Editor:
Christian Degrigny
cdegrigny@mcr.edu.mt
Assistant editor:
James Crawford
jamesbcrawford76@yahoo.com.au
METAL*Consn*-info

Metal working group

Bulletin of the Research On MEtal Conservation

February 2004

BROMEC9

Editorial

In this new issue we discover two research projects from countries where national correspondents have recently been appointed. The Portuguese abstract is about protection of lead artefacts with adsorbents. The second one presents a research project on re-restoration and re-conservation policies in Bulgaria.

Other papers are related to the use of electrochemical techniques in conservation (cleaning and stabilisation of lead artefacts, stabilisation of aircraft remains made of aluminium alloys and study of corrosion mechanisms) and the alteration of paintings on copper supports. Regarding the use of electrochemical techniques in conservation, the EthIC sub-Working Group has just completed a relatively comprehensive bibliography that can be consulted on the Metal homepage of the ICOM-CC website (http://icom-cc.icom.museum/WG/Metals/ and click on EThIC activities). Do not hesitate to send us any reference related to that topic in order to regularly up-date this bibliography

You must have noticed that the online access to BROMEC has been promoted on the Cons DistList. It is hoped that new members from this electronic forum will join the working group.

Metal alteration and protection were discussed in recent seminars and workshops (IAQ and COST Action G8). The abstracts of these conferences can be downloaded from websites given in the general information section. The same section presents future conferences where metal conservation shall be discussed. It might be that other seminars and workshops related to metal conservation will be organised in the near future. Do not hesitate to inform us about them.

An important reminder to all is that **Metal 2004**, the triennial conference of our Metal Working Group of ICOM Committee for Conservation, will be held in Canberra, Australia, 4-8 October 2004. This is the valuable, 3-yearly opportunity to meet and discuss the group's research activities and to further the objectives of the profession in person. It will also provide the first large forum to discuss the recently evolving Sub-Working Groups (Sub WG's) of the ICOM-CC Metal Working Group.

Hoping that you will find this new issue as useful and interesting as usual.

The editor
Christian DEGRIGNY
The assistant editor

James Crawford

Contents

Page

Ongoing research projects

 Adsorbent materials used to prevent alteration of metallic objects exposed in museums: the case of lead 3

 The formation of a corrosion layer on paintings made with a copper support 4

 Conservation of lead printing letters by electrolytic reduction 5

 The effects of manufacturing techniques on the deterioration of paintings on copper 7

New research projects

 Long term corrosion of iron, unalloyed or mild steel in clay soils. Physico-chemical characterization and electrochemical study of archaeological models 8

 Conservation of aircrafts – 2 case studies 9

 The thin copper-alloy fittings of small Roman and Merovingian wooden chests in the Römisch-Germanisches Museum Cologne 10

 Re-conservation and re-restoration of archaeological metal artefacts 11

Calls for collaboration

 Anticorrosive protection of daguerreotypes 12

Ongoing research projects

Adsorbent materials used to prevent alteration of metallic objects exposed in museums: the case of lead (***DCB-USL***)

The protection of metallic objects from gases or vapours in the museum environment, particularly in showcases, can be achieved by their installation within the proximity of materials that have the capacity to remove those pollutants from the atmosphere through physical or chemical processes. In the case of lead, it is of particular importance to remove acetic acid, which can be liberated (in that form), from the surrounding materials, or can result from the transformation of other substances, such as aldehydes.

Porous solids can be used to achieve this goal due to their adsorbent properties. With the aim of evaluating the more efficient solid adsorbents (that are generally commercially available) for the protection of lead objects exposed to acetic acid vapours, several porous materials were tested, namely activated carbons (RB1, RB3 and RB4, from Norit; and Carbon Tech), zeolites (13X and Y, both in sodium form), silica-gel (SG60) and a modified clay (Wyoming clay pillared with aluminium oxide).

Two kinds of tests were performed. Firstly, the adsorbents were exposed to acetic acid vapours to measure the total saturation capacity and, on the other hand, the isotherms were obtained at low partial pressures, since these are the conditions usually found in museum atmospheres. Secondly, two of the adsorbent materials, which showed the most promising results (carbon RB4 and zeolite 13X), were then used in real lead protection tests. In this case, the samples of metal were exposed to vapours of acetic acid and water in the presence of the adsorbents. The results obtained showed that the adsorbent materials, particularly the RB4 activated carbon, significantly retard the alteration of the lead probes and, consequently, can be used to benefit the protection of objects, namely lead objects, exhibited inside showcases.

