Scientific insights and ethical considerations in the treatment of a rare 17th-century aigrette

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Abstract

This paper examines a rare early 17th-century aigrette donated to the Rijksmuseum in 2021. This piece, believed to be of Eastern European origin, is decorated with gold, enamel, gemstones, and pearls, was extensively restored. X-ray computed microtomography (µCT) uncovered details about the construction and previous repairs. The ethical considerations were numerous, and the outcome of the scientific analyses shaped the treatment process, particularly regarding the structural alterations. The findings underscore the value of combining scientific analysis with conservation expertise to respect both the object's history and aesthetic integrity.

Keywords

X-ray computed microtomography, ethics, aigrette, hat ornament, decision-making, jewellery, enamelled gold

Introduction

In 2021, the Rijksmuseum received a rare piece of early 17th century jewellery: a hat ornament, also known as an aigrette (inv. nr. BK-2021-201) (Figure 1). Hat ornaments originated in Northern Italy and gained popularity across Europe, becoming fashionable around 1600 (Tait 1986, 92; Hackenbroch 1996, 1; Hackenbroch 2015, 29). Aigrettes are a specific type of hat ornament which either holds real feathers, or are made in the shape of jewelled feathers (Newman 1981,14; Hackenbroch 1996, 184). The name aigrette comes from the word *egret*, the French name for white heron, a bird that has a plume of feathers on its head (Newman 1981,14). Aigrettes were worn by both men and women (Figures 2 and 3). Given its substantial size measuring to 12.6 cm in height, this particular aigrette was most likely designed for a man (Awais-Dean 2017, 67). Only a few aigrettes have survived, but from contemporary paintings we know that they came in several shapes and sizes (Tait 1986, 92–93). The decoration of the aigrette suggests that the jewel was made in eastern Europe, maybe Hungary (Falke 1912, 18), around circa 1600–1630.

Figure 1 The front and back of the aigrette before conservation treatment. © Staeske Rebers/Rijksmuseum

This highly decorated piece is composed of various materials, including gold, enamel, gemstones, and pearls, which are common materials used for jewellery from the 16th and 17th century (Wypyski 2001, Van Leeuwen et al. 2014). It consists of two parts; the lower part features a large rectangular sapphire, showing characteristics that indicate a probable Sri Lankan origin (Zwaan 2024), set on a medallion adorned

Figure 2 Portrait of Elizabeth, countess of Kellie (1576–1621) by Paul van Somer, ca. 1619. The countess is wearing an aigrette with both real and stylised feathers on her hat. © Yale Center for British Art, Paul Mellon Collection

Figure 3 Portrait of Floris van Pallandt II, count of Culemborg (1577–1639), by Jan Antonisz. Van Ravensteyn (unknown date). The count is wearing an aigrette on his hat with stylised representations of feathers, comparable to Rijksmuseum aigrette. © Rijksdienst voor het Cultureel Erfgoed

with fruits and flowers, which is surrounded by floral elements, leaves and fruits, executed in brightly coloured opaque and transparent enamels. The top consists of seven stylized feathers, all set with a row of table cut diamonds. The back is no less impressive, as it is ornamented with floral patterns in transparent and opaque enamel. The reverse of the feathers is decorated with alternating black and white opaque enamel. In some areas the enamel is adorned with gold leaf paillons, which are small shaped pure gold emblems that are fused to the enamel (Speel 1998, 112).

This 400-year-old jewel has undergone several extensive repairs and conservation treatments throughout its history (Figure 4). This type of jewellery was normally sewn onto clothing or a hat, and this was likely the case with this aigrette. However, on the reverse of the jewel a frame was added, which presumably once held a hinged pin. Two small tubes from the hinge are still present on the lower part of the mount, while the rest is missing. The frame does not seem original as it differs significantly from the other parts of the aigrette in terms of style and manufacturing technique. Much of the fastening of the frame was obscured by a dark waxy substance, probably beeswax (analyses with an ALPHA Bruker, portable ER-FTIR with a spectral range from 400 to 7000 cm^{-1}), making it unclear how the frame was attached.

On the reverse of the central 'feather', about halfway up, a silver repair is present, which is now heavily tarnished. This 'sleeve' was mechanically fastened by bending the silver sheet along the edges towards the front. It is not clear why it was added or whether any original 17th century enamel is still present behind it, or, if so, what condition it is in.

