SACRIFICIAL KNIFE (TUMI) IVC 23683 - CU ALLOY

Artefact name Sacrificial knife (tumi) IVc 23683

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The object

Credit HE-Arc CR, A.Gerber.

Fig. 1: Sacrificial knife with decorated handel - Copper and arsenic alloy - front face,

Fig. 2: Decorated handel (detail) - front face,

Credit HE-Arc CR, A.Gerber.

Fig. 3: Decorated handel (detail) - back face,

Credit HE-Arc CR, A.Gerber.

Description and visual observation

Description of the artefact

Sacrificial or ceremonial knife with semi circular flattened cutting edge and covered with blue-green corrosion products and sediments. Handle decorated with an anthropomorphic figure representing a whole person, holding a knife in his right hand and a severed head in his left hand. The character presents incrustations of organic and mineral materials.

Type of artefact

Sacrificial knife (tumi in vernacular language)

Origin

Peru

Recovering date

Date unknown

Chronology category

None

chronology tpq

200 A.D.

chronology taq

700 A.D.

Chronology comment

Probably from the Mochica culture, from the late period

Burial conditions / environment

Unknown

Artefact location

Museum der Kulturen, Basel

Owner

Museum der Kulturen, Basel

Inv. number

IVc 23683

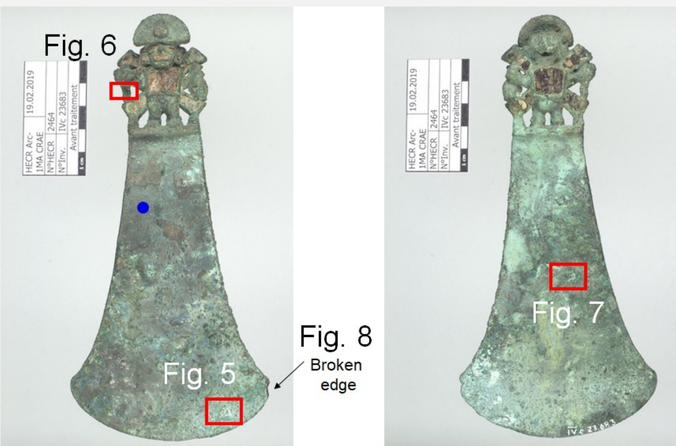
Recorded conservation data

Objects that were part of biopassivation tests of cuprous archaeological objects, in a master's work at the HE-Arc CR. (Gutknecht, 2018)

Complementary information

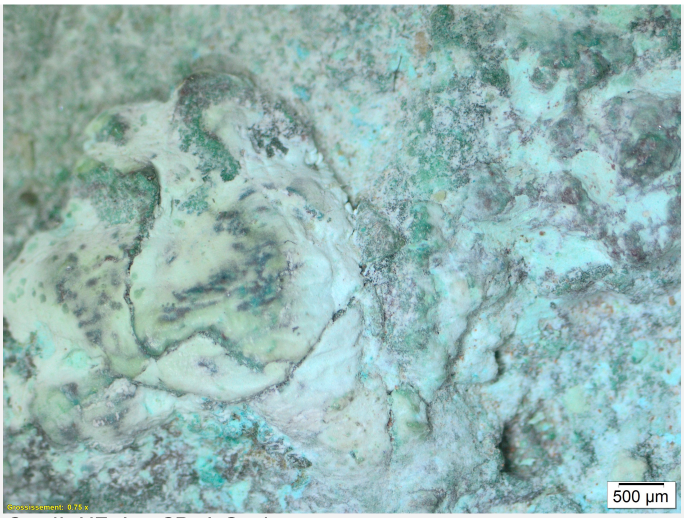
The original archaeological context is unknown, so there is very little information about the culture of origin and no exact dating. The object entered through a purchase and donation to the museum.

