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METAL*Consn*-info

Metal working group

Bulletin of the Research On MEtal Conservation

February 2006 **BROMEC17**

Editorial

You will remember that in BROMEC 16 we raised the issue of accessibility to the scientific information available on the Metal WG homepage of the ICOM-CC website. Since then other WG coordinators of ICOM-CC have asked the ICOM Directory Board to revise its policy of restricted access to the ICOM-CC website to the paying members. Today no solution has yet been taken.

The activities developed within the Metal WG depend both on non-paying and paying members. When we look back at previous BROMEC issues and outcomes of sub-WGs we find that half of the work is provided by non-paying members. To acknowledge this important contribution we needed to create a new portal fully accessible to all professionals that are willing to share their knowledge on metal conservation. The new homepage "METAL*Cons*-info" will respond to this need. It will contain all data available on the Metal WG homepage as well as any other information related to metal conservation that needs to be disseminated. The webmasters will be David Hallam, assistant coordinator of the Metal WG and the coordinator himself. Information will be provided mainly by the team of national contact persons that replaces the team of national representatives of the Metal WG coordinator. Hopefully the new portal should be online soon.

Although this new BROMEC issue concentrates more on copper based materials (four abstracts refer to them), two abstracts relate again to iron based artefacts. One expands further on the conservation treatment research being conducted by the Friends of the *Hunley* as mentioned by the *USS Monitor* team in BROMEC 16. It shows the potential of sub-critical solutions to stabilise iron-based artefacts impregnated with chlorides. The second abstract concerns the stability of freshly excavated iron artefacts and is relevant to the activities of the AIAE sub-WG. Furthermore it is important to mention that Solenn Reguer's PhD (characterisation of chlorinated iron archaeological artefacts presented in BROMEC 16) report can be downloaded from the following website: http://www-drecam.cea.fr/lps/theses/Theses.php. PhD reports of other researchers that have worked on similar topics (Enrique Vega and Delphine Neff (BROMEC 8)) can be found on the same website.

The abstracts on copper based alloys mainly concern corrosion layers that were formed artificially or naturally during excavation or in the atmosphere, their characterisation using Raman spectroscopy, electrochemical and other more traditional investigation techniques and their behaviour during conservation treatment. Two approaches were considered here: the

stripping of all corrosion layers (Egyptian abstract) or the application and testing of corrosion inhibitors (collaborative work between French and Moroccan specialists).

The two other abstracts are: the presentation of an innovative cleaning procedure - the CO_2 "dry-ice" cleaning method applied on a 19th c. collection of metal artefacts from the Science Museum of the University of Lisbon and; the subject of the second abstract is a technological one - an art painting technique on anodised aluminium called aluchromy.

As usual, we hope that you will find this issue as useful and as interesting as ever. Please note the editor's new email address: christian.degrigny@gmail.com.

Editor
Christian DEGRIGNY
Assistant editor
James CRAWFORD

Contents

Ongoing research projects

Use of micro-Raman spectroscopy for the study of atmospheric corrosion of copper alloy cultural heritage (***VUB - DMEMS***)

Copper has played a crucial role in human development. The profusion of copper-based artefacts led to the development of an important interest for these objects and their conservation. In the field of art, copper based objects are preferred in the corroded state, not only because of the aesthetically pleasing colours reached by the alloys, but most of all because the presence of corrosion products becomes evidence of past time and passing time, hereby adding extra value to the object.

The variety of corrosion products that can form on copper alloys is enormous. It is important to precisely identify the composition of the corrosion compounds present on art objects and to follow their evolution. This knowledge provides valuable information for art historians about the past environment of the object and its original composition. It also helps conservators to decide whether an object's patina is stable in the current environment and which conservation treatment could be used, if one is required.

Many different analysis techniques are used for the investigation of the composition of the corrosion of copper alloys. However, few of them provide the needed information in a non-destructive way, consequently preserving the integrity of the object. Raman spectroscopy (RS) has been used successfully in the field of art analysis, whereby the composition of different materials was analysed non-destructively. The successful application of RS to other domains of art consequently encouraged us to start an extensive study of the possibilities offered by this technique for the investigation of corrosion products on objects of cultural importance. The main goal of this PhD project was the positioning of RS in respect to existing methods and most of all, the development of a general methodology that could be used to determine with RS the composition of the corrosion products.