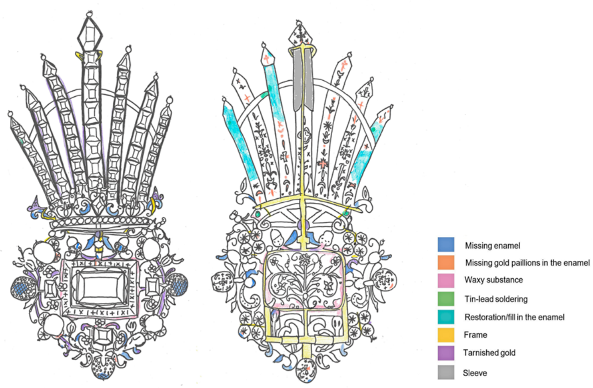

Figure 4 Line drawing of the back and front of the aigrette with a mapping of damages and repairs. © Ellen van Bork-Koopmans/Rijksmuseum

The gemstones used, now diamonds and a large sapphire, are all set in rectangular bezel settings. The edges of the settings around the gemstones are severely damaged, suggesting that

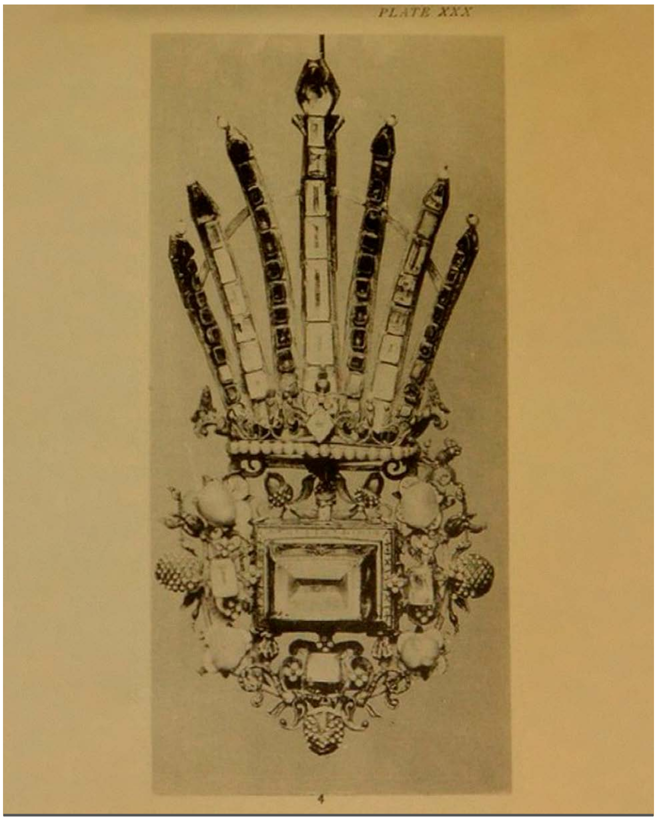

Figure 5 The first known image of the aigrette in the 1908. Note the alternating colours of the gemstones in the feather, and the cut of the central stone that differs from the cut of the current sapphire. The frame and sleeve are already present