The work is still in progress. A study of the adsorbent properties of these and other adsorbents related to other pollutants with significance in museums, namely hydrogen sulfide, is also in progress.

This work was presented during the international meeting: "*Metallic alloys: research and conservation*" held on the 13-14 November 2003, in Porto at the Facultade de Letras da Universidade do Porto.

Contact: António João Cruz (DCB-USL)
Funding: Faculty of Sciences, University of Lisbon Foundation

Ongoing research projects

The formation of a corrosion layer on paintings made with a copper support ***(QU)***

The scope of this project was to determine whether the methods used to prepare copper plates could affect the formation of a corrosion layer between the ground layer and the copper plate. Samples were made using variations of traditional preparation methods and materials. Therefore, three variables were chosen in the preparation of the samples: the roughening method, the type of oil used in the ground layer and the presence of an additional oil layer between the copper and ground layer. Samples were prepared using five different preparation techniques to pre-treat the surfaces: one set was rubbed with a nylon pad, a second with garlic clove, a third set with ash, and a fourth set with both garlic clove and ash. A fifth set of samples had no surface roughening. Each method described above was then repeated, but with the addition of an oil layer brushed onto the copper before the application of the ground layer. Three different types of oil were used for each preparation method: linseed oil, poppyseed oil and walnut oil. A ground layer, made using titanium white pigment, was applied on every sample. All samples were dried for two weeks at normal ambient room temperature and humidity levels. The samples were then isolated for a month in a high humidity chamber, where the RH was maintained at 91%.

All the samples had a reddish tint before the humidity treatment and changed to a greenish tint after treatment. Generally, all the samples with an additional coat of oil presented a slightly more intense green colour.

A small piece of each sample was then cut and embedded into Bioplastic resin to make cross-sections. They were observed under magnification and two types of corrosion layers were distinguished: a distinct vivid green layer and a pale green one, which formed a layer within the ground. These two types of corrosion were randomly distributed throughout all the samples and were not particular to any type of preparation method. Some pitting was also visible, caused by ash left on the surface of the copper. This pitting is very much like the second type of corrosion found on the samples. In most cases, the corrosion layer had separated from the copper plate, but always remained attached to the ground layer. In some cases, the corrosion layer had split in two: one part remaining attached to the ground layer and the other adhered to the copper plate. The corrosion layer did not delaminate from the ground layer for any of the samples. The thickness of the corrosion layer was also measured on every sample. In general, the linseed oil gave the thickest corrosion layer, the poppyseed oil the second thickest, and the walnut oil the thinnest corrosion layer. However, there seemed to be no correlation between the preparation method employed and the thickness of the corrosion layer.

Fourier transform infrared (FTIR) spectroscopy and X-ray diffraction (XRD) analyses were conducted to attempt to identify the composition of the corrosion layers, FTIR spectra showed that with 98% of the samples the corrosion layer is the same. However, in about 2% of the samples, the presence of ash residue seemed to create a variation in the corrosion layer. XRD could not detect the composition of the corrosion layers. The precise nature of the corrosion layers found is inconclusive. The results of this experiment tend to indicate the presence of a metal soap, but further testing would be necessary to determine exactly the nature of the corrosion layers produced in paintings made on copper plates.

Contact: Heloise Paquet (CCQ)
Funding: no external funds

Ongoing research projects


Conservation of lead printing letters by electrolytic reduction (***TMB***)

Within the framework of the archaeological research performed by the Moravian Museum, a unique set totalling about four thousand printing letter blocks was found. This find proves the book-printing activity of the Czech Brothers who operated a secret printing house in the city of Kralice in the second half of the 16th century. The first Czech translation of the Old and the New Testament – the so-called Kralice Bible originates directly from this printing house.

