BRACELET WITH DRAGONFLIES IIB 4025.01 – LEADED BRONZE – LATE BRONZE AGE

Artefact name Bracelet with dragonflies IIb 4025.01

Authors Perret-Gentil. Emeline (HE-Arc, Neuchâtel, Neuchâtel, Switzerland) & Christian. Degrigny (HE-Arc CR, Neuchâtel, Neuchâtel, Switzerland)

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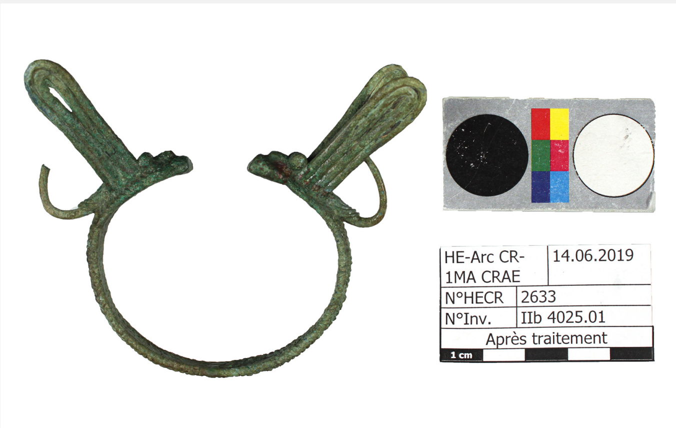
The object

Credit HE-Arc CR, E.Perret-Gentil.

Fig. 1 : Bracelet with zoomorphic decorations before conservation interventions,



Credit HE-Arc CR, E.Perret-Gentil.

Fig. 2 : Bracelet with zoomorphic decorations after conservation interventions,

Description and visual observation

Description of the artefact

Decorated bracelet with zoomorphic extensions looking like dragonflies (Fig. 1 and 2), covered with dark green corrosion layers and sediments. Dimensions: Ø= 60mm, Lmax = 24mm, WT =

40.82 g (Figs.1 et 2).

Type of artefact	Jewellery
Origin	Thailand, Udon Thani, Siam, Nong Han, Ban Chiang archaeological site
Recovering date	Date unknown
Chronology category	Late Bronze Age
chronology tpq	300 B.C.
chronology taq	200 A.D.
Chronology comment	
Burial conditions / environment	Soil
Artefact location	Museum der Kulturen, Basel
Owner	Museum der Kulturen, Basel
Inv. number	IIb 4025.01
Recorded conservation data	N/A

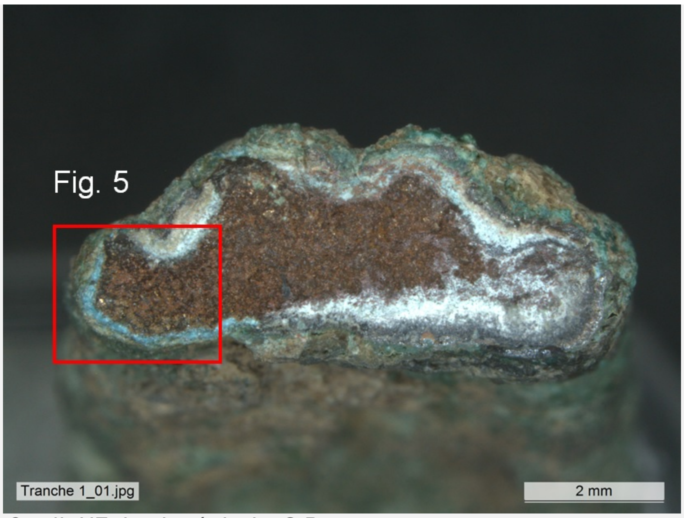
Complementary information

No information on the archaeological or historical context before 2008 (year of donation to the museum). The artefact was brought to HE-Arc CR in 3 fragments. Preliminary information on corrosion structures could be observed on cross-sections exposed.

