Artifact Authentication and Characterization

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Introduction

The Bronze Age was home to remarkable developments in the field of metallurgy, as people in the middle east began to explore the possibility of the world's first intentional alloy: bronze. A mixture of copper and tin, bronze has a lower melting point than pure copper and more robust mechanical properties, making it easier to process and less prone to usage failures. Such an exploratory stage of human development is the apple of many historian eyes; it also appears to be a strong career path for forgers, as exhibited by the cast lion artifact evaluated here.

Objectives

Verify the following stipulations about the artifact shown in Figure 1

- Made of bronze
- Dates to 1200 BC
- Mesopotamian

Figure 1: Digital photograph of lion, showing primary corrosion layer. Loop present for hanging (ornament, jewelry).

Procedure

- Analyzed internal structure with micro computed tomography
- Cut lion with jeweler's saw and diamond saw
- Cold mounted samples in epoxy, polished to 1 micron for scanning electron microscopy
- Etched in ammonium hydroxide and peroxide for optical microscopy

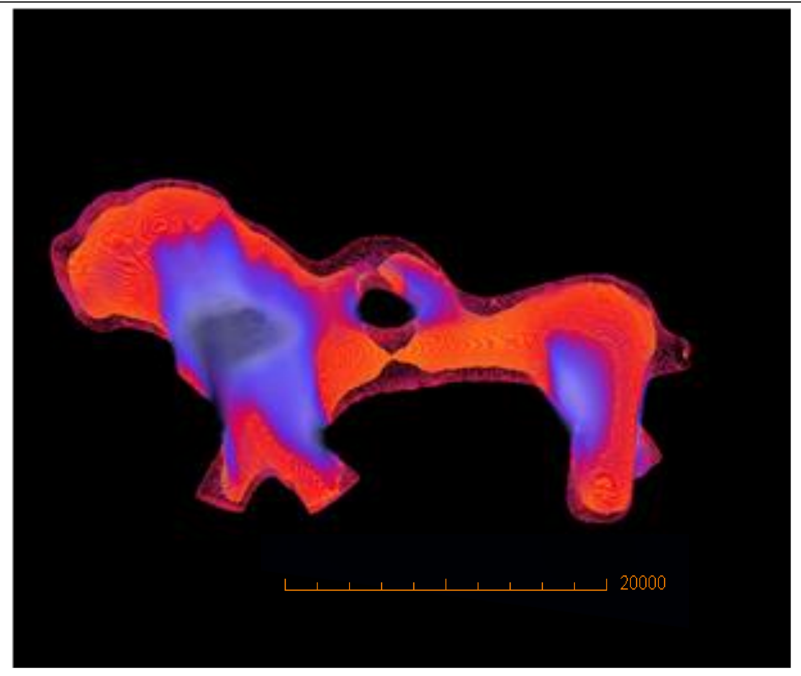


Figure 2: MicroCT scan of whole lion. Darker colors indicate areas of low density (neck, corrosion).

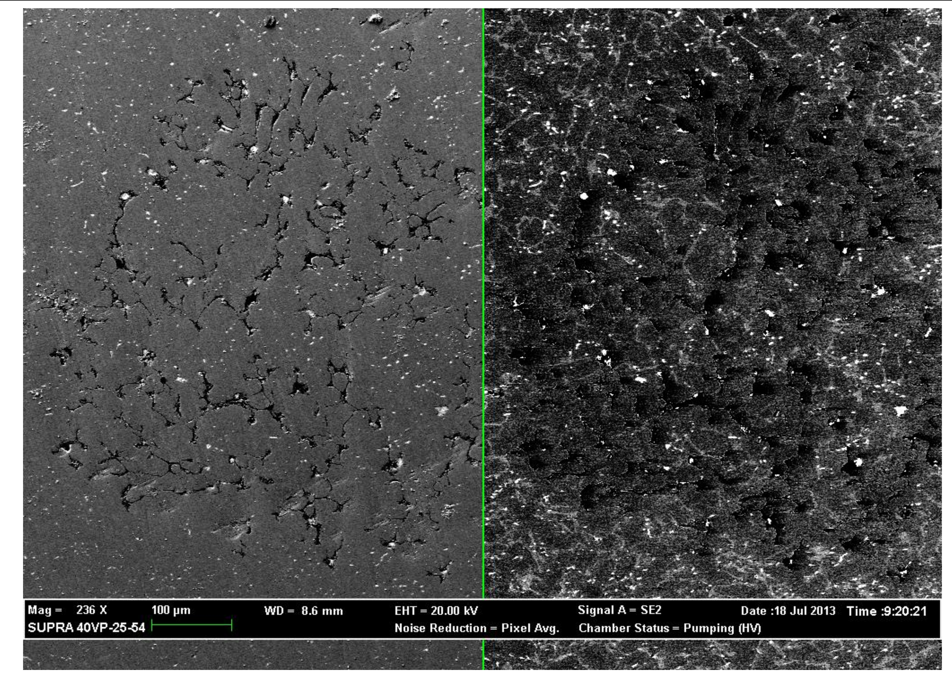


Figure 3: SEM image of porous area in neck region of artifact. SE2 on left, AsB on right.

