

Anglophone editor & translator:

James Crawford
jamesbcrawford76@gmail.com

Francophone coeditor:

Michel Bouchard
mbouchard@caraa.fr

Francophone translators:

Nathalie Richard
n.richard.elmesti@videotron.ca

Elodie Guilminot
elodie.guilminot@arcantique.org

Julie Masson-MacLean
jmassonmaclean@gmail.com

Hispanophone coeditor:

Diana Lafuente
diana.lafuente@gmail.com

Hispanophone translators:

Ana Crespo
crespo-ana@hotmail.com


Ana Pastor
a.pastor.restaura@gmail.com

Contents

New research projects

	<i>AIRCHECQ – Air Identification & Registration for Cultural Heritage: Enhancing Climate Quality</i>	3
---	--	---

Ongoing research projects

	<i>The stabilization of iron archaeological artefacts with subcritical fluids: dechlorination of corrosion product layers</i>	4
---	---	---

	<i>Design of a cell using a polymeric gel electrolyte for in situ measurements on metallic heritage</i>	5
---	---	---


	<i>COST Action TD1201: Colour and Space in Cultural Heritage (COSCH)</i>	6
---	--	---

	<i>The corrosion, conservation and protection of antimony-rich lead alloys in cultural heritage objects</i>	7
---	---	---

Finalized research projects


	<i>De Colorando Auro: Art and Ancient Recipes by Medieval Goldsmiths for Colouring Gold: an Analytical Approach</i>	8
---	---	---

	<i>Rust removal by siderophores: application to painted iron</i>	9
---	--	---

	<i>Cleaning principles for ancient bronze artefacts based on the recognition of cuprite as the original surface and an evaluation of cleaning methods</i>	10
---	---	----

	<i>PANNA – Plasma And Nano for New Age Soft Conservation</i>	11
---	--	----

Research project implementations

	<i>AirCorr corrosion loggers: real-time monitoring of air corrosiveness by electrical resistance</i>	12
---	--	----

Abbreviations and acronyms	13
----------------------------------	----

General information

Future seminars and conferences	15
---------------------------------------	----

Announcements.....	15
--------------------	----

Websites	15
----------------	----

National Contacts	18
-------------------------	----

Cover image: Optical microscope image of the cross-section of a warty corrosion showing multiple corrosion layers of principally cuprite and copper chlorides in an archaeological bronze fragment from Hasanlu, northwest Iran. Refer to abstract by Mortazavi, "Cleaning principles for ancient bronze artefacts based on the recognition of cuprite as the original surface and an evaluation of cleaning methods".

BROME C website: warwick.ac.uk/bromec

BROME C subscription: warwick.ac.uk/bromec-subscription

AIRCHECQ – Air Identification & Registration for Cultural Heritage: Enhancing Climate Quality ¹ (UA)

New research project



Contact: Olivier Schalm
(olivier.schalm@uantwerpen.be) (UA)

Funding: BELSPO² in BRAIN-be
Axis 6, 1 October 2014 – 30
September 2018, €949 024

Preventive conservation methods are based upon the principle that deterioration and damage to works of art can be controlled or slowed by managing the conditions under which collections are housed and safeguarded. Therefore, it is possible to prolong the lifespan of objects by improving indoor air quality (IAQ).

The problem with environmental monitoring in museums is that they are usually limited to temperature and relative humidity. In some instances, visible light and UV measurements are also made. It is known that many other airborne substances, such as particulate matter and reactive gases (e.g. H₂S, O₃, organic acids), play a crucial role in the deterioration of heritage materials. However, often these parameters are not monitored.

Additional problems hamper the evaluation of mitigation measures:

- *Complex relationships between environmental parameters and transformation rates:* the relationships between the causes of transformation and their consequences are to a large extent unknown. By measuring the behaviour of a series of materials (e.g. corrosion rate of iron, copper, silver or lead, dimensional changes of wood) it should be possible to evaluate how harmful environmental parameters are for a mixed collection;
- *How IAQ is measured:* IAQ is determined by monitoring several environmental parameters (e.g. temperature, relative humidity) and the behaviour of representative test materials (e.g. online measurement of metal corrosion rates). Such measurements will be compared with accompanying threshold values and will be summarized by a single IAQ-index. The measurements will be converted into a data stream of IAQ-indexes describing the fluctuation of the indoor air quality over time;
- *IAQ for mixed collections:* Some environmental conditions might be suitable for some materials within a collection, but can be harmful to others. Therefore, IAQ is determined through a combination of environmental parameters, the materials and objects present in the mixed collection and by the properties of the building itself. Moreover, the threshold values describe the harmfulness of the parameters for the collection;
- *Human decisions vs. analytical results:* All measured parameters require a threshold value which defines whether or not a given amount is harmful. This value is not always based on objective data, but is often chosen by humans. A method needs to be developed to define how threshold values are established. This is especially problematic for mixed collections.

This project aims to develop: a monitoring kit which is able to measure several parameters over time; user-friendly IAQ monitoring software which calculates the IAQ-index over time; and a work flow for heritage caretakers to setup performance monitoring of mitigation actions. The overarching aim is to alert decision makers in museums of air pollution problems.

1. Original language version; submitted by author in English.

2. www.belspo.be/belspo/index_en.stm

The stabilization of iron archaeological artefacts with subcritical fluids: dechlorination of corrosion product layers¹ (AC, CNRS)

Ongoing research project



Contact: Marine Bayle
(marine.bayle@cea.fr),
Delphine Neff, Philippe
Dillmann (NIMBE
/LAPA/CEA/CNRS/UMR3299);
Philippe de Viviés, Jean-Bernard
Memet (AC).