The letters were deposited in the museum and, during the audit performed in 1999, it was found that a substantial part was in a poor state. The letters are 2,5 cm high, their width varies from about 0,3 to 1,0 cm. Some of the print elements are finished with various types of reliefs depicting letters and signs. The letters were damaged by corrosion evidenced by white-brown corrosion products. The extent of the corrosion varies from thin corrosion layers to more voluminous, porous corrosion products that were separating from the base metal. Highly damaged letters were partly cracked and some of them even broken.

In co-operation with the conservation department of the Technical Museum in Brno it was decided to treat 200 pieces of selected letters and to establish the global treatment methodology for the whole collection.

First of all, the chemical composition of the alloy was analysed by EDS. Based on this analysis, it was found that the alloy used for the casting of letters is composed of lead, tin and antimony with very variable proportions (Pb from 57 to 87%, Sn from 0 to 33%, Sb from 0 to 16%). Complex compounds of lead, phosphorus and silicon oxides (5 $PbO.P_2O_5.SiO_2$) were identified by XRD.

The preservation of the letters and signs in relief represents the main requirement for the conservation of these objects. The corrosion products do not form a protective layer, but instead deform the object and cause the corrosion to advance. Therefore, it was proposed to remove the corrosion layers when a metal core was still preserved and where more voluminous corrosion products had developed on the surface it was proposed to reduce them back to lead metal. When selecting the method it also had to be considered that a large number of small objects, with individual evidence, are in question. Eventually, the electrolytic reduction was selected as the convenient conservation method.

The metal compounds from which the corrosion layer is composed were reduced back to the metal. The letters were placed in series of ten pieces on a fine stainless steel net connected to the cathode. The net was separated from the anode made from the same material by means of polyethylene net. The corroded letters had to be first ranked into groups according to the level of corrosion. A 0,3 M solution of Na_2SO_4 was used as the electrolyte. Since the pH decreases during the reaction with this electrolyte, it is necessary to adjust the optimum pH 8 by adding drops of 0,5 M NaOH. Also, 10% Na_2CO_3 was tested as an electrolyte, its pH 10 remained almost the same at the end of the reaction. The values of current were chosen in function of the level of corrosion of letters. For the removal of superficial corrosion (50 letters) a current density of 2 to 5 $A.dm^{-2}$ was applied. The reduction process was accompanied by hydrogen evolution that cleaned the metal surface. The total duration of the process was about 2 hours.

When reducing the thick corrosion layer (140 letters) the so-called consolidation reduction was used with a substantially lower current density, about 100 $mA.dm^{-2}$, the reduction process was not accompanied with any visible evolution of hydrogen and the reduced lead remained on the surface of the letters. The process was considered complete when the surface of the artefacts appeared completely clean. The whole duration of the process was from several days to a week. The letters were washed in distilled water, then in ethylalcohol and dried. This was followed with the completion of the surface cleaning with tooth brushes and glass brushes. Finally, the letters were protected with lacquer KP 709 diluted with acetone.

The electrolytic reduction proved to be the appropriate treatment for such a large set of lead letters. The particular letters and signs in relief were successfully preserved at a rate of about 80%. Thanks to the reduction of the oxidation layer, the surface is more compact, the corrosion traces are less visible and the edges are sharper.

Contact: Alena Selucká (TMB)
Funding: no external funds

Ongoing research projects

The effects of manufacturing techniques on the deterioration of paintings on copper (***ICRS-MCR / WM***)

The scope of this dissertation work is to investigate the manufacturing techniques of paintings on copper and how these techniques influence the deterioration of the paintings. It was decided to base the investigations and observations on actual paintings on copper and not to use laboratory test samples. The investigations were carried out on six paintings on copper belonging to two different public collections in Malta. Two of the paintings, one depicting the reliquary of Saint Cecilia and the other depicting Our Lady of the Rosary, are both by anonymous artists, and both belong to the Wignacourt Museum, a public collection in Malta. These two paintings were chosen for these investigations as their severely deteriorated state permitted the taking of several small samples for analysis. The other paintings observed consisted of a set of four biblical scenes and belong to The National Fine Arts Museum in Malta. These four paintings have been tentatively attributed to an 18th century Maltese artist Francesco Zahra, who had developed his artistic skills in Malta. These paintings are in a very good condition and it is hoped that the close inspection and comparison of the painting techniques used in the above paintings will allow the formation of a relationship between the techniques used and the type of deterioration created.