Study area(s)

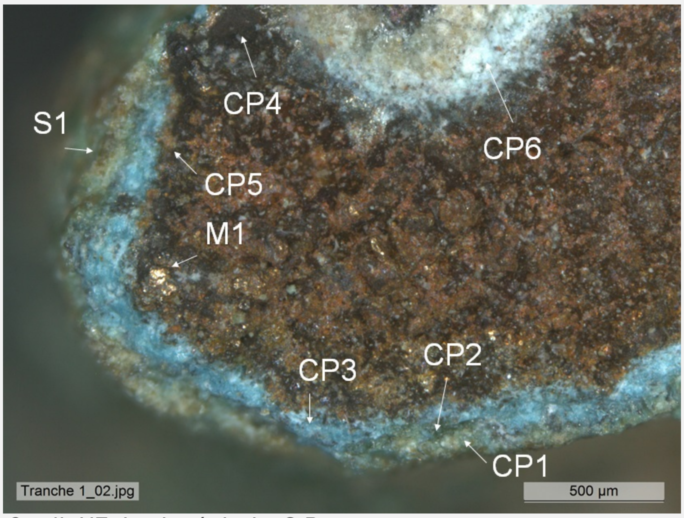
Credit HE-Arc CR, E.Perret-Gentil.

Fig. 3 : Broken fragment of Fig. 1 without zoomorphic extensions and location of the cross-sections observed on Figs. 4 and 6,



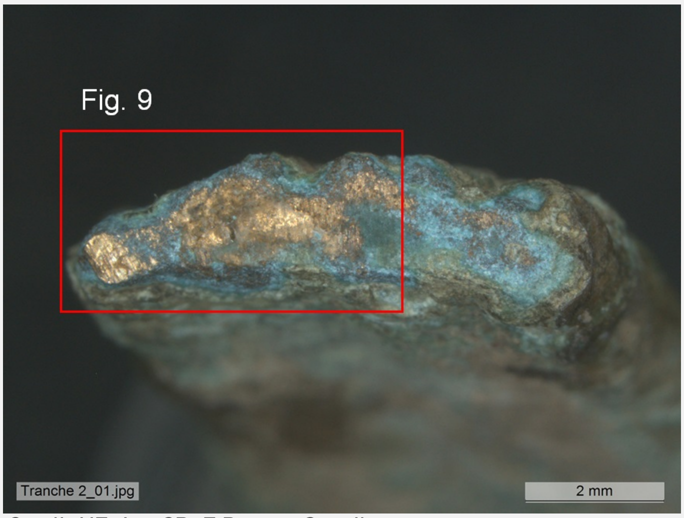
Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 4 : Visual observation on cross-section of section 2 of the broken fragment (Fig. 3),



Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 5 : Detail of Fig. 4 with indication of the different strata represented on Fig. 7,

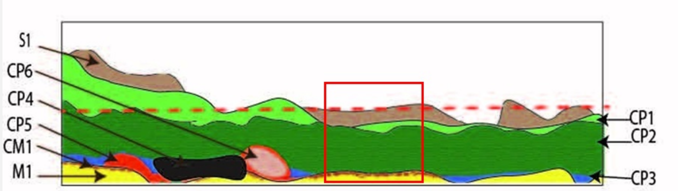


Credit HE-Arc CR, E.Perret-Gentil.

Fig. 6: Visual observation on cross-section of section 1 of the broken fragment (Fig. 3) with location of Fig. 9,

Binocular observation and representation of the corrosion structure

The schematic representation below gives an overview of the strata encountered on the bracelet from a first visual macroscopic observation under a binocular microscope both on the surface and section 2 exposed (Fig. 5).



S1	Sand grains ; beige	CP5	Dense, cohésive ; brown-orange
CP1	Powdery and not very cohesive ; green	CP6	Powdery, not very cohesive ; white
CP2	Bright, slick, not very cohesive ; green	CM1	Intergranular corrosion ; brown
CP3	Powdery, cohesive ; blue	M1	Metal ; yellow
CP4	Powdery,slick,not very cohesive ; black		

Credit HE-Arc CR, E.Perret-Gentil.

Fig. 7 : Stratigraphic representation of the fractured cutting edge of the bracelet in cross-section by macroscopic observation with indication of strata of Fig. 5 and the MiCorr stratigraphy in the red rectangle (Fig. 21) built from the polished surface of section 1.