Funding: No external funding

The excavation of iron archaeological artefacts causes a dramatic disruption of environmental equilibrium, causing conservation problems. Oxygen concentration, pH and the presence of substances like chlorides in the archaeological environment influence the formation of corrosion product layers. Uncontrolled post-excavation storage of artefacts reactivates corrosion mechanisms on a microscopic scale, causing severe macroscopic degradation. In order to limit this phenomenon, stabilization techniques for archaeological artefacts aim to extract chlorides from the corrosion layers.² Even if these methods are effective, processes remain long and difficult. To reduce the treatment time, the Clemson Conservation Center (USA) used the transport properties of subcritical fluids to establish a fast dechlorination treatment.^{3,4}

The objectives of this study carried out by the Laboratoire Archéomatériaux et Prévission de l'Altération and the company A-CORROS Expertise – which has developed the first European prototype of a subcritical treatment chamber – are to understand the influence of treatment parameters (solution, temperature, pressure) on chloride extraction. To this end it is necessary to identify the corrosion products and comprehend at a microscopic scale the transformation mechanisms occurring within the corrosion layers during treatment.

The analytical protocol is based on studying phases commonly found inside the corrosion layers of archaeological iron: oxides and oxyhydroxides. Chemical and physical transformations of the corrosion layers are investigated. For comparison, powdered samples from archaeological objects and laboratory-synthesized phases are chemically characterized (Raman spectroscopy, μ XRD and SEM-EDX) before and after treatment in alkaline solutions (NaOH) at 35 bars and 180 °C. Cross-sections of representative sets of artefacts from archaeological environments (terrestrial, marine and subaquatic) are similarly characterized before and after subcritical treatment. *In situ* characterization over time by Raman spectroscopy within a high pressure-high temperature (HP-HT) cell allows determination of intermediate products and also reaction kinetics. Dechlorination rates are determined by periodic testing of treatment solutions with Chloride QuanTab® test strips.

The kinetics of corrosion product transformations and the dechlorination mechanisms are expected to be similar between the powders sampled from archaeological artefacts and the cross-sections of corrosion layers. The specific surface area of phases and the porosity of the corrosion layers will affect the dechlorination mechanisms. Initial results indicate that the reactivity of powdered phases sampled from archaeological artefacts is more representative of the behaviour of archaeological artefacts than of the synthesized phases. Subsequent results will permit further optimization of the subcritical treatment and understanding of the transformation phenomena of archaeological iron corrosion products.

1. Original language version; submitted by author in English and French.

2. Kergourlay, F., et al., 2011. Mechanisms of the dechlorination of iron archaeological artefacts extracted from seawater. *Corrosion Science*, 53(8), 2474-2483.

3. Näsänen, L.M.E., et al., 2013. The applicability of subcritical fluids to the conservation of actively corroding iron artefacts of cultural significance. *The journal of supercritical fluids*, (79) 289-298.

4. deViviés, P., et al., 2007. Transformation of akaganeite in archeological iron artefacts using subcritical treatment. In METAL 2007 Interim meeting of the ICOM-CC METAL Working Group. Amsterdam, 17-21 September 2007. (5) 26-30.

Design of a cell using a polymeric gel electrolyte for *in situ* measurements on metallic heritage¹ (CENIM-CSIC)

Ongoing research project



Contact: Emilio Cano (ecano@cenim.csic.es) (CENIM-CSIC), Ana Crespo (CENIM-CSIC), Diana Lafuente (CENIM-CSIC), Blanca Ramirez (CENIM-CSIC)

Funding: Ministerio de Ciencia e Innovación, Plan Nacional I+D+i 2008-2011. Subprograma de Proyectos de Investigación Fundamental, HAR2011-22402.

Electrochemical impedance spectroscopy (EIS) has been widely used in industry to analyze coatings for metals and to evaluate their damage. Despite excellent results, its use for metallic cultural heritage is very recent and limited, due to difficulties such as the manipulation of liquid electrolytes.

Researchers at the department of Ingeniería de Superficies, Corrosión y Durabilidad at CENIM (Centro Nacional de Investigaciones Metalúrgicas) have developed a small cell capable of making *in situ* electrochemical measurements. The design of the cell is based on a conventional three electrode cell: a reference electrode (RE) made of silver wire coated with silver chloride; a counter electrode (CE) made with stainless steel mesh; and a working electrode (WE), which is the metal under study. The main innovation of this design is the use of a polymeric gel as the electrolyte, rather than a liquid.²

Gelling-polymer electrolytes (G-PE) have been widely used in the fabrication of batteries and other electrochemical devices, since they have good ionic conductivity. In the electrochemical cell developed by CENIM, agar has been used as a gelling agent, as it comes from a natural substance and is innocuous for both the organism and the environment. The G-PE provides a considerable resistance and some flexibility. This solves the problems presented by the liquid electrolyte and makes it possible to produce a cell capable of carrying out measurements by conforming to different shapes and orientations. Moreover, electrolytes of different compositions can be used; permitting measurements in diverse environments.

The cell has been tested on the bronze Sphinx statues outside the entrance of the Museo Arqueológico Nacional in Madrid, yielding good results. Currently, the project focuses on the analysis of the EIS data obtained using the electrochemical cell with G-PE.

1. Translated by A. Crespo, D. Lafuente and J. Crawford. Original version submitted by author in Spanish; refer to BROMECC 35 Spanish version.

2. Cano, E., Crespo, A., Lafuente, D., Ramirez Barat, B., 2014. A novel gel polymer electrolyte cell for *in-situ* application of corrosion electrochemical techniques. *Electrochemistry Communications*, (41) 16-19.

COST Action TD1201: Colour and Space in Cultural Heritage (COSCH)¹ (HEACR, HSM)

Ongoing research project



Contact: Christian Degriigny (HEACR) (christian.degrigny@he-arc.ch), Frank Boochs (HSM), Stefanie Wefers (HSM)

Funding: COST - European Commission

COST (www.cost.eu) is an intergovernmental framework for European cooperation in the field of scientific and technical research which permits on a European level the coordination of nationally funded research projects.