To this end the following factors were investigated; the preparation of the copper support prior to painting and any evidence of tool-marks left during the process used to roughen the surface of the copper support; the presence or absence of a ground layer and, if present, its constituent materials and thickness; the presence of a green layer formed at the interface between the copper and paint layers and how its presence affects the adhesion between the paint layer and the support; the crack network formed by the different types of pigments used and their possible contribution to the deterioration of the painting; the observation and documentation of the different types of corrosion products created by the reaction of the copper support, both on the paint surface and the reverse, with its environment and the way these corrosion products contribute to the further deterioration of the painting.

Since the four paintings from the Fine Arts Museum are in very good condition only non-invasive investigation could be achieved. A series of non-invasive examinations were in fact carried out on all of the paintings. The examinations included observations using a VSC2000/HR multifunctional digital imaging workstation allowing the examination of the paintings under normal and raking light up to a magnification of x1000. This apparatus also permitted the examination of the paintings under long and short-wave incident UV light, long wave transmitted UV, incident and transmitted IR and at a magnification ranging from x2 to x70. All images were recorded digitally. From the observations done using this apparatus, the presence of tool marks on the surface of the copper were found in several locations in the paintings of St Cecilia and Our Lady of the Rosary. The presence of a translucent green layer was also observed in both of these paintings at the interface of the copper and overlaying paint layers and therefore confirmed the information found in the literature. The presence of a pale brown ground layer was also observed at the edges of some losses, again on both of the paintings.

However, the amount of information that can be obtained from non-invasive visual observation has its limitations and so the next stage of the investigations will concentrate on the analysis of the cross sections of samples taken from the St Cecilia and Our Lady of the Rosary paintings. The samples taken from the two deteriorated paintings are to be examined under SEM to observe the interface between the copper support and the ground and paint layers. Other examinations include the presence and thickness of the translucent green layer found between the copper support and the paint layer and the investigation of the penetration of corrosion products originating from the copper surface and infiltrating the paint layers. The extent and effects of this type of infiltration on the stability of the painting is also to be recorded. SEM/EDS and PLM investigations will finally be used to identify the materials used.

Contact: Raymond Spiteri (student, ICRS-MCR)
Funding: no external funds

New research project

Long term corrosion of iron, unalloyed or mild steel in clay soils. Physico-chemical characterization and electrochemical study of archaeological models (***ANDRA / UTC***)

Within a PhD research project financed by the Agence nationale pour la gestion des déchets radioactifs (ANDRA - National Agency for the Management of Radioactive Waste) and presented in November 2002, iron archaeological artefacts from Gallo-roman (0-400AD), Merovingian (400-700AD) and 1st world war (1914-1918) periods have been studied to better understand the long term corrosion mechanisms of iron in soils. This thesis was conducted at the University of Technology, Compiègne (UTC). The UTC has participated since 1995 in the ANDRA programme on the storage of highly active and long lasting radioactive waste in deep geological layers. The iron based remains are archaeological models used to predict the behaviour of iron, unalloyed or mild steel containers or outer secondary protective containers.

A double approach was followed. Firstly, the physico-chemical characterization of corrosion products by Raman spectroscopy was performed. Secondly, the behaviour of corrosion layers identified with electrochemical methods was studied.

Although the materials considered were different (ferrite in the case of Gallo-roman and Merovingian remains, hypoeutectoid steel for 1914-1918 remains), the stable phases that could be identified in the corrosion products are the same : essentially iron oxides and iron oxyhydroxides. From a macroscopic point of view these products are distributed in two layers: internal and external, the latter containing markers characteristic of the soil (quartz crystals). A complex composite structure appears under the microscope. The α–FeOOH goethite that is always present is often in contact with the metal. The average corrosion rate during the burial, obtained from the layers' thicknesses, shows an important decrease in the corrosion beyond the first 100 years in the soil.

The electrochemical study of 1914-1918 remains has shown the important role of transport phenomena in the pores of the corrosion layers. The behaviour of the metal – internal layer system can be compared to the porous electrode model (De Levie theory). The internal layer, although it is porous, is protective and consequently decreases the corrosion rate by a factor of one decade.

Contact: Emmanuelle Pons (EDF)
Funding: ANDRA / UTC

New research project

 Conservation of aircrafts – 2 case studies (***TEI***)

There are two conservation studies currently taking place in collaboration with the Greek airforce.

