SACRIFICIAL KNIFE (TUMI) IVC 24745 - CU ALLOY - PERU

Artefact name Sacrificial knife (tumi) IVc 24745

Authors Christian. Degrigny (HE-Arc CR, Neuchâtel, Neuchâtel, Switzerland) & Marion. Billot (HE-Arc CR, Neuchâtel, Neuchâtel, Switzerland) & Valentin. Boissonnas (HE-Arc CR, Neuchâtel, Neuchâtel, Switzerland)

Url /artefacts/348/

The object

Credit HE-Arc CR, M.Billot.

Fig. 1: Sacrificial knife made of copper,

Description and visual observation

Description of the artefact

Sacrificial knife made of an arsenical copper alloy. Semi circular flattened cutting edge. Trapezoidal handle with rectangular section.

L = 105 mm; W handle = 25 mm; W blade = 55 mm; T = 1 mm; WT = 18,7 g

Type of artefact Sacrificial knife (tumi in vernacular language)

Origin Probably Cajamarca (Peru), Cajamarca, Cajamarca, Peru

Recovering date Unknown

Chronology category None

chronology tpq 200 A.D.

chronology taq 1300 A.D.

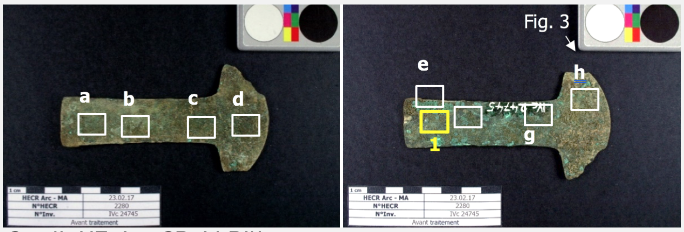
Chronology comment Between 200 at 1300 AD

Burial conditions / environment	Soil
Artefact location	Museum der Kulturen, Basel
Owner	Museum der Kulturen, Basel
Inv. number	IVc 24745
Recorded conservation data	Not conserved

Complementary information

Little information on the origin of the artifact. Most likely not documented before being donated to the museum.

Study area(s)



Credit HE-Arc CR, M.Billot.

Fig. 2: Location of Fig. 3, XRF analyses (white squares) and the sampling area (yellow square),

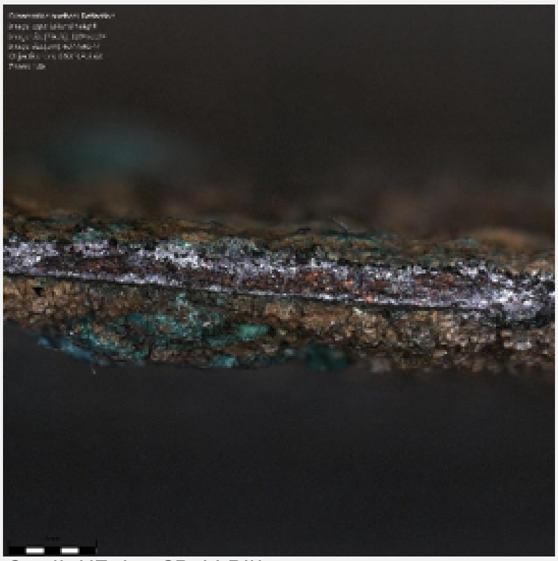

Credit HE-Arc CR, M.Billot.

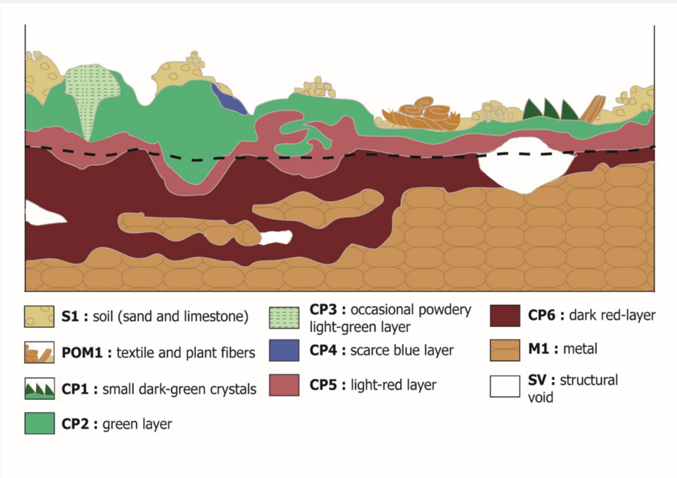
Fig. 3: Detail of the corrosion stratigraphy of the fractured cutting edge. To be related to the schematic stratigraphy in Fig. 6,

Fig. 4: Detail of the sampling area for XRF and XRD analysis,

Credit HE-Arc CR, M.Billot.

