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A LATE MEDIEVAL METAL SEAL

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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.

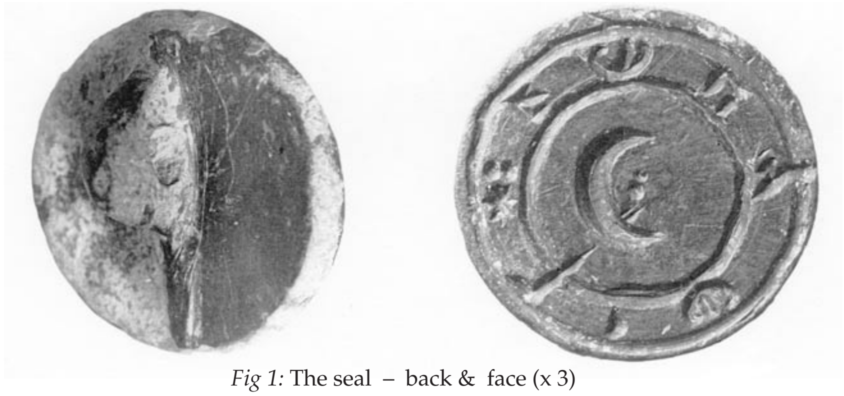

Fig 1: The seal – back & face (x 3)

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,[2] 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.[3] 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,[4] 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[5] 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[6] of 196 different medieval Islamic brasses and bronzes,[7] only one small rivet[8] 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,[9] 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)

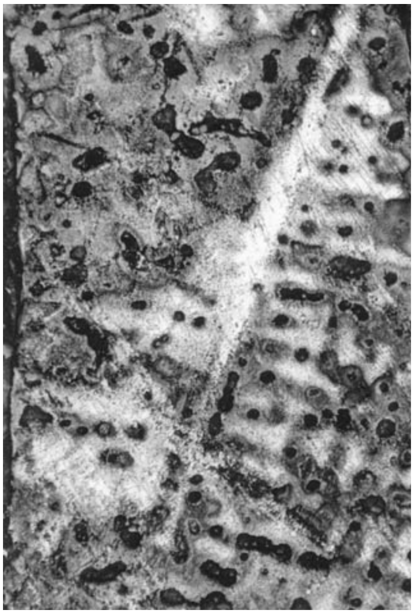

Fig 3: As-cast dendritic structure (x 625)

Fig. 4: Back of the seal – surface (x 20)

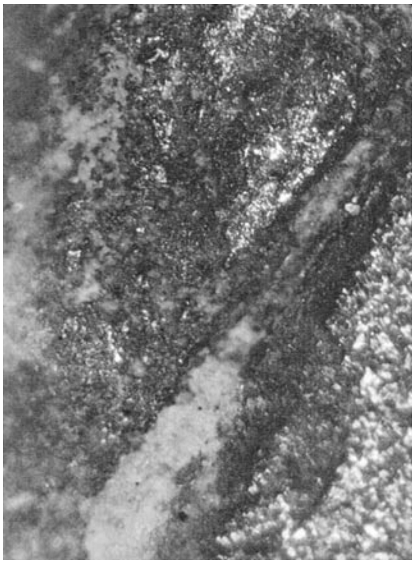

Fig. 5: Face of the seal – surface (x 50)

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,[10] 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

Fig. 6: Carved surface of the seal (x 7)

Fig. 7: Carved surface of the seal (x 7)

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 according to his familiar left-to-right routine.

(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?

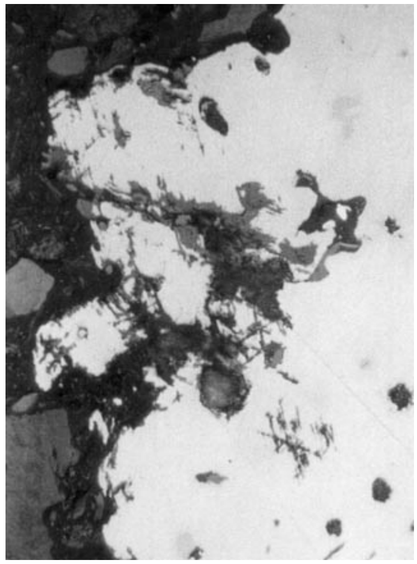

Fig 8: Unetched corrosion (x 1250)