In order to reach this aim, a model system was set up. The study was started from reference products consisting of various copper based minerals, expected to occur in the corrosion of copper based alloys. Their Raman spectra were determined and added to a database, in order to obtain a unique signature for each of the compounds. In a following step, the model was extended to the study of different corroded samples. Finally, the established model was used for the study of the corrosion and the spectra of some examples of naturally formed corrosion. A searching algorithm based on principal component analysis was developed to ease the identification procedure.

It was shown that RS constitutes an efficient tool for the identification of the main products formed during natural corrosion in various environments or during artificial corrosion and that the established model system was a good choice to achieve the considered goal. The study of RS allowed drawing interesting conclusions concerning the method but also the investigated materials. The established methodology can be further extended to the study of many other corrosion processes and metals, like e.g. iron or aluminium. The importance of studying the corrosion, in fields other than the domain of art objects, has not to be proven. The results of this work will consequently have a great technological value and contribute to the development of these fields.

Contact: Dr Valérie Hayez (VUB - DMEMS)
Funding: Institute for the Promotion of Innovation through Science and Technology in Flanders

Ongoing research projects

 CO_2 cleaning method applied to metal objects from the Science Museum 19th c. Chemical Laboratory (***AAA, Lda – ETA***)

The laboratories created in the 19th century were, at the time, large centres for scientific and technological development promoting quality in industry, agriculture and medicine. In spite of the degradation caused by their almost daily use, over 150 years, by many thousands of students, the *Laboratorio Chimico* is one very rare example of the history of Chemistry at the turn of the 19th century. Its heritage value as an historical, scientific and social record is enormous [1].

The Science Museum plans to restore this *Laboratorio Chimico* to its original and well-documented state. The old instruments and apparatus will return to their places and the whole area will absorb the visitor in an exclusive and real 19th century Chemistry setting. As a part of the conservation programme the metal objects (scientific instruments) are being preserved.

The cleaning procedure is one of the most relevant stages in conservation and restoration processes, since its effectiveness is reflected in later treatments of corrosion inhibition and protection. The CO_2 cleaning – dry-ice blasting procedure has been chosen among other more traditional techniques. This method has been industrially tested since the 1980s; the process is pneumatic jet-based and operates with dry-ice pellets as the single-way blast medium. Dry-ice pellets consist of solid carbon dioxide at a temperature of –78-58Cº [2].

The cleaning process efficiency depends on three parameters groups: equipment, particles and process.

The advantages of this process are the low hardness of the pellets - between 2 and 3 Mohs, similar to the hardness of calcium sulphate and calcium carbonate - and the non existence of residues, as dry-ice directly sublimates when hitting the surface [2].

The CO_2 cleaning process is already an alternative to the existing methods, even though with some limitations, demanding for additional investigation related to the optimization processes and equipment development can be, in the near future, a relevant contribution to metal conservation.

References:
[1] in http://www.museu-de-ciencia.ul.pt/lab/indexe.html
[2] G. Spur et al. *Wear* 233-235 (1999), 402-411

Contact: Isabel Tissot (AAA, Lda – ETA)
Funding: Museu da Ciência da Universidade de Lisboa and P.O.C – Plano Operacional para a Cultura
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Ongoing research projects

Growth and properties of oxidation layers and patinas at the surface of copper alloy objects of archaeological or artistic interest (***C2RMF / CEA-CRMP***)

Surface layers grown by oxidation or corrosion onto copper-based objects belonging to cultural heritage are often rich with important information concerning the object's original aspect, the abandonment circumstances and the conservation state. They are often of complex nature and structure. Their complete analysis is difficult because it is submitted to severe preservation constraints.

This PhD research completed in autumn 2005 concerns high temperature oxidation layers and intentional antique patina grown on the surface of copper-base alloys.

Non-destructive analysis methods and experimental devices best adapted to that problematic have been specifically developed, mostly based on ion beam analyses. High temperature oxidation of the copper-tin system has been comprehensively studied: nature of the layers, growth kinetic and reaction mechanisms. A model has been proposed which takes into account the experimental observations and the inhibiting effect of tin addition.

The antique intentional patina obtained through chemical surface treatment done by the craftsmen in order to modify the surface colour and aspect of the metal has been also studied. A corpus of objects from national museums, produced during a period of 2000 years from the antique Egypt to the Roman Empire, have been analysed.

