MetalPAT

Newsletter 6 – November 2022

The MetalPAT project brings together a large group of professionals spread over the Interreg France-Switzerland region. The numerous collaborations set up between the project partners and the end-users involved contribute to the success of the project through the exchange of knowledge and experience.

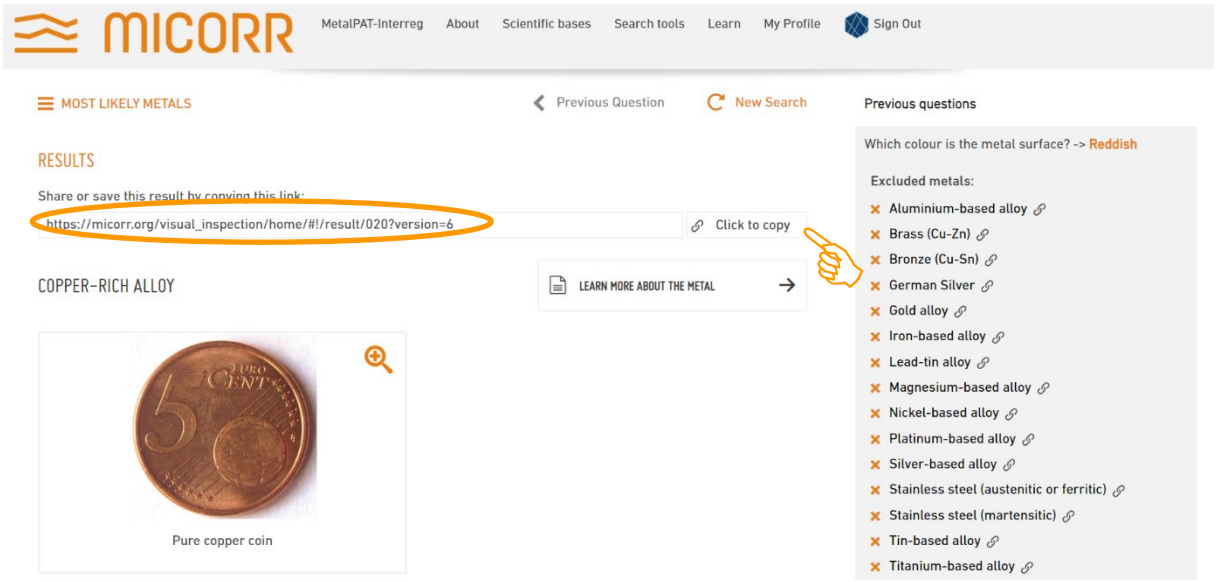
The project partners

This sixth newsletter is the last one of the MetalPAT project. It shows how far we have come since the start of the collaboration between the project partners and the end-users involved. In two years, the MiCorr+ application has been equipped with robust search engines which should make it a real diagnostic support platform where metal is considered in all its entirety and diversity.

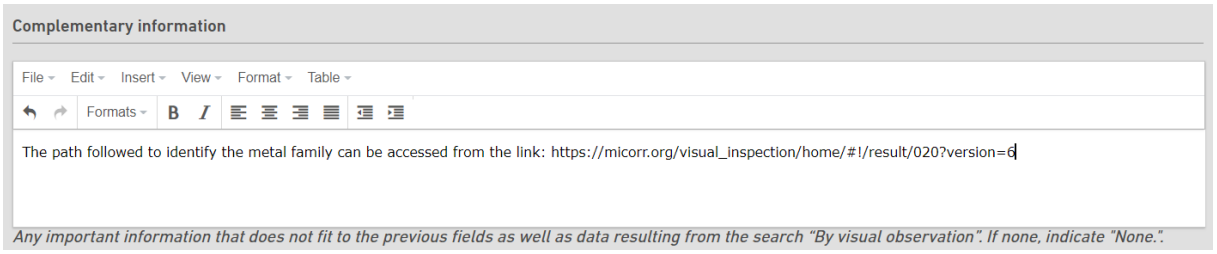
- **COLLABORATION BETWEEN METALPAT'S PARTNERS**

The fifth newsletter reported on the implementation, thanks to the financial support of the *Communauté du Savoir* (CdS) and our partnership with the HEG-Arc, of an online version of the heritage metal identification engine, integrated into the MiCorr+ application and called "By visual inspection". The user goes through the decision-making chain leading to identification proposals via the series of questions/answers, but he/she also has access to two levels of information enabling him/her to progress in his/her identification: the a priori probable families of metals and the assessment of the families retained following the answers given.

