eISSN 2783-6843 | ISSN 1392-0316 | DOI: 10.37522/aaav.108.2023.153

Study of Original Painting and Gilding Technology on a Nineteenth-Century Terracotta Sculpture

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——— Conservation research has a main role to play during the decision-making process of restoration – how an object should look, what should be removed, what should be clearly exposed, and how to connect history and conservation with the aesthetic effects expected by the owner. In many situations we do not have enough historic material to fully establish this. In this article we would like to describe the process and steps taken during microchemistry research to identify the original technology used in the painting and gilding layers of a terracotta sculpture, dated to the late nineteenth century.

Keywords: terracotta, gilding, nineteenth century, polychrome, technology.

Although terracotta sculpture is most recognized in the ancient Terracotta Army of the Chinese emperor Qin Shi or in the Italian Renaissance masterpieces of the Della Robbia family, it was also present at almost every time and in almost all areas of the world, but of course with a different frequency. Terracotta is a very plastic and easy to use material for sculptural work as well as relatively cheap (compared to, for example, marble). The reason a terracotta sculpture appeared in a small village in central Poland at the end of the nineteenth century is still unknown. The most probable possibilities are that it was a German import (at the time, central Poland was under German occupation) or an order by local Catholic society as a mark against the *Kulturkampf*. It was most certainly made in the neoclassical fashion: reminiscent of the past, like most nineteenth-century artistic trends.

The terracotta sculpture described in this article is from Gostyń, a medieval town of about 20,000 inhabitants in central Poland, halfway between Poznań and Wrocław. The object depicted Saint Margaret of Antioch and was displayed on a column outside the city parish church.

The sculpture's face was destroyed during the world wars and refilled with cement mortar in the late 1940s. Incorrectly selected physical and mechanical parameters for the cement mortar and its unfavorable effect on the historic material caused the object's slow and uncontrolled destruction. Water-soluble salts contained in the mortar emigrated to low-porous terracotta structures and weakened the sculpture over the years. The deterioration was visible as cracks in the saint's neck as well as the base area, where cement mortar was also used, probably for better stabilization. During the conservation, all old mortar was removed [fig. 1] and the terracotta was desalinated. The next step was putting the parts of the terracotta together and gluing and reconstructing the sculpture.

Besides the old mortar problem, there was also another one to solve: the original color. The issue with which we started was to examine whether the sculpture was originally without polychrome or if it had any decorative layers. When the sculpture was brought to our department for the first time, it was coated with secondary layers of paint. The last layer

1.
Sculpture face's state of preservation after removing old mortar and layers, photo by Agata Ogińska, 2019

was white, shiny oil paint. We conducted a comparative study with similar sculptures from similar periods (mostly made of stone because terracotta sculptures from this period were not well researched), which showed that most of the sculptures were realistically painted. We started looking for polychrome. First, we made a stepped outcrop on the back and discovered that the initial historical paint layer was orange. We made two more outcrops in different places (part of the hair, part of the neck, and part of the shoulder of Saint Margaret and part of the body of the dragon) and were surprised when we found layers that did not correspond in any way to the realistic appearance which we expected: the orange layer was preserved almost only on the back, while on the front of the sculpture were about 3–4 layers that appeared to be contemporary, laid directly on the terracotta. The dragon was also covered with about 4–5 layers. We decided to take cross-section stratigraphic samples of layers and examine them under the microscope. We took 25 samples from the sculpture [fig. 2]. Expecting this method to help us find the true colors (we still expected realistic ones) of the original paints, we were confused by the results we got. The samples showed from 3 to 10 colorful layers, and most of them appeared in most of the samples, but not all and not always in the same order. The orange layer, as well as a gray beige layer over it, was present in most of the samples. After an in-depth analysis, we noticed there was no dirt between the orange layer and the terracotta (apart from the explainable places where, for example, areas of the orange layer appeared to have fallen off or chipped off, but its particles

2.
Places of sampling for testing: cross-sections of layers (blue font) and powders of individual layers (red font).
Picture of the object before conservation, photo by Agata Ogińska, 2019

had been embedded in the new layer of paint) or between the orange and gray beige layers [table 1]. This was the first reason to interpret them as original, but it was of course not enough to make a decision with certainty.

This moment coincided with the receipt of the analysis results of the composition and salinity of the secondary mortar filling the face of the sculpture: the level of water-soluble salts was about 6–7%. To stop the terracotta's destruction, we needed to remove the mortar. For my color research, this was a green light to consider the layers over the mortar as secondary and removable. This involved three layers: two white and one beige. I took powder samples of these layers and removed them from all over the sculpture. However, as before, we still had many layers left to identify.