These analyses allowed to sensibly increase the literature data on these kind of objects and practice. Laboratory analogues have been elaborated through the experimentation of various reported recipes. The results on archaeological objects and laboratory experimentation lead to significant progress in the knowledge of these particular oxide layers, and also in the field of the history of techniques and stylistic history in the Mediterranean antiquity.

Now that the PhD is completed the work continues on black patinated bronzes, the objective being to increase the number of objects investigated (antique Egypt, Roman Empire and, if possible, antique Orient).

The PhD report can be downloaded on the following website: http://tel.ccsd.cnrs.fr/ (search by name).

Contacts: François Mathis (CEASTB15 – UdL) and Marc Aucouturier (C2RMF)
Funding: Ministère de la Recherche

Ongoing research projects

 New approaches to iron stabilisation research (***WLCC/Clemson University***)

Since early 2003, the Warren Lasch Conservation Center (WLCC) has been working on an experimental treatment for the removal of chloride (Cl^-) from cast and wrought iron (BROMEC 4). The objective of this study has been to compare Cl^- removal using this experimental process to the traditional methods, especially alkaline soaking and alkaline soaking under cathodic reduction. This work was initiated because the conventional treatments for corroded cast and wrought iron artefacts are long and slow processes and for something the size of the *Hunley* would require large amounts of chemical and produce large quantities of waste that must be disposed of. In addition, because of the presence of cast and wrought iron in contact with each other, the use cathodic reduction on the *Hunley* would probably require at least partial disassembly. Finally, the implementation of any electrolytic techniques on a large scale such as required by the size and complexity of the *Hunley* has yet to be fully assessed and researched.

The hypothesis behind this investigation was that by employing subcritical water solutions, the Cl^- removal efficiency could be dramatically increased and treatment times significantly reduced. This study was based on extensive previous work with sub and supercritical water carried out in the School of Materials Science and Engineering at Clemson University. Subcritical water is water maintained at a pressure above atmospheric pressure and 100^oC and below the critical temperature and pressure of water, T_c =374 ^oC, P_c = 220 bar. In the subcritical region, the transport properties of H_2O as a solvent media will be between those of liquid H_2O and supercritical H_2O. Prior to the initiation of this research, there were no reports in the literature on the utilization of either super or sub-critical fluids for the stabilization of metal artefacts.

Experiments have been conducted over the temperature range from 130 to 230^oC. These temperatures were selected as representing the best compromise between practical considerations (if a very large artefact was to be treated) and treatment effectiveness. In addition, the pH has been varied from 11.6 to 13.1 and the reactor size increased from 40 to 600 ml. A 35 l reactor, to be constructed in early 2006, has been designed for the next phase of the research.

To date, over 60 experiments have been conducted at the Lasch Center on wrought and cast iron samples. Although most samples were from the *Hunley,* there were two samples from the *Monitor* Project and several cast iron specimens from two Civil war era artillery shells (with graphitized layers up to ~1cm). The subcritical water treatment has effectively removed very high levels of Cl^- from the samples in very short periods of time. None of the treatments has exceeded 5 days compared to over 6 months using conventional treatments on some of the comparative cast iron specimens. In a very limited set of experiments simple soaking in NaOH or Na_2CO_3 alone was found to not be effective in removing all of the Cl^- present from *Hunley* rivet shaving specimens that had been allowed to completely dry out in air. In contrast to these results, sub critical treatment of comparative samples was successful in removing all of the Cl^-. More importantly, it was shown that the sub critical treatment resulted in the apparent transformation of β-FeOOH into other iron oxides. For all of the subcritical treated specimens their physical appearance, mechanical properties as well as their apparent corrosion resistance (even those stored in a saturated water vapour chamber for at least 2

years) seems to be very good and the results from these experiments continue to be extremely encouraging.

While selected results from this work have been presented at Metal 04 in Canberra, Australia, at the XIV International Materials Research Congress in Cancun, at the Eastern Analytical Symposium and recently at the Williamsburg Conference, a more detailed description will be submitted to Studies in Conservation in early 2006.

