

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

Artefact name Bracelet with dragonflies Iib 4025.01

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∨ The object



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

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

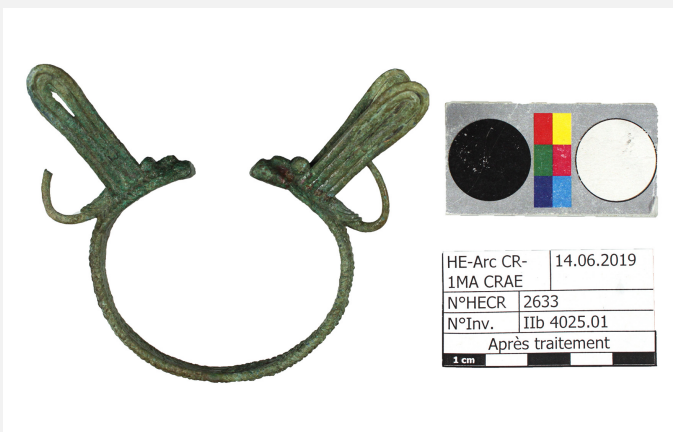


Fig. 2 : Bracelet with zoomorphic decorations after conservation interventions.

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

∨ 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: \varnothing = 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

Ilb 4025.01

Recorded conservation data

Not conserved

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.

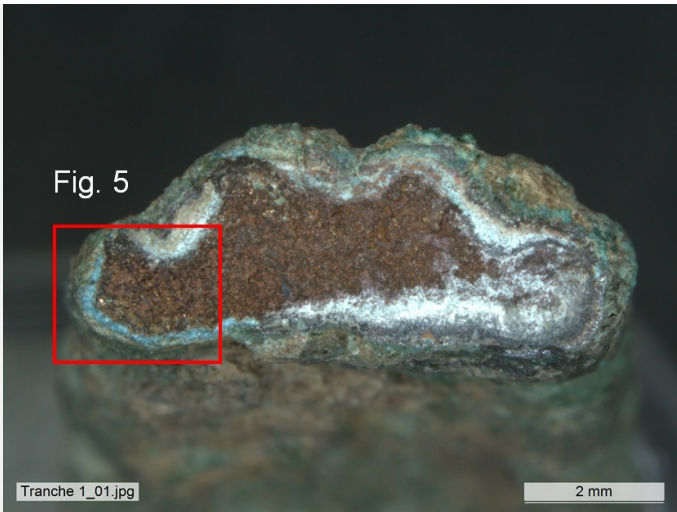
Study area(s)



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

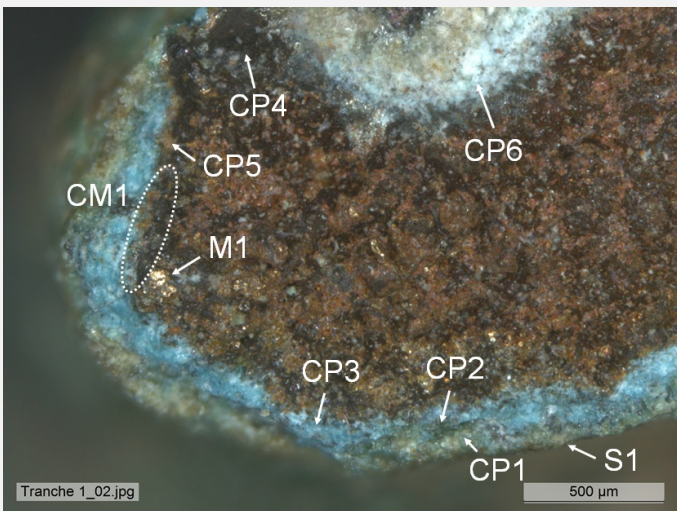
Fig. 3 : Broken fragment of Fig. 1 without zoomorphic extensions and location of the cross-sections observed on Figs. 4 and 6.