Looking for a different way to identify historical paint layers, we decided to analyze the binders and pigments of the paints. This was a risky method which did not give satisfactory results at all due to the approximate time of the sculpture's creation, that is, the end of the nineteenth century. At that time, the majority of dating pigments were no longer used, and the use of new binders and modified resins, so eagerly introduced to the market

Table 1. The distribution of paint layers based on the analysis of stratigraphic sections, by Agata Ogińska.

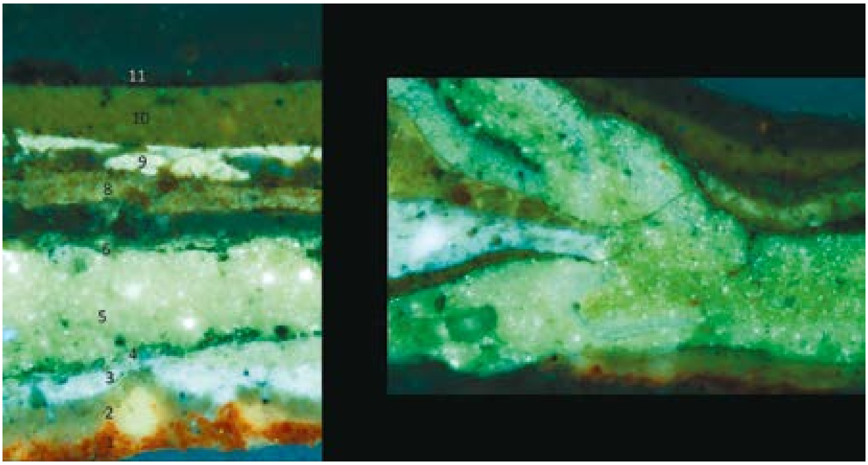
	(dirt)	yellow beige	orange	gray beige	gilding	(dirt)	gray beige	(dirt)	light blue	(dirt)	gray	gray with yellow grains	(dirt)	green	yellow beige	white 1	white 2
Crown (1)			+	+	+	+			+			?	+		+	+	+
Crown - gem (4)			+	+	+	+							+		+	+	+
Face - nose (3)								cement mortar							+	+	+
Face - cheek (19)			+	+					cement mortar						+	+	+
Face - cheek (20)								cement mortar							+	+	+
Hair (11)	?		+	+		+			+	+	+		+	?	+	+	+
Hair (13)			+	+		+			+	+	+		+	+	+	+	+
Hair (16)	?		+	+		?		+	+	+	+	+	+		+	+	+
Hair (18)			+	+		+			+	+	+	+	+	+	+	+	+
Coat (6)			+	+		+	+	+				+	+	+	+	+	+
Coat (10)			+	+		+			+				+	+	+	+	+
Dress (8)			+	+		+			?			+	+		+	+	+
Palm leaves (12)		+	+	+		+	+	+	+	+		+	+		+	+	+
Brooch (14)			+	+	?	+	+	+	+	+	+		+		+	+	+
Brooch (15)			+	+	+	+			+				+	+	+	+	+
Cross (upper side) (17)			+	+		+	+	+	+	+			+	+	+	+	+
Cross (underside) (22)			+	+		+	+	+	+	+	+		+	+	+	+	+
Dragon chain (7)				+		+								?	+	+	+
Dragon wing(2)	+		+												+	+	
Dragon neck (23)			+	+		+	+	+	+	+		+	+	+	+	+	+
Dragon body (24)			+					+	+		+	+	+	+	+	+	+
Chain (25)		+	+	+		+			+	+	+	+		+	+	+	+
Shoe sole (5)			+	+		+			+				+		+	+	+

(modifications of casein and tempera binders, oil-resin paints, and paints based on artificial resins) began. In the research we used microscopic ultraviolet fluorescence[1] to find the first points of attachment. We found zinc white, shining with yellow fluorescence, and heavy chemical elements that absorb ultraviolet radiation in the newest and in the oldest layers [fig. 3].

A thesis was put forward related to the color of the painting layers that the pigments that absorbed ultraviolet light contained lead or titanium. For the first time in the course of the research, the idea appeared that the lowest orange layer might owe its unusual color to lead minium. After researching methods, I decided to analyze the stratigraphic samples embedded in synthetic resin (based on polymethyl methacrylate) before and after using on them amido black and Sudan black solutions. Amido black should show us protein binder and the Sudan black should show oil binder present in Sudan black solution. We can see that almost all layers reacted - besides the two oldest layers, orange and gray beige [fig. 4]. This was the second indication to interpret those two layers as original.

