A LATE MEDIEVAL METAL SEAL

Sariel Shalev

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INTRODUCTION

A personal metal seal, found outside of its original production and utilization context and with no records of its post-usage depositional history, appeared recently on the antique market. Was it genuine? How was the history of this unique artifact reliably to be reconstructed? To answer these questions, we carried out an interdisciplinary analysis using methods and information drawn from the fields of history, archaeology and metallurgy. The aim of this study was to clarify the following questions:
(1) What were the artifact’s date of production and period of use?
(2) How and from what material was the object made? Do the analytical results fit the proposed date of origin?
(3) What happened to the artifact during its long depositional time? Does the type of corrosion fit the proposed date, and what does it tell us about the environment in which this object was deposited?

The object's history was reconstructed by means of historical and paleographical analyses and comparison with parallel archaeological finds. We then validated the historical reconstruction and authenticated the artifact by means of metallurgical and metallographic optical and electron microscopy analyses.

HISTORICAL AND ARCHAEOLOGICAL ANALYSIS

(1) What were the artifact’s date of production and period of use?

Typological affinities

The object, weighing 15.15 g, is shaped as a round, flat token, 25.8 mm in diameter and 4.1 mm thick. It has an elevated protrusion on its back, making a maximum thickness of 12.8 mm. Carved on its face, between an inner and an outer circle, are eight Hebrew letters (two of which are combined in a ligature) and one symbol, and in the middle, a crescent (Fig 1). The letters form the personal name Moshe (Moses) Alsheikh: משה אלשיך.

Possible archaeological context

In shape and size, the object resembles several medieval personal metal seals from western Europe, though its relatively crude finish points to a more provincial locus of production. All known similar objects date from the medieval period, from the thirteenth-century seal bearing the name of the illustrious legal scholar and commentator Nahmanides (R. Moses b. Nahman, known in Hebrew as the Ramban),1 to several fourteenth and fifteenth-century seals bearing Jewish personal names.

A
famous Jewish preacher, commentator and religious leader called Moshe Alsheikh is known from sixteenth-century Palestine. From historical sources, we know that he was born at the beginning of the sixteenth century in Asia Minor, traveled to Salonica, Venice and Constantinople, and was active in the second half of the century in Safed, Palestine.

Is our metal artifact a genuine seal, likely ordered for and used by a person bearing the name of a known Jewish figure living in sixteenth-century Palestine? To assess this question, the seal’s archaeometallurgical affinities were thoroughly analyzed.

Archaeometallurgical analyses
The seal was analyzed in the archaeometallurgical lab of the Kimmel Center for Archaeological Science at the Weizmann Institute of Science, and in the Department of Materials at Oxford University. Surface analysis was conducted using an Olympus ZS40 zoom stereoscope. For the purpose of metallographic and elemental analysis, a minute chip, less then 0.3mm thick, was cut from the handgrip edge with a jewel-piercing saw. The sample was then hot mounted in a phenolic resin with carbon filler and ground and polished to the number 1µm using a monocrystalline diamond suspension. This was analyzed, unetched and etched, using an Olympus PME3 inverted metallurgical microscope, under incident and polarized light, with magnifications of up to 1250. A quantitative chemical analysis was performed by detecting the spectra and intensity of emitted X-ray photons during excitation of the sample surface with a high-energy electron beam. Finally, an elemental analysis was conducted, with the help of C. Salter in Oxford, on a Jeol JXA 8800R electron microprobe. The detection limit for the analyzed elements, using a wavelength dispersive spectrometer (WDS), is 0.02 weight percent (wt%).

ANALYTICAL RESULTS
(2) How and from what material was the object made? Do the analytical results fit the proposed date of origin?