The third project of the CdS, *AID-Metal*, led us to test and optimise this search engine in on-site applications (inventory campaign, documentation of collections, condition reports, etc.). In addition to the improvements made to the tool following exchanges with workshop participants, an administrative support platform was created by the HEG-Arc allowing the MiCorr+ administrator to have control over the questions in the decision-making chain, all of the texts and the images illustrating the stages of the query and the results obtained. Thanks to the corrections made by the administrator (adjustment of the questions, more logical order of the questions, adapted and no longer generic results), the engine has gained in relevance. Users can also share the intellectual path followed when querying an object by inserting in the object file, under the heading "Complementary information" in the "Description and visual observation" section, the link to the result giving the possibility of doing the reverse path (see below).



a)



b)

Sharing the identification of the metal family of a studied object, from the link of the result of the query "By visual inspection" (a)) inserted on the file of the same object (b)).

In parallel, the HE-Arc (CR and G), the LMC-IRAMAT and the LAPA continued their partnership to optimise the "Find similar" function of the "By stratigraphy representation" search engine. This function is at the heart of the diagnostic support because it allows the comparison, via the algorithm developed, of stratigraphies of unknown objects with those of materials in the database. The approach now applies to several levels:

- From the stratigraphies obtained under binocular microscopes, conservators can see whether or not the corrosion forms observed are listed in the database. If so, they can access information about the core of their metals that would otherwise be inaccessible, via the correspondences established between stratigraphies under binocular microscopes (similar to their own) and on cross-sections of the database;
- Researchers working more on cross-sectional stratigraphy compile analytical data to support the search for the causes of a specific corrosion phenomena.

The possibility, with "Find similar", of modifying the weight of the sub-characteristics characterising each stratum, of emphasising the positioning of the strata in relation to each other, and of accessing the calculation of the matching percentages, allows users to refine their results, or even to analyse them to better interpret them.

The MiCorr+ platform has also set up an editing committee for the artefact sheets. The current members, representing the MetalPAT partners, cover, through their respective expertise, the variety of materials encountered and are therefore in a position to verify the quality of the content of the sheets submitted. Other experts will join the editing committee according to the new materials and issues addressed.

Finally, we have opted to protect the MiCorr data under the CC-BY-NC-ND 4.0 licence[1], one of the most protective. All exported data will have to integrate the mention of the license while the data must be credited with the name of the institution and the author.

- **COLLABORATION WITH END-USERS**

The workshops of the AID-Métal project made it possible to test the "By visual inspection" search engine in real conditions: simulation of an inventory at the Lausanne Historical Museum, of reflection for the improvement of conservation conditions at the Centre de Conservation et d'Etude des Musées de Lons-le-Saunier, of a condition report on ethnographic objects at the Musée d'Ethnographie de Genève and of the documentation of technical collections at the Musée d'Horlogerie de Morteau.

The creation of the administrative support platform allowed the MiCorr+ administrator to integrate all the improvements suggested by the participants during the workshops:

- Adapted and more precise content of questions, answers and information bubbles;
- Selected pictures corresponding to the stages of the interrogation and the results obtained.

Although the relevance of the engine has been improved (its use rarely leads to inconclusive results), its handling requires a good understanding of the logic pursued, the content of the questions and the information bubbles accompanying the proposed answer options. Thus, when the metal option "Fully visible" is selected at the start of the query, it is implied that the metal is free of corrosion, surface deposits or dirt and coatings (paint, enamel, polymeric material, etc.), the latter playing an aesthetic or even functional role rather than corrosion resistance. A surface treatment (anodising for aluminium alloys or surface enrichment for sterling silver) or coating (metallic)/plating which clearly limits any development of corrosion of the underlying metal falls into this category. This information is specified in the information bubble associated with the "Fully visible" choice.

Furthermore, the use of the search engine takes into account the expertise of the users. Thus, the presence of tarnished areas of red-brown colour on the surface of a metal, whether or not it is covered by a surface deposit, does not necessarily mean that the underlying metal is copper, as shown by the case of the altimeter below whose metal under the yellow deposit is a priori brass.

[1] The data must be credited, a link to the licence must be included and any modifications must be indicated. No commercial use of the data may be made and no modified version of the data may be distributed.

a) b)

Overall view and detail of an altimeter (a)) and a commemorative medal (b)), HAM Foundation, A. Tarchini.