The main objectives of the COST Action TD1201 are to promote research, development and application of optical measurement techniques – adapted to the needs of heritage documentation – based on interdisciplinary cooperation at a European level. It also aims to offer a novel and reliable independent and global *knowledge base* facilitating the use of current and future optical measurement techniques to support the documentation of European heritage.

Therefore COSCH provides an open forum for organisations, institutions and companies interested in collaborating within the emerging field of precise spectral and spatial imaging techniques, in physical and chemical sciences applied to cultural heritage objects, as well as in research and applications into the conservation and art-historical analysis of such objects. Participation is open to researchers across a wide range of disciplines, including computer scientists, museum professionals, art historians and academics in heritage-related fields. COSCH is a trans-domain Action of the COST Domain Materials, Physics and Nanosciences (MPNS) which facilitates and promotes innovation in material science.

COST TD1201 covers the following scientific domains: spectral object documentation (WG1), spatial object documentation (WG2), algorithms and procedures (WG3), analysis and restitution of surfaces and objects of material culture (WG4) and visualisation of cultural heritage objects and its dissemination (WG5).

Regular meetings involving EU delegates of the action or only members of the WGs (taskforce meetings) are organized to exchange the current knowledge within a broader group, to discuss new themes and provide the possibility for new collaborations. Imaging techniques covered by COSCH - and of interest to metal conservators - are 3D scanning, reflectance transformation imaging (RTI), photogrammetry/structure from motion. Important tools of COSCH for end-users are the training schools for specific topics and the Short-Term Scientific Missions (STSMs) designed to train scientists or conservation professionals from one country represented in COST TD1201 at institutions from another similarly represented country.

The COST Action TD1201 started in November 2012. Funding is available for four years (2012-2016). Twenty five countries are participating in the management committee. Up-to-date information about COSCH activities, including its scientific and training programmes, abstracts of presentations and a list of participants can all be found on the Action website at www.cosch.info.

1. Original language version; submitted by author in English.

The corrosion, conservation and protection of antimony-rich lead alloys in cultural heritage objects¹ (UA)

Ongoing research project



Contact: Patrick Storme
(patrick.storme@uantwerpen.be) (UA)

Funding: No external funding (1 October 2013 – 30 September 2017)

In 2011, corrosion phenomena were observed in part of the collection of lead printing letters at the Museum Plantin-Moretus, Antwerp.² This represented the start of a first research phase aiming to evaluate the scale of the problem and to identify the most important warning signs for museum staff. This resulted in a report and a related publication.³

It is known that lead corrodes more severely in the presence of VOCs, but the rate and the corrosion product expansion that these particular alloys in the collection showed were unprecedented. Tendencies in the relationship between the corrosion formation and the alloy compositions pointed towards high levels of antimony and low levels of tin in the lead alloy. Further research on these specific alloys should result in a well-defined grouping of different environmental corrosion rates versus lead alloy compositions; especially according to the antimony-tin ratios. This knowledge should enable conservators to pay more attention to the exact alloy composition of lead-based objects so they can advise collection managers and museum staff members in a more detailed way or to isolate susceptible objects from their surrounding environment.

The development of advanced treatment methods for corrosion stabilization and for the protection of metal objects will be addressed in a second phase of the research. Methods derived from past and present studies using atmospheric plasma will be adopted: IWT-Tetra project Smartplasma (2005-2007) and the current EU-Project PANNA (2011-2014). These projects mainly focus on silver and silver alloys. The applied plasma technique is a variant on the widely known hydrogen low pressure plasma since it is used in open air and the surface treatment occurs in the afterglow of the plasma. This results in a very versatile application (oxidative or reducing capacities according to the gas mixtures) at very low temperatures (<40 °C with newly developed torches). As a dry and non-contact treatment method, it presents a viable alternative for some objects.

The scope of this research should lead to advanced insights into specific corrosion issues related to silver and lead alloyed objects, in conjunction with advanced treatment options for cleaning and protecting objects.

1. Original language version; submitted by author in English.

2. www.museumplantinmoretus.be/Museum_PlantinMoretus_EN

3. Storme, P., 2013. Research on Corrosion of Lead Printing Letters from the Museum Plantin-Moretus, Antwerp, *Procedia Chemistry* (8), 307-316

De Colorando Auro: Art and Ancient Recipes by Medieval Goldsmiths for Colouring Gold: an Analytical Approach ¹ (KIK-IRPA/VUB)

Finalized research project



Contact: Amandine C. Crabbé
(amandine.crabbe@gmail.com)
(VUB/KIK-IRPA)

Funding: Belgian Science Policy (SPP) and the European Commission FP7 under the CHARISMA Grant Agreement n° 228330.

“How to restore and conserve gilded silver artworks without damaging them or losing information about their history?” This important question was raised in 2006 at the Royal Institute for Cultural Heritage during the conservation-restoration treatment of silver gilded statuettes from the Holy Lady Shrine of Huy (13th century, Belgium). After some promising results at the beginning of 2009, extended research was undertaken with the aim of answering this very practical question. To do so, it was necessary to know more about possible historical surface treatments for medieval fire gildings. The strategy, developed during this research, combines the need for scientific characterization of fire gildings by following the ethical obligations inherent to the field of cultural heritage: non-destructive and non-invasive analytical techniques were applied.

During this research, the appearance of precious historical samples coming from the Holy Lady Shrine statuettes was characterized with optical reflection methods. In order to understand which surface treatments might have been applied to the shrine, we surface treated contemporary model samples using medieval recipes to mimic the appearance of the historical samples. In a following step these samples were artificially aged to produce a surface state as close as possible to the historical samples.

All these samples were fully characterized with advanced analytical techniques such as field emission scanning electron microscopy (FE-SEM) and synchrotron radiation (SR) based X-ray absorption spectroscopy (XAS). The latter allows non-destructive and non-invasive analyses to chemically characterize the historical samples. This approach allowed us to compare the aged model samples with historical samples.