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



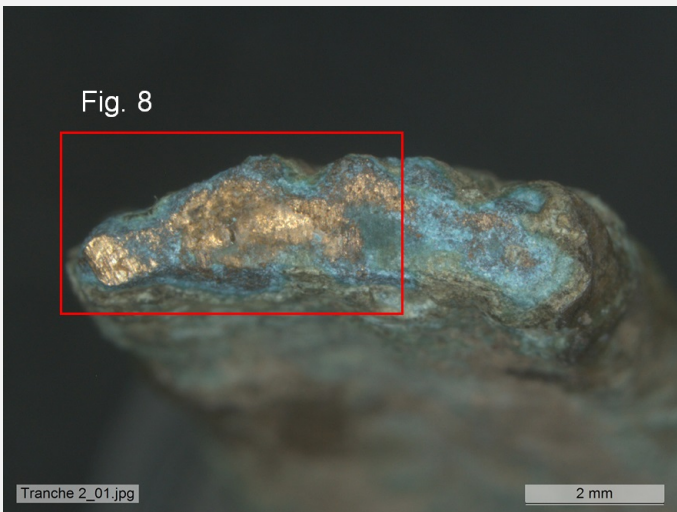
Credit HE-Arc Ingénierie, S.Ramseyer.

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



Credit HE-Arc Ingénierie, S.Ramseyer.

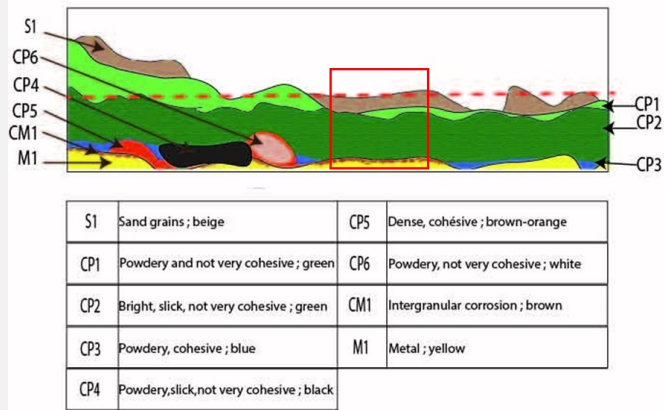
Fig. 6: Visual observation on cross-section of section 1 of the broken fragment (Fig. 3) with location of Fig. 8.



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

✧ 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).

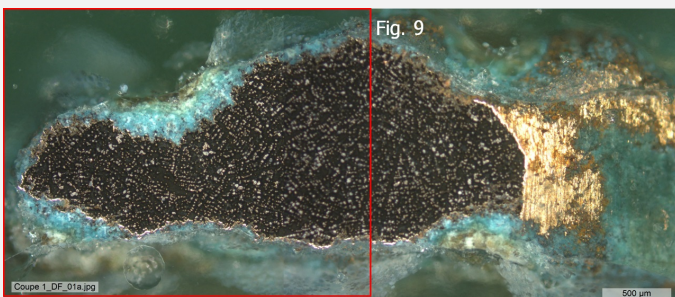


Credit HE-Arc CR, E.Perret-Gentil.

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. 10) built from the polished surface of section 1.

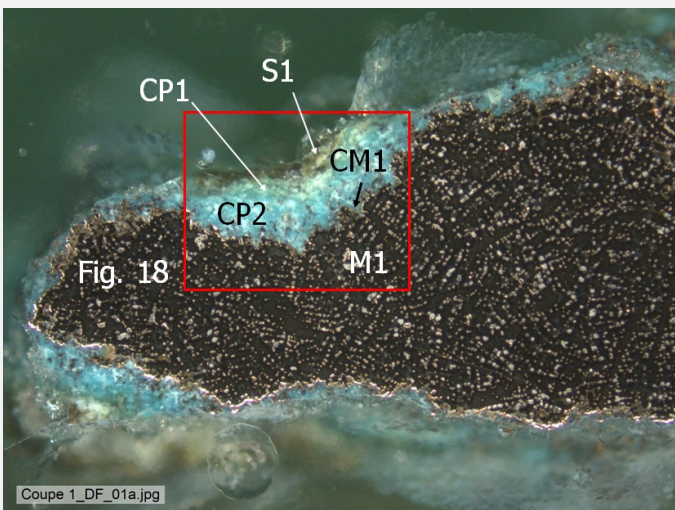
∨ MiCorr stratigraphy(ies) – Bi

∨ Sample(s)



Credit HEI Arc, S. Ramseyer.