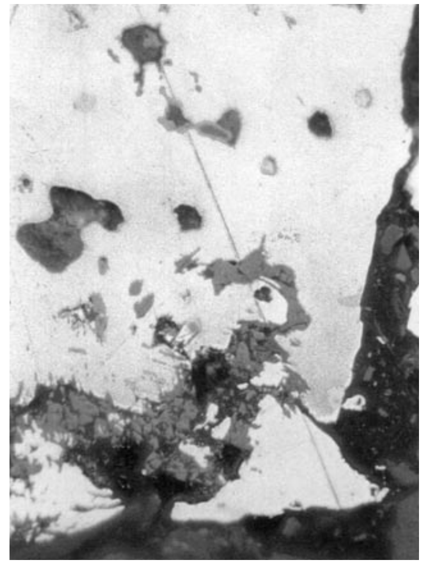

Fig 9: Unetched corrosion (x 1250)

Optical surface corrosion analysis

The surface corrosion left intact on the back side of the signet (Fig. 4) is identical in composition and structure to some marginal corrosion remains on the edge of its cleaned face (see, e.g., Fig. 6, above the letter *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 object, before being partially cleaned, was uniformly patinated with corrosion 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 surface corrosion product. Magnifying both edges of the cut sample (Figs. 8 and 9) to a degree of 1250 shows a clear intergranular corrosion (the silver-gray in Figs. 8 and 9), with some intragranular 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 produced by counterfeiters trying to make a purported antique look old). The surface macro-evidence shows that this corrosion, before being removed, covered the whole signet, including the carvings, and started to penetrate the metal microstructure below the surface. The artifact, after being cast, polished, engraved and probably 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 contributes to the study of archaeology and of history, by disclosing information 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)

Sample	*Cu*	*Zn*	*Sn*	*Fe*	*Co*	*Ni*	*As*	*Ag*	*Sb*	*Au*	*Pb*	*Bi*	*S*
P-01 line 1	86.38	6.62	3.97	0.35	0.01	0.07	0.47	0.38	0.22	0.00	1.53	0.00	0.00
P-01 line 2	80.03	6.37	4.26	0.32	0.01	0.08	0.55	0.43	0.23	0.07	7.40	0.08	0.17
P-01 line 3	83.53	6.66	4.69	0.34	0.01	0.10	0.57	0.41	0.29	0.00	3.25	0.00	0.15
P-01 line 4	84.65	6.29	5.23	0.35	0.00	0.11	0.65	0.36	0.30	0.03	2.01	0.00	0.02
P-01 line 5	78.99	5.64	7.39	0.27	0.00	0.11	0.94	0.77	0.48	0.01	5.36	0.03	0.01
P-01 Mean	**82.72**	**6.32**	**5.11**	**0.33**	**0.01**	**0.09**	**0.64**	**0.47**	**0.30**	**0.02**	**3.91**	**0.02**	**0.07**
Parallels:													
C97-2	84.2	6.21	5.62	0.34	0.03	0.08	0.73	0.18	0.36	0.03	2.02	0.05	0.10
C97-5	81.3	6.51	5.63	0.31	0.01	0.07	0.50	0.16	0.47	0.02	4.40	0.04	0.51
C97-19	82.0	7.50	4.19	0.54	0.09	0.06	0.25	0.03	0.11	0.02	4.78	0.02	0.39
C97-21	80.7	6.29	3.27	0.27	0.01	0.03	1.13	0.08	0.28	Tr.	7.41	0.08	0.40
1878-12-30, 681	76.5	7.20	5.10	0.40	0.04	0.05	0.50	0.09	0.20		8.80	0.01	
1878-12-30, 680	80.5	8.60	4.30	0.12	0.01	0.03	0.20	0.14	0.85		4.40	0.01	
Modern:													
Ca99-1	71.3	23.62	2.02	1.36	0.01	0.35	0.02	0.02	0.06	0.01	1.18	0.01	0.02

1. See M. Broshi and Y. Nir-El, "The רמב"ן Seal – Authentication Analysis," *Tarbiz*, 55/3 (1996), pp. 527–528 (Hebrew).
2. See S. Shalev, "A Fatimid Metal Hoard from Caesarea," in A. Raban (ed.), *Caesarea Excavations* (forthcoming).
3. See P.T. Craddock, S.C. La Niece and D.R. Hook, "Brass in the Medieval Islamic World," in P.T. Craddock (ed.), *2000 Years of Zinc and Brass* (British Museum Occasional Paper, 50), second revised edition, London 1998, pp. 73–114.
4. See, e.g., R.E. Reed-Hill and R. Abbaschian, *Physical Metallurgy Principles.*, third edition, Boston 1992, Table 20.2.
5. See Broshi and Nir-El (above, note 1).
6. See Craddock *et al.*, "Brass" (above, note 3), p. 112.
7. *Ibid*., pp. 90–108.
8. *Ibid*., p. 94.
9. See, e.g., Z. Goffer, *Archaeological Chemistry: A Sourcebook on the Applications of Chemistry to Archaeology*, New York 1980, pp. 45–47.
10. See O. Untracht, *Metal Techniques for Craftsmen*, London 1968, p. 112.