The research project was concluded in March 2014 during the defence of a PhD thesis which presented the complete and multidisciplinary collaborative work. Based on the results, some important recommendations towards future restoration-conservation treatments were formulated. Indeed according to these results, it is highly possible that the gilded silver pieces of the Holy Lady Shrine were chemically treated to modify their appearance. The surface aspect seems to be partially due to the presence of iron and copper chemical compounds, leading to, for example, advice against the use of EDTA or other cleaning baths with reducing agents.

Articles in journal and conference proceedings with peer-review.²⁻⁶

1. *Original language version; submitted by author in English*

2. Crabbé, A.C., Languille, M.-A., Vandendael, I., Hammons, J., Silly, M.G., Dewanckel, G., Terry, H., Wouters, H.J.M., 2013. “Colorando Auro”: contribution to the understanding of a medieval recipe to colour gilded silver plates. *Applied Physics A* (111), 39-46.

3. Crabbé, A.C., Giumlia-Mair, A., Wouters, H.J.M., Terry, H., Vandendael, I. “De Colorando Auro”: Experiments and Literature Study of Medieval Colouring Recipes on Gilded Plates. *Studies in conservation*.

4. Crabbé, A.C., Wouters, H.J.M., Terry, H., Vandendael, I., 2013. “Colorando Auro”: medieval goldsmith’s craft and ancient recipes for colouring gold: an analytical approach to evaluate the stability of a medieval colour-modified gilded ‘repoussé’ silver-plate. *METAL 2013 Interim Meeting of the ICOM-CC Metal Working Group Conference Proceedings, Edinburgh, Scotland 16-20 September 2013*. 247-251.

5. Crabbé, A.C., Vandendael, I., Dewanckel, G., Terry, H., Wouters, H.J.M., 2013. “Colorando Auro”: third century colouring surface treatment of fire gildings. *Surface Engineering* (29) 159-163.

6. Crabbé, A.C., Dewanckel, G., 2011. *Projet d’étude des recettes de la coloration de l’or sur les orfèvreries anciennes, Archives des Bibliothèques de Belgique* (94) 1581-1591.

Rust removal by siderophores: application to painted iron¹ (SABKS)

Finalized research project



Contact: Annika Maier,
(amaier.de@gmail.com)
(SABKS)

Funding: No external funding

Siderophores (gr. iron carrier) are generated by living organisms for transporting iron ions. With a view to removing rust stains from painted surfaces which cannot be removed by mechanical cleaning methods without harming substrates, it was decided to determine the potential for siderophores to sequester iron corrosion products.

Based on investigations using an oil-painted iron sheet from the 19th century, different experiments were conducted during a diploma thesis² for the Stuttgart Objects Conservation Programme. Established sequestering agents for oil paintings, disodium ethylenediamine tetra-acetic acid (Na₂-EDTA) and diammonium hydrogen citrate were compared to the siderophore desferrioxamine B-methansulfonate; most known from medicine. Trace element analyses of dissolved metal ions by ICP-MS were performed by the Institute of Mineralogy, University of Stuttgart.

All tested sequestering agents affected the pigments, while the sequestering effect on rust was low and proceeded very slowly. The embedding of the pigments in a binding material offered a certain protection for the pigments. White lead and cinnabar were not attacked by the sequestering agents, while the remaining pigments and fillers – for example malachite, Naples-yellow and iron oxide black – were coordinated to differing extents. Diammonium hydrogen citrate was barely capable of dissolving corrosion products. EDTA attacked the pigments the most. In conclusion, although the siderophore desferrioxamine B-methansulfonate showed the highest selectivity to iron, it is insufficiently selective for painted surfaces.

1. Original language version; submitted by author in English.

2. Maier, A., 2014. Rost mit Fassung. Eignung von Komplexbildnern zur Korrosionsbehandlung an bemaltem Eisen. VDR Beiträge zur Erhaltung von Kunst- und Kulturgut, Heft 2, 89-96.

Cleaning principles for ancient bronze artefacts based on the recognition of cuprite as the original surface and an evaluation of cleaning methods ¹ (AUI)

Finalized research project



Contact: Mohammad Mortazavi
(m.mortazavy@au.ac.ir) (AUI)

Funding: No external funding

Removing massive corrosion products from archaeological bronze artefacts is a complicated and difficult task. Revealing original characteristics of the object as an aesthetic entity; and also conserving all of the evidence they contain as historical documents prompts crucial challenges during decision-making and cleaning. The aim of this thesis is to present a framework for cleaning archaeological bronzes based on original surface properties, their main composition, an assessment of cleaning methods and the codes of ethics and guiding principles for conservation.

Literature research and field and laboratory studies were conducted in three capacities. In the first part, codes of ethics and principles were critiqued with regard to characteristics of the original surface and attached materials. In the second part, the original surface and technical difficulties encountered with respect to corrosion structures were investigated. Various types of corrosion in archaeological bronzes were investigated for any remaining original surfaces and for the viability of their recovery. In the third part, damage resulting from chemical cleaning methods on cuprite layers – regarded as the original surface – was assessed using laboratory experiments. An artificial cuprite marker layer was formed electrochemically. The extent of dissolution of the cuprite layer and copper in cleaning reagents was determined by atomic absorption spectroscopy (AAS). In addition, deterioration of the morphology and visual effects of the artificial cuprite caused by cleaning reagents were respectively studied by scanning electron microscopy (SEM) and colourimetry. Furthermore, to understand the electrochemical behaviour of the cuprite layer during immersion in various cleaning solutions, evolution of the open circuit potential (E_{corr}) was investigated.