Fig. 8 : Polished cross-section of section 1 (detail of Fig. 6) with location of Fig. 9, unetched, dark field.



Credit HEI Arc, S. Ramseyer.

Fig. 9: Detail of Fig. 8 with indication of the strata represented in Fig. 10.

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. 8 and 9) to build the MiCorr stratigraphic representation (Fig. 10). 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

∨ 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. 11). 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).

Fig. 11: SEM image of the cross-section similar to Fig. 8, BSE-mode. The area selected for elemental chemical analysis (Fig. 12) is marked by a rectangle. Fig. 18 is similarly indicated.

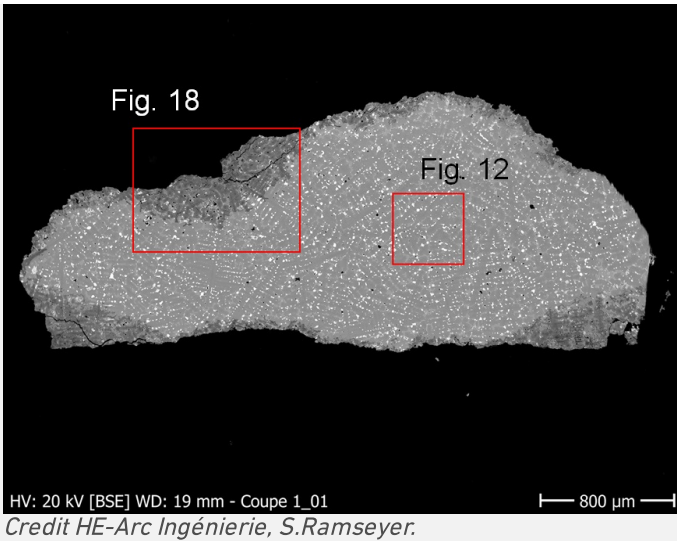


Fig. 12 : EDS spectrum of the alloy of the bracelet.

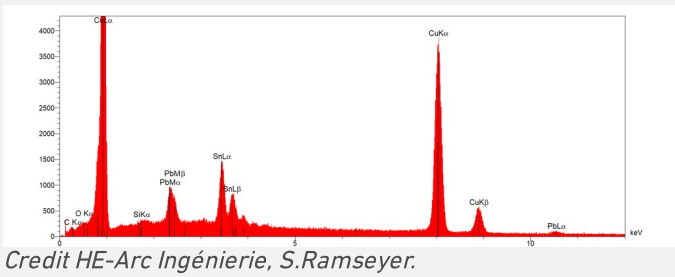


Fig. 13 : Micrograph showing the dendritic microstructure (reversed picture of Fig. 11), etched, bright field.

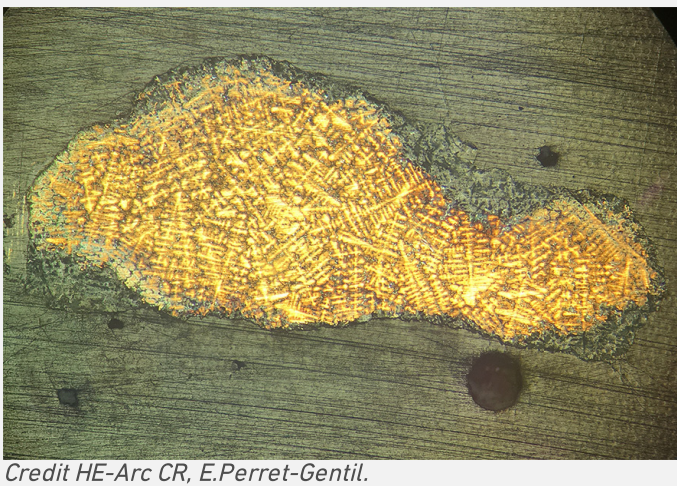


Fig. 14: Micrograph of a selected area of Fig. 13, etched, bright field, showing the dendritic (A), interdendritic (B) phases and lead nodules (C).