MiCorr stratigraphy(ies) – Bi

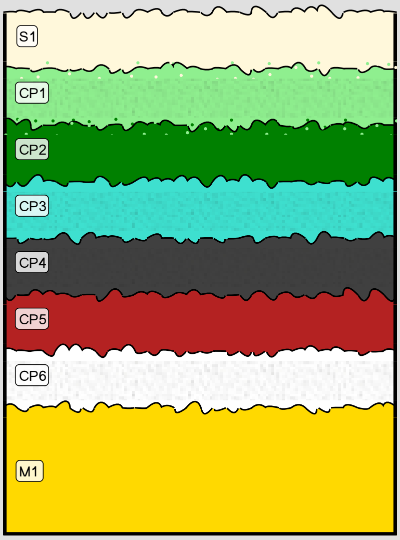
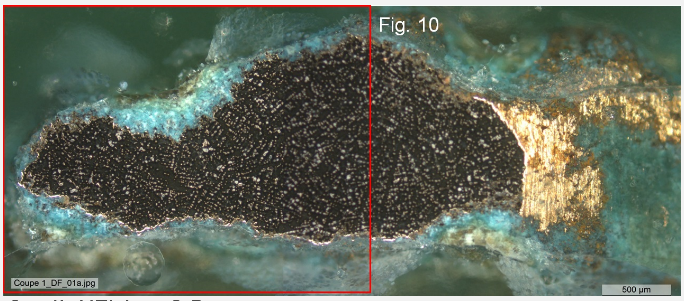


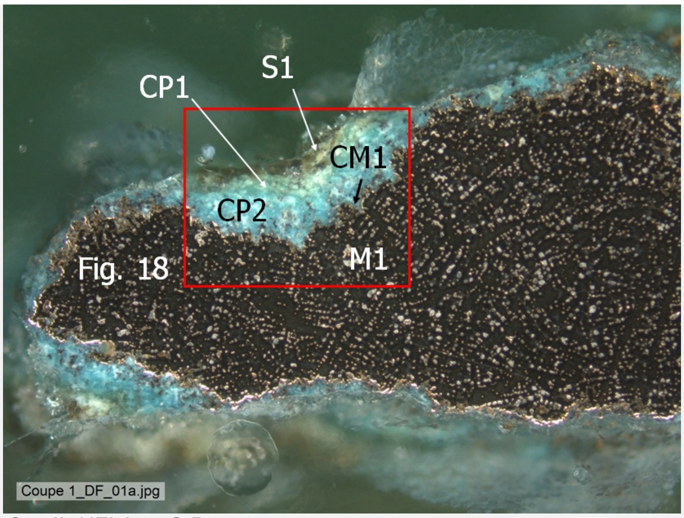
Fig. 8 : Stratigraphic representation of the corrosion structure of the bracelet observed macroscopically under binocular microscope from Fig. 5 (cross-section of section 2) using the MiCorr application. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation, Credit HE-Arc CR, E.Perret-Gentil.

Sample(s)



Credit HEI Arc, S.Ramseyer.

Fig. 9 : Polished cross-section of section 1 (detail of Fig. 6) with location of Fig. 10, unetched, dark field,



Credit HEI Arc, S.Ramseyer.

Fig, 10: Detail of Fig. 9 with indication of the strata represented in Fig. 21,

Description of sample	After section 1 of the fragment of Fig. 3 has been consolidated with Technovit 5071 (bicomponent resin (powder+liquid) from Dibenzoylperoxid and Methymethacrylate NN, N-dimethyl-p-tolviol), it was embedded, polished and observed on cross-section (Figs. 9 and 10) to build the MiCorr stratigraphic representation (Fig. 21). Once examined the fragment was extracted, the consolidant was dissolved in acetone and the fragment could be reintegrated on the artefact.
Alloy	Leaded Bronze
Technology	Cast and cold worked
Lab number of sample	1
Sample location	Museum der Kulturen, Basel
Responsible institution	Museum der Kulturen, Basel
Date and aim of sampling	14.05.2019, chemical and structural analyses

Complementary information

Nothing to report.

Analyses and results

Analyses performed:
Metallography (etched with ferric chloride reagent), SEM-EDS (Jeol JSM-6400 device), XRD.

Non invasive analysis

None.

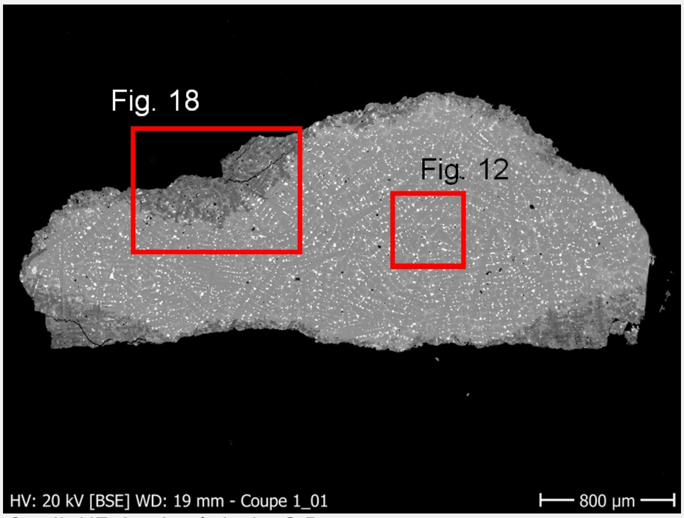
Metal

The remaining metal is a porous leaded bronze (Fig. 11) with a high concentration of Sn and Pb (Table 1 and Fig. 12). The 9% Pb concentration is due to the area analysed where Pb nodules false the result which should be more around 5%.