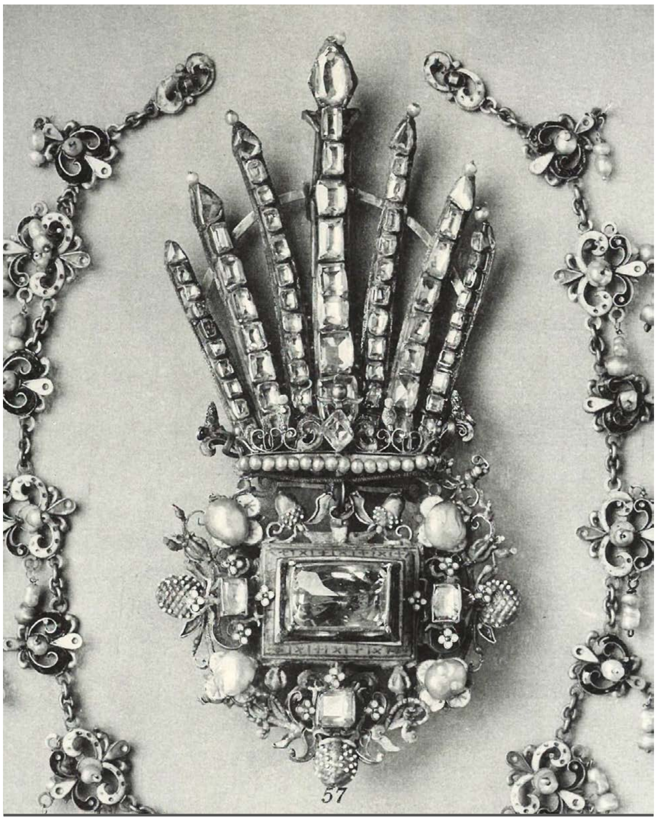

Figure 6 This image from a 1912 publication shows the aigrette set with ill fitting diamonds in the feathers and the central stone is now a sapphire

they were opened in the past. Archival research confirms that the gemstones were replaced on at least one occasion sometime between 1906 and 1912. The first mention of the aigrette is in an exhibition catalogue from 1906 where it is described as [..] '*a large feathered aigrette. Gold with coloured enamel, pearl decoration and rich gemstone setting* (Hermann 1906, 78). A 1908 publication includes the earliest known image of the aigrette where the gemstones on the feathers are in alternating colours, just like the enamel on the reverse, and the central stone is an emerald (Figure 5). It is described as: '*Enamelled gold aigrette set with emeralds, pearls, etc.*' (Clifford Smith 1908, 230–231). A 1912 publication shows the same piece (Figure 6) but with ill-fitting diamonds, a large central sapphire, and displaying the heavily damaged settings. It describes the aigrette as follows: '*Hat ornament (aigrette) made of precious stones, enamelled gold and pearls. [..] Each stripe is set with 8 to 12 table-cut diamonds at the front and enamelled white or black with fine recessed gold ornaments at the back. In the centre of the lower part rests a large rectangular faceted dark blue sapphire in a high box* [..].' (Falke 1912, 17). Note that the frame and sleeve were already present in the 1908 publication, proving that the aigrette has undergone at least two major repairs or conservation treatments throughout its history.

Qualitative non-destructive chemical analyses of five colours of opaque enamel was carried out, using a Bruker ARTAX-2.0 X-ray fluorescence system, confirming that the enamel composition aligns with that used in the 17th century. The condition of the original enamel varies significantly across the object. For instance, the enamel on the reverse side of the 'feathers' is heavily damaged and extensively restored, particularly the white enamel, whereas the floral ornaments on the central part of the back are almost completely intact. There are also numerous cracks in the enamel in these damaged areas. The restorations made to the white enamel have deteriorated and become unsightly; they have yellowed and the surface is uneven. They are clearly visible to the naked eye, but a UV-image provides a better indication of where the restorations are located (Figure 7). Tin-lead solder is present underneath the old enamel restorations suggesting that the aigrette was dropped upside down at some point, heavily damaging the 'feathers'. On the front, the enamel on the pinecone motifs is particularly damaged, and some 'cells' are completely empty, where they were once filled with enamel. Additionally, much of the gold paillon inlays within the enamel is missing in various sections on both the front and reverse.

The diamonds on the front typically show variable reactions under UV, from no reaction to very strong, in various colours, but predominantly blue to white. The sapphire shows an

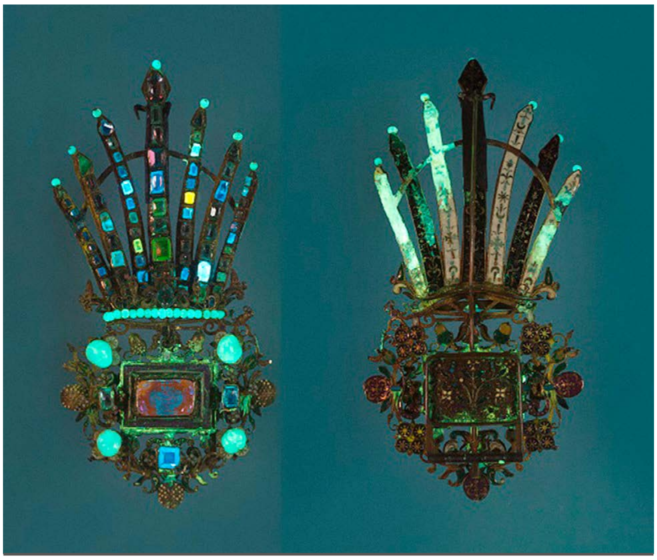

Figure 7 UV-image of the front and back of the aigrette. It shows the fluorescence of the repairs in the enamel, the waxy substance, the various reactions of the diamonds and the apricot fluorescence of the central sapphire. © Albertine Dijkema/ Rijksmuseum

'apricot' fluorescence, which is typical for sapphire from Sri Lanka, whereas most sapphires are inert under UV (Figure 7).

