

# SACRIFICIAL KNIFE (TUMI) IVC 23683 – CU ALLOY – UNKNOWN

**Artefact name** Sacrificial knife (tumi) Ivc 23683

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**Url** /artefacts/1101/

## ∨ The object



Fig. 1: Sacrificial knife (tumi) with decorated handel, front face,

*Credit HE-Arc CR, A.Gerber.*

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



Credit HE-Arc CR, A.Gerber.

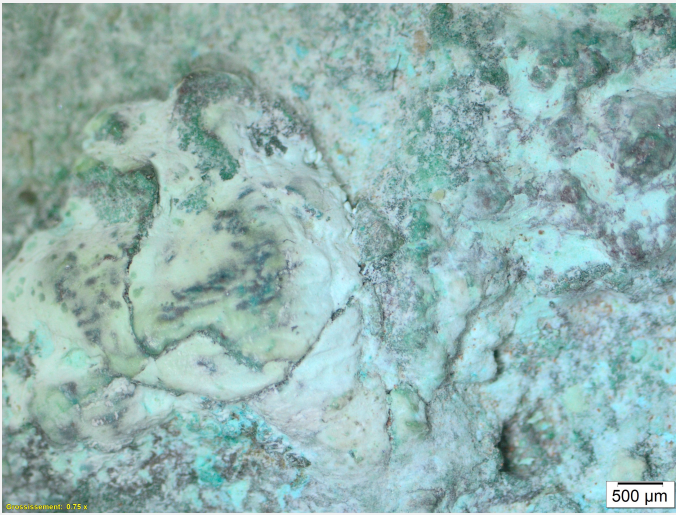


Credit HE-Arc CR, A.Gerber.

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

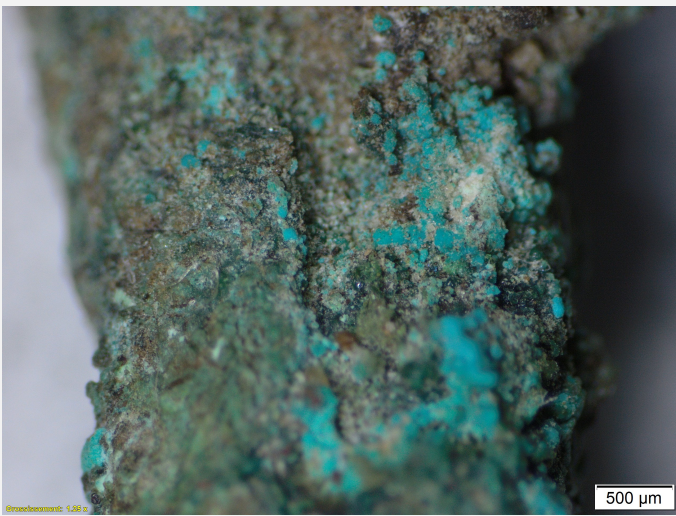


Credit HE-Arc CR, A.Gerber.



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



Credit HE-Arc CR, A.Gerber.

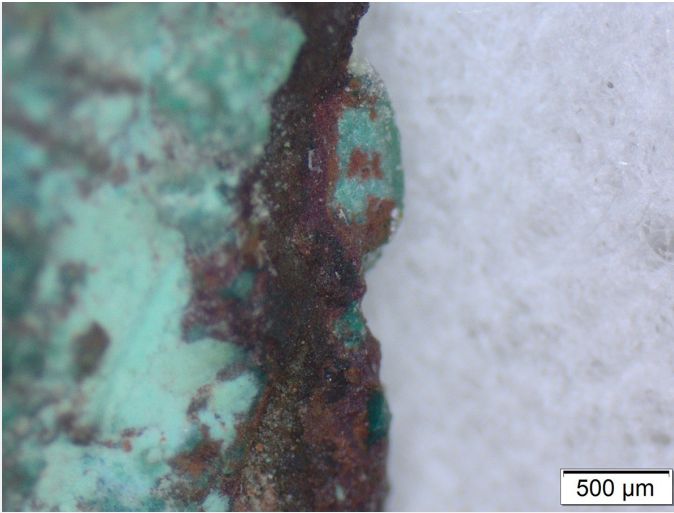
Fig. 6: Detail of Fig. 4 with blue corrosion products in cluster, sample 2 (CP4)



Credit HE-Arc CR, A.Gerber.