The first is a study on how to preserve the painted layers of the commemorative airplanes *Olympus* and *Tigris,* which are made of a type of aluminum alloy. Both planes are F-104G *Strarfighters* used by the Greek airforce. Presently, they are housed inside the Airforce Museum in Tatoi near Athens, Greece. They have an international significance due to the style of the painted surfaces they carry. Unfortunately, both planes were initially stored outside the museum from 1993, and many areas of the painted layers are flaking away. The research that has begun will document the condition of both airplanes and propose a method to preserve the painted layers.

The second is a conservation study of the aircraft *Bristol Blenhein MK IV,* which was lifted from the Greek sea in the summer of 1996 and is also on display in the Airforce Museum. The airplane was shot down in 1941 near the port of Rethymnon, Crete. Unfortunately, the plane, made of an aluminum alloy, was cleaned with a sand-blasting method by members of the airforce. As a result, the chlorides were not effectively removed from the aluminum alloy, and the aircraft is now in a very bad state of conservation. The study will apply the use of cathodic polarization for the stabilization of parts of the plane, relying on past work established by researchers, such as C. Degrigny (1990, Ph.D. thesis). The study will be used as an example to educate the Museum curators and members of the airforce on a more effective way to stabilize submerged aircraft, which are lifted from the sea.

Contact: Vasilike Argyropoulos (TEI)
Funding: no external funds

New research project

 The thin copper-alloy fittings of small Roman and Merovingian wooden chests in the Römisch-Germanisches Museum Cologne (***RLMB***)

Compared to other copper alloy finds treated over many years in the conservation department of the Rheinisches Landesmuseum, the thin (0.1 – 0.3 mm) copper-alloy fittings under investigation are in astonishingly good condition despite having been buried in soil for 2000 years. This project combines the archaeological description of the large collection of Roman and Merovingian fittings of the Römisch-Germanisches Museum Cologne with research on ancient production techniques and the corrosion resistance of the alloy. To date, 40 samples have been analysed by SEM-EDX at the Institute of Inorganic Chemistry of the University of Bonn. Metallographic investigations are planned for the near future.

Although the finds come from different sites and different time periods, they were made of the same brass alloy. The following questions will be addressed:

- Is there any technical advantage in using this particular alloy for thin fittings?
- How were they produced? Is there any development in the early medieval period?
- Does the metallic structure influence the corrosion resistance? Is there any influence of smithing?
- How does this relate to other alloys?
- Is there any influence of hammering?
- Is there evidence for industrial production of brass sheets as raw material traded to metal workshops?

To test hypotheses on production, the techniques shall be replicated experimentally. Later, Rhineland finds from the Rheinisches Landesmuseum, and elsewhere, shall also be investigated to get a better understanding of Roman brass production, its distribution, and further development in the early Middle Ages.

Contacts: Frank Willer & Michael Schmauder (RLMB)
Funding: no external funds

New research project

 Re-conservation and re-restoration of archaeological metal artefacts (***SNAFA***)

This thesis on conservation theory aims to:

- examine the different steps in the conservation of cultural artefacts (set-up of collections, museums, national and international organizations)
- pursue the development of aesthetic and ethical concepts and conservation methods worldwide and more particularly in Bulgaria
- standardize the reasons for new interventions on artefacts
- describe all possible re-conservation and re-restoration approaches in a catalogue with case studies

A lot of artefacts in museums have been conserved according to different conservation approaches and techniques. Conservation practices are characteristic of certain periods and were superseded at later times by new approaches that became considered as being more appropriate. It is known that new aesthetic concepts and new exhibition theories influence the re-restoration of artefacts.

Other reasons for re-restoration practises exist too. For example, the use of inappropriate materials causing corrosion processes such as organic materials or metal reconstructions and solders. The change of conditions in storage rooms or exhibition halls might also be the reason for the re-restoration of environmentally sensitive artefacts.

Any artefact in museum collections needs at least one re-conservation or re-restoration process, but the potential problem exists that during any of these treatments we might lose part of its authenticity or its value as a document of human history.