Results

- Table 1 shows the brass composition of the artifact, as was then confirmed throughout the entire sample.
- Figure 2 displays a region of low density within the neck of the lion, which Figure 3 shows to be a series of pores.
- Figure 4 indicates that the lion was placed in an artificial chlorine environment to induce corrosion quickly.
- Figure 5 highlights lead inclusions evenly distributed throughout the copper-zinc matrix.
- Figures 6 and 7 show both alpha and beta phases of brass that would result from zinc compositions over 28%.

	Corrosion atomic %	Bulk Material atomic %
Cu	35.03	65.90
Zn	16.57	30.69
O	31.40	-
Cl	8.97	-
Pb	0.69	0.72
Fe	1.49	-
Sn	0.70	0.54
Al	1.54	1.92
Ti	0.87	-
Si	1.31	0.23
S	0.86	-
Ca	0.58	-

Table 1 compares the result of SEM compositional analysis on the bulk of the material (Figure 5) and the outer corrosion layers (Figure 4).

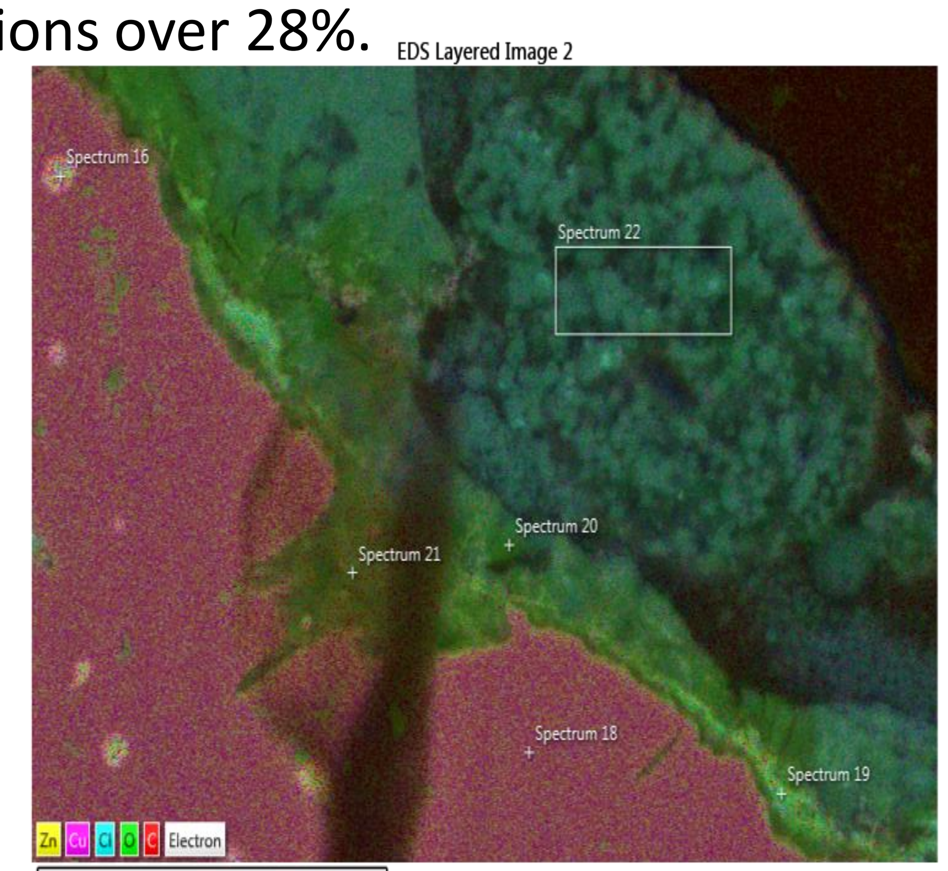


Figure 4: SEM shows corrosion layer on the outside of the lion. Inside of the sample is pink (Cu, Zn), corrosion layers are green/ teal (O, Cl).