Studies of corrosion product structures showed that revealing the original surface in the case of warty corrosion, periodic corrosion, pitting corrosion and layered structures was not possible. Moreover, it was found that cleavage at the interface of the original surface was not a usual property which could be used during mechanical cleaning. Research in conservation theory showed that, although the original surface contains primitive characteristics of bronze artefacts which can be used as markers for cleaning, there was also evidence in the outer layers which formed a potential source of information. Additionally, sodium hexametaphosphate (CalgonTM), sodium tripolyphosphate (STPP) and alkaline Rochelle salt were found to cause less deterioration of cuprite surfaces than other reagents. Finally, this research proposed a decision-making model for the cleaning of archaeological bronze artefacts.

1. Original language version; submitted by author in English

PANNA – Plasma And Nano for New Age Soft Conservation ¹ (VN, UA)

Finalized research project



Contact: Alessandro Patelli
(alessandro.patelli@venetonanotech.it) (VN), Patrick Storme (UA)

Funding: FP7, European Commission, Project n°282998, 1 November 2011 – 31 October 2014, €2 832 072

The aim of this project was to establish a full-life protocol spanning a whole conservation treatment. To this end an atmospheric plasma torch was developed for cleaning surfaces, for the deposition of protective coatings and for their complete removal.

New protective coatings based on organic coating technology and the hybridization of organic-inorganic sol-gel technology were developed. This approach enables a wide range of adjustable properties like transparency, permeability/porosity, hydrophobicity, abrasion resistance. Optional features of the coatings include the capability to impart self-diagnostic properties and invisible markers for identification and anti-counterfeiting purposes.

The development of the plasma torch was made in conjunction with simultaneous tests using existent commercial plasma torches used for reducing corrosion products and for removing soot, black crusts and aged protective coatings. The torch was also tested for the removal of the protective coatings developed during the project; demonstrating their reversibility. Its portable design renders it practical for use by the conservator in the lab and in the field.

The development of the coatings and the plasma torch was assisted by continuous feedback from tests performed on selected CH substrates: silver, bronze, marble, sandstone, wall paintings.

The output of the project² can be seen on three levels.

- At a technological/research level, the project allowed the development of a true cold plasma torch; achieving the best compromise between treatment temperature and efficiency (densities of plasma and active species). Furthermore the plasma was tested on a wide range of materials. Also, the project allowed the creation of low-cost smart hybrid protective coatings for use in various fields.
- For CH practice, the establishment of a comprehensive protocol for cleaning, depositing and removing materials provides a complete suite of tools for the conservator. The protocol is available so conservators can improve heritage conservation-restoration technologies. This potentially has an important impact on techniques by reducing their cost and it could revolutionize current techniques used in the domain; making a leap forward in the state-of-the-art.
- Regarding exploitation of results, the strong participation of SMEs as conservation operators and technology companies dramatically increases the opportunity to disseminate the technology and to put new products on the market. Indeed the new atmospheric plasma torch is already available from Nadir and the new coatings are available from ChemStream: the SME partners in the project.

The Consortium:

- Veneto Nanotech, Marghera, Italy (project leader)
- Consiglio Nazionale delle Ricerche - Istituto per l'Energetica e le Interfasi (CNR-IENI), Padua, Italy
- Rathgen Research Laboratory, Berlin, Germany
- Universiteit Antwerpen, Antwerp, Belgium
- Nadir, Veneto, Italy
- Center for Restoration of Art Works, Sofia, Bulgaria
- Botega Z, Sofia, Bulgaria
- Lorenzon Costruzioni, Veneto, Italy
- ChemStream, Antwerp, Belgium

1. Original language version; submitted by author in English

2. Further information: www.panna-project.eu

AirCorr corrosion loggers: real-time monitoring of air corrosiveness by electrical resistance¹ (IC, ICT)

Finalized research project



Contact: Erwan Diler
(erwan.diler@institut-corrosion.fr) (IC), Tomas Prosek (IC), Milan Kouril (ICT)
Mohammad Mortazavi

Funding: Institut de la Corrosion & EU research project MuseCorr (Seventh Framework Programme, Theme 6: Environment, Duration: June 2009 – July 2012 Contract No. 226539)

Temperature and humidity are routinely monitored and controlled in museums, archives and depositories to protect displayed or stored artefacts from deterioration. However, corrosion of metals is dramatically accelerated by air pollutants such as nitric or sulphur oxides, organic acids etc. Air quality control might either be inadequate or excessive, and unless monitored – with a means providing rapid-feedback – indications of actual corrosiveness can occur too late.

AirCorr corrosion loggers allow real-time monitoring of air corrosiveness for metals and alloys: Ag, Cu, CuSn, Fe, Pb, Sn, Zn and ZnCu. They are the culmination of the EU-funded MuseCorr project, which was conducted in collaboration with museums around the world: www.musecorr.eu. The concept of the device is simple and yet highly effective: the electronic unit logs the change over time in the electrical resistance (ER) of a thin metal track. If the metal corrodes, the cross-sectional area of the track decreases and the electrical resistance increases. Compensation for resistivity changes due to varying temperature is made using a protected reference. There are four principal parts: an electronic logger for measuring and recording ER, a metal sensor, a communication interface between the logger and a computer and a software programme for measurement interpretation.

Three versions of AirCorr loggers are available, all using replaceable corrosion sensors. AirCorr I uses a single corrosion sensor. AirCorr I Plus uses two corrosion sensors, has an LCD showing current corrosiveness and also logs temperature and relative humidity. They are both well-suited for indoor atmospheres e.g. display cases. AirCorr O is a watertight logger for extreme environments. Sensors of differing thicknesses are available according to the corrosiveness of the atmosphere and the required sensitivity.

The main benefits of the AirCorr monitoring system are:

- quick response time and a highly sensitive measurement due to the high precision of the electronic device and the geometry of the metal track;
- availability of a wide range of sensors;
- small size;
- easy replacement of sensors – thereby reducing the ongoing costs;
- non-contact data reading, e.g. through display case glass;
- long battery life: up to five years; and
- user-friendly software allowing rapid interpretation of results using available standards and recommendations.²

1. Original language version; submitted by author in English

2. ISO 11844-1, ISO 9223, ISA S71.04.1985 and Sacchi E. and Muller C., 2005. Air quality monitoring at historic sites – redefining an environmental classification system for gaseous pollution, American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc. Atlanta GA, USA, 7.