Binocular observation and representation of the corrosion structure

The schematic representation below gives an overview of the corrosion layers encountered on the tumi from a first visual macroscopic observation under binocular microscope.

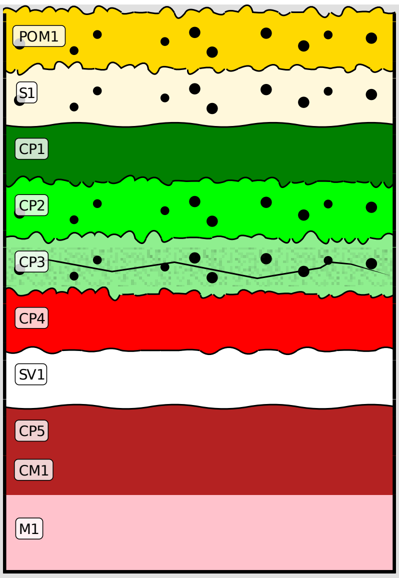


Credit HE-Arc CR, M.Billot.

Fig. 5: Stratigraphic representation of the sacrificial knife in cross-section by macroscopic observation,

MiCorr stratigraphy(ies) – Bi

Fig. 6. Stratigraphic representation of the tumi in cross-section using the MiCorr application, Credit HE-Arc CR, M.Billot.



Sample(s)

Description of sample Not applicable since invasive sampling was not authorized by the museum.
Only one powder sample was taken of the green corrosion product.

Alloy Cu Alloy

Technology Cast and cold worked

Lab number of sample 1

Sample location HE-Arc CR, Neuchâtel, Neuchâtel

Responsible institution HE-Arc CR, Neuchâtel, Neuchâtel

Date and aim of sampling 02.04.2017, chemical and structural analyses

Analyses and results

X-ray radiography[1], XRF[2], SEM-EDS, and XRD.

Conditions of the XRD analysis: Stoe Mark II-Imaging Plate Diffractometer System (Stoe & Cie, 2015) equipped with a graphite-monochromator. Data collection was performed using Mo-Kα radiation (λ = 0.71073Å, beam diameter 0.5mm). Two-dimensional diffraction images (10min. per exposure) were obtained at an image plate distance of 200mm with a continued sample rotation. The resolution was Dmin - Dmax 24.00 - 1.04Å and intensity integration has been performed over the entire image (360°).

---

[1] The conditions are unknown.

[2] On the object with portable X-ray fluorescence spectrometer (NITON XL3t 950 Air GOLDD+ analyser, Thermo Fischer®.

Non invasive analysis

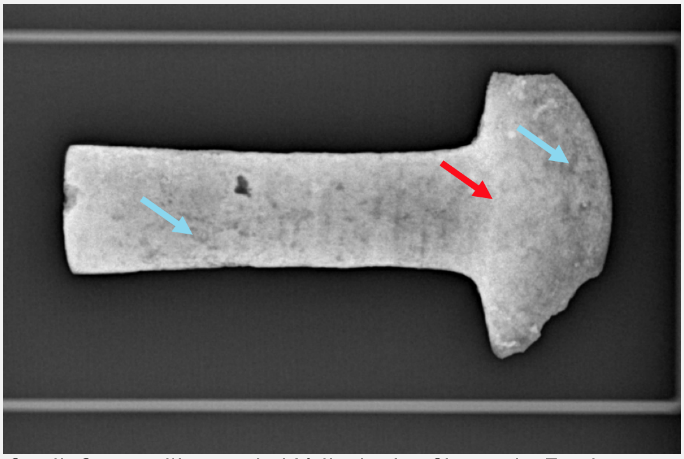
Metal

The metal is an arsenical copper alloy with low concentration of iron and traces of silver (Table 1).

