Metallographic analysis of icon oklad – *St. Great Martyr George*

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**Abstract.** This paper analyzes from the metallographic point of view the icon oklad (St. Great Martyr George), on which silver Russian hallmarks [1] are stamped in: the maker’s mark - "ПГ" (PG), the assayer’s mark - "И·А/1858" (I·A/1858), the silver standard mark "84" (.875) and the town mark. As a result of the optical microscopy and SEM-EDX investigations, it was concluded that the icon oklad was not made of silver alloy, according to silver title 84, but was made of silver plated copper. The presence of Russian silver hallmarks clearly indicates the intention to mislead. So it's a counterfeit. The hallmarks could be replicated (copied/falsified) after original silverware or by the old hallmarks that have been published in various catalogs [2]. Unfortunately, in Eastern Europe there is a large production of modern pieces with forged Russian hallmarks masked in old artifacts [3].

1. **Introduction**

Following the conversion of Grand Duke Vladimir to the religion of the Byzantine Empire (Orthodox), which took place in the 10th century (year 988), icons began to occupy a special place in Russian culture. Although the first painted icons have been imported from Constantinople in Kievan Rus’ since the 10th century, the first icons oklads made of precious metal date back to the beginning of the 11th century [4].

Since the Byzantine period, the precious metal objects were stamped with official control marks that ensured compliance with the purity standard (fineness) [5].

The hallmarks stamped on the Russian icons oklads provide evidence of the maker’s mark (the silver craftsman), the silver standard mark, the assayer’s mark (the master-controller), date and place of the final verification. The silver - copper alloys are best suited for silversware works. Copper can be alloyed with silver in different proportions by melting the two metals and blending them in a molten state. The resultant alloy had all the features necessary to produce long-lasting silverware [6].

Over time, artisans have developed methods of applying thin layers of silver to base metals, with the aim of decorative effects, precious metal savings, or to deceive the customers [7]. Since antiquity, the base metals were sometimes plated for fraudulent purposes [8].
Deposition of thin layers of pure silver on the surface of base metals is made by electrodепозитing (since 1840) or by the action of chemical preparations or mixtures in which fine silver is the main ingredient [6].

Plating silver by amalgamation (the amalgam silvering method) consists in: preparing a silver-mercury amalgam, applying it to the surface of the product, followed by the evaporation of mercury by heating. The silver remains as a very thin coating [9].

The identification of the technique used for silver plating can be achieved by cross-sectional examination of the border (interface) between silver and base metal [8].

Among the silver plating techniques are: mechanical methods, silver-copper eutectic bonding (silver solders; diffusion bonding: Sheffield plate), close plating, mercury silvering, depletion silvering, silver coatings applied molten, French plating, silvering pastes and solutions and electroplating [7], electroforming-process [5].

Mastery of craftsmanship and the knowledge of old silversmith techniques can lead to execution of convincing fakes, especially as the attention of collectors is always directed towards the presence of the hallmarks and less on the quality of the pieces [5].

Over time, almost in all over Europe have been produced counterfeits of silver pieces, among the types of frequent counterfeits are: additions, transformations, subtractions, transpositions and counterfeit marks [8].

Counterfeiting / forgery, smuggling and theft of works of art are the most common crimes against cultural heritage [10]. Some people in the art world prefer to sell art suspected of being counterfeit than selling art suspected of being stolen. If counterfeit is never discovered, financial loss is avoided [11].

Uncertainties caused by counterfeits generate real resource costs in the form of money, time and effort spending for information and search activities [12].

2. Materials and methods

2.1. The method of identifying stamped marks on the oklad

There are four types of markings on the icon oklad of the “St. Great Martyr George”:

1. The maker’s mark (the craftsman mark) “ПГ” (PG);
2. The assayer’s mark (the verification mark) “И·А/1858” (I·A/1858);
3. The silver standard mark (the silver title mark) “84”;
4. The town mark (the mark of the city) – “St. George slaying the Dragon”.

The maker’s mark “ПГ” (PG) (catalog position 407) may have belonged to an anonymous craftsman who was involved in the making of icon oklads [1].

The monogram of the master-controller "И·А" of the assayer’s mark “И·А/1858” (catalog position 2110) probably belonged to Avdeev I. who worked in Moscow between 1852 and 1862, after which he was elected in the leadership of the Center for the Verification of Precious Metal Titles in Moscow [1].

The silver standard mark “84” is specific to the Russian silver alloy with a silver content of .875 (875/1000).

Stamped representation of the city's mark leads to the 19th century Moscow coat-of-arms [1].

2.2. Investigation methods and materials used

To verify the authenticity of the oklad (Figure 1), a sample of about 1 mm² was taken from a non-vital area (from the degraded edge of the oklad). Optical and electronic microscopy was performed on the sample.

In order to highlight the structure of the material collected, as well as the processing method, the metallographic sample was prepared and examined under the optical microscope.