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

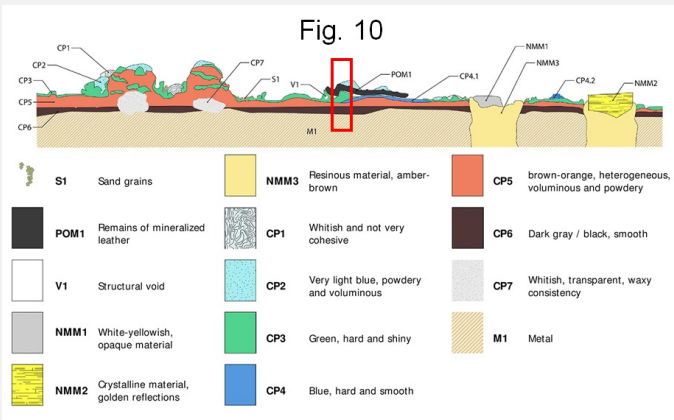
Fig. 8: Broken edge of the blade (see Fig. 4), showing the different corrosion layers in cross-section,



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

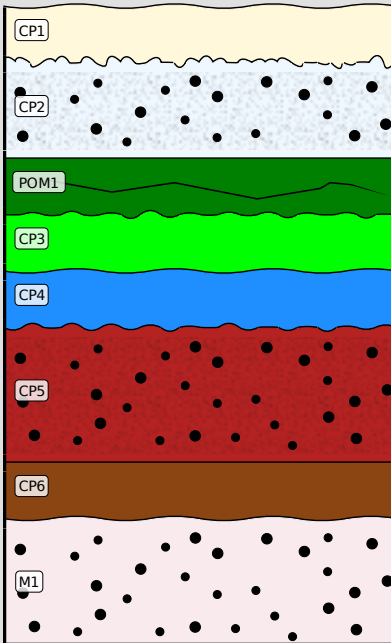


Credit HE-Arc CR, A.Gerber.

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

MiCorr stratigraphy(ies) – Bi

Fig. 10: Stratigraphic representation of the corrosion structure of the sacrificial knife observed macroscopically under binocular microscope 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)

<b>Description of sample</b>	Invasive sampling was not authorized by the museum. Only a few corrosion products on the surface of the sacrificial knife were sampled.
<b>Alloy</b>	Cu Alloy
<b>Technology</b>	Cast and cold worked
<b>Lab number of sample</b>	None
<b>Sample location</b>	HE-Arc CR, Neuchâtel, Neuchâtel
<b>Responsible institution</b>	HE-Arc CR, Neuchâtel, Neuchâtel
<b>Date and aim of sampling</b>	10.04.2019, chemical and structural analyses

### Complementary information

None.

### Analyses and results

#### **Analyses performed:**

X-ray radiography and tomography\*, XRF\*\* and SEM-EDS\*\*\*.

\* Conditions were not documented.

\*\* Directly on the metal with a handheld X-ray fluorescence spectrometer NITON XL3t 950 Air GOLDD+ analyser from Thermo Fischer®. Mining mode Cu/Zn, acquisition time 120s (filters: M30/Lo30/H30/Li30)

\*\*\* On a few samples with a Jeol JSM-6400 device, HEI Arc, La Chaux-de-Fonds, Switzerland

## Non invasive analysis

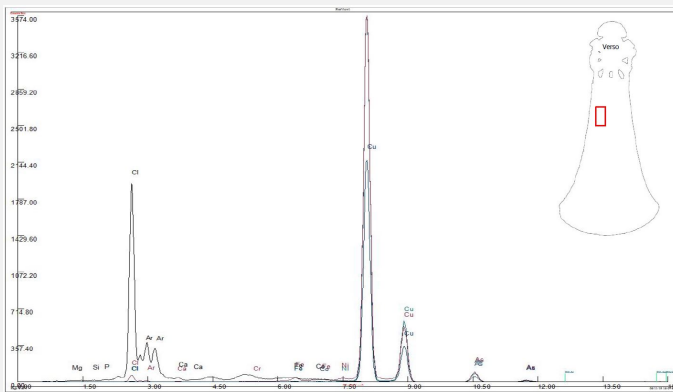
The metal is an arsenical copper alloy with 2-3% (in mass) As (Table 1 and Fig. 11). As can be seen from the stratigraphy in Fig. 9, other materials make up the figure of the decorated handle: a whitish-yellowish opaque material as well as a crystalline material with golden reflections in a resinous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