XRF analyses have been conducted on eight areas, on the two sides of the non-cleaned artifact. Almost all analyses are the same except for the area "e" (Fig. 2, Table 1) where a slightly higher concentration of arsenic was measured.

Elements mass%	Cu	As	Ag	Fe	Cl	Al	Si	K	P	Ca	S	BAL
a	61.9	0.5	0.05	0.4	0.3	3.6	12.6	0.7	0.2	1.1	0.2	18.3
b	51.9	0.3	0.04	0.4	0.3	1.4	11.9	0.7	0.07	0.8	0.1	31.8
c	51.4	0.3	0.04	0.5	0.3	2.5	14.4	0.8	0.1	0.9	0.1	28.2
d	52.7	0.3	0.04	0.5	0.4	2.6	16.6	0.8	0.06	1.1	0.2	24.5
e	**39.8**	**1.1**	0.03	0.9	**2.2**	3.1	13.6	0.8	0.07	1.0	0.4	36.7
f	52.6	0.3	0.03	0.3	0.2	1.8	11.7	0.7	0.04	1.5	0.4	30.3
g	52.5	0.3	0.04	0.3	0.3	2.1	11.5	0.6	0.2	1.6	0.3	30.1
h	38.4	0.2	0.03	0.8	0.1	3.0	16.5	0.8	0.1	0.9	0.2	38.8

Table 1: Chemical composition of the non-cleaned metal surface. Method of analysis: XRF. Mining mode Cu/Zn, acquisition time 180s (filters: M30/Lo30/H60/Li60), in the support. BAL corresponds to the elements not analysed: O and C. The exogenous elements are indicated in light-yellow while remarkable concentrations are highlighted in yellow, credit MiCorr_HE-Arc CR, C.Degrigny.



Credit Centre d'Imagerie Médicale, La-Chaux-de-Fonds.

Fig. 7: X-ray radiography of the artifact. The base of the blade is thicker and is probably as-cast (red arrow). The blue arrows indicate casting flaws or localized corrosion,

Microstructure None

First metal element Cu

Other metal elements As

Complementary information

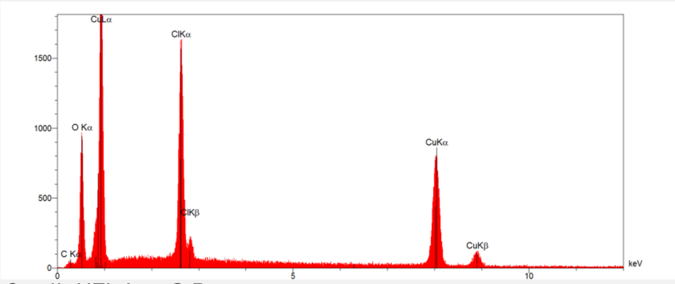
Complementary information given by X-radiography (Fig. 7) shows that the object is not totally mineralized and still has a lot of remaining metal. Irregularities and different thicknesses are visible and parallel lines show that the artifact was hammered. The whiter the area, the thicker the metal is.

Corrosion layers

Results from XRF analysis of the non-cleaned metal surface (Table 1) indicate an elevated concentration of chlorine.

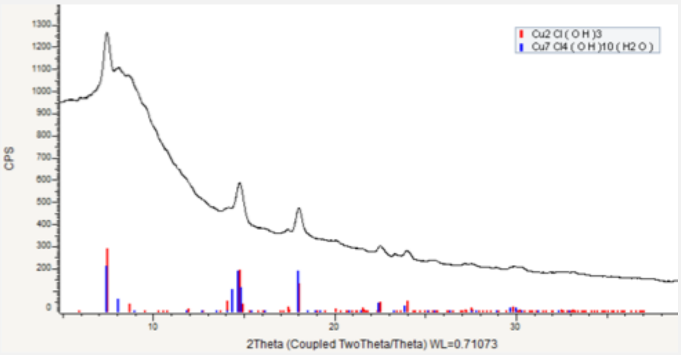
The exogenous elements come from the landfill are mainly Si and Al, certainly associated to aluminosilicates.