References

M. J. Drews, P. de Viviés, N. G. González and P. Mardikian, "A study of the analysis and removal of chloride in iron samples from the "Hunley"," Metal 04, Proceedings of the International Conference on Metals Conservation, Canberra, Australia, October 2004, Ed. J. Ashton and D. Hallam, National Museum of Australia, Canberra, 247-260(2004).

M. J. Drews, P. de Viviés, N. G. González, P. Mardikian and K. Grogan, "Evaluation of new technologies for the stabilization of archaeological iron," XIV INTERNATIONAL MATERIALS RESEARCH CONGRESS, August 21 – 25, 2005, Cancún, México.

M. J. Drews, P. de Viviés, N. G. González and P. Mardikian, "Chloride Distribution Measurements and Chloride Distribution on the *H. L. Hunley*," Book of Abstracts, Eastern Analytical Symposium, November 14-17, Somerset, New Jersey, USA, **125**, 16(2005).

P. Mardikian, N. G. González, M. J. Drews and P. de Viviés, "New Perspectives Regarding the Stabilization of Terrestrial and Marine Archaeological Iron" Conservation of Archaeological Materials: Current Trends and Future Directions, Colonial Williamsburg, Virginia, USA, November 13-17, 2005 (In prep).

Contacts: Paul Mardikian (WLCC) and Michael Drews (Clemson University)
Funding: Friends of the *Hunley*, Clemson University

Ongoing research projects

Corrosion and protection of bronzes covered with a patina: electrochemical and spectroscopic study of the surface of archaeological artefacts and synthesis of a similar patina on a commercial bronze (*LISE*)

Bronzes are naturally covered with a patina when exposed to a corrosive media. This layer, often green or greyish green, gives to the archaeological artefacts a pleasing appearance that holds archaeological information. For that reason we try to preserve this patina instead of giving the artefact its original shiny aspect. In general the patina becomes stable with time and protects the metal substrate but this stability might be ruined during the excavation of the artefact due to the change of environment or after its exposure to aggressive atmosphere conditions. Corrosion starts again and at a very high speed. Protection of the metal is required then through the consolidation of the patina or the direct protection of the bronze substrate. But natural patinas depend on the formation conditions and are then very specific. Furthermore the formation of natural patina in a controlled atmospheric medium requires a lot of time. We thought then that it would be interesting to synthesise a patina in a quite short time.

It was our objective then to design a protocol to form a patina by electrochemical means on a B66 bronze (Cu13Pb8Sn %w/v, a composition very close to the one of Post Roman Empire coins found on archaeological sites in Morocco) and to compare, with a cavity microelectrode, its electrochemical behaviour with the patina covering an archaeological artefact. We tested afterwards the inhibiting affect of three organic corrosion inhibitors: bitriazole, aminotriazole and benzotriazole (to compare with a traditional system). EDS, XRD and Raman spectroscopy analyses were used to characterise the different products forming the patina and to understand the mechanisms involved. The monitoring of the electrochemical processes through impedance spectroscopy revealed the protection effect of the corrosion inhibitors.

This PhD work was performed between the Laboratory of Interfaces and Electrochemical Systems (LISE), UPR 15 CNRS and the Ibn Tofail University, Morocco.

Contact : Kamal Rahmouni and Hisasi Takenouti (LISE)
Funding : Programme d'action intégrée Franco-Marocain, EGIDE funds of the French Ministry of Foreign Affairs

Ongoing research projects

 The impact of different soils on the corrosion of copper-based artefacts and methods of their conservation (***CD-FA-CU***)

The study concentrated on the different factors that influence the underground corrosion of copper alloy artefacts that have been found in different burial environments in several archaeological sites in Egypt, with varying geological and environmental threats. These artefacts date back to a wide range of historical periods from the Early Dynastic 3200-2700 BC to the Umayyad period 630-750 AD. An analytical study was performed on samples from different archaeological sites and locations.

The samples were prepared for metallographic examination, examined by SEM/EDS and the elements were screened via elemental mapping. A sample of the metal core, whenever remaining, has been analysed by means of an Inductively Coupled Plasma (ICP) spectroscopy. All corrosion products occurring on the artefacts have been sampled using an optical microscope and analysed by X-ray diffraction (XRD). Soil analyses were performed and soil survey analyses were consulted.