Study area(s)



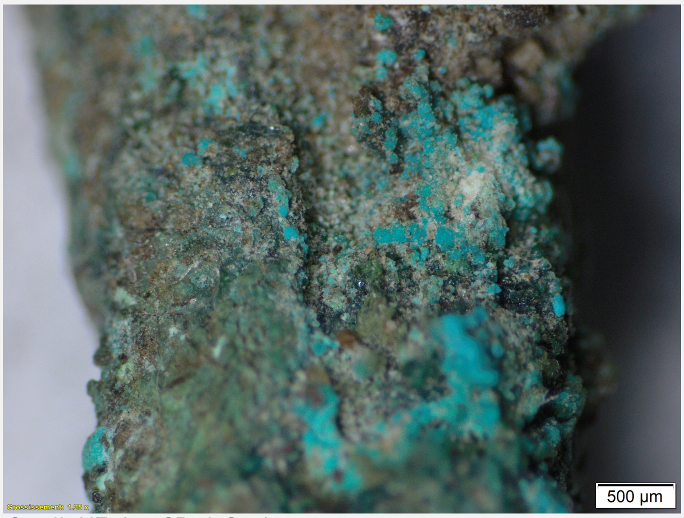
Credit HE-Arc CR, A.Gerber.

Fig. 4: Sacrificial knife front (left) and back (right) faces with location of XRF analysis (blue spot) and samples for SEM-EDS analyses (red squares),



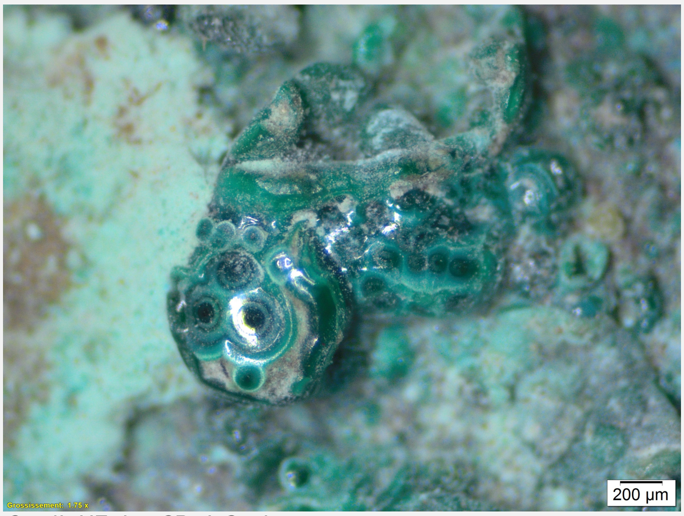
Credit HE-Arc CR, A.Gerber.

Fig. 5: Detail of Fig. 4 with whitish and not very cohesive corrosion product, sample 1 (CP1),



Credit HE-Arc CR, A.Gerber.

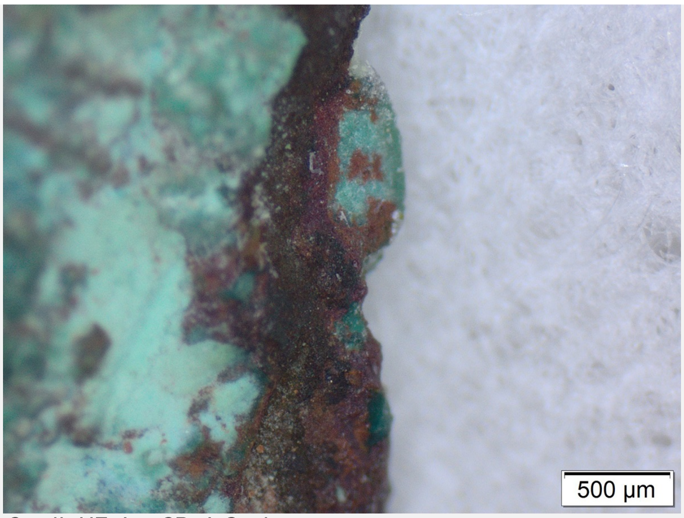
Fig. 6: Detail of Fig. 4 with blue corrosion products in cluster, sample 2 (CP4)



Credit HE-Arc CR, A.Gerber.

