LEAD CAMES OF A STAINED GLASS WINDOW 52583 - AL ALLOY - SWITZERLAND

Artefact name	Lead cames of a stained glass window 52583
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Url	/artefacts/674/

The object

Fig. 1: Stained glass panel "Stokar" both sides, *Credit Museum zu Allerheiligen.*

Description and visual observation

Description of the artefact	Stained Glass panel from the 16th century representing prominent families of Schaffhausen (CH) through coat-of-arms. Object typically swiss called "Wappenscheiben". The object is made of incolor and colored glass (light blue, pink and red) decored with grisaille, silver yellow stain and blue enamel. The glass parts are crimpted with lead-alloy cams. The cams are fastened to one another by welding points of a lead-tin alloy on both side of the panel.
Type of artefact	Supporting structure
Origin	Schaffhausen, Schaffhausen, Switzerland
Recovering date	None
Chronology category	None
chronology tpq	1501 A.D.
chronology taq	1600 A.D.

Chronology comment 16th century AD

Burial conditions / environment Outdoor to indoor atmosphere

Artefact location Museum zu Allerheiligen, Schaffhausen

Owner Museum zu Allerheiligen, Schaffhausen

Inv. number Inv. Nr. 52583

Recorded conservation data Restauration in 2009 by Urs Wohlgemuth (Boniswil)

Complementary information

The study of this object is based on a simple problematic: in 2009 two stained glass panels were placed in a showcase for a permanent exhibition, the lead cames were then in a good conservation condition. In 2018, the lead showed voluminous efflorescence of white, powdery corrosion products.

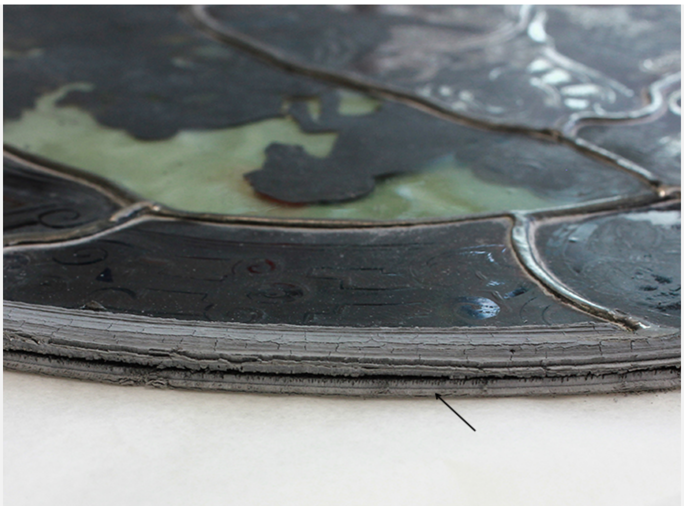
The environment of this showcase contained a high level of acetic acid. Lead being sensitive to organic acids, it corroded strongly. This is not new, but what is interesting here is that the two objects corroded in a very heterogeneous way. One lead cam may be deformed and completely covered with bulky white efflorescences, and the one next to it shows no corrosion.

The "stokar" window, which is of interest here, was restored in 2008, just before it was put on display. The restoration consisted of replacing some of the lead cams. Thus, while the object is dated to the 16th century, the replaced cams were new when they entered the display case. In 2018, they were completely corroded. In comparison, the other stained glass panel, with older lead cams, was placed in the same display case at the same time. For this second panel, the cams are slightly corroded in 2018, but not as badly as those of the 'Stokar' panel. The metal chosen by the restorer reacted more strongly with the corrosive environment (the display case) than the historical metal.

Study area(s)

Credit HE-Arc CR, A.Gerber.

Fig. 2: XRF analysis of the different lead cames of the "Stokar" stained glass panel. Tin (Sn) content is very variable from one came to another. Those with a very low Sn but a high Sb (1.4%) contents are much more corroded,



Credit Museum zu Allerheiligen.

Fig. 3: Corroded "modern" lead came on the "Stokar" stained glass panel (sampling area for cross-section indicated by the black arrow),

Credit Museum zu Allerheiligen.