Electron-probe quantitative chemical analysis
Five analyses were carried out on randomly selected areas measuring 25µm x 30µm each, so that the mean results represent an average composition of the as-cast, non-homogeneous material. The quantitative chemical analysis, whose results are displayed in Table 1 (Appendix), showed that the copper (Cu)-based material is alloyed with 6.3% zinc (Zn), 5.1% tin (Sn) and at least 4% lead (Pb). Other elements are present in quantities of less than 1%: 0.6% arsenic (As); 0.5% silver (Ag); 0.3% antimony (Sb) and iron (Fe); and close to 0.1% nickel (Ni) and sulfur (S). Traces of gold (Au) and bismuth (Bi) were found in quantities of less than several hundred ppm (parts per million), close to the 0.02 wt% detection limit of the WDS. The material is thus a good-quality leaded brass/bronze alloy with significant trace amounts of arsenic, accompanied by antimony, silver and sulfur and some traces of iron. All these impurities, in their quantity and spectrum of elements, represent remains either of the original sulfidic ore or of the remelting of scrap.

The metal composition of this alloy, as well as the trace element levels, fit very well with compositional analyses of some well dated archaeological casts from early Islamic and medieval times, as shown in Table 1. Comparative material from a Fatimid hoard from around the turn of the eleventh century CE, found in recent archaeological excavations at Caesarea in Israel, includes a heart-shaped weight (C97-2), lampstand-plate (C97-5) and base (C97-19), and a box-body (C97-21), all as-cast objects. The two other comparative samples are from a British Museum analysis of medieval Islamic brass. The closest parallels are the lid (1878-12-30, 681) and foot (1878-12-30, 680) of an incense burner from fourteenth-century Egypt/Syria.

As opposed to the striking similarity of our seal’s metal composition to that of other known
medieval Palestinian brasses, it differs distinctly from modern brass, even where the modern sample is one of scrap brass produced by a traditional sand-casting process in old Cairo (Table 1: Ca99-1). To imitate medieval brass and produce a convincing fake, alloy quantities could perhaps be altered and controlled, and the relatively high levels of iron in modern brass could be reduced by more intensive separation. Even then, however, we would still be left with the very convincing fingerprint of the invisible trace elements. If the material of our seal were relatively modern, it would contain, as in the modern brass example, higher levels of nickel and much lower levels of arsenic and antimony, and probably less silver as well. It may be concluded that the metal from which our seal was made is similar in composition to well documented medieval examples, and its composition could not have been achieved in a modern brass.

The only published metallurgical analysis of a similar object is the X-Ray fluorescence spectroscopy (XRF) analysis by Broshi and Nir-El of the thirteenth-century seal bearing the name of Nahmanides, now in the Israel Museum. There is a striking difference between the metal composition of our analyzed object and the XRF results of the Nahmanides seal. The XRF results show a composition of unalloyed copper with impurities of less than 0.7%. The discrepancy between this and the WDS results of our analysis could reflect the original use of different source material for the production of these objects between the thirteenth and the sixteenth centuries. However, the chemical composition of the unalloyed copper, with such low levels of the typical alloying elements (less than 0.01% zinc, 0.1% tin and 0.5% tin), is highly exceptional for medieval metals. Of 362 AAS and ICP-AES analyses of 196 different medieval Islamic brasses and bronzes, only one small rivet of a brass box was found to be made of copper, and even then it had close to 1% lead in it. This, coupled with the relatively low sensitivity of the XRF method, leads one to suspect that the results might represent analysis of the Nahmanides seal’s surface corrosion product, rather than its solid metal. Before any further conclusions about it are drawn, the chemical composition of its solid metal, as free as possible of corrosion and redeposited copper, ought to be reanalyzed.

