SACRIFICIAL KNIFE (TUMI) IVC 24745 – CU ALLOY – UNKNOWN – 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)

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The object

Fig. 1: Sacrificial knife, *Credit HE-Arc CR, M.Billot.*

Description and visual observation

Description of the artefact Sacrificial knife (tumi) covered with green corrosion products and sediments. 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 Unknown

chronology tpq 200 A.D.

chronology taq 1300 A.D.

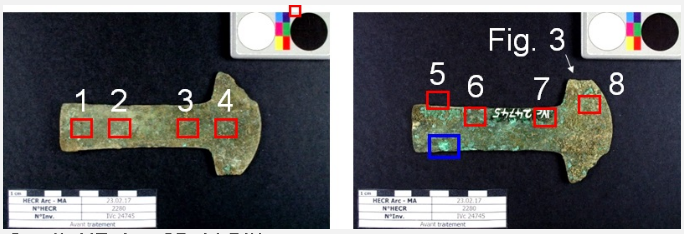
Chronology comment None

Burial conditions / environment	Soil
Artefact location	Museum der Kulturen, Basel
Owner	Museum der Kulturen, Basel
Inv. number	IVc 24745
Recorded conservation data	N/A

Complementary information

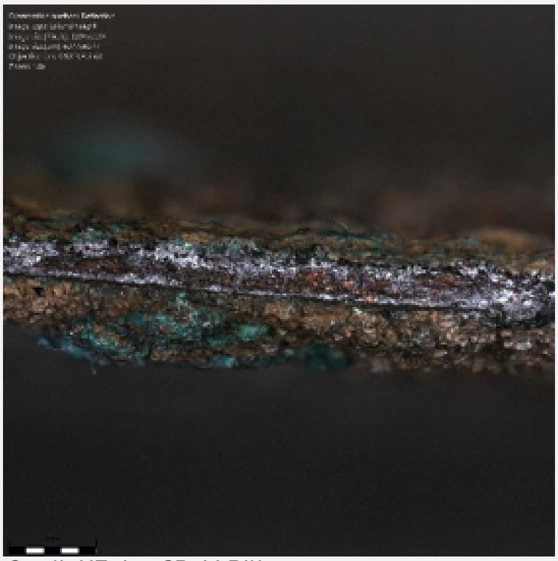
Little information on the origin of the artifact. Most likely not documented before being donated to the museum.

Study area(s)



Credit HE-Arc CR, M.Billot.

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



Credit HE-Arc CR, M.Billot.

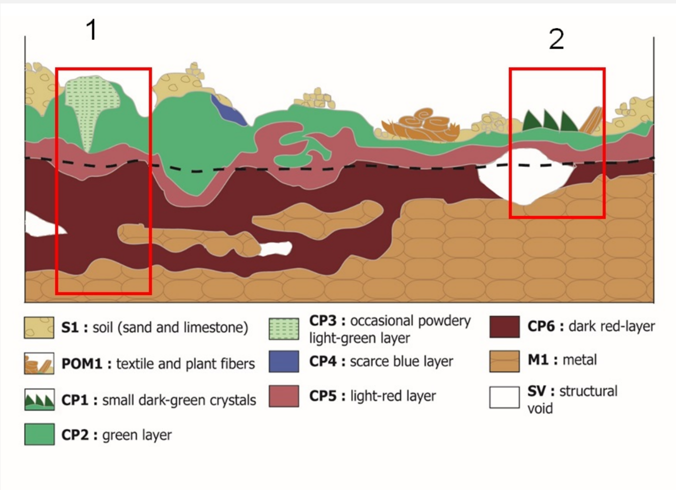
Fig. 3: Detail of the corrosion structure of the fractured cutting edge of the knife. To be related to the schematic stratigraphy of Fig. 6,

Fig. 4: Detail from Fig. 2 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.