Fig. 7: Detail of Fig. 4 with green corrosion product, with eye-like stucture, sample 3 (CP3)

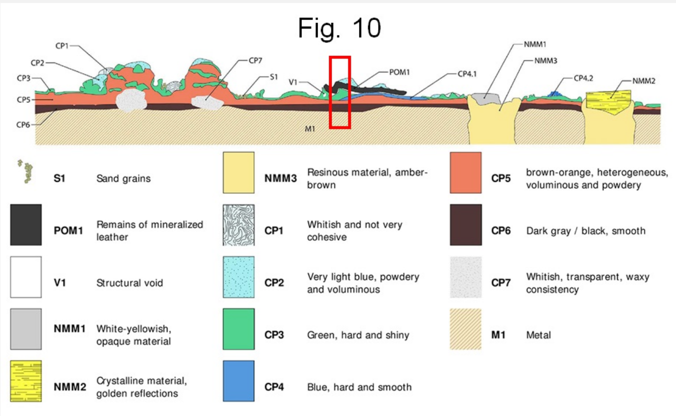
Fig. 8: Broken edge of the blade (see Fig. 4), showing the different corrosion layers in cross-section,



Credit HE-Arc CR, A.Gerber.

Binocular observation and representation of the corrosion structure

The schematic representation below gives an overview of the corrosion layers encountered on the sacrificial knife from a first visual macroscopic observation

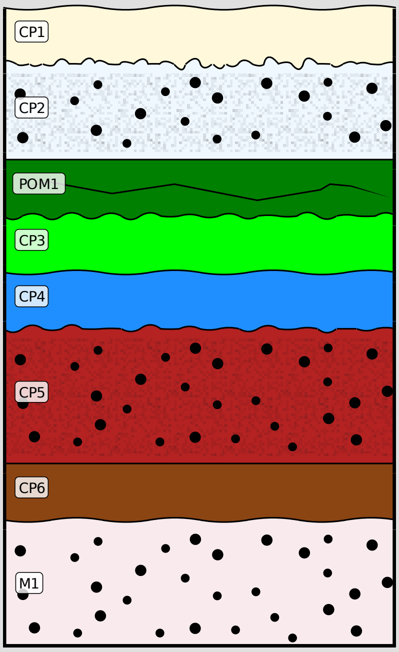


Credit HE-Arc CR, A.Gerber,

Fig. 9: Stratigraphic representation of the sacrificial knife in cross-section by macroscopic observation with indication of the MiCorr stratigraphy without CP1 (Fig. 10),

MiCorr stratigraphy(ies) – Bi

Fig. 10: Stratigraphic representation of the sacrificial knife under binocular using the MiCorr application with reference to Fig. 9. 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)

Description of sample	Not applicable since invasive sampling was not authorized by the museum. Only a few corrosion products on the surface of the sacrificial knife were sampled.
Alloy	Cu Alloy
Technology	Cast and cold worked
Lab number of sample	
Sample location	HE-Arc CR, Neuchâtel, Neuchâtel
Responsible institution	HE-Arc CR, Neuchâtel, Neuchâtel
Date and aim of sampling	10.04.2019, chemical and structural analyses

Complementary information

Nothing to report.

Analyses and results

Analyses performed:
X-ray radiography and tomography*, XRF** and SEM-EDS***.

* Conditions were not documented.
** Directly on the metal with a portable X-ray fluorescence spectrometer NITON XL3t 950 Air GOLDD+ analyser from Thermo Fischer®.
*** On a few samples with a Jeol JSM-6400 device, HEI Arc, La Chaux-de-Fonds, Switzerland

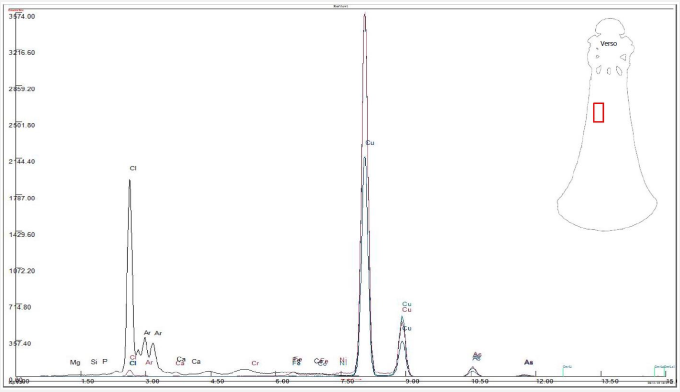
Non invasive analysis

Metal

The metal is an arsenical copper alloy with 2-3% (in mass) As (Table 1 and Fig. 11). As can be seen from the stratigraphy in Fig. 9, other materials make up the figure of the decorated handle: a whitish-yellowish opaque material as well as a crystalline material with golden reflections in a resinous material (amber?).