A sample was taken in the powdered light-green isolated layer (Figs. 2, 4 and 5). Chlorine, copper and oxygen was analysed by SEM-EDS. The presence of high concentration of Cl as well as Cu and O seems to indicate active corrosion (Fig. 8). XRD analysis confirmed the presence of paratacamite often associated to active corrosion (Fig. 9).



Credit HEI-Arc, S.Ramseyer.

Fig. 8: EDS spectrum of a sample of the powdered light-green isolated layer (Fig. 2), Lab of Electronic Microscopy and Microanalysis (Néode),



Credit Empa, A.Neels.

Fig. 9: XRD spectrum of a sample of the powdered light-green isolated layer (Fig. 2), Laboratory of Analytical Chemistry, Empa, HE-Arc,

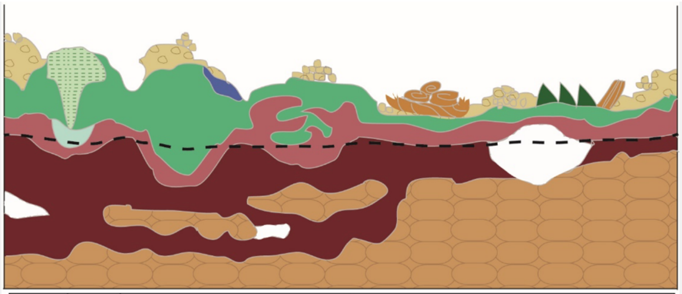
Corrosion form	Multiform - transgranular
Corrosion type	Type II (Robbiola)

MiCorr stratigraphy(ies) – CS

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

Based on the analysis carried out, the schematic representation of the stratigraphy of corrosion layers (Fig. 5) was corrected. The limit of the original surface (represented by the dotted line on the figure below) was identified as still present and is located at the interface between CP6 and CP7.

Fig. 10: Improved stratigraphic representation of the tumi from visual observations and analyses,



	Name	Aspect	Composition
	S1	Soil (sand and limestone)	Si, O, C, Al,K, P, Ca, S (Al_2O_3, SiO, etc.)
	POM1	Textile and plant fibers	
	CP1	Small dark-green crystals	Unknown, maybe paratacamite $Cu_2Cl(OH)_3$?
	CP2	Green layer	Unknown, probably malachite $Cu_2CO_3(OH)_2$
	CP3	Occasional powdery light-green layer	Paratacamite $Cu_2Cl(OH)_3$ and hydrated hydroxychloride $Cu_7Cl_4(OH)_{10}$ (H_2O)
	CP4	Light-blue ponctual layer	Unknown, probably nantokite CuCl
	CP5	Scarce blue layer	Unknown, probably azurite $Cu_2CO_3(OH)_2$
	CP6	Light-red layer	Unknown, probably cuprite CuO
	CP7	Dark red-layer	Unknown, probably cuprite CuO
	M1	Metal	Probably Cu with low percent of As and Fe. Trace of Ag.
	SV	Structural void	——

Credit HE-Arc CR, M.Billot.

Conclusion

This tumi is an arsenic copper alloy with a low percentage of iron, as well as traces of silver. This alloy was common in pre-Columbian South America[1]. The X-ray radiography shows that this object was formed from a metal sheet and cold hammered.

Chlorine is found locally in the form of paratacamite.

The limit of the original surface has been altered by the corrosion products but can be found at the interface of CP6 and CP7. This tumi follows the type II corrosion model of L. Robbiola.

---

[1] Pillsbury, 2001, p. 97.

References

References object

1. Pillsbury, J. Moche art and archeology in ancient Peru. National Gallery of Art, Washington, 2001.

References on analytic methods and interpretation

2. Scott, D. Copper and Bronze in Art: Corrosion, Colorants, Conservation. Getty Conservation Institute, Los Angeles, 2002.

3. Robbiola, L. Caracterisation de l'altération de bronzes archéologiques enfouis à partir d'un corpus d'objets de l'âge du bronze. Mécanismes de corrosion. Université Pierre et Marie Curie - Paris VI, 1990.