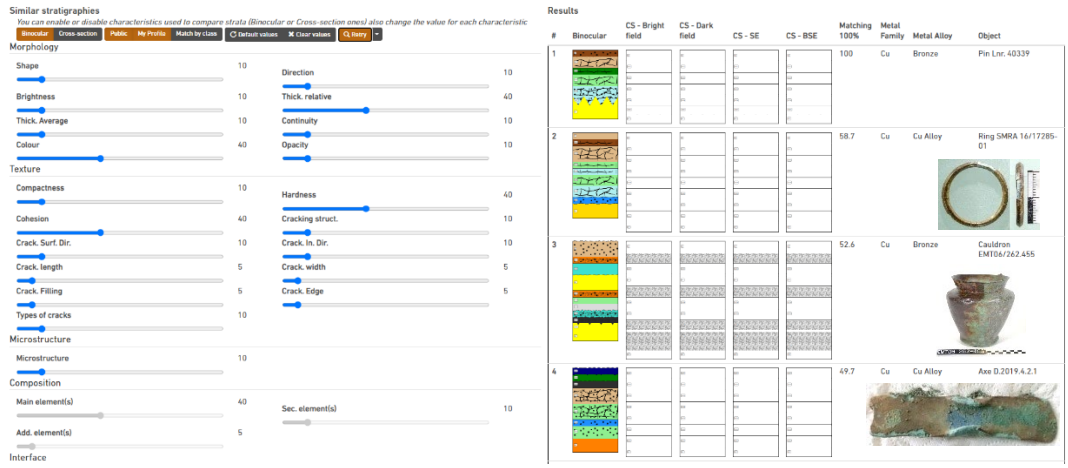
Similarly, the presence of white efflorescence on the surface of a fully oxidised grey metal does not necessarily mean that the object is lead. Zinc-based alloys can also be altered by forming white efflorescences as shown in the commemorative medal above, which is mostly zinc (98% by mass) but also contains some lead (1%), which may be the cause of the localised corrosion observed. Other criteria allow us to distinguish zinc from lead: its granular surface appearance and the detachment of oxide layers in patches.

Although the "By visual inspection" search engine combined with the user's expertise gives convincing results in the vast majority of cases, heritage objects may contain unexpected metals that make their identification problematic. As the tool is participatory, it is important that users confronted with these specific cases inform the MiCorr+ administrator of the identification difficulties encountered. This feedback will soon be implemented by the HEG-Arc.

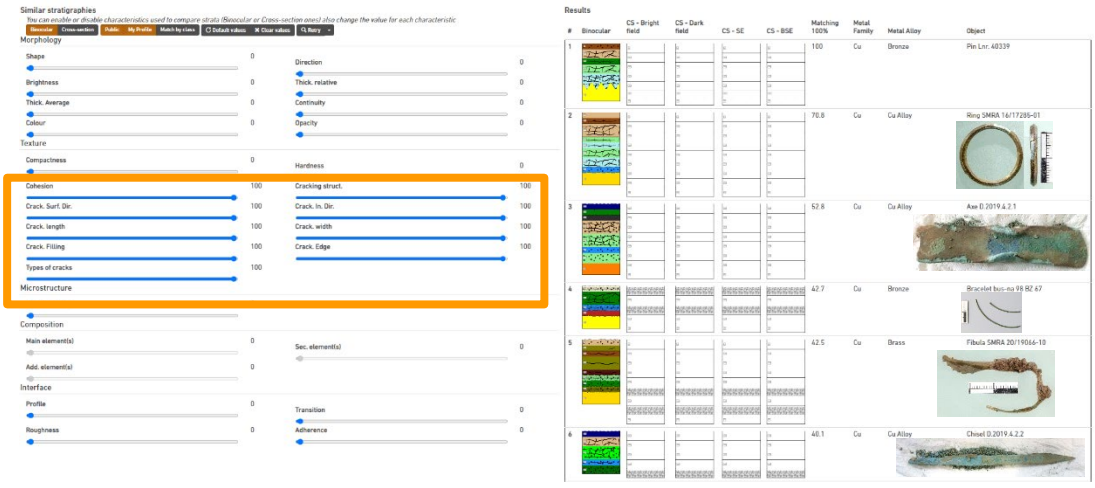
In terms of collaboration with end-users - conservators, Naïma Gutknecht (NGU), conservator and research assistant at the HE-Arc CR and Valentina Valbi (VVA), researcher in conservation-restoration and post-doc at the LMC-IRAMAT, have continued the study of the selected corpus. In the previous newsletter, we mentioned the work carried out on the lake patinas of copper-based alloys and the phenomenon of delamination on bronzes from terrestrial excavations.