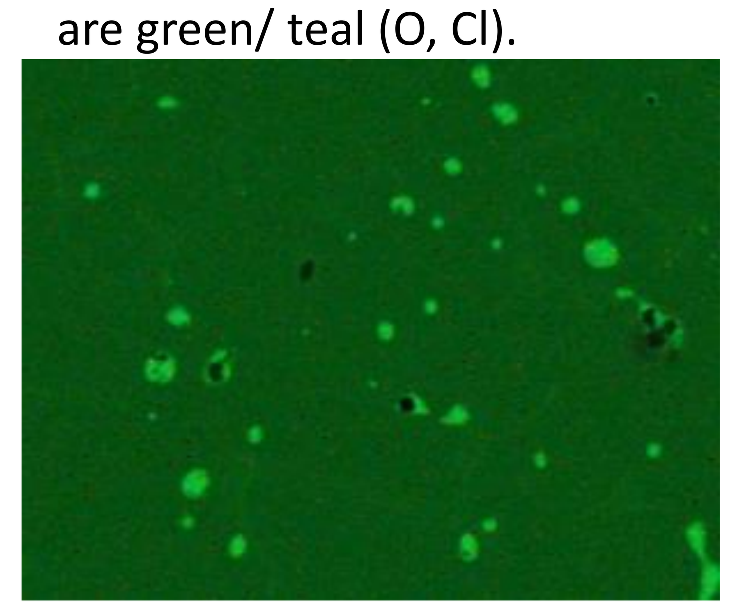
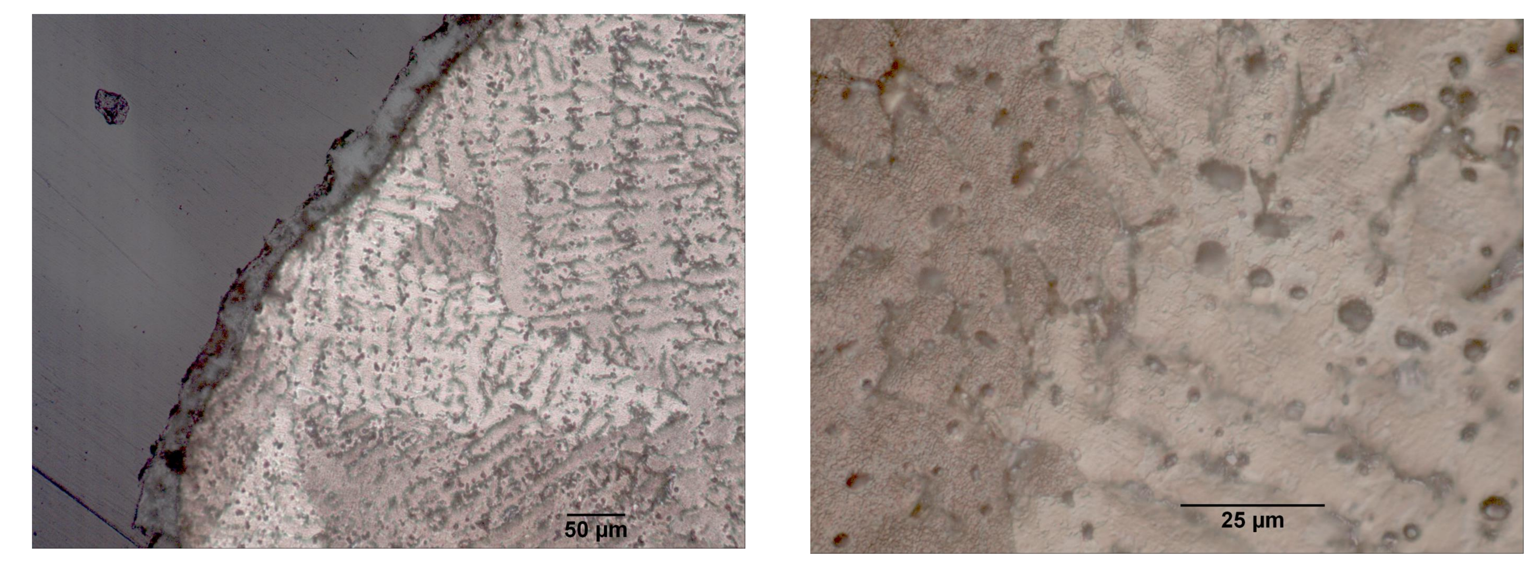


Figure 5: SEM shows the distribution of elements throughout the bulk material, revealing bright globules of lead surrounded by the dark green copper-zinc matrix.

Conclusion

During the Bronze Age people did not have the technology to make brasses above 28% zinc. Furthermore, most brasses were made accidentally and therefore contained 5-15% zinc. It is not until the mid-1500s AD that brasses over 30% zinc were used in China. As a result, there is almost no way the artifact can be from 1200 BC or Mesopotamia. It is likely a modern forgery.



Figures 6 (left) and 7 (right): Optical microscopy of alpha and beta phases, lead visible as dark circles in Figure 7.

Future Work

Future work can be conducted in two main areas relating to this study:

1. Expanding upon the newly emerging use of micro computed tomography in the field of archaeometallurgy
2. Efficiently applying scientific resources to the daunting task of artifact authentication

Acknowledgments

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References

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