Treatment protocol and ethical considerations

The aim of this project was to get a better understanding of the manufacturing techniques, the conservation history of the object, and to get closer to the original appearance, whilst respecting the history of the object. The repairs and adjustments to the piece tell a story about its history, value, and appreciation. The fact that this object was repaired and refitted shows that it was valued throughout its existence. If this had not been the case, the aigrette would most likely have been dismantled, and the raw materials used separately. A repair or restoration can thus hold its own intrinsic value (Bede 2013). These previous alterations were carried out with great precision, and for several reasons: to change the function from a hat ornament to a brooch, to repair various types of damage, for aesthetic reasons, and for financial reasons, such as the replacement of valuable original gemstones for less costly ones. The decision to remove or retain a repair must therefore be carefully considered, with various factors playing a role, such as the physical consequences or damage that may occur when old repairs are removed, the intention behind the previous repair (Bede 2013), or aesthetic outcomes, which can be either positive or negative (Bede 2013).

The most significant question in this case was whether to remove or retain the added frame and silver sleeve. Aesthetically, the addition and repair are somewhat distracting, but this is countered by the argument that removing them could be difficult and might potentially cause damage to the original material, and that they tell part of the story of the object. The primary questions that needed answering to support the decision-making process, was how the frame was attached and whether original enamel was still hidden beneath the sleeve. To make an informed decision about the sleeve, more information was needed, because if original 17th-century enamel were concealed there, this would be the strongest argument for its removal.

Technical research

X-ray computed microtomography

Introduction

X-ray computed microtomography (μCT) scanning is an innovative technique which is increasingly used within cultural heritage to obtain information about an object, such as its manufacturing techniques or internal structure (Appelbaum 2007, 43; Dorscheid et al. 2022; Bossema et al. 2023). This absorption-based technique is particularly suitable for this object as it can differentiate between the density of different materials, in this case gold and enamel. It provides a greyscale 3D image that can be virtually sliced open to expose the different layers of an object (Bossema et al. 2023). The aim of the research with μCT was to determine why the sleeve was added and whether original enamel was still present underneath the silver sleeve.

Method

Microtomography measurements were conducted at Naturalis Biodiversity Center in an attempt to visualise the materials present underneath the sleeve. Objects can be placed in a large sample chamber, with a recommended maximum solid sample thickness of 100 mm (maximum scanning area 100 × 100 × 100 mm). The aigrette was kept in an upright position in a soft Ethafoam mount. Imaging was performed on a Zeiss Xradia 520 Versa, equipped with a 160 kV micro focus X-ray source, with maximum 10 W. Due to a unique setup of scintillator and 16-bit CCD 2024 × 2024 pixel camera, magnification is achieved by a two-stage technique, including a microscope objective system, with 0.4×, 4× and 20× objectives. This enables a beam path through the sample with very little divergence, which allows large working distance at high resolutions. For the imaging, the 0.4× objective was used, with spatial resolution of 20 μm.

A series of tests were run to define the ideal parameters for the highest contrast between the different phases present in the aigrette. X-rays were generated with 160 kV accelerating voltage and 62.5 μA target current (maximum power of 10 W). The beam was prefiltered by a 2.5

mm thick copper plate, to reduce beam hardening effects. To obtain 3D imagery of the whole ornament, complete scans of four slightly overlapping segments in a row were performed. These segments were scanned with a full 360° sample rotation (0.225 increment) and an exposure time of 14 seconds per frame, generating 1601 exposures for each segment. For a pixel size of 45.5 µm, the scan time was six hours and ten minutes; the total scan time of the four segments was then 24 hours and 40 minutes.

Reconstruction was performed with Scout-and-Scan Control System Reconstructor, on a PC, with a 64-bit operating system, including two 2.2 GHz processors. The Reconstructor side panel was used to prepare a raw tomography dataset (.txrm file) for reconstructions. Then, during the reconstruction process, a .txm file is produced, which can be viewed and analyzed with a TXM3DViewer of Zeiss. A full dataset typically was 3.3 Gb per segment, for four segments in total 13.2 Gb. Reconstructions took about two hours in total, and subsequently, the four segments were stitched together (normal stitch, one column of four segments). Movies and still images were made, under different angles, including cross-sections of levels of interest in the aigrette.