Elements	Cu	Sn	Pb
mass%	76	15-16	9

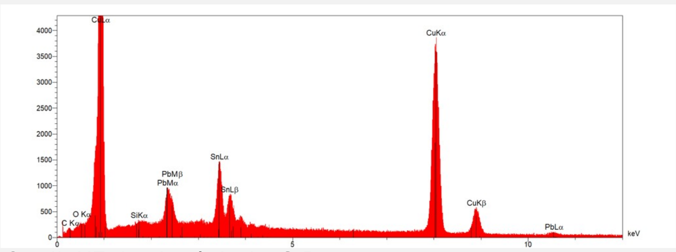
Table 1: Chemical composition (mass %) of the metal (from Fig. 12). Method of analysis: SEM/EDS. HE-Arc Ingénierie.

In bright field, the etched alloy shows a dendritic structure (Fig. 13). Therefore, the metal is as-cast. Fig. 14 shows that the yellow inner dendrite phase is richer in Cu (A; Fig. 15) while the orange-brown interdendritic phase is richer in Sn (B; Fig. 16) with lead nodules (C; Fig. 17).



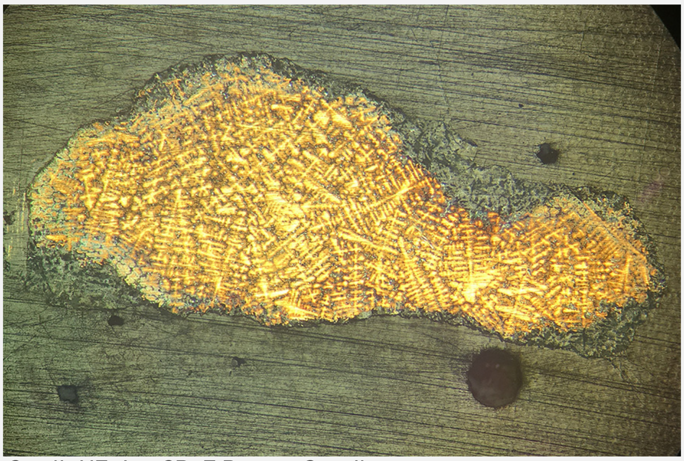
Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 11: SEM image of the cross-section similar to Fig. 9, BSE-mode. The area selected for elemental chemical analysis (Fig. 12) is marked by a rectangle. Fig. 18 is similarly indicated,



Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 12 : EDS spectrum of the alloy of the bracelet,



Credit HE-Arc CR, E.Perret-Gentil.

Fig. 13 : Micrograph showing the dendritic microstructure (reversed picture of Fig. 12), etched, bright field,

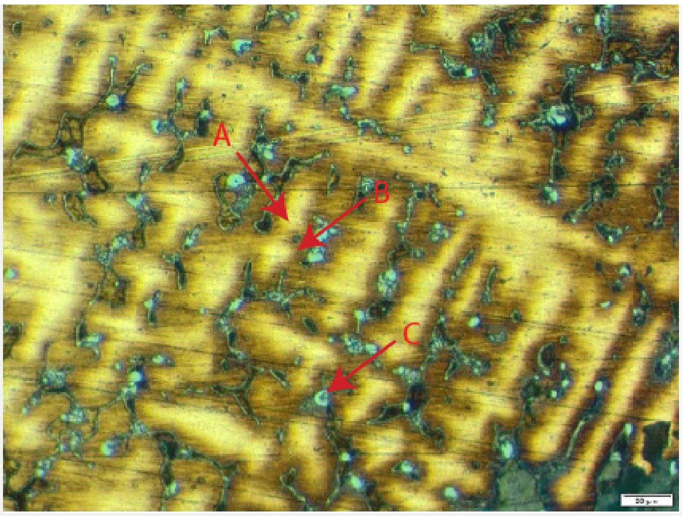


Fig. 14: Micrograph of a selected area of Fig. 13, etched, bright field, showing the dendritic (A), interdendritic (B) phases and lead nodules (C),

Credit HE-Arc CR, E.Perret-Gentil.