Samples of orange and gray beige layers in the form of powders were taken from the sculpture to analyze the binder and the pigments. I ran

1 The interpretation was based on: Joanna Arszyńska, Zuzanna Rozłucka, and Maria Roznerska, *Mikroskopia fluorescencyjna* (Toruń: Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika, 2000).



3.
Appearance of stratigraphic section samples during exposure to ultraviolet light, photo by Agata Ogińska, 2019

4.
The samples of stratigraphic section after the use of amido black (on the left) and Sudan black (on the right), photo by Agata Ogińska, 2019

a few more tests in the laboratory and sent the samples for FT-IR and XRF analyses. Once again tests for the presence of the oil, amido and – as an added binder – carbohydrate binder were carried out. This time the Sudan or amido black were not used, but the saponification reaction (oil binder), reaction with ninhydrin (protein binder) and reaction with aniline (carbohydrate binder) were run. The only reaction which presented visible results was the reaction with aniline.

The FT-IR analysis did not offer many conclusions, but we discovered that the binders of both those two layers (orange and gray beige)

5.
Preserving the original first paint layer – lead minium based on a carbohydrate binder with the addition of an oil binder, by Agata Ogińska, 2019

6.
Preserving the original second paint layer – lead white and iron yellow based on a carbohydrate binder with the addition of an oil binder, by Agata Ogińska, 2019

7.
A preserved part of the gilding, lower part of Saint Margaret's robe. Condition after cleaning, photo by Agata Ogińska, 2019

have much in common in chemical structure. Moreover, there are quite a lot of organic compounds present, but they are hard to identify. After consulting with researchers from the Department of Technologies and Techniques of Fine Arts NCU Toruń, including Adam Cupa, M.Sc., about the FT-IR results, a decision was made that the composition of the binder of the original paint layers also includes oil additives. The XRF analysis completed the picture: in both layers is lots of lead. The first layer – orange – has typical minia color and no extras, so it was finally classified as a paint layer with minia pigments and carbohydrate-oil binder[2] [fig. 5]. The second layer – gray beige – was harder to interpret, but after microscopy analysis of the pigments' colors it was described as a paint layer with lead white and (probably) iron yellow and minia pigments and carbohydrate-oil binder [fig. 6]. Both of them were concluded to be original.

During the process of removing old oil layers, one more interesting issue emerged and significantly influenced the concept of the exterior

2 Jan Hopliński, *Farby i spoiwa malarskie* (Wrocław: Zakład Narodowy im. Ossolińskich, 1990), 13.

appearance of the sculpture after conservation. A clear part of a gilding was found on the lower part of Saint Margaret's robe [fig. 7]. A thoughtful and careful cleaning process made it possible to keep as much as possible of this tiny gilded area, which was approximately 20 square centimeters in size. There was one wider stripe (about 2 cm wide) and a narrower one running along the wider one.

Besides the area on the robe, there were traces of the gilding on other parts of the sculpture, located on the crown, collar, edges of the robe and sleeves, and the star-shaped brooch [fig. 8].

To identify the technology of the gilding, another study was run along two lines: the first was to examine the "gold leaf" and the second was to identify the base of the gilding. A small sample of the metal leaf was taken and tests were run in the laboratory with concentrated nitric acid (V) and with aqua regia.[3] The leaf stayed untouched after pouring nitric acid and dissolved in aqua regia, so the conclusion was clear – the terracotta was gilded with true gold leaf. To find out what the original gilding technology was, FT-IR analysis was performed. We found oils, so the gilding was put on a mixtion or a mordant. This is confirmed by the fact that no traces of bole were found – the gilding was placed "directly" on the gray beige layer.

After all research results were collected, their collective analysis was started. The result of this analysis led to several conclusions as follows:

1. Although there were many paint layers, only the two oldest ones were original.

2. The two oldest layers have a very similar binder, based on carbohydrate and oil compounds.

3. The first original layer is an orange color, probably applied to unify the color of the terracotta or/and to raise the gray beige color.

4. The second original layer is a gray beige color and originally completely covered the sculpture to cover the red color of terracotta and (probably) to help the sculpture seem to be stone or marble, which was a more expensive (and exclusive) material of sculptures than terracotta.