Casting of four different copper-based alloys representative of the materials found on site was performed for the study of the corrosion rate and behaviour of the alloys in the soil media. Electrochemical Impedance Spectroscopy (EIS) was used. The alloys were immersed in a soil/solution slurry simulating real conditions using the data from the Tell El-Louli site, North Sinai as they were the most aggressive conditions with no need for artificially accelerating settings.

Furthermore the evaluation of 6 treatment solutions used to remove corrosion products from the simulated cast copper alloys was carried out. These solutions are alkaline dithionite, citric acid, acetonitrile, Ethylene Diamine Tetracitic acid, Rochelle salt, and sodium carbonate. The solutions were sampled at regular intervals and analysed for chloride and copper with periodic checks on the lead, tin and zinc concentrations. Weight loss was also calculated for all the samples. The change of appearance caused by treatment solutions was also observed.

The analyses of the samples was performed at the laboratories of the Deutsches Bergbau Institute, Bochum, under the supervision of Prof. Dr. Andreas Hauptmann while the Electrochemical Impedance Spectroscopy (EIS) was performed at the University of Tor Vergata, Rome under the supervision of Prof. Dr. Gualtiero Gusmano.

This research is a PhD thesis that has been recently finalised at the Conservation Department, faculty of archaeology, Cairo University.

Contact: Mai Rifai (CD-FA- CU)
Funding: No external funding.

New research projects

 Low-oxygen and low-temperature storage of freshly excavated iron artefacts ***(HE-Arc)***

Post-excavation corrosion of archaeological iron artefacts still remains one of the major problems in metal conservation. Formation of akaganéite and cracking of objects are well known phenomenon and can lead to complete loss of the artefact. No stabilisation treatment has proven 100% effective in the removal of chlorides. Also treatments are often problematic as they can be followed by colour changes in the artefact, changes in the corrosion layers or loss of important information contained within the object. While searching for better stabilisation procedures we need good storage conditions: for the short-term storage of objects just recovered from excavation and waiting for treatment or for the long-term storage of objects that cannot be treated in the near future.

High relative humidity (RH) levels and access of oxygen have been found to be the major factors responsible for the transformation of iron (II) chloride to β-FeOOH, akaganéite. For this reason, a lot of effort has been put into the development of low RH storage environments. Below 30% RH corrosion reactions on chloride contaminated iron artefacts should be slowed down. At and above 30% RH these reactions will speed up. Storage at low RH is carried out mostly by the use of silica gel and in plastic boxes. This requires regular monitoring and changing of the silica gel. Another option could be the removal of oxygen in the storage environment to slow down corrosion reactions.

This work will investigate the use of the RP-System^{TM}, an oxygen absorber developed by Mitsubishi Gas Chemical Company. Synthesised samples made of a mixture of iron powder/iron (II) chloride powder and archaeological material (nails) will be submitted to low-oxygen environments. The aim is to see if akaganéite forms in these environments. A second part of the work will be the investigation of low-temperature storage as an option for freshly excavated iron artefacts. Synthesised samples and archaeological material (nails) will be put into the cold (5°C) to see if corrosion (formation of akaganéite) takes place. For one group of the samples in the cold the RH will be lowered to observe reactions in this environment.

The project aims to clarify if oxygen-free storage of freshly excavated archaeological iron artefacts is an effective way of preventing or slowing down akaganéite formation. The second part should show if cold storage also affects akaganéite formation.

This project is carried out as a final year diploma at the High school of applied arts (conservation of archaeological artefacts) of La Chaux-de-Fonds, Switzerland. Partners involved are English Heritage, London and Birkbeck College, London.

Contact: Salomé Guggenheimer (HE-Arc)
Funding: No external funding

New research projects

 Aluchromy: an art painting technique on anodised aluminium (***RAFACS-DHA / VUB – DMEMS***)

The aluchromy technique, developed in 1961 by two Belgian artists, utilises the capacity of freshly anodised aluminium to absorb a wide range of colorants applied by various techniques. The colouring matter consists of pure organic and mineral pigments dissolved in acetone and/or methylglycol or dimethyl-formamide. The colorants penetrate the fine surface pores and cling to the oxide layer without affecting any surface condition obtained by mechanical, chemical, or electrochemical pre-treatment. The thickness of the anodic oxide layer is generally in the range of 20 μm. Examples of aluchromy art will be presented and discussed in this artistic and scientific study of the technique.