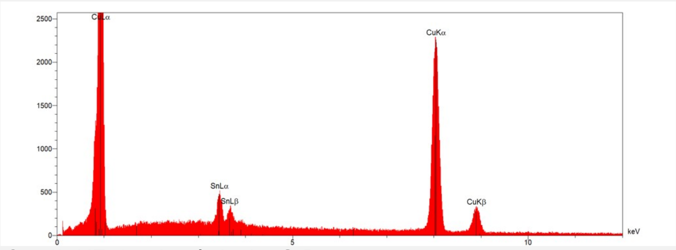


Fig. 15 : EDS spectrum of the dendritic phase,

Credit HE-Arc Ingénierie, S.Ramseyer.

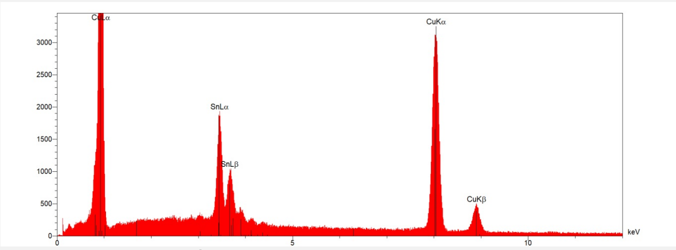


Fig. 16 : EDS spectrum of the interdendritic phase,

Credit HE-Arc Ingénierie, S.Ramseyer.

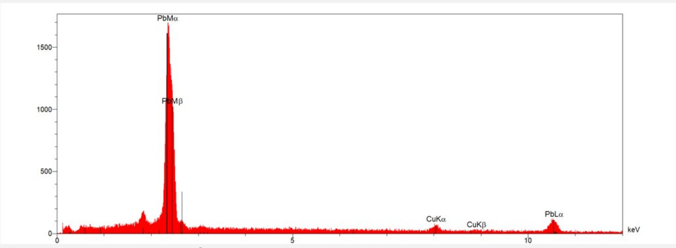


Fig. 17: EDS spectrum of Pb nodules,

Credit HE-Arc Ingénierie, S.Ramseyer.

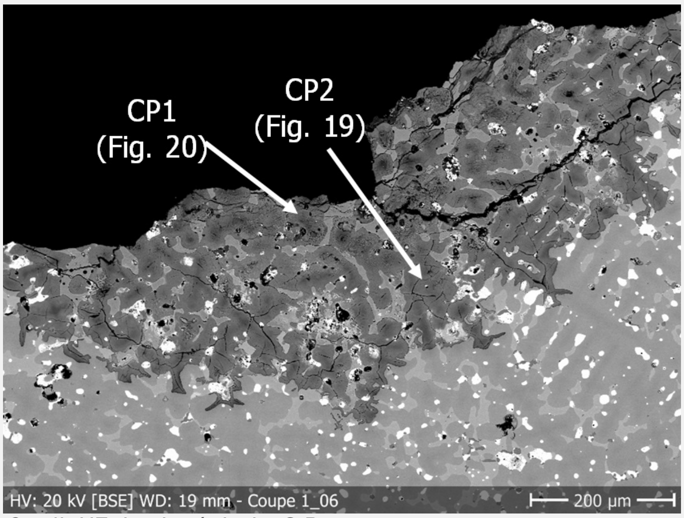
Microstructure	Dendritic structure with inclusions
First metal element	Cu
Other metal elements	Sn, Pb

Complementary information

Traces of As have been found locally in some phases of the metal.

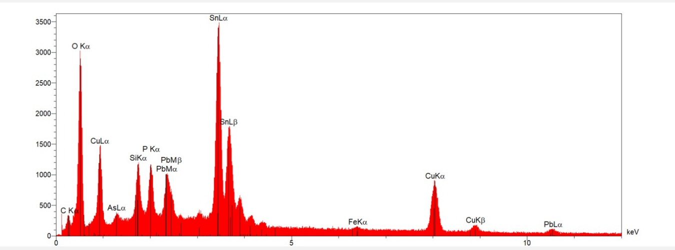
Corrosion layers

Interdendritic corrosion is visible at the interface metal/corrosion product (Fig. 18) and peudomorph of dendritic structure is visible in CP2 (Figs. 10 and 18). EDS analysis of CP2 and CP1 indicates the presence of higher concentration of Sn in CP2 than CP1 and the presence of P in both layers, validating the funeral context where the object was found. The results of the XRD analysis were irrelevant due to the instability of fragment of Fig. 3 on the support of the device.