This last form of corrosion is found on both sides of the Franco-Swiss border, as shown by the study of the Kehrsatz pin of the Archaeological Service of the Canton of Bern. After creating the MiCorr digital stratigraphy representative of the corrosion forms observed under binocular microscope, we compared it, via the "Find similar" function in default mode, to those in the database. The best matches were obtained with other objects also showing surface delamination of the corrosion products layers. The only exception was a cauldron from the Mormont site (Canton of Vaud). As delamination is characterised by a strong fracturing of the corrosion products layers, we gave more weight to this sub-characteristic (advanced interrogation mode) and the interrogation proved to be much more relevant by discarding the Mormont cauldron and proposing other objects from Swiss and French sites in the Interreg region, which effectively present the same delamination phenomenon.

a)



b)



c)

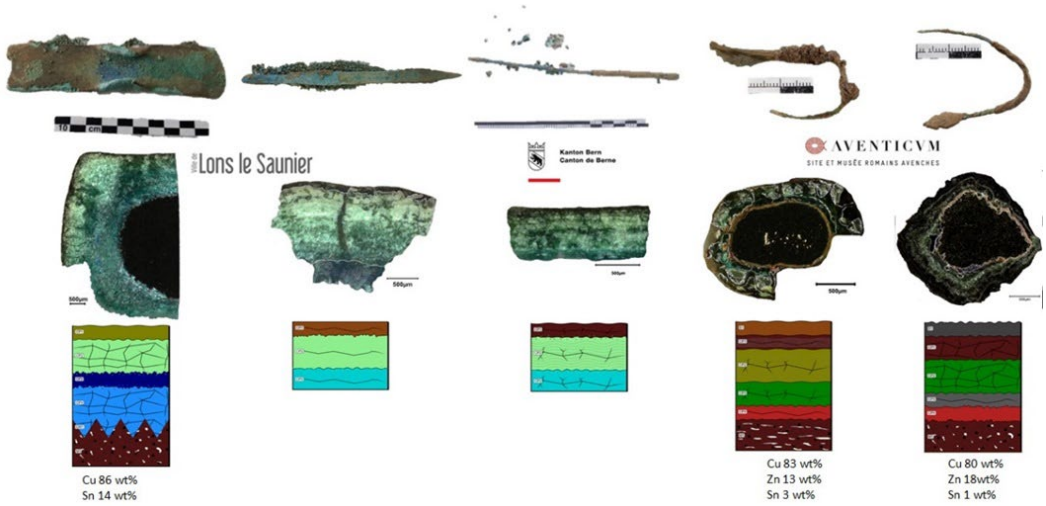
Query of the MiCorr+ database, via the "Find similar" function in default (b)) and advanced (c)) modes, in order to diagnose the delamination phenomenon on the Kehrsatz pin of the Archaeological Service of the Canton of Bern (a)).

Searching the database in binocular mode will only find materials with similar alterations. It does not give access to the causes of the phenomenon. For this purpose, observations on cross-sections of fragments detached from the corrosion products layers (awl and pin below) and taken from the objects (including the residual metal) are necessary.

Partenaires : haute école arc neuchâtel berne jura, LMC IrAmat, ARCHEOMATERIAUX LAPA PREVISION ALTERATION

Co-financeurs : Kanton Bern Canton de Berne, JURA CH RÉPUBLIQUE ET CANTON DU JURA, ne.ch RÉPUBLIQUE ET CANTON DE NEUCHÂTEL, CANTON DU VALAIS KANTON WALLIS, canton de vaud

MiCorr digital stratigraphies of the materials previously observed under binocular microscope are close, as shown in the figure below. They show that the corrosion products layers systematically contain copper sulphide inclusions and numerous porosities and are extensively fractured. Furthermore, copper hydroxycarbonates are identified below the limit of the original surface, whereas these usually appear in the upper layers, above the same limit.



Digital cross-sectional stratigraphies of objects in the MiCorr+ database similar to that of the Kehrsatz pin in Canton Bern.

We have not been able to define the exact causes of the delamination phenomenon, but we now have consistent evidence that could contribute to the formulation of hypotheses for corrosion mechanisms. Further study, in particular examining the influence of the different parameters identified, would be necessary to better understand this phenomenon and its mode of occurrence.