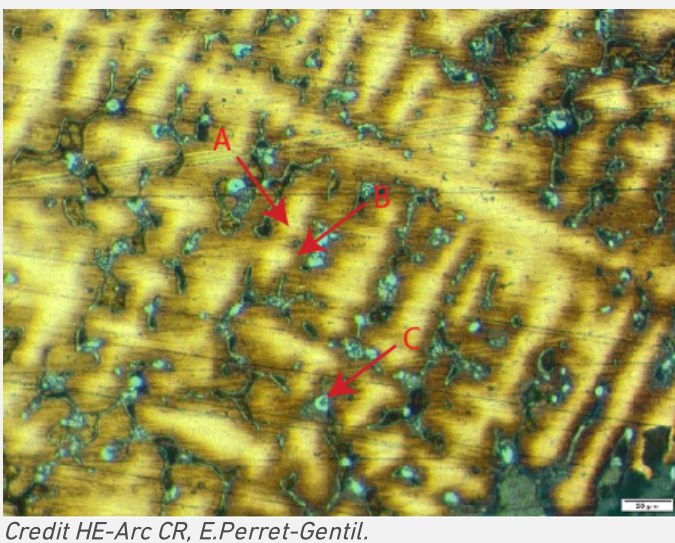
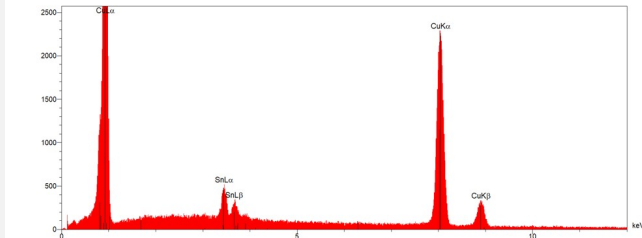
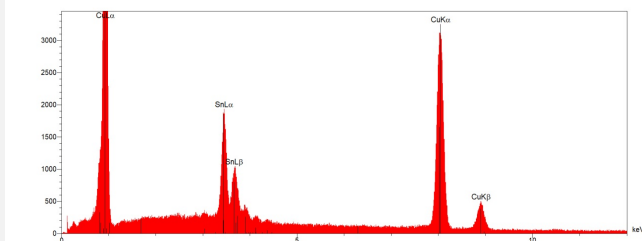


Fig. 15 : EDS spectrum of the dendritic phase.



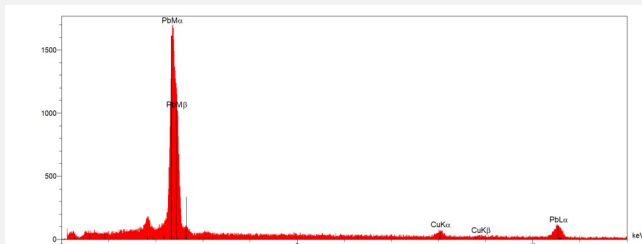
Credit HE-Arc Ingénierie, S.Ramseyer.