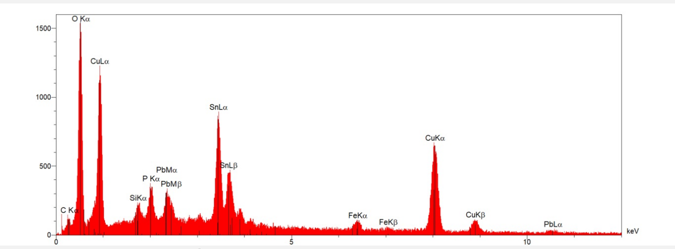
Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 18: SEM picture showing interdendritic corrosion with locations of Figs. 19 and 20,



Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 19: EDS spectrum of the area (CP2) located in Fig. 18,



Credit HE-Arc Ingénierie, S.Ramseyer.

Fig. 20: EDS spectrum of the area (CP1) located in Fig. 18,

Corrosion form Other

Corrosion type Mostly type I with locally type II (Robbiola)

Complementary information

None.

MiCorr stratigraphy(ies) – CS

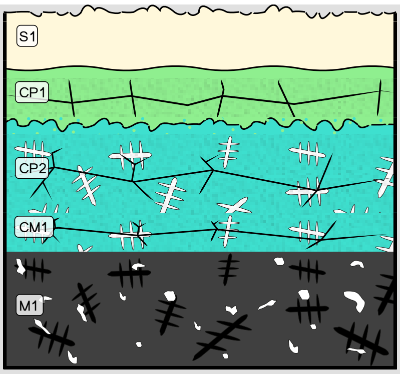


Fig. 21 : Stratigraphic representation of the bracelet in cross-section (dark field) using the MiCorr application with reference to Fig. 10. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation, Credit HE-Arc CR, E.Perret-Gentil.

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

The schematic representation of corrosion layers of Fig. 7 integrating additional information based on the analyses carried out is given in Fig. 22. Strata CP1 and CP2 in the stratigraphy of Fig. 8 are merged into CP1 in Fig. 21. Similarly, strata CP3 to CP6 in Fig. 8 are merged into CP2 and CM1 in Fig. 21.

	Description	Interpretation
S1	Sand grains ; beige	Sand and soil of the archaeological context
CP1	Powdery and not very cohesive ; green	Copper carbonate : malachite $Cu_2CO_3(OH)_2$ (?)
CP2	Bright, slick, not very cohesive ; green	Copper carbonate : malachite $Cu_2CO_3(OH)_2$ (?)
CP3	Powdery, cohesive ; blue	Copper carbonate : azurite $Cu_3(CO_3)_2(OH)_2$ (?)
CP4	Powdery, slick, not very cohesive ; black	(?)
CP5	Dense, cohesive ; brown-orange	Copper oxide, Cuprite Cu_2O (?)
CP6	Powdery, not very cohesive ; white	Copper chloride, nantokite CuCl (?)
CM1	Intergranular corrosion ; brown	Copper oxide, Cuprite Cu_2O (?)
M1	Metal	Leaded bronze with a high concentration of Sn et Pb

Credit HE-Arc CR, E.Perret-Gentil.

Fig 22 : Improved representation of the stratigraphy of corrosion layers of the bracelet from visual observations and analyses,

Conclusion

The metal of the bracelet is a leaded bronze with a high concentration of Sn et Pb. The object was cast and certainly cold-worked to smooth the surface. The metal is heterogeneously corroded with Robbiola types I and II. The limit of the original surface is at the CP1 and CP2 interface. Both layers contain high amounts of Sn and P, validating in the latter case, the funeral context where the object was found.

References

References on object and samples

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3. Warangkhana, 1983 : Warangkhana, Rajpitak. The development of copper alloy metallurgy in Thaïland in the pre-buddhist period, with special reference to high-tin bronze

4. White, 2008 : White, J.C. “Dating Early Bronze at Ban Chiang, Thailand”. In From Home erectus to the living traditions: Ühoice of Papers from the 11th International Conference of the European Association of Southeast Asian Archaeologists, Ûougon, 25th-29th September 2006, édité par Pautreau, J.-P, ... [et al.], pp. 91-104.