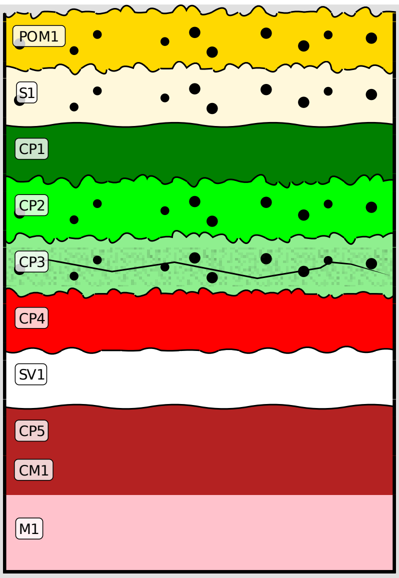


Credit HE-Arc CR, M.Billot.

Fig. 5: Stratigraphic representation of the sacrificial knife by macroscopic observation with indication of corrosion structures 1 and 2 used to build the MiCorr stratigraphy of Fig. 6,

MiCorr stratigraphy(ies) – Bi

Fig. 6. Stratigraphic representation of the corrosion structure of the knife (combination of corrosion structures 1 and 2 of Fig. 5) observed macroscopically under binocular microscope using the MiCorr application. 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, M.Billot.



Sample(s)

Description of sample	Invasive sampling was not authorized by the museum. Only one powder sample was taken of the green corrosion product (Fig. 4).
Alloy	Cu Alloy
Technology	Cold worked (laminated)
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

Complementary information

None.

Analyses and results

Analyses performed:
X-ray radiography*, XRF**, 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°).

* The conditions are unknown.
** On the object with handheld X-ray fluorescence spectrometer (NITON XL3t 950 Air GOLDD+ analyser, Thermo Fischer®. Mining mode Cu/Zn, acquisition time 180s (filters: M30/Lo30/H60/Li60)

Non invasive analysis

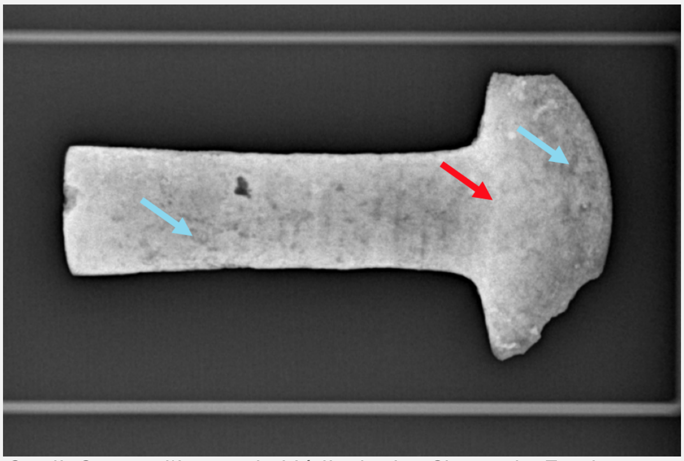
The metal is an arsenical copper alloy with low concentration of iron and traces of silver (Table 1). XRF analyses have been conducted on eight areas, on the two sides of the non-cleaned artefact. Almost all analyses are the same except for the area "5" where a slightly higher concentration of arsenic was measured.

Elements mass%	Cu	As	Ag	Fe	Cl	Al	Si	K	P	Ca	S	BAL
1	61.9	0.5	0.05	0.4	0.3	3.6	12.6	0.7	0.2	1.1	0.2	18.3
2	51.9	0.3	0.04	0.4	0.3	1.4	11.9	0.7	0.07	0.8	0.1	31.8
3	51.4	0.3	0.04	0.5	0.3	2.5	14.4	0.8	0.1	0.9	0.1	28.2
4	52.7	0.3	0.04	0.5	0.4	2.6	16.6	0.8	0.06	1.1	0.2	24.5
5	**39.8**	**1.1**	0.03	0.9	**2.2**	3.1	13.6	0.8	0.07	1.0	0.4	36.7
6	52.6	0.3	0.03	0.3	0.2	1.8	11.7	0.7	0.04	1.5	0.4	30.3
7	52.5	0.3	0.04	0.3	0.3	2.1	11.5	0.6	0.2	1.6	0.3	30.1
8	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. 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.