Metallographic analysis of the polished sample
The microstructure of the polished sample, after etching with ferric chloride, very clearly shows an as-cast microstructure. In the micrographs (Figs. 2 and 3), two distinct phases are clearly visible: one of dendrite arms rich in copper (light brown in the micrographs), and an interdendritic phase (gray in the micrographs) richer in zinc and tin, as well as arsenic and antimony, with detectable inclusions of lead and silver. The black holes

**Fig. 2:** As-cast dendritic structure (x 250)

**Fig. 3:** As-cast dendritic structure (x 625)

**Fig. 4:** Back of the seal – surface (x 20)
are due to shrinkage cavities and gas porosity of the original cast and some corroded inclusions, mainly of lead. The metallography shows that this alloyed object was cast and left, at least below the surface, in an as-cast state, without any further thermo-mechanical treatment, except surface polishing and engraving.

**Optical cleaned surface analysis**

Scanning the cleaned parts of the artifact's surface revealed additional data concerning the surface treatment after casting. The cast blank was smoothed and cleaned, mainly by filing. Some filing marks, such as those on the lower edge of the handgrip at the back (Fig. 4), were left unpolished. Most of the surface was polished (Figs. 6 and 7), leaving only scarcely visible rough patches, like the mark seen to the right of the first shin (in the name Moshe, Fig. 6). After polishing, the ornamental patterns were engraved in several stages. First, the inner and outer circles and the half-circle of the lunar crescent were marked, with a divider, leaving a dent in the middle of the signet (Fig. 7, the larger dent). After that, the letters and the singe (*: marking from where and in which direction the name was to be read) were positioned, and their outlines were marked. Remains of the positioning marks are still visible above the letters mem and heh and below the second shin (Figs. 6 and 7).

The sequence in which the eight engraved symbols were plotted was decipherable by following the interval pattern between them. There is a constant interval of 7 mm between each character and the next, with one exception: In the name Alsheikh, the interval between the center of the combined initial letters, alef and lamed, and the second shin is 11 mm longer than the rest, but less than double the usual distance. This exceptional interval preserves the distance that remained between the first and the last signs cut by the signet maker. The separation of “Al” in “Alsheikh” from the three remaining letters does not correlate with the correct reading of the Hebrew name, disclosing that the signet maker was unfamiliar with the meaning of the letters he was commissioned to engrave. Moreover, he initiated the marking facing the rising moon and moving counterclockwise, as if plotting a name that was to be read from left to right, as in Greek or Latin. This sequence must have been the opposite of the plan brought to him by the seal’s commissioner, who surely intended the Hebrew name to start on the other side of the crescent moon.

The engraving itself was done with a square-point tool, as shown by the v-shaped grooves (Figs. 6 and 7). In this stage, too, the engraver worked in a counterclockwise direction, as can be seen from the remains of the original engraving marks in the inner circle, to the left of the final khaf and to the right of the heh. First the circles and the moon were engraved, and afterwards the name, as evidenced by the khaf, which cuts the circle, and by the two shins and the heh, which cover or alter parts of the circle edge (Figs. 6 and 7). The small dent inside the crescent and the two short carvings on the continuation of the tail of the khaf preserve errors of the signet-maker in measuring the center and identifying the letter’s end-point.

The combined results of the
chemical analysis, metallography and macro-surface observations show, beyond any reasonable
doubt, that this “placeless and timeless” object was cast from
medieval brass. It was then filed, polished, marked and carved by a
signet-maker who, unaware of the
meaning of the Hebrew letters and
the name he was commissioned to
engrave, positioned the signs ac-
cording to his familiar left-to-right
routine.

(3) What happened to the artifact dur-
ing its long depositional time? Does
the type of corrosion fit the proposed
date, and what does it tell us about the
environment in which this object was
deposited?

**Optical surface corrosion analysis**
The surface corrosion left intact on
the back side of the signet (Fig. 4) is
identical in composition and struc-
ture to some marginal corrosion
remains on the edge of its cleaned
face (see, e.g., Fig. 6, above the let-
ter heh). Similar corrosion remains
are visible at higher magnification
(Fig. 5) inside and around a surface
scratch near the tail of the letter
khaf. This shows that the entire ob-
ject, before being partially cleaned,
was uniformly patinated with cor-
rosion covering its face as well as
the engraved marks and carvings.

