

COIN HOARD FROM VARUDI – VANAKÜLA. QUESTIONS AND ANSWERS IN CONSERVATION

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Abstract

The article discusses the conservation issues of Roman coins on the example of a specific find, gives an overview of the conservation process and material studies. It analyses corrosion products and the historic patina survived on the coin surface. The author endeavors to establish connections between the composition of the coin metal and corrosion.

Keywords: Roman coins; Conservation, Composition of metal; Corrosion; Patina.

Introduction

In April 2015 hobby archaeologists and archaeologist Ain Mäesalu, who were looking for the site of a historic battle in the landscape, came across a hoard near Uhtna, Lääne-Viru County, which consisted of coins and various ornaments. Initial examination verified that the coins were apparently sestertii from the era of the Roman Empire. The find, consisting of 51 coins, immediately doubled the number of Roman coins registered in Estonian museums, since so far Roman coins had been discovered in Estonia only on rare occasions.

The treasure was discovered from an old hayfield on a river floodplain by a bridge. Upon discovery the coins and ornaments were not in their original hiding place anymore: XXth century drainage and ploughing had spread them over a few square meters wide area. At the time of hiding the area was rather moist, therefore it cannot be associated with a former settlement [1]. Money was not known in this region at the time, therefore coins must have been used as raw material for e.g. jewelry, weights or luxury items.

Materials and methods

Conservation

Decisions taken by the conservator determine the appearance of the monument or the artefact. Hence the responsibility of the conservator is enormous: he/she must elaborate the critical decision on the object itself. Historians may change their mind and re-evaluate their opinions at any time, the decisions of the conservator will permanently survive on the object. All objects made by man, i.e. artefacts are historical documents that carry data about the materials used, working methods and techniques applied. Time passes and adds its marks,

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which are regarded as material expressions of historicity, summarized in the term patina. Therefore patina is considered as an integral part of the original substance, brought to us through history. Any attempts to remove it will harm the original substance of the object and lead to historical contradictions, since patina-free old objects appear as fresh and made of new material [2].

Switching from conservation philosophy to practical conservation activity: the patina on archaeological bronze items may be categorized into three layers [3-10]:

- Primary (or precious) patina that has formed in the process of making and using the object, mainly in contact with Oxygen and Sulphur.
- Secondary patina, which starts to develop when the object gets into the soil and which may be also called corrosion layer. The main factors here are moisture, oxygen, aggressive (acid or alkaline) environment and chlorides.
- Depending on the properties of the soil and the length of time in ground, some objects may have tertiary patina, which develops as a result of mineralization and fossilization of secondary patina and mixing with the earth, and which sometimes is called concretions.

The process of conservation should distinguish between those layers, focusing on preserving primary patina as much as possible, and removing later corrosion products.

Various chemical and mechanical treatments may cause physical loss in the object's structure or material, which in turn will bring about losses in historical or esthetical values [11]. But it may also be the other way round – bringing forward or making the original image of the object visible may provide significant new information and so supplement the so-called historic document, which coins first and foremost are.

The main objective of the current conservation work was to find a method that would be least harmful to the coins in order to preserve as much information as possible for numismatists and historians. Therefore it was decided that removing the active corrosion layer could only be done to the extent that it would not damage the coin surface or historic patina. Practical conservation was complicated, because so far only few Roman coins have been found in Estonia and there was lack of earlier experience in this field. The best method had to be found in the actual conservation process, considering the preservation state and properties of the material, which became evident in the work process.

State of the coins

The coins were brought to the conservation laboratory at the next day after the excavation. They were packed in reclosable plastic bags together with moist soil, to prevent the coins from drying. The coins seemed to be in good condition, the level of surface damage was more difficult to assess, because the coins were covered with soil residue and corrosion products (Fig. 1). The method of radiography was applied to determine the level of damage on the surface, unfortunately it did not give the expected result. The X-ray photos failed to bring out details of the stamp, but they affirmed that generally the coin metal had well preserved. Only a few coins demonstrated cracks on the edges and slots on the metal surface.