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

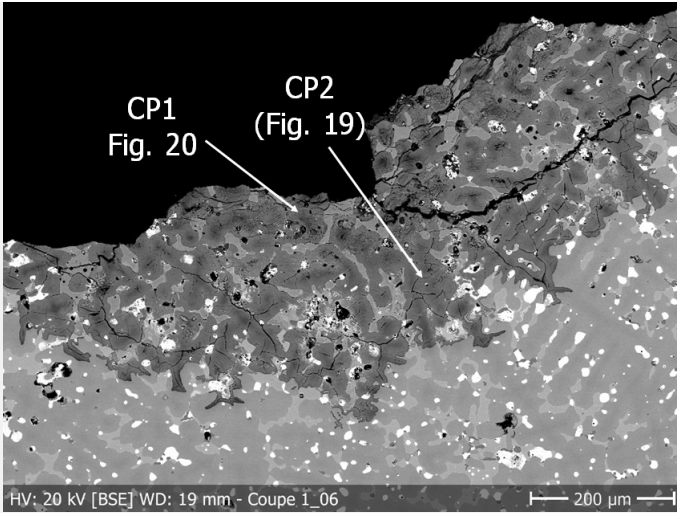
Complementary information

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

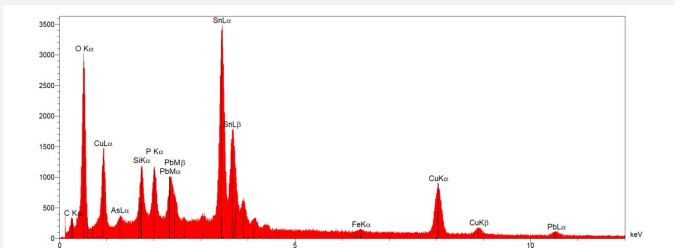
Corrosion layers

Interdendritic corrosion is visible at the interface metal/corrosion product (Fig. 18) and pseudomorph 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.

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

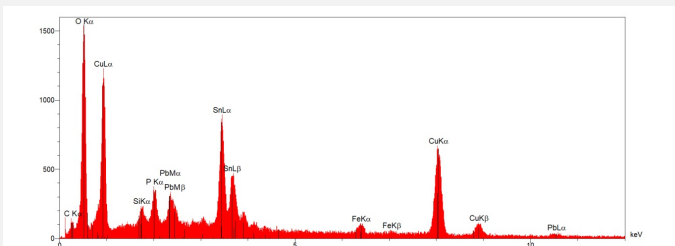


Credit HE-Arc Ingénierie, S.Ramseyer.



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)

∨ MiCorr stratigraphy(ies) – CS

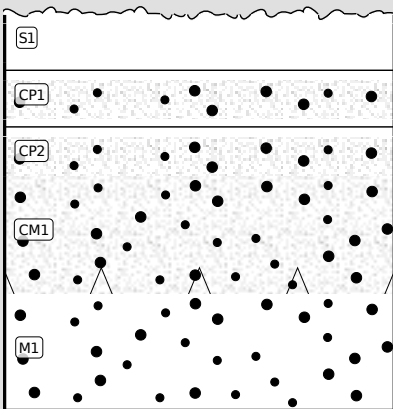


Fig. 10 : Stratigraphic representation of the bracelet in cross-section using The MiCorr application. The characteristics of the strata are only accessible by clicking on the drawing that redirects you to the search tool by stratigraphy representation, Credit HE-Arc CR, E.Perret-Gentil.

✧ 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. 21.



Fig 21 : Improved representation of the stratigraphy of corrosion layers of the bracelet from visual observations and analyses.

	Description	Interpretation
S1	Sand grains ; beige	Sand and soil of the archaeological context
CP1	Powdery and not very cohesive ; green	Copper carbonate : malachite $\text{Cu}_2\text{CO}_3(\text{OH})_2$ (?)
CP2	Bright, slick, not very cohesive ; green	Copper carbonate : malachite $\text{Cu}_2\text{CO}_3(\text{OH})_2$ (?)
CP3	Powdery, cohesive ; blue	Copper carbonate : azurite $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$ (?)
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.

✧ 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:

1. Scott, 1991 : Scott, David A. *Metallography and Microstructure of Ancient and Historic Metals*. Getty Publications, Los Angeles, 1991
2. Scott, 2002 : Scott, David A. *Copper and bronze in Art : corrosion, colourants, conservation*. Getty Publications, Los Angeles, 2002
3. Warangkhan, 1983 : Warangkhan, Rajpitak. *The development of copper alloy metallurgy in Thailand in the pre-buddhist period, with special reference to high-tin bronze*
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