**Metallographic analysis of the corrosion remains in the polished sample**
Microanalysis of the unetched polished sample was conducted to
determining the nature of the sur-
face corrosion product. Magnify-
ing both edges of the cut sample
(Figs. 8 and 9) to a degree of
1250 shows a clear intergranular
corrosion, visible here as black,
straight, thin intersectioned lines. To this we could add the partially
corroded lead inclusions and some
interdendritic corrosion (Figs. 4
and 5).

The metallographic evidence
clearly shows a state of a naturally
processed long-term corrosion,
not a short, artificially enhanced
event (such as might be pro-
duced by counterfeiters trying to
make a purported antique look
old). The surface macro-evidence
shows that this corrosion, be-
fore being removed, covered the
whole signet, including the carv-
ings, and started to penetrate the
metal microstructure below the
surface. The artifact, after being
cast, polished, engraved and prob-
ably used, was affected by natural
corrosion, probably as a result of
being deposited in a dusty, humid
environment.

**CONCLUSIONS**
This small example demonstrates
how archaeometallurgy contrib-
utes to the study of archaeology
and of history, by disclosing informa-
tion about the nature and age of
found objects and distinguishing
archaeological artifacts from fakes
produced for the antique market.
The artifact examined here proves
genuine. Metallographic analysis
shows its chemical composition to
be distinctly unlike that of modern
brass and similar to documented
samples of medieval brass. The
surface corrosion, too, appears to
be the natural product of a long-
term process. The seal was made
several centuries ago, by a signet
maker who evidently did not
understand Hebrew, for a person
bearing a Jewish name who was,
most likely, a highly important
figure of the time.
Appendix

Table 1: RESULTS OF WDS ANALYSES OF A METAL SAMPLE OF A JEWISH MEDIEVAL SEAL (IN WT)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cu</th>
<th>Zn</th>
<th>Sn</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
<th>As</th>
<th>Ag</th>
<th>Sb</th>
<th>Au</th>
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<tbody>
<tr>
<td>P-01 line 1</td>
<td>86.38</td>
<td>6.62</td>
<td>3.97</td>
<td>0.35</td>
<td>0.01</td>
<td>0.07</td>
<td>0.47</td>
<td>0.38</td>
<td>0.22</td>
<td>0.00</td>
<td>1.53</td>
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<td>P-01 line 2</td>
<td>80.03</td>
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<td>4.26</td>
<td>0.32</td>
<td>0.01</td>
<td>0.08</td>
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<td>0.43</td>
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<td>0.10</td>
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<td>P-01 line 4</td>
<td>84.65</td>
<td>6.29</td>
<td>5.23</td>
<td>0.35</td>
<td>0.00</td>
<td>0.11</td>
<td>0.65</td>
<td>0.36</td>
<td>0.30</td>
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<td>0.00</td>
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<td>P-01 line 5</td>
<td>78.99</td>
<td>5.64</td>
<td>7.39</td>
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<tr>
<td>P-01 Mean</td>
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<td>6.32</td>
<td>5.11</td>
<td>0.33</td>
<td>0.01</td>
<td>0.09</td>
<td>0.64</td>
<td>0.47</td>
<td>0.30</td>
<td>0.02</td>
<td>3.91</td>
<td>0.02</td>
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Parallels:

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<th>Cu</th>
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<th>Sn</th>
<th>Fe</th>
<th>Co</th>
<th>Ni</th>
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<th>Au</th>
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<tr>
<td>C97-2</td>
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<td>6.21</td>
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<td>0.05</td>
<td>0.50</td>
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Modern:

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<th>Fe</th>
<th>Co</th>
<th>Ni</th>
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<td>1.18</td>
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5. See Broshi and Nir-El (above, note 1).
7. Ibid., pp. 90–108.
8. Ibid., p. 94.