Initial observation suggested two groups of coins:

- 1) Coins with surfaces covered with historical patina and a fairly thin layer of corrosion, surface relief identifiable. Such coins were in minority (Fig. 2)
- 2) Coins with surfaces densely covered with a thick layer of corrosion products, surface relief un-identifiable. Surfaces of the coins were generally covered with a thick black corrosion layer with crystalline products, the like of which the author had never before encountered on items of copper alloys, and which alternated with green corrosion (Fig. 3). Such coins formed the majority.



Fig. 1. Coins prior to cleaning and conservation (AI-7484:33-38)

Cleaning the coins and stabilizing the material

First, surfaces of the coins were cleaned under running water from traces of soil. Then chloride tests were carried out on the coins, which gave a negative result. The next task was removing distortive corrosion products in such a way that historic patina on the coins could survive.

The first group of coins, with surfaces covered with well preserved historic patina (See Fig. 2) presented no major problems. The dark crystalline corrosion layer could fairly easily be mechanically removed.

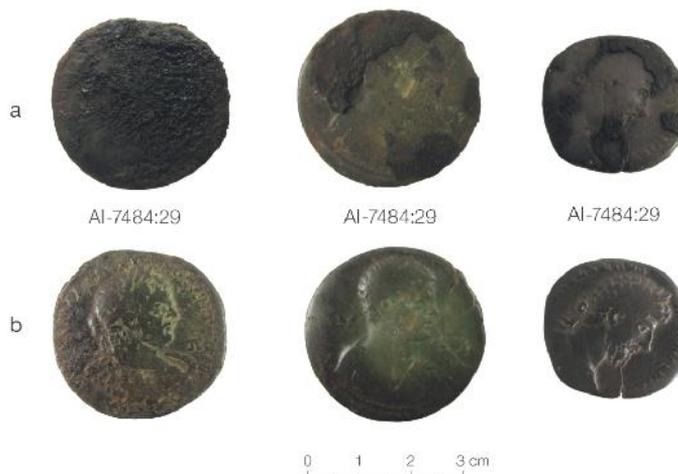


Fig. 2. a) before cleaning – surfaces partly covered with corrosion;
b) after cleaning – primary patina has survived on the surfaces.

The majority of coins in Group 2, which were covered with a thick corrosion layer, required significantly more attention to remove distorting corrosion layer from their surfaces. After cleaning, it appeared that the surface relief had almost entirely disappeared on all these coins, only barely recognizable contours of the stamped images could be identified in very rare cases. The primary patina could not be found neither preserved on those coins (Fig. 3).

The most commonly used conservation methods for metals (incl. coins) are mechanical, chemical and electrochemical [12] in addition some more modern technologies like plasma and laser treatment are available [13, 14].

In order to remove corrosion products several chemical solutions were tested. Formic acid, phosphoric acid, alkaline Rochelle salt and ammonia solutions were experimented, starting with 5% concentration and three hours, up to 15% and 24 hours. Strong acids were avoided in order not to damage the historic patina on the coins. Initial tests resulted in acknowledging that the black dense corrosion is quite immune to chemical treatment. Electrolytic, plasma and laser treatments were ruled out as brutal under the circumstances, since such treatments could distort the historic substance of the coins (changes in material, deformed surface etc.) [15].



Fig 3. a) before cleaning – surfaces are covered with a corrosion layer;
b) after cleaning – primary patina has not survived.