Website for AirCorr product: www.institut-corrosion.fr/?page_id=336&lang=en

Abbreviations and acronyms

AAS: atomic absorption spectroscopy

AC: A-CORROS Expertise, Arles, France

AUI: Art University of Isfahan, Faculty of Conservation, Department of Conservation of Artistic and Historical Works, Iran

BELSPO: Belgian Federal Bureau for the Development of Scientific Research

BRAIN-be: Belgian Research Action through Interdisciplinary Networks

CE: counter electrode

CENIM-CSIC: Centro Nacional de Investigaciones Metalúrgicas-Consejo Superior de Investigaciones Científicas, Spain

CH: cultural heritage

CNRS: Centre national de la recherche scientifique, France

COST: European Cooperation in Science and Technology

EDTA: ethylenediamine tetra-acetic acid

EDX: energy dispersive X-ray spectroscopy

EIS: electrochemical impedance spectroscopy

ER: electrical resistance

FE-SEM: field emission scanning electron microscopy

G-PE: gelling-polymer electrolyte

HEACR: La Haute Ecole de Conservation-Restauration Arc, Switzerland

HP-HT: high pressure-high temperature

HSM: Hochschule Mainz – University of Applied Sciences, Mainz, Germany

IAQ: indoor air quality

IC: Institut de la Corrosion, Brest, France

ICOM-CC: International Council for Museums – Committee for Conservation

ICP-MS: inductively coupled plasma mass spectrometry

ICT: Institute of Chemical Technology, Prague, Czech Republic

IIC: International Institute for Conservation of Historic & Artistic Works

IWT-Tetra: Agentschap voor Innovatie door Wetenschap en Technologie, Vlaanderen (Institute for Innovation through Science and Technology, Flanders, Belgium); TEchnology TRAnSfer call

KIK-IRPA: Royal Institute for Cultural Heritage, Brussels, Belgium

LAPA: Laboratoire Archéomatériaux et Prévision de l'Altération

MPNS: Materials, Physics and Nanosciences

NIMBE/LAPA/CEA/CNRS/UMR3299: Laboratoire Archéomatériaux et Prévision de l'Altération; CEA, France.

PANNA: Plasma and Nano for New Age Soft Conservation

RE: reference electrode

RTI: reflectance transformation imaging

SABKS: Staatliche Akademie der Bildenden Künste Stuttgart, Germany

SEM: scanning electron microscopy

SME: small and medium enterprise

SR-XAS: synchrotron radiation based X-ray absorption spectroscopy

STSM: short-term scientific mission

STPP: sodium tripolyphosphate

UA: University of Antwerp, Belgium

VN: Veneto Nanotech, Marghera, Italy

VOC: volatile organic compound

VUB: Vrije Universiteit Brussel, SURF research group, Brussels, Belgium

WE: working electrode

WG: working group

μ XRD: X-ray microdiffraction

General information

Future seminars and conferences

New

19th International Congress on Ancient Bronzes (13-17 October, 2015). The J. Paul Getty Museum, Los Angeles, USA. The theme for the meeting is "Artistry in Bronze: The Greeks and their Legacy". Archaeologists, art historians, conservators, curators, scientists, and students will convene at both the Getty Villa in Malibu and the Getty Center in Brentwood to investigate the artistry, craftsmanship, production, conservation, and science of ancient bronzes. The deadline for paper and poster presentations is 5 January, 2015. For more information: http://www.getty.edu/museum/symposia/bronze_congress.html

New

MetalEspaña 2015 (1-3 October, 2015), Royal Mint, Segovia, Spain. The 2nd Congress on Conservation-Restoration of Metal Heritage will host the following topics: techniques of metal heritage research; archaeological, industrial, scientific, historical and religious metal heritage conservation-restoration, and promotability, value and spread of this heritage. The deadline for abstracts is 15 January, 2015. For more information: <http://www.metalespana2015.es/>

Announcements

New

ICOM-CC Metals Working Group Triennial meeting: The Indira Gandhi National Centre for the Arts (IGNCA) in New Delhi, India will be hosting Metal 2016. Further details to follow.

Websites

New

Staffordshire Hoard Symposium papers from the March 2010 meeting held at the British Museum are available: <http://finds.org.uk/staffshoardsymposium>

New

Conservation science tutorials created by the Foundation of the American Institute for Conservation of Historic and Artistic Works (FAIC) and the Getty Foundation are available: <http://cool.conservation-us.org/byform/tutorials/conscitut/index.html>

American Institute for Conservation (AIC) Metals Conservation Wiki - contributors requested! <http://www.conservation-wiki.com/index.php?title=Metals>

ANDRA: Agence Nationale pour la Gestion des Déchets RadioActifs. The following documents can be ordered for free from this website: *Analogues archéologiques et corrosion* (French) and *Prediction of Long Term Corrosion Behaviour in Nuclear Waste Systems* (English) (http://www.andra.fr/interne.php3?publi=publication&id_rubrique=82&p=produit&id=5).

Archaeological Iron Conservation Colloquium 2010 (24-26 June 2010, State Academy of Art and Design, Stuttgart) extended abstracts (Gerhard Eggert and Britta Schmutzler (Eds.)) are online:

- http://www.iron-colloquium.abk-stuttgart.de/Documents/Tagungsband_session_1.pdf
- http://www.iron-colloquium.abk-stuttgart.de/Documents/Tagungsband_session_2.pdf
- http://www.iron-colloquium.abk-stuttgart.de/Documents/Tagungsband_session_3.pdf
- http://www.iron-colloquium.abk-stuttgart.de/Documents/Tagungsband_session_4.pdf
- http://www.iron-colloquium.abk-stuttgart.de/Documents/Tagungsband_postersession.pdf

ARTECH network: Network facilitating the access of conservation professionals to different investigation techniques for Cultural Heritage artefacts (<http://www.eu-artech.org/>).