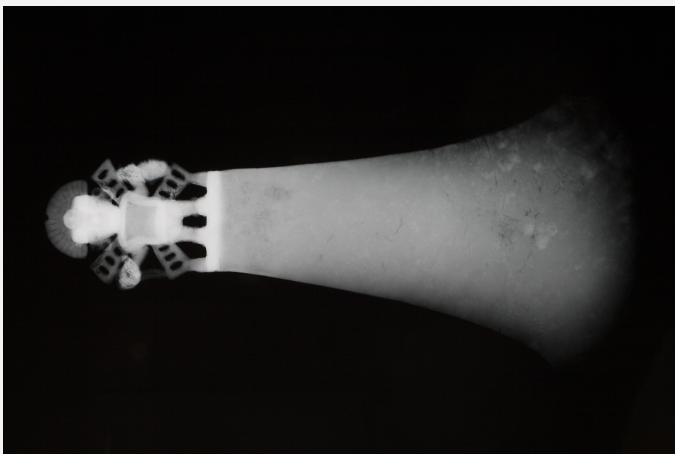
## Metal

The metal constituting the sacrificial knife seems to be an arsenic-copper alloy (Fig. 11). The same result was obtained by Billot (Billot, 2018). The X-radiography of Fig. 12 shows that the metal is porous.



Credit HE-Arc CR, A.Gerber.

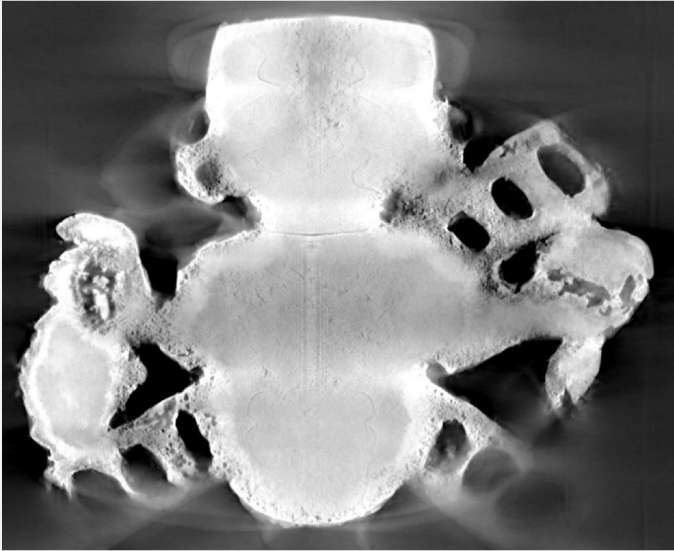
Fig. 11: XRF Analysis carried out on a partly cleaned area of the front face of the sacrificial knife (see Fig. 4),



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.

<b>Microstructure</b>	Unknown
<b>First metal element</b>	Cu
<b>Other metal elements</b>	As

#### Complementary information

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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.

<b>Corrosion form</b>	Multiform
<b>Corrosion type</b>	Unknown

#### Complementary information

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The surface of the object is corroded in a very heterogeneous way. Some zones correspond to Type I corrosion model 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 loss of the limits. 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.

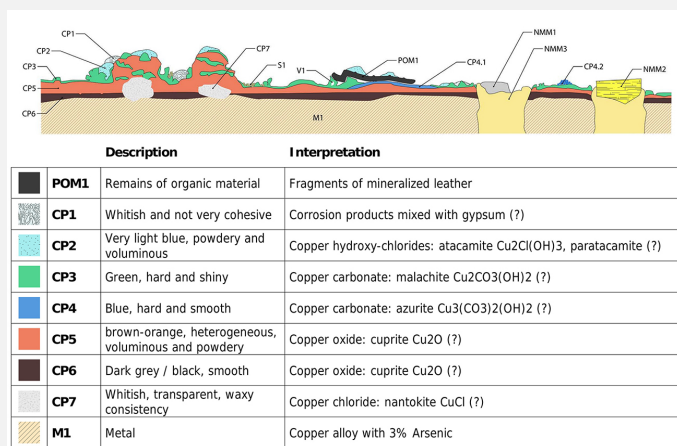


Fig. 14: Improved representation of the stratigraphy of corrosion layers of the sacrificial knife from visual observations and analyses,

Credit HE-Arc CR, A.Gerber.

✧ 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 chlorine 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, Arbeitsblätter, 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 Neuhâtel, Conservation-Restauration, non-publié.
4. Robbiola, L. (1990) Caractérisation 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.

Angeles.

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