Fig. 4: Detail of the corroded lead came

Binocular observation and representation of the corrosion structure

Visual description of the corrosion: Voluminous forms of corrosion, white powdery efflorescence can be observed.
The schematic representation (Fig. 6) gives an overview of the corrosion layers encountered on the object from a first visual macroscopic observation.

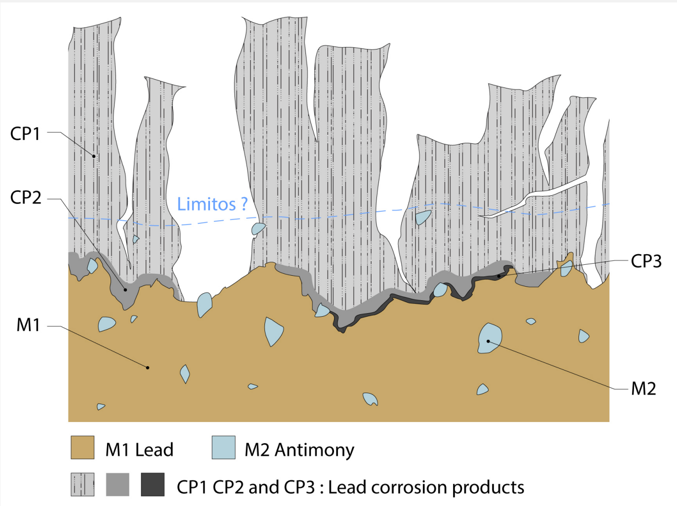


Fig. 5: Stratigraphic representation of a corroded lead came by microscopic observation,

Credit HE-Arc CR, A.Gerber.

MiCorr stratigraphy(ies) – Bi

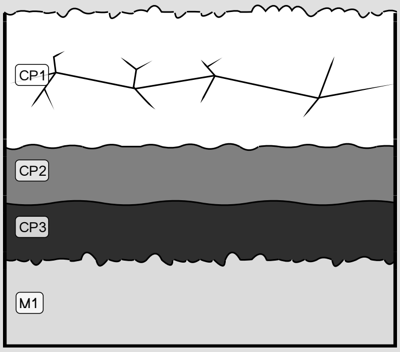
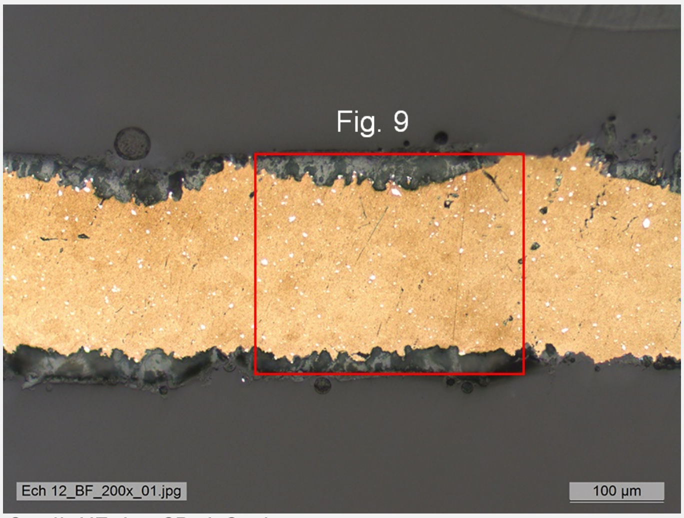


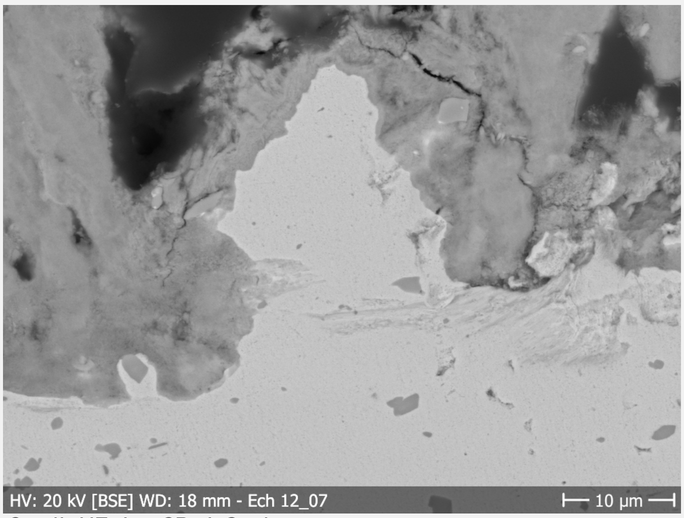
Fig. 6: Stratigraphic representation of the lead came under binocular using the MiCorr application with reference to Fig. 5. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation, Credit HE-Arc CR, A.Gerber.