BigStuff 2004: Care of Large Technology Objects (<http://www.awm.gov.au/events/conference/bigstuff/index.asp>).

Big Stuff 2007 presentations available: <http://www.bergbaumuseum.de/web/aktuelles-veranstaltungen-2007-bigstuff>

British Museum's Library Catalogue is accessible to external scholars: http://www.britishmuseum.org/research/libraries_and_archives.aspx

BROME C subscription: For direct email notification of BROME C publication web links and calls for submission of abstracts and announcements, simply subscribe with your preferred email address: (warwick.ac.uk/bromec-subscription).

Bronze Conservation Colloquium (State Academy of Art & Design Stuttgart, Germany, 2012). For the abstracts and brochure see: <http://www.bronze-colloquium.abk-stuttgart.de/bronze-colloquium-download.html>

CAMEO: Chemical, physical, visual, and analytical information on over 10,000 historic and contemporary materials used in the conservation, preservation, and production of artistic, architectural, and archaeological materials (<http://cameo.mfa.org/>).

Cost Action G7: Artwork conservation by laser: (<http://alpha1.infim.ro/cost>).

Cost Action G8: Non-destructive analysis and testing of museum objects: Abstracts and booklets from previous workshops can be downloaded as well as announcements of past activities (Short Term Scientific Mission deadlines, training schools...) (<http://srs.dl.ac.uk/arch/cost-g8/>).

Cost Action D42: ENVIART: Chemical Interactions between Cultural Artefacts and Indoor Environment. Register (free) to access all information (<http://www.echn.net/enviart/>).

Dechlorination mechanisms of ferrous archaeological artefacts corroded in marine environments: a case study with aerated and deaerated alkaline solutions. The PhD thesis of Florian Kergourlay describes the characterization of the corrosion system on seawater-corroded iron ingots by an array of multi-scale analytical techniques before, during and after a dechlorination treatment. The research raises questions on the dechlorination mechanisms and models for chloride ion diffusion proposed in the literature: http://tel.archives-ouvertes.fr/docs/00/72/11/76/PDF/Kergourlay_2012_these.pdf

Electrochemistry in Historical and Archaeological Conservation (11-15 January 2010, Leiden, the Netherlands). The majority of presentations from this workshop held at the Lorentz Center (<http://www.lorentzcenter.nl/>), are available for download: <http://tinyurl.com/lorentzpresentations>

e-Preservation Science: Online publication of papers in conservation science (<http://www.morana-rtd.com/e-preservation-science/>).

European Cultural Heritage Network: European network of professionals interested in the conservation of Cultural Heritage (<http://www.echn.net/>).

European Federation of Corrosion's Working Party 21: dedicated to corrosion of archaeological materials <http://www.efcweb.org/Working+Parties/WP+21.html>

Ge-Conservacion is a periodical published by GEIIC (Grupo Español de Conservación/Spanish Conservation Group of the International Institute for Conservation of Historic and Artistic Works: www.ge-iic.com/) in association with the Duques de Soria Foundation. Its purpose is to contribute to the scientific development, dissemination and exchange of cultural heritage conservation and restoration knowledge: <http://ge-iic.com/revista/index.php?lang=en>

Getty Conservation Institute's electronic publications: freely available PDF documents covering a range of conservation subjects: http://www.getty.edu/conservation/publications_resources/pdf_publications/

ICOMAM: International Committee of Museums and Collections of Arms and Military History: (<http://www.klm-mra.be/icomam/>).

ICOM-CC Enamel Working Group The main purpose of this group is to facilitate the contact and the circulation of information between conservators, scientists, historians, curators and enamelers. It can also address issues relating to enamel-metal composites. If you wish to join the group and receive the newsletter by e-mail, please send a message to Agnès Gall Ortlik (gallortlik@yahoo.fr) with your address and contacts. For more information: <http://www.icom-cc.org/88/ENAMEL/#.UO6p328z034>

ICOM-CC Metals Working Group: (<http://www.icom-cc.org/31/working-groups/metals/>). This site is for all official ICOM-CC Metals WG activities, forums, news, file downloads and information. The co-ordinator can email members from this site once members have registered on-line as a member of the Metals WG. Public access to this site is limited.

Incredible Industry: The proceedings from the Nordic Association of Conservators 18th Conference, “Incredible Industry, Preserving the Evidence of Industrial Society” (25-27 May 2009, Copenhagen, Denmark) are now freely available online (www.nkf-dk.dk/Bulletin/NKF-Incredible-industry09.pdf).

Industrial artifacts review: Industrial design and the role of art and photography in promoting cultural heritage (<http://industrialartifactsreview.com/>).

Infrared and Raman for cultural heritage: (<http://www.irug.org/default.asp>).

Laboratoire Pierre Sue: LPS PhD thesis related to the alteration of archaeological artefacts can be downloaded in French. Follow the link to “Archéomatériaux et prévision de l’altération” (<http://www-drecam cea.fr/lps/>).

LabS-TECH network: (<http://www.chm.unipg.it/chimgen/LabS-TECH.html>).

La limite de la surface d’origine des objets métalliques archéologiques (“The original surface limits of metallic archaeological artefacts”): PhD thesis by Régis Bertholon, establishes a detailed methodology for determining and describing the location of the former original surface, as modified by its corrosion mechanisms. In French, the document provides an invaluable archaeological metals conservation resource through its synthesis of archaeology, mineralogy and corrosion science. Useful for the conservator and researcher alike, numerous detailed photographs and schema complement the comprehensive text: <http://tel.archives-ouvertes.fr/docs/00/33/11/90/PDF/Limitos.pdf>

Metal 2010 proceedings: The Editors and ICOM-CC Metal Working Group Coordinator announce that the conference proceedings from Metal 2010 are available for sale. Please go to www.lulu.com and search for “METAL 2010” to purchase your full colour or black and white copy. Included in the proceedings are 49 full text papers, 13 poster abstracts, transcripts of the question and answer session for each paper, transcripts of the panel discussion for all 12 sessions, and an author index; totalling 489 pages.