Galvanic treatment was also tested [16]. The coins were wrapped into aluminum foil, where small holes had been made in order for the electrolyte (15% solution of washing soda Na_2CO_3) to be in full contact with the coin metal. The coins were kept in galvanic wrap for five days, yet no notable changes occurred in the corrosion layer during that time. The surface corrosion layer did not soften, therefore it was not possible to remove it even to the slightest degree. From the mechanical cleaning methods initially sandblasting was considered, because this method allows to efficiently removing the distorting corrosion products. The downside of this method is the intractability of the process and serious danger of damaging the coin surface. The desired outcome could not be achieved also by using the mini-drill and the milling cutter – such treatment only slightly removed a thin layer of the surface corrosion. Since the initial experiments with traditional cleaning methods did not give the desired results, a new approach was needed. One such experiment with some coins was a so-called thermal shock, where the coins were plunged several times in turn into boiling water ($+100^\circ\text{C}$) and liquid nitrogen (-196°C), expecting that thermal tensions would make the corrosion layer more fragile and easier to remove. However, this method proved to be not successful.

Finally a combined cleaning method was worked out that gave satisfactory results on the problematic coins. At first the coins were kept for several hours in hot ($90\dots100^\circ\text{C}$) Na_2CO_3 solution, and were in between repeatedly treated in ultrasonic bath. The corrosion products started to partially detach already then, also the remaining corrosion layer became softer and easier to treat. The final cleaning of the coins was done manually under the optical microscope with a scalpel and a timber peg. This job was extremely primitive and slow, yet unavoidable under the circumstances. Cleaning revealed that in the process of drying the dark layer of corrosion products turned even harder and therefore more difficult to remove. For this reason the coin surface had to be kept moist all the time (both lower and upper side).

Treatment of the coins uncovered in places up to four layers of corrosion products that behaved differently in the cleaning process – the black hard corrosion layer varied often with the softer greenish layer. Apparently layered corrosion has been found on bronze items also before [17]. Cleaning the hard uppermost corrosion layer with the scalpel presented the risk of cutting into the next softer layer with the scalpel and thus create scratching marks into the patina of the lower layer. On some occasions the hard black glassy corrosion layer detached by large patches together with the green corrosion and the thinned metal. Such situation was not acceptable and therefore we decided to find out the content of the problematic corrosion products, also to study the content of the coin metal and ascertain their possible interrelationship.

Results and discussions

Analysis of the corrosion products

Some coins were covered with a thick dark brown or black corrosion layer whose origin and content raised questions, as nothing similar had earlier been noted on coins. The content of corrosion products that separated from the coins surface in the ultrasonic bath was analyzed by the XRD method. The results are presented in Table 1.

Table 1. Content of corrosion products

Compound	Content (wt %)
CuO	47.3
Cu ₂ O	21.9
Fe ₂ O ₃	21.9
CuFe ₂ O ₄	8.9

As shown, the corrosion layer consists of a mixture of copper and iron oxides. It is evidently the iron(oxide) that explains the unusual appearance and properties of the corrosion layer on the coins. The question raised whether the iron content in the corrosion layer may originate from iron items that had been buried together with the coins, but which in time had completely decayed. To clarify that, two soil samples were taken for analysis – one directly from the excavation trench and another from a few dozen meters further away. The mineral components of the samples were comparatively analyzed by energy dispersive X-ray microanalysis method (SEM-EDS). It appeared that both samples contained an equal amount (about 3.7 wt%) of iron. It may be concluded that the iron compounds in the coins corrosion layer evidently originate from the soil where they have precipitated from iron-rich ground water.

Analysis of the coin metal

A selection was made from coins with different condition and their metal was analyzed by the SEM-EDS method. To save coins from excessive damage, only a limited area on one edge of the coins was used for analysis, where the corrosion layer was removed with a file until the coin metal was exposed up to a couple of square millimeters.

Results of the content of the analyzed coins are presented in Table 2.

All coins were made from copper-based alloys, but the combination of alloying elements for each item varies to a great degree. The main alloying elements were zinc (Zn), tin (Sn) and lead (Pb). The alloy of some coins (AI-7484:33, 23, 28, 49, 50, 51) may be regarded as brass, because the main additive in their content was zinc. Another group of coins (AI-7484:7, 10, 38, 43, 37, 34) remains somewhere between brass and bronze for their content, because their elements include both zinc, tin and lead. One coin (AI-7484:29) consists of pure tin-lead-bronze without any zinc.