Contacts: Carmen Lenoir & Patrick Storme (RAFACS-DHA) and Iris de Graeve & Herman Terryn (VUB – DMEMS)
Funding: No external funding, thesis support for the research by VUB

Promotion of books

 Alicia Perea, Ignacio Montero and Oscar Garcia-Vuelta (eds) Tecnologia del Oro antiguo: Europa y America (Ancient gold technology: America and Europe). Consejo Superior de Investigaciones Cientificas, Instituto de Historia, Departamento de Historia Antigua y Arquelogia, Madrid 2004. 431pp. illustrated

ISBN: 84-00-08293-1
E-mail for ordering: publ@orgc.csic.es
Approximate price: 50 Euro

The year 1989 was probably the year of the beginning of what has now come to be known as Gold archaeology. That was the year in which the exhibition on L*e premier or de l'humanité en Bulgarie, 5ème millénaire* was inaugurated at the Museum of St Germain-en-Laye, France. It revealed the magnificent grave goods excavated in the necropolis of Varna since 1972, but the scientific meeting that closed the event pointed also out that archaeometallurgy of gold had sufficient weight to become a discipline on its own.

Since then prehistoric gold has become a line of research within the broad field of archaeology. Notable progress has been made particularly in two areas: a) research into techniques and processes of transformation thanks to the increasingly powerful and non destructive instrumental methods of elemental analysis (PIXE, LA-ICP-MS, XRF, EDS, etc…) b) the inclusion of gold as yet another element of expression of social groups. These two lines have made gold archaeology an interdisciplinary forum, where there is a natural dialogue between archaeologists, historians, anthropologists, goldsmiths, sociologists, mathematicians, physicists, chemists, geographers, geologists and many other specialists.

The Department of Prehistory of the Instituto de Historia, CSIC (Madrid), has been working in the field of gold archaeometallurgy at an institutional level since 1993, within what we have called *Project Au*. Over the years our knowledge of the technology and social meaning of the prehistoric gold of the Iberian Peninsula has advanced in a spectacular way, and we have created an archive of analytical data and images of objects and metallographic structures that is the only one of its kind. Due to the growing complexity of the methods of archaeometric research we have felt as well the need to create new forms and channels of communication between specialists.

The 1st international symposium on ancient gold technology: Europe and America (SITOA) is the result of our efforts to communicate with colleagues, particularly those of Latin America. It was held in Madrid between 23 and 25 October 2002. The proceedings of the SITOA have been structured around the topics of the working sessions held in the Museo Arqueologico Nacional and the Museo de America in Madrid. Section 1: Metallurgical techniques and analytical methods. Section 2: New finds and regional studies. Section 3: Economic and social processes. Section 4: Origin and circulation of the raw material.

The papers are in Spanish and English.

The proceedings can be ordered from the Department of Publications of CSIC. A pro form invoice price + postage will be sent back to you.
Dpto. de Publicaciones CSIC, Vitruvio 8, 28006 Madrid, Spain (Tel: + 91 515 96 70 and fax: + 91 561 48 51 and website: www.csic.es/publica)

General information

Websites

- ARTECH network: http://server.icvbc.cnr.it/progetti_futuri/progetto_artech.htm. Network facilitating the access of conservation professionals to different investigation techniques of Cultural Heritage artefacts

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

- **CAMEO**: website containing 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://www.mfa.org/_cameo/frontend/

- 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 as well as announcements of future activities (Short Term Scientific Missions deadlines, training schools…).

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

- **e-Preservation Science**: http://www.e-preservationscience.org. Online publication of papers in conservation science.

- **European Cultural Heritage Network**: http://www.echn.net/. European network of professionals interested in the conservation of Cultural Heritage.

- IR and Raman for cultural heritage: http://www.irug.org/default.asp

- LabS-TECH network http://www.chm.unipg.it/chimgen/LabS-TECH.html

- **Laboratoire Pierre Sue**: LPS PhD thesis related to the alteration of archaeological artefacts can be downloaded from http://www-drecam.cea.fr/lps/ (in French) and go to "Archéomateriaux et prévision de l'altération."