M2ADL: Microchemistry and Microscopy Art Diagnostic Laboratory (http://www.tecore.unibo.it/html/Lab_Microscopia/M2ADL/).

New York Conservation Foundation: (<http://www.nycf.org/>).

PROMET: A 3.5 year European 6th Framework funded project (21 partners from 11 countries around the Mediterranean basin) that developed conservation strategies for outstanding metals collections throughout the Mediterranean (<http://www.promet.org.gr>).

Restauración Metal Sur América: (<http://www.restauraciondemetales.cl/>).

TEL: PhDs on line (<http://tel.ccsd.cnrs.fr/>).

Yahoo Groups Metals Conservation: A discussion group for all who are interested in Metals Conservation. Join in and make this a “Metals Cons-Dist List” (<http://groups.yahoo.com/group/Metals-Conservation-Discussion-Group>).

National Contacts

Argentina: Blanca Rosales (brosales@fibertel.com.ar), researcher, CIDEPINT, La Plata.

Australia: David Hallam (zzdhatta.oatlands@gmail.com), senior conservator-restorer of objects, R.M. Tait and Associates, Oatlands.

Belgium: François Mathis (francois.mathis@ulg.ac.be), archaeometrist, Centre for Archaeometry, University of Liège (Université de Liège), Liège.

Bulgaria: Petia Penkova (petiapienkova@yahoo.com), conservator-restorer, National Academy of Arts, Department of conservation-restoration, Sofia.

Chile: Johanna Theile (jtheile@udd.cl), conservator-restorer and lecturer, Faculty of Art, University of Chile The Oaks (Facultad de Arte, Universidad de Chile Las Encinas), Santiago de Chile.

Croatia: Zoran Kirchhoffer (zoran.k@tehnicki-muzej.htnet.hr), conservator-restorer, Zagreb Technical Museum (Tehnički muzej Zagreb) and Sanja Martinez (smartin@fkit.hr), electrochemist and lecturer, Faculty of Chemical Engineering and Chemical Technology, University of Zagreb (Sveučilište u Zagrebu), Zagreb.

Denmark: Karen Stemann Petersen (karen.stemann@natmus.dk), conservator-restorer, The National Museum of Denmark (National Museet), Copenhagen.

Egypt: Wafaa Anwar Mohamed (wafaaanw@yahoo.com), conservator-restorer, Giza.

Finland: Pia Klaavu (pia.klaavu@nba.fi), conservator-restorer, National Museum of Finland (Suomen kansallismuseo), Helsinki.

France: Elodie Guilminot (elodie.guilminot@arcantique.org), conservation scientist, Arc'Antique, Nantes.

Germany: Britta Schmutzler (britta.schmutzler@gmx.de), PhD "object conservation" student, State Academy of Art and Design (Staatliche Akademie der Bildenden Künste), Stuttgart.

Greece: Vasilike Argyropoulos (bessie@teiath.gr), assistant professor, Department of Conservation of Works of Art, Technological Educational Institution, Athens.

Hungary: Balazs Lencz (lenczb@gmail.com), senior conservator-restorer, Conservation Department, Hungarian National Museum (Magyar Nemzeti Múzeum), Budapest.

India: Achal Pandya (achalpandya@hotmail.com), head of department, Cultural Archives and Conservation, Indira Gandhi National Centre for the Arts, New Delhi, India.

Italy: Paola Letardi (paola.letardi@ismar.cnr.it), scientist, Institute for Marine Corrosion of Metals (Istituto per la Corrosione Marina dei Metalli), Genova.

The Netherlands: Ineke Joosten (ineke.joosten@icn.nl), conservation scientist, The Netherlands Institute for Cultural Heritage (Instituut Collectie Nederland), Amsterdam.

Norway: Douwtje Van der Meulen (d.l.v.d.meulen@iakh.uio.no), conservator-restorer, Conservation Department, University of Oslo (Universitetet i Oslo), Oslo.

Poland: Cátia Lamerton Viegas-Wesolowska (k_viegas@yahoo.com), conservator of metallic heritage artefacts, Gdansk, Poland.

Portugal: Isabel Tissot (isabel.tissot@archofactu.pt), conservator-restorer, Portuguese conservation-restoration Institute (Instituto Português de Conservação e Restauro), Lisbon.

Romania: Dorin Barbu (barbu_dorin_laboratory@yahoo.com), conservator-restorer, National Brukenthal Museum (Muzeul Național Brukenthal), Sibiu.

South Africa: Bradley Mottie (bmottie@iziko.org.za), conservator, Iziko Museums of Cape Town, South Africa.

Russian Federation: Andrey Chulin (andrey_chulin@yahoo.com), conservator-restorer, the State Hermitage Museum, St Petersburg.

Spain: Emilio Cano (ecano@cenim.csic.es), scientist, National Centre for Metallurgical Research (Centro Nacional de Investigaciones Metalúrgicas), Spanish Council for Scientific Research (Consejo Superior de Investigaciones Científicas), Madrid.

Sweden: Helena Strandberg (helena.st@comhem.se), conservator-restorer and conservation scientist, freelancer, Göteborg.

Switzerland: Valentin Boissonnas (valentin.boissonnas@he-arc.ch), conservator-restorer and lecturer, Technical University (Haute école de conservation-restauration Arc), Neuchâtel.

United Kingdom: Maickel van Bellegem (Mbellegem@thebritishmuseum.ac.uk), conservator-restorer, British Museum, London.

United States of America: Paul Mardikian (pmardik@clemson.edu), senior conservator, Clemson University Restoration Institute, South Carolina.