Metal

As indicated above, the metal of the knife might be an arsenic-copper alloy. Its manufacturing technique is not known but the X-radiography image seems to indicate that the artefact might have been produced as-cast with internal flaws (Fig. 7). The object has still a lot of remaining metal. Irregularities and different thicknesses are visible and parallel lines show that the knife was hammered. The whiter the area, the thicker the metal is.



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

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

Microstructure Unknown

First metal element Cu

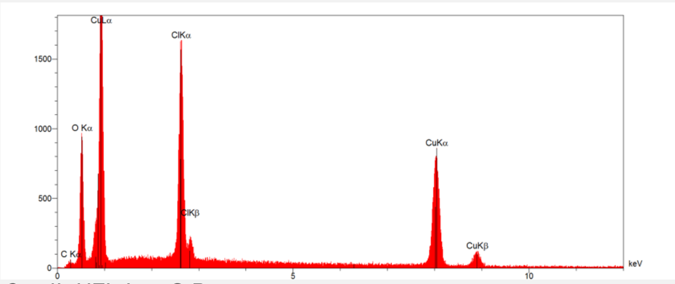
Other metal elements As

Complementary information

None.

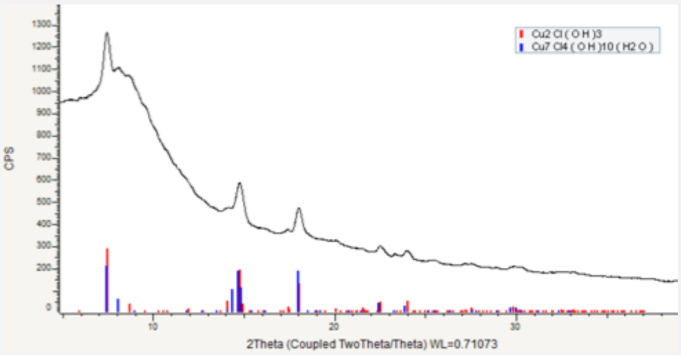
Corrosion layers

Results from XRF analyses of the non-cleaned metal surface (Table 1) indicate the presence 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 EDS-SEM. The presence of a high amount 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. 4), 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. 4), Laboratory of Analytical Chemistry, Empa, HE-Arc,

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

Complementary information

None.

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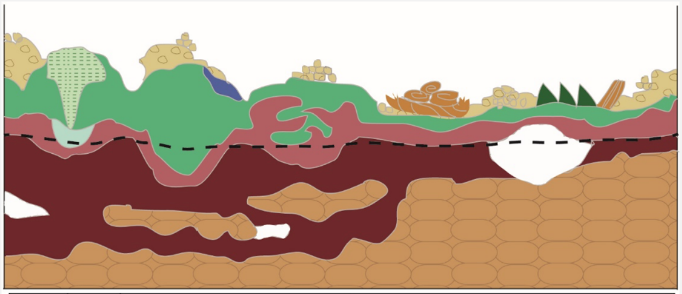
Synthesis of the binocular / cross-section examination of the corrosion structure

The schematic representation of corrosion layers of Fig. 5 integrating additional information based on the analyses carried out is given in Fig. 10. 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.



	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.

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

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 (Pillsbury 2001). 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.

References

References on object and sample

References object

1. Pillsbury, J. (2001) Moche art and archeology in ancient Peru. National Gallery of Art, Washington, 97.
2. Gerber, A. (2019) MiCorr file on a sacrificial knife.

References on analytic methods and interpretation

3. Scott, D. (2002) Copper and Bronze in Art: Corrosion, Colorants, Conservation. Getty Conservation Institute, Los Angeles.
4. Robbiola, L. (1990) 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.