5. According to the theory above, we need to see the other marble sculpture decorations. An addition of a gilding in an area of, for example,

3 Aqua regia – a mixture of concentrated hydrochloric and nitric acid in a volume ratio of 3:1. It has very strong oxidizing properties, dissolves gold, platinum, palladium and other precious metals and other chemically resistant metals.

8.
Preserving the original gilding – gold leaf on an oil base, by Agata Ogińska, 2019

clothing edges or jewelry was popular, and it was in those areas the traces of gilding were found on the Saint Margaret sculpture.

After this research, the restoration process of the polychrome could begin. We decided to use paints based on mastic-keton binder because they have high photostability, so the possibility of color change is very low. They also have a quality that was desired: matte shine. As the original binder was oil-carbohydrate, most probably based on natural gums, and the level of shine was not very high, the mastic-keton paints were the best option to achieve an effect aesthetically similar to the original appearance.

After reconstruction of the paint layers, the gilding was also restored. Twenty-three-carat gold leaf was put on the Kölner Instacoll System glues on the crown, brooch, and edges of the clothes. A thinner gilding strip along the edge of Saint Margaret's mantle, was made from gold powder and Incral 44[4] [fig. 9].

4 Incral 44 – protective varnish based on acrylic resin with antioxidant additives, in organic solvent solution, used for protecting works of art in bronze and other copper alloys; trade name of a product of C.T.S. Europe.

9.
Sculpture of Saint Margaret of Antioch from Gostyń. Condition after conservation, photo by Agata Ogińska, 2020

The research and analyses conducted, as well as the conservation and restoration of the terracotta sculpture based on their results, allowed the sculpture to be restored to its former aesthetic and historical value. This sculpture example from Gostyń is almost unique due to the original decorative layers (polychrome and gilding) having been preserved, despite the external exposure without any protection against changing weather conditions and the direct impact of human activities (causing the destruction of the face). The figure of the patron saint of the city church in Gostyń was moved to the interior of the church after conservation.

Received —— 29 11 2021

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Santrauka

XIX a. terakotos skulptūros originalios tapybos ir auksavimo technikos tyrimas

Agata Ogińska, Piotr Niemcewicz

Reikšminiai žodžiai: terakota, auksavimas, XIX a., polichromija, technologija.

Šiame straipsnyje išsamiai pristatomi tyrimai, atlikti siekiant nustatyti Šv. Margaritos Antiochietės terakotinės skulptūros iš Gostynio (Lenkija) pirminius ir antrinius dekoro sluoksnius. Originalūs dekoro sluoksniai sudaryti iš polichromijos (iš pradžių buvo uždėti dviejų spalvų sluoksniai) ir auksavimo. Aliejinių dažų sluoksniai buvo laikomi antriniais. Taip pat antrinė buvo skulptūrinė forma, papildyta cemento skiediniu, galbūt su natrio silikato priemaiša. Pirminių dažų sluoksnių technologija buvo pagrįsta angliavandenių aliejiniu rišikliu ir švino pigmentais: raudono švino (*red lead*) ir švino baltuoju (*lead white*), taip pat geležies geltonos (*iron yellow*) priedu. Originali polichromija buvo atlikta dviem sluoksniais: oranžinės spalvos (vidinis) ir pilko smėlio spalvos (išorinis). Auksavimas buvo atliktas ant aliejinio pagrindo aukso folijos technika. Dažų sluoksniams identifikuoti buvo atlikti šie instrumentiniai tyrimai: Furjė transformacijos infraraudonųjų spindulių spektroskopija (FT-IR), rentgeno fluorescencija (XRF) ir fluorescencinė mikroskopija. Be to, atliktos mikrocheminės reakcijos su anilinu (angliavandenių rišiklio aptikimas), sudano juodu (aliejinio rišiklio aptikimas), amido juodu (baltymų rišiklio aptikimas), ninhidrinu (baltymų rišiklio aptikimas) ir muilinimo reakcija (aliejinio rišiklio aptikimas). Siekiant nustatyti auksavimo būdus ir technologijas, atlikta FT-IR analizė ir mikrocheminė reakcija su koncentruota azoto rūgštimi (V) ir *aqua regia* (koncentruotos druskos ir azoto rūgšties mišinys tūrio santykiu trys su vienu).

Šis objektas nagrinėjamas Agatos Ogińskos meno kūrinių konservavimo ir restauravimo krypties magistro darbe, specializacija – architektūra ir skulptūra. Mokslinis vadovas – Torunės Mikalojaus Koperniko universiteto profesorius Piotras Niemcewiczius.