Some of the coins were assessed to be sestertii minted in Rome, some of them are so-called provincial coins. According to sources [18, 19] sestertii were originally (Monetary

Reform by Augustus from the beginning of the Ist century AD) made from brass (Latin *orichalcum*), with the zinc content of 20-25%. Frequent remelting caused the zinc content of the coins to diminish over time, since zinc with its lower melting temperature than copper tends to partly volatilize during melting. From the time of Emperor Aurelius (161 – 234 AD) the coin metal of sestertii started to probably consciously be gradually weakened with bronze (brass as an alloy was more precious than bronze) [18]. Since the coins from the Varudi – Vanaküla hoard were dated to the end of the IInd – beginning of the IIIrd century, it is plausible that the content of the coin metal represents a typical cross-section of the coins of the time, with some coins made of brass (although with a diminished zinc content) and some already of brass/bronze mixture.

Table 2. Composition of the coin metal (wt%).

Nomination*	Marker	Cu%	Zn%	Sn%	Pb%	Fe%	S%
Julia Paula (218–222), Tarsos, provincial	AI-7484:10	73.1	12.0	10.4	4.5	-	-
Caracalla, Tarsos, provincial	AI-7484:7	75.2	7.5	11.5	5.8	-	-
Caracalla, provincial	AI-7484:33	86.4	13.4	-	0.2	-	-
sestertius	AI-7484:23	87.0	12.7	-	-	0.2	-
provincial	AI-7484:49	90.6	7.6	1.0	-	0.3	0.5
sestertius (or provincial)?	AI-7484:50	86.8	10.9	1.2	1.1	-	-
provincial	AI-7484:51	86.2	12.2	0.3	0.8	0.5	-
Caracalla, Tarsos, provincial	AI-7484:38	72.7	3.4	13.8	9.1	1.0	-
Caracalla, Tarsos, provincial	AI-7484:29	83.2	-	8.0	8.8	-	-
provincial	AI-7484:43	73.6	7.9	10.5	6.8	1.2	-
Faustina Younger, sestertius	AI-7484:37	87.0	7.0	4.6	-	0.7	0.7
provincial	AI-7484:28	88.8	10.6	-	0.3	0.3	-
Faustina Younger, sestertius (or provincial)?	AI-7484:34	86.5	8.7	3.9	-	0.4	0.5

* Coins were assessed by Risto Koovit [1]

The comparison of the content and condition of the coins clearly demonstrated that the first (well preserved) group consisted of bronze or bronze-like brass coins, and the second group (poorly preserved, covered with a thick corrosion layer) was dominated by coins of pure brass (Fig. 4). Brass as an alloy is in fact more liable to corrosion than bronze, because zinc tends to leave from the surface layer, leading to intergranular corrosion and damage to the surface. Figure 5 presents the coins after their conservation.



Fig. 4. Comparison of the preservation of coins: a, b – bronze (AI-7484:29); c, d – brass (AI-7484:28)



Fig. 5. Coins from the Varudi – Vanaküla hoard (AI-7484:1-51) after cleaning and conservation. (Photo: Mauri Kiudsoo)

Conclusions

The conservation of a large part of the Varudi – Vanaküla coins turned out to be unexpectedly problematic. It required a number of tests and combining various methods. However, considering the state of the coins, the conservation can be considered as satisfactory (Fig. 5).

The find is an extremely rare discovery in Estonia and also in our neighbouring countries [1] and therefore no background information existed for conservation. Much to our surprise it turned out that the coins seemingly similar in appearance and value could consist of different content and hence require a totally different treatment.

The analyses demonstrated clear connections between the state of the coins and the character of the corrosion layer on the one hand and their metal content on the other hand – the bronze coins had a strong protective patina layer and a good state of preservation, but the brass coins lacked such layer and they were much more affected by corrosion.

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