Contact: Petia Penkova (SNAFA)
Funding: no external funds

Calls for collaboration

 Anticorrosive protection of daguerreotypes

The basic purpose of this work is the search of protective coatings ensuring anticorrosive stability of daguerreotypes. The anticorrosive protection chosen is based on systems used by metal conservators on museum objects and the practice of anticorrosive treatments of metals (*silver and copper alloys*) in the chemical and electronic industries (use of corrosion inhibitors, passivation by chromates and use of solutions of salts of metals).

Since daguerreotypes in Russia are quite rare, preliminary tests were performed on daguerreotypes bought from the USA. Positive results were obtained, but further treatments and researches are required. Among other experiments, the testing of anticorrosive coatings in climatic chambers and the investigation of the surfaces treated with Scanning Electron Microscopy and Energy Dispersive X-ray analysis would definitely be required.

Since the State Hermitage Museum does not have sufficient necessary equipment for experiments this project is proposed as collaborative work.

More information can be obtained from the author on request.

Contact: Andrey Chulin

General information

Websites

- IAQ. Presentation abstracts and additional notes from the 5th meeting of the Indoor Air Pollution Working Group: "Indoor Air Quality in Museums and Historic Properties", University of East Anglia, April 28-29 2003 are available on the following website: http://iaq.dk/iap.htm

- Cost Action G8: Non destructive analysis and testing of museum objects. http://srs.dl.ac.uk/arch/cost-g8. Abstracts and booklets from previous workshops can be downloaded.

- Cost Action G7: Artwork conservation by laser
http://alpha1.infim.ro/cost

- Working Group Metals ICOM Committee for Conservation
http://icom-cc.icom.museum/WG/Metals/

Future seminars and conference

- "Structuring Working Group 3 (Degradation process, corrosion and weathering)**"** (13-14 February 2004, Wertheim-Bronnbach, Germany). Seminar organised by COST Action G8 and the Fraunhofer-Institut für Silicatforschung. For more information contact Christian Degrigny (cdegrigny@mcr.edu.mt)
- **"Oxydes et composés métalliques"** – Ecole de Printemps sur la couleur des matériaux (22-26 March 2004, Roussillon, France). Seminar organised by Le Centre Français de la Couleur, l'association Okhra, le laboratoire d'Optique des Solides, Paris VI, le CNRS, le C2RMF et l'ECP. For more information consult http://www.cf-couleur.org/Ecoles/2004/Rous2004.html
- Philosophy, ethics, history and mechanics of cleaning, 2004 American Institute for Conservation (AIC) annual meeting (09-14 June 2004, Portland, Oregon). Session organised by the Object Speciality Group within AIC. For more information contact Alice Paterakis (alicepaterakis@yahoo.com)
- Ancient and Historic Metals: Technology, Microstructure, and Corrosion. (July 5-16, 2004, UCLA Summer Institute, Los Angeles, USA). Course organised by Prof David A. Scott, Chair. Apply on-line at http://www.summer.ucla.edu/institutes
- Workshop on "Heritage Conservation/Corrosion of Archaeological Objects" (14 September 2004, Nice, France) within the EUROCORR 2004 congress (12-16 September 2004). Organised by Philippe Dillmann, CEA & Gérard Béranger, UTC. Papers presented at this workshop will be published in the Proceedings of EUROCORR 2004 (CD-ROM). Abstracts should be submitted electronically to CEFRACOR via: www.scifrance.org/congres/eurocorr2004. Submission deadline January 16, 2004.
- Metal 2004, Interim meeting of the ICOM-CC Metal Working Group (04-08 October 2004, Canberra, Australia). The meeting will take place at the National Museum of Australia. For more information consult http://rsc.anu.edu.au/~hallam/metals2004.html
- Conservation and Management of Oudoor Bronze Monuments (2-4 December 2004, Genoa, Italy). Organised by ISMAR, ICR, SPSADL, SRBACL and CG. For more information contact Paola Letardi (paola.letardi@ismar.cnr.it)