- **M2ADL** - Microchemistry and Microscopy Art Diagnostic Laboratory is now available at the following website: http://www.tecore.unibo.it/html/Lab_Microscopia/M2ADL/

- **PROMET** website: http://www.promet.org.gr

- **RESTAURACION METAL SUR AMERICA**: www.restauraciondemetales.cl

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

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

- Online publications of Surface Engineering Journal . Issue addressing specifically to Metal issues: **Surface Modification Issues in Art**, Volume 17, Issue 3, June 2001. Can be downloaded from:(http://www.ingentaconnect.com/content/maney/se/2001/00000017/00000003;jsessionid=1xpmlw91522a3.victoria)

Future seminars and conference

- BAC and NDTMA sub-WG meeting (1-2 March 2006, Gif /s Yvette, France). Kick-off meeting. For more information contact Christian Degrigny (christian.degrigny@gmail.com)
- ETIC sub-WG meeting (13 March 2006, Gent, Belgium). For more information contact Christian Degrigny (christian.degrigny@gmail.com)
- 7th biennial Infrared and Raman User Group (IRUG) 07 meeting (18-31 March 2006, The Museum of Modern Art, NYC, USA). More information can be obtained from the following website: www.irug.org
- Final workshop of COST Action G8 "Non-destructive analysis and testing of museum objects" (18-20 May 2006, Nicosia, Cyprus). For more information contact Annemie Adriaens (annemie.adriaens@ugent.be)
- Xe journées-débats de conservation préventive - Constats, diagnostics, évaluations : la conservation préventive en action (14-15 June 2006, Institut National d'Histoire de l'Art, Paris). Call for papers will be closed on the 15th of March. For more information contact Silvia Païn (spain@cg78.fr)
- IRON, STEEL AND STEAM 2006: On site seminar (last week of June 2006) in response to Australia-wide and some initial overseas interest, the Western Australian Maritime Museum will be convening Australia's second on-site iron and steam ship archaeology seminar. For more information please contact the convenor m.mccarthy@museum.wa.gov.au
- The Beginnings of the Early Use of Metals and Alloys: metallurgy and civilisation (15-20 September 2006, Beijing, China). Deadlines for abstracts: 15 March 2006. For more information contact Alessandra Giumlia-Mair (giumlia@yahoo.it)
- French Section of the ICOM-CC Metal WG (28-29 September 2006, INP, Paris). For more information contact Christian Degrigny (christian.degrigny@gmail.com) and Marie-Anne Loeper-Attia (loeperattia@noos.fr)
- SR2A 2006 workshop on Synchrotron Radiation in Art and Archaeology (27-29 September 2006 in Berlin, Germany) organized jointly by Berliner Elektronenspeicherring - Gesellschaft für Synchrotronstrahlung m.b.H. (BESSY), Bundesanstalt für Materialforschung und -prüfung (BAM), Staatliche Museen zu Berlin (SMB) and Technische Universität Berlin (TUB). .More information can be obtained from the following website: www.bessy.de/workshops/
- **Archaeometallurgy in Europe** (May or June 2007, Grado and Aquileia, Italy) organized by the Associazione Italiana di Metallurgia. For more information visit the following website: www.aimnet.it/archaeometallurgy2.htm

Abbreviations and acronyms

AAA, Lda – ETA : Archeofactu, Arqueologia e Arte, Lda & Ecomor – Tecnologias do Ambiente
CD-FA- CU: Conservation Department of the Faculty of Archaeology, Cairo University
CEA-SRMP : Centre pour l'Energie Atomique - Service de Recherche en Métallurgie Physique
CEASTB15 – UdL: Centre Européen d'Archéométrie - Sart Tilman B15 - Université de Liège

C2RMF: Centre de Recherche et de Restauration des Musées de France
CU : Clemson University
EIS: Electrochemical Impedance Spectroscopy
HE-Arc: Haute école d'arts appliqués Arc
ICP : Induced Coupled Plasma Spectroscopy
LISE : Laboratoire interfaces et Systèmes Electrochimiques – UP15 CNRS
RAFACS-DHA: The Royal Academy of Fine Arts Conservation Studies, Dept. Hogeschool Antwerpen
RH: Relative Humidity
RS: Raman Spectroscopy
SEM-EDS : Scanning Electron Microscopy – Energy Dispersive Spectroscopy
VUB – DMEMS: Vrije Universiteit Brussel, Department Metallurgy, Electrochemistry & Materials Science
WLCC: Warren Lasch Conservation Center
XRD: X-Ray Diffraction

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