Sample(s)



Credit HE-Arc CR, A.Gerber

Fig. 7: Micrograph of the cross-section of the corroded lead came with location of Fig. 9, unetched, dark field. The grains of the metal are slightly visible, and the light-coloured dots in the alloy are Sb-rich inclusions,



Credit HE-Arc CR, A.Gerber.

Fig. 8: SEM image (BSE mode) of a detail of the cross-section of the corroded lead came. The area in light grey is the metal, the corrosion is in darker grey with a blurred appearance. Sb-dots are dark grey. Corrosion progresses around them, without mineralising them,

Description of sample	The sample is a piece of metal taken from the corroded lead cam of the stained glass. This cam was replaced during the 2009 restoration. The purpose was to understand why this new metal has been completely corroded in a few years, while the historical metal next to it is not affected at all.
Alloy	Al Alloy
Technology	None
Lab number of sample	
Sample location	None
Responsible institution	Haute École Arc Neuchâtel, Neuchâtel
Date and aim of sampling	

Complementary information

For this lead cam, the alloy used is a lead alloy with about 1.5% antimony. Under a microscope, the alloy is not homogeneous. The antimony has formed nodules in the alloy, which are visible both under an optical microscope and under SEM.

The cross-section shows that corrosion does not attack the antimony nodules in the alloy, it progresses by mineralizing the lead around these nodules.

Analyses and results

Metallography: hand polishing (grit sizes 200, 500, 1000, 1200, 2500, with water), then machine polishing Struers® LaboForce-3 with diamond oil solution (grit sizes 3 µm and 1 µm). Finally, chemical and mechanical polishing (same machine), with Struers® OP-S solution (0.04 µm grit size) with 10% H2O2.

X-ray Fluorescence, in ***General Metals*** mode, acquisition time 60s (filters: M20/Lo20/Li20).

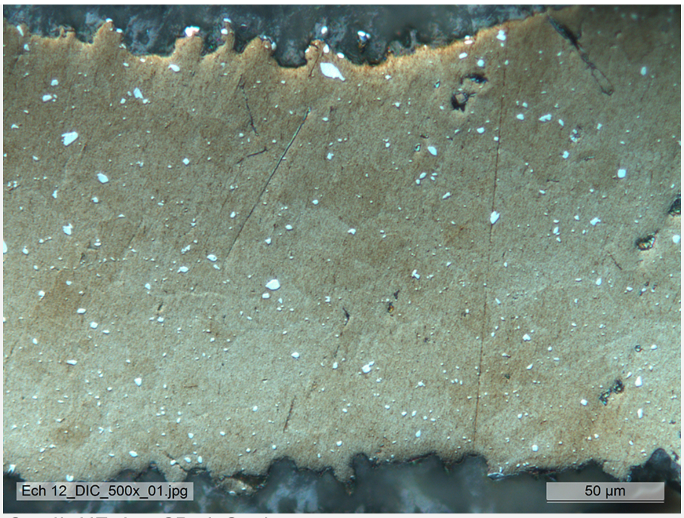
Fourier transform IR spectroscopy (FTIR) to identify the various corrosion products found on the object.

Scanning electron microscope/Energy-dispersive X-ray spectroscopy (SEM/EDX).

Non invasive analysis

Metal

Lead alloy with approximately 1.5% antimony. Heterogeneous alloy with a lead-rich main phase and antimony-rich nodules. Grains visible under differential interference contrast.



Credit HE-Arc CR, A.Gerber.