Other types of alterations were documented in detail, such as the cavernous corrosion of the iron ring in the Roman Site and Museum of Avenches, the lake patina of the bronzes in the Laténium, and the corrosion of copper-based alloys rich in lead (coins of the Peney hoard). The technological study of certain materials was also addressed, explaining the presence of drafts in the corpus of bracelets of the Archaeological Service of the State of Fribourg and specifying the nature of the soldering and gilding of the silver alloy elements of the Great Châsse of Saint Maurice from the abbey of the same name.

The table below, already presented in newsletters n°3 to 5, shows that a large part of the materials selected within the framework of the MetalPAT project have been studied and thus make it possible to increase the number of objects sheets (85 compared to the forty or so at the beginning of the MetalPAT project) in the MiCorr+ database.

These sheets are currently being validated.

The reading of the objects sheets requires several expertises (conservation of heritage metals, analytical techniques, corrosion mechanisms), the editing committee set up, gathering the partners of the MetalPAT project, should be able to produce the required critical feedback to the various contributors.

Materials	Research theme	Canton / department	End-user[2] and corpus	2021		2022	
				Semester1	Semester2	Semester3	Semester4
Iron	Metallographic study and atm. corrosion of cast iron and puddle iron	Territoire Belfort	UTBM / columns, beams and girders				
	Crevice corrosion	Canton de Vaud	SMRA / ring				
	Corrosion of composite objects	Département du Doubs	MBAA / buckle plate				
		Canton du Jura	SAP / knifes				
		Département du Doubs	MBAA / knifes				
	Metallurgic studies	UTBM / LAPA	Inrap				
			MCAH / semi-finished objects				
Copper	Delamination of corrosion products layers	Canton de Berne	SACB / pin				
		Canton de Vaud	SMRA / ear pick & fibula				
		Département du Jura	CCE LS / axe				
	Lake corrosion and corrosion in humid environment	Département de Saône et Loire	Inrap (Autun) / craft				
		Canton de Neuchâtel	Laténium / pins				
	Metallurgic studies / typical corrosion	Canton de Vaud	MCAH / situla and other containers				
		Etat de Fribourg	SAEF / bracelets				
		Canton de Genève	MAHG / coins				
	Metal soaps	Canton de Berne	Foundation HAM / composites				
		Département du Haut-Rhin	MNAM / car parts				
Silver	Horn silver	Canton de Berne	SACB / coin				
	Technological study	Canton du Valais	ABSM / shrine				
Modern metals	Zinc pest	Département du Haut-Rhin	MNAM / car parts				

Technology | Corrosion mechanisms | Conservation | Work completed

Summary of the collaborations initiated with end-users – conservators.

- **COMMUNICATIONS**

Publication

C. Degrigny, N. Gutknecht, V.Valbi, D. Neff, P. Dillmann, M. Berranger, C. Gaspoz, B. Letourmy, Transdisciplinary collaboration for the multi-scale description of corrosion structures in metallic heritage, in EFC series ('Green Book') – Bridging the gap: corrosion science for heritage contexts, Elsevier (en cours).

Présentations

Presentation by V. Valbi during the colloquium *Patrimoine industriel et matériaux anciens au regard de la transition écologique :* « La corrosion des structures en fonte dans des bâtiments du patrimoine industriel : le cas de l'usine Japy de Fonteneilles » held on 16 June 2022 at the UTBM in Belfort (France).

Presentation by V. Valbi at the conference Eurocorr 2022 : « MiCorr application: a new support for the study of corrosion forms on ancient metal artifacts » held from 28 August to 1 September 2022 in Berlin (Germany).

Presentation by V. Valbi at the conference Sfμ Junior 2022 : « MiCorr : une application de support au diagnostic des métaux patrimoniaux » held from 2 to 4 November 2022 in Orléans (France).

[2] ABSM : Abbaye de Saint-Maurice ; CCE-LS : Centre de conservation et d'étude des Musées de Lons-le-Saunier ; Fondation HAM : Fondation matériel historique de l'armée suisse à Thun ; Inrap : Institut national de recherches archéologiques préventives ; Laténium : Parc et musée d'archéologie de Neuchâtel ; MAHG : Musée d'art et d'histoire de Genève ; MBAA : Musée des Beaux-Arts et d'archéologie de Besançon ; MCAH : Musée cantonal d'archéologie et d'histoire de Lausanne ; MNAM : Musée national de l'automobile de Mulhouse ; SACB : Service d'archéologie du Canton de Berne ; SAEF : Service archéologique de l'Etat de Fribourg ; SAP : Section d'archéologie et paléontologie du Jura ; SMRA : Site et musée romains d'Avenches ; UTBM : Université Technologique de Belfort-Montbéliard.