Element	Cu	As	Cl	S	P	Ca	BAL
mass %	75	2-3	11.5	0.2	0.2	0.1	10-11

Table 1: Chemical composition of the partly-cleaned metal surface. Method of analysis: XRF. Mining mode Cu/Zn, acquisition time 120s (filters: M30/Lo30/H30/Li30). BAL = non-analysed elements (probably O and C).



Credit HE-Arc CR, A.Gerber.

Fig. 11: XRF Analysis carried out on a partly cleaned area of the front face of the sacrificial knife (see Fig. 4),

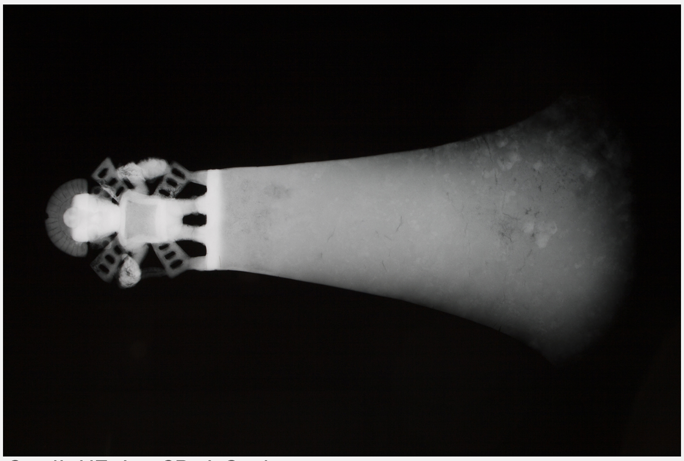
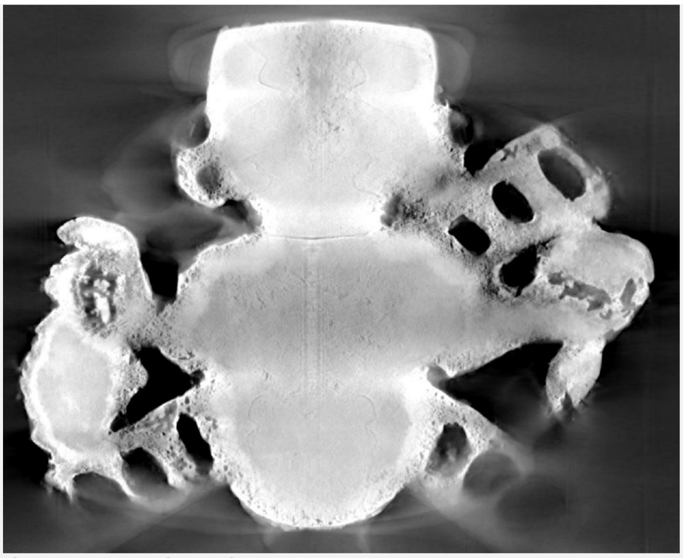

Credit HE-Arc CR, A.Gerber.

Fig. 12: X-ray radiography of the sacrificial knife showing how incrustations are put in place, the various thickness of the blade and its porosity (black holes on the right) as well as corroded areas (close to the cutting edge),

Fig. 13: X-ray tomography of the handle decorated with a character of the sacrificial knife indicating the porosity of the metal,



Credit HE-Arc CR, A.Gerber.

Microstructure None

First metal element Cu

Other metal elements As

Complementary information

The metallographic structure is unknown, but it is likely that the object was cast and then reworked cold.
Depending on the area, there should be cored grains with remaining dendritic structure and, if the metal was annealed, grains with twin lines.

Corrosion layers

Table 1 shows a high amount of the chlorine element on the surface of the front face of the sacrificial knife.