Fig. 10: Micrograph (detail of Fig. 7), unetched, dark field,

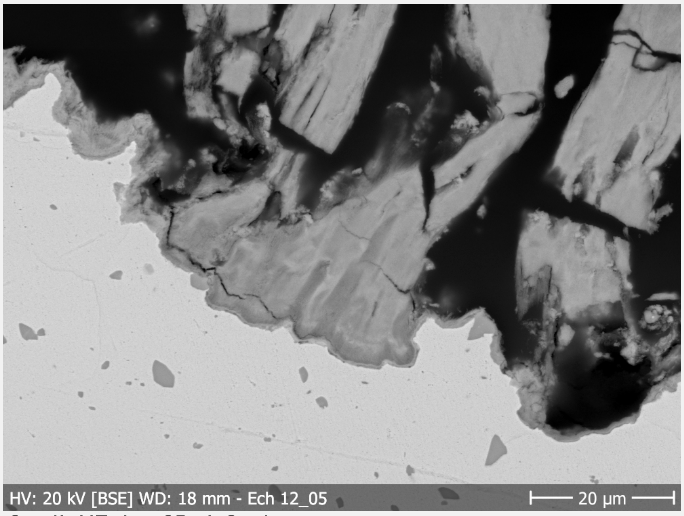
Microstructure	Polygonal grains with inclusions
First metal element	Pb
Other metal elements	Sb

Corrosion layers

CP1 seems to be an heterogeneous compound as indicated on Fig. 10. But EDX analyses do not indicate a significant difference in composition. The attack of lead by organic acids causes the formation of salts, such as lead acetate which are then transformed into basic lead carbonates by the action of CO2 from the environment as indicated by FTIR analysis of CP1.

Corrosion develops specificilly on cams made of a lead-antimony alloy, where antimony inclusions constitute the cathode (0.150 V/SHE) versus lead (-0.125 V/SHE) which corrodes as an anode in presence of lead acetate (the electrolyte).

The limit of the original surface lies somewhere in the corrosion layers. Antimony nodules are inferior markers of the limit of the original surface.



Credit HE-Arc CR, A.Gerber.

Fig. 11: SEM image (BSE mode) of the cross-section of the corroded lead came,

Corrosion form	Uniform - transgranular

Corrosion type Active corrosion of lead

MiCorr stratigraphy(ies) – CS

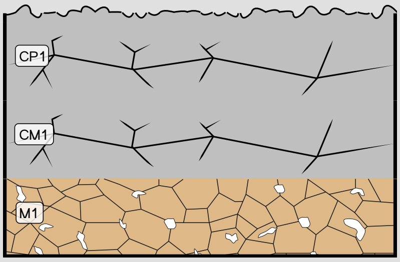


Fig. 9: Stratigraphic representation of the lead came in cross-section (dark field) using the MiCorr application with reference to Figs. 7 and 10. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation, Credit HE-Arc CR, A.Gerber

Synthesis of the binocular / cross-section examination of the corrosion structure

Heterogeneous active corrosion on lead cams. The tin content of the alloy indicates whether or not a cam will corrode ; with a low tin content lead is likely to corrode more. In a lead-antimony alloy, corrosion preferentially attacks the lead.

Conclusion

Lead is a metal that is very sensitive to organic acids. But it can be alloyed with elements that can either increase its resistance to corrosion (tin) or make it more sensitive to organic acids. Antimony (Sb) is such an element that enhances active corrosion due to the galvanic effect between this element and lead.

References

References on object and sample

References object

1. Hasler (2010). Die Schaffhauser Glasmalerei : des 16. bis 18. Jahrhunderts. Corpus Vitrearum, Vitrocentre Romont, Peter Lang, 2010.

References sample

2. Gerber (2018). Corrosion du sertissage en plomb de vitraux - Recherches autour de la dégradation de deux objets dans leur vitrine au Museum zu Allerheiligen de Schaffhouse. Haute Ecole Arc Neuchâtel, travail de diplôme de Bachelor, non-publié, 2018.

References on analytic methods and interpretation

3. Costa and Urban (2005). Lead and its alloys: metallurgy, deterioration and conservation. In Studies in Conservation, 50:sup1, 2005, 48-62.
4. Tétreault et al. (2003). Corrosion of copper and lead by formaldehyde, formic and acetic acid vapours, 4, Studies in conservation, 48, 4, 2003, 237-250.
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