Sample preparation [13] was done by grinding and polishing it on a Buehler Alpha machine with a vector head, as follows:
- the grinding was done in four steps, using abrasive papers with granulations of 75, 45, 25, 15 μm, with the following parameters: 4 N/mm² pressing force; 300 rot/min turntable speed; 3 min/step grinding time; water;
- the polishing was done on a "Buehler-Microflok" textile support in five steps using diamond suspensions as abrasive materials with granulations of 9, 6, 3, 1 μm with the following parameters: 4 N/mm² pressing force; 200 rpm turntable speed; 3 min/step polishing time;
- the final polishing step was carried out on a "Buehler-Vibromet" vibration polishing device, using as abrasive an aqueous suspension of colloidal silica with granulation of 0.02 μm for 6 hours.

![Figure 1](image.png)

**Figure 1.** The icon oklad of the *St. Great Martyr George*: a) overview and b) hallmarks details (1- the maker’s mark, 2- the assayer’s mark, 3- the silver standard mark, 4- the town mark).

After final polishing, the sample was attacked with 15% ammonium persulfate by immersion for 30 seconds.

The metallographic analysis was performed on an optical microscope ReicherT Univar transmitted-light setup.

The samples were also analyzed by Scanning Electron Microscopy (XL-30-ESEM Phillips) using a Quanta Inspect F50, with a field emission gun (FEG) with 1.2 nm resolution and an Energy Dispersive X-ray Spectrometer (EDXS) having 133 eV resolution at MnKα.

3. **Results and discussions**

The icon oklad of the “*St. Great Martyr George*”, with a detachable element (aureole of St. George), was made using the following techniques: mechanical stamping, with areas where bending and / or incisioning techniques were applied, respectively electrolytic deposition of pure silver in uneven coat of about 25μ thick on a copper-specific structure (according to metallographic analysis performed).
Initially, we were tempted to consider, based on the existence of the Russian specific marks and the specialized literature, that the icon oklad of the “St. Great Martyr George”:
- was made by the master who has the monogram “II” (PG), which had as occupation the realization of the icons oklads, especially in the hammering technique [1];
- and that in 1858 the title of silver (875/1000 parts of pure silver from the specific Russian alloy “84”) of the icon oklad was verified by the master-controller I. Avdeev [1].

At first sight, the suspicion regarding the authenticity of the work was based on the inferior quality of the four marks specific of Russian silver workshops: the craftsman's mark, the verification mark (which includes the monogram of the master-controller and the year of control), the silver title, and the mark of the city. Thus, one could notice with the naked eye the unskilful stamping, for example:
- the figure of "St. George killing the dragon" from the city's stamp, it did not have a clear, well-defined relief, as it happened in the case of a genuine Russian mark of a city's coat of arms;
- in the case of the silver title mark, the embossed contour of the "84" number was almost completely deformed and devoid of a relief pattern specific to an original mark;
- in the case of the verification mark, the unclear contour of the year of the silver title verification could be observed locally (the first numer of "8" in the year "1858" was almost completely devoid of relief contour); which is not usually the case for an authentic brand.

As a result of the investigations, it was confirmed that the marks affixed to the icon “St. Great Martyr George” are counterfeited. This demonstrates the importance and the necessity of scientifically assessing the icon oklads [13] before purchasing, placing them in commerce or their artistic valorisation.

3.1. Results of optical microscopy analysis

The Quantitative Analysis Bulletin was issued by the Quantitative Analysis Laboratory of the Department of Materials Science, Physical Metallography of the Polytechnic University of Bucharest.

The results of optical microscopy analysis are presented in Figure 2 and Figure 3.

![Figure 2. Optical Microscopy - calibrated 0.12315 μm/Pixel: a) captured image and b) Processed image.](image)

Examination on the ReicherT Univar metallographic microscope reveals that the sample has a deposited, uniform layer thickness of approx. 25μm, the structure of the base material, copper, is composed of polyhedron grains with different shades and crystallographic orientation - the typical structure of copper and copper alloys in cast and annealed condition.
3.2. Results of scanning electron microscopy analysis

The results of SEM-EDX investigations are presented in Figures 4 to 7.

Figure 4. SEM images: a) Silver layer thickness and copper matrix (darker) and b) areas where EDX determinations were made.
Figure 5. EDX1 analysis revealed the deposition of pure silver.

Figure 6. EDX2 analysis revealed the basic material - copper.

Figure 7. Sample investigation with the overall distribution of the elements per area analyzed.
The EDX analysis on the sample (Figure 4b) was made for each area:
- Micro-area 1 (EDX1) which belongs to the silver layer deposited on the copper matrix (Figure 5).
- Micro-area 2 (EDX2) for the copper matrix (Figure 6).

4. Conclusions
The result obtained from present work can be summarized as follows:

In the field of falsification of works of art, the development of technology has reached very high rates;

The markings applied on the surface of the icon oklad are intended to mislead: the Russian silver title mark “84” - the equivalent in the metric system of the silver alloy 875/1000 (.875 pure silver parts), as well as the other 3 marks (maker’s mark, the verification mark and the mark of the city). For an competent person all the marks shows sign of suspicion;

According to the analyzes by optical and electronic microscopy, it was established that the icon oklad of “St. Great Martyr George” is made of a copper plate on the surface of which pure silver was electrolytically deposited in an uneven layer of about 25 μ thick;

The result of the microstructural analysis underlin ed the importance and necessity of investigating the oklads of old icons if there is doubt about their authenticity.

In the future, we aim to identify and develop non-invasive and economical analysis methods to facilitate the detection of counterfeits.

5. References

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