Abbreviations and acronyms

ANDRA: Agence pour la Valorisation des Déchets Radioactifs, France
CCQ: Centre de Conservation du Québec, Québec, Canada
CG : Comune di Genova
CNRS: Centre National de la Recherche Scientifique, France
C2RMF: Centre de Recherche et de Restauration des Musées de France, Paris
DCB-USL : Department of Chemistry and Biochemistry, University of Sciences, Lisbon
ECP : Ecole Centrale de Paris
EDS or EDX: Energy Dispersive Spectroscopy
FTIR: Fourier Transformed Infrared
ICR: Istituto Centrale del Restauro, Roma
ICRS-MCR: Institute for Conservation and Restoration Studies - Malta Centre for Restoration
MCR: Malta Centre for Restoration
QU: Queen's University, Kingston, Ontario, Canada
RLMB: Rheinisches Landesmuseum Bonn**,** Germany
SEM: Scanning Electron Microscope
SNAFA: Sofia National Academy of Fine Arts, Bulgaria
SPSADL : Soprintendenza al Patrimonio Storico Artistico e Demoetnoantropologico della Liguria, Italy
SRBACL : Soprintendenza Regionale per i Beni e le Attivita Culturali della Liguria, Italy
TEI: Technical Educational Institute, Athens
TMB : Technical Museum of Brno, Czech Republic
UTC: Université Technologique de Compiègne, France
WM: Wignacourt Museum, Rabbat, Malta
XRD: X-ray Diffraction

Contacts

Vasilike Argyropoulos / TEI (Bessie@teiath.gr)
Andrey Chulin (andrey_chulin@yahoo.com)
António João Cruz / DCB-USL (ajcruz@fc.ul.pt)
Eloise Paquette / CCQ (epaquette2@yahoo.ca)
Petia Penkova / SNAFA (☎ 359.2.9575291 - petiapenkova@yahoo.com)
Emmanuelle Pons / EDF (emmanuelle.pons@edf.fr)
Alena Selucká /TMB (selucka@technicalmuseum.cz
Raymond Spiteri / ICRS-MCR (rspiteri@mcr.edu.mt)
Frank Willer / RLMB (☎ 49.228.9881.263 – frank.willer@lvr.de)

National correspondents

Argentina: Blanca Rosales, Buenos Aires (brosales@sion.com) & Miguel Crespo, Buenos Aires (cloclo@infovia.com.ar)
Australia: David Hallam, Canberra (d.hallam@nma.gov.au)
Belgium: Patrick Storme, Antwerp (patrick.storme@skynet.be) & Gilberte Dewanckel, Brussels (gilberte.dewanckel@kikirpa.be)
Brazil: Luiz Roberto Martins de Miranda, Rio de Janeiro (miranda@metalmat.ufrj.br)
Bulgaria: Petia Penkova, Sofia (petiapenkova@yahoo.com)

Chile: Johanna Theile, Santiago de Chile (jtheile@abello.dic.uchile.cl)
Czech Republic: Alena Silhova, Prague (silhova@arup.cas.cz)
Denmark: Karen Stemann Petersen, Copenhagen (karen.stemann.petersen@natmus.dk)
France: Jean-Bernard Memet, Nantes (arcantique.recherche@wanadoo.fr) & Régis Bertholon, Paris (bertholon7@aol.com)
Germany: Gerhard Eggert, Stuttgart (gerhard.eggert@abk-stuttgart.de)
Greece: Vasilike Argyropoulos, Athens (Bessie@teiath.gr)
Italy: Paola Letardi, Genova (paola.letardi@ismar.cnr.it)
The Netherlands: Bart Ankersmit, Amsterdam (bart.ankersmit@icn.nl)
Norway: Birgit Wilster-Hansen, Oslo (b.w.hansen@ukm.uio.no)
Portugal: Isabel Tissot, Lisbon (isabeltissot@hotmail.com)
Romania: Dorin Barbu, Sibiu (dorin.barbu@brukenthalmuseum.ro)
Russian Federation: Andrey Chulin, St Petersburg (andrey_chulin@yahoo.com)
South Africa: Jaco Boshoff, Cape Town, (jboshoff@iziko.org.za)
Spain: Emilio Cano, Madrid (ecano@cenim.csic.es)
Sweden: Helena Strandberg, Göteborg (helena.s@hem.utfors.se)
Switzerland: Valentin Boissonnas, La Chaux-de-Fonds (v.boissonnas@heaa-ne.ch)
United Kingdom: David Thickett, London (david.Thickett@english-heritage.org.uk)
USA: Paul Mardikian, Charleston (mardikian@hunley.org)