As shown in the stratigraphy of Fig. 9, the metal of the sacrificial knife is covered with a double layer of orange-brown / dark grey corrosion products (CP5 / CP6). In some areas, the powdery orange-brown sub-layer is interspersed with a green corrosion layer (CP3) (pustules) or covered with hard blue corrosion products (CP4). A whitish, transparent corrosion product of waxy consistency (CP7) was found under the pustules. Locally and on the surface, a light blue corrosion product (CP2) was found with a whitish layer (CP1) on top.

EDS analyses of these different corrosion products showed that CP7 contains Cu and Cl and is identified as nantokite, CP5 and CP6 could be cuprite since they contain exclusively Cu and O, CP3 and CP4 containing both Cu, O and C could be malachite and azurite respectively. The eye-like aspect of CP3 seems to validate this hypothesis. CP2 is identified as atacamite or paratacamite since it contains both Cu, O and Cl. CP1 could not be identified. Most of the corrosion products contained phosphorus (P), suggesting that the sacrificial knife was probably buried in a grave, or near any significant amount of decaying organic matter.

Corrosion form Multiform

Corrosion type ?

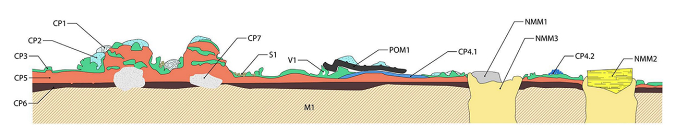
Complementary information

The surface of the object is corroded in a very heterogeneous way. Some zones correspond to Type I corrosion models according to Robbiola, and others to Type II with the formation of pustules (Formigli 1975). Parts of the object that have been cold worked and / or deformed are those with the most corroded surfaces, sometimes with complete lost of the limitos. The edge of the blade, for example, was hammered after casting and was bent during its use: it is one of the most corroded areas.

MiCorr stratigraphy(ies) – CS

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

The schematic representation of corrosion layers of Fig. 9 integrating additional information based on the analyses carried out is given in Fig. 14. The limit of the original surface was identified as still present and is located at the interface between CP5 and CP6.



		Description	Interpretation
	POM1	Remains of organic material	Fragments of mineralized leather
	CP1	Whitish and not very cohesive	Corrosion products mixed with gypsum (?)
	CP2	Very light blue, powdery and voluminous	Copper hydroxy-chlorides: atacamite Cu2Cl(OH)3, paratacamite (?)
	CP3	Green, hard and shiny	Copper carbonate: malachite Cu2CO3(OH)2 (?)
	CP4	Blue, hard and smooth	Copper carbonate: azurite Cu3(CO3)2(OH)2 (?)
	CP5	brown-orange, heterogeneous, voluminous and powdery	Copper oxide: cuprite Cu2O (?)
	CP6	Dark grey / black, smooth	Copper oxide: cuprite Cu2O (?)
	CP7	Whitish, transparent, waxy consistency	Copper chloride: nantokite CuCl (?)
	M1	Metal	Copper alloy with 3% Arsenic

Credit HE-Arc CR, A.Gerber.

Fig. 14: Improved representation of the stratigraphy of corrosion layers of the sacrificial knife from visual observations and analyses,

Conclusion

The metal of the sacrificial knife is an arsenical copper alloy. The object was cast and then cold-worked, probably hammered. The metal is heterogeneously corroded with Robbiola types I and II and pustules. In the analyzes carried out, the chlore element appeared, indicating a so-called "active" corrosion of the metal. The limit of the original surface is at the CP5 and CP6 interface.

References

References on object and sample

Reference object

1. Billot, M. 2018 MiCorr file of a Tumi from Peru.

References on analytic methods and interpretation

2. Formigli, E. (1975) Die Bildung von Schlichtpocken auf antiken bronzen, Arbeisblätter, Heft 1, 51-74.
3. Gutknecht, N. (2018) La corrosion active sur les alliages cuivreux archéologiques - Evaluation de la stabilisation par biopassivation fongique. Mémoire de Master, Haute École Arc Necuhâtel, Conservation-Restauration, non-publié.
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.
5. Scott, D. (2002) Copper and Bronze in Art: Corrosion, Colorants, Conservation. Getty Conservation Institute, Los Angeles.

6. Scott, D. (1991) Metallography and Microstructure of Ancient and Historic Metals. Getty Conservation Institute, Los Angeles.