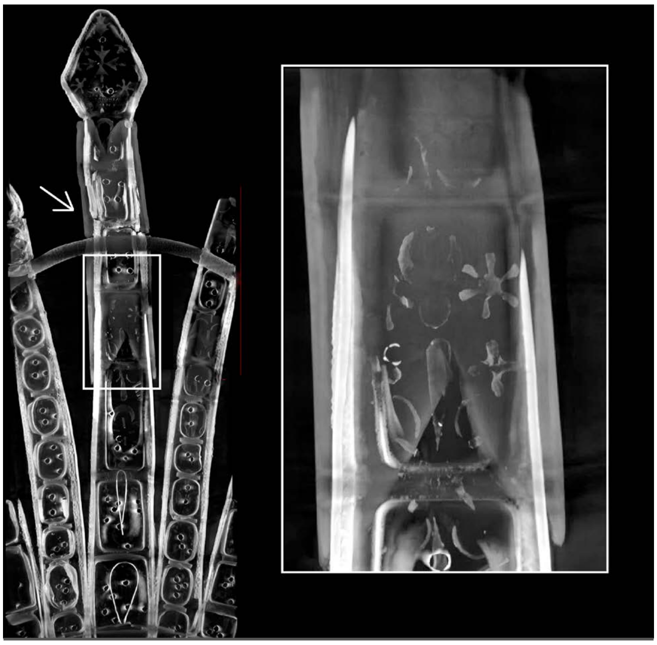

Figure 8 µCT-image of the aigrette with an overview of the central feather (left) and a detail (right). The gold paillions are clearly visible underneath the silver sleeve. The arrow indicates the crack. The drill holes, with an unknown purpose, are visible throughout the feathers. © Naturalis Biodiversity Center

Results

The scans revealed the reason the sleeve was added in the first place; a large crack or break is present throughout the top part of the feather, and the sleeve was added to attach the top, that had broken off, to the feather (Figures 8 and 9). It also showed that much of the original enamel was still present underneath the repair. The gold paillions that were fused into the enamel were clearly visible. From the scan it was estimated that at least half of the original enamel was still present.

An unexpected find was small drill holes located in the layer of gold between the enamel and bezel settings. The purpose of these holes remains unknown, but they may have been added to relieve tension from the gold, to save gold, to release trapped air or moisture or to give more grip to the enamel on the gold, of which the latter sounds most plausible.

Final treatment

The wax obscuring the fastening was mostly mechanically removed, and the last remnants were cleared using Shellsol D. Notably, the mount was entirely mechanically attached to the jewel with small prongs to clamp it securely. The fact that it was only mechanically fastened, and not with e.g. solder, was a strong argument for its removal, as this could be done without damaging original material. The frame was therefore removed by gently opening the prongs under a magnification (Leica M70 binocular), with a variety of tools such as small pliers and dentist instruments. The prongs could easily be bent open, as they were probably annealed before they were bent onto the aigrette, remaining pliable. Once all the prongs were opened, the frame could be carefully lifted from the aigrette, without damaging the original material (Figure 9).

The information gained from the µCT was crucial in the decision making regarding the sleeve. Though it was originally added as a repair it was deemed safe to remove the silver sleeve to reveal the beautiful original enamel. With a small fine file, the silver was filed down on one edge, until it became so thin that it could be peeled off, without touching any original material. The sleeve could then be gently removed, revealing a break that was through and through, and the original 17th-century enamel (Figure 9).

The filling material used for the severely damaged white enamel was unoriginal, and it had aged and yellowed over time. They were therefore mechanically removed under magnification with a scalpel and dentist tools. This revealed that much tin-lead solder was present underneath the fills. This was left in place, as it ensured the structural strengths of the feathers. Using a small brush, the cracked and loose enamel was consolidated with 5 wt% Paraloid B72 in 9 parts acetone/1 part ethanol. Subsequently, the

Figure 9 The reverse of the aigrette during conservation treatment. The frame and sleeve were removed, revealing the original enamel and the break of the top of the central feather. © Rijksmuseum

Figure 10 The front and back of the aigrette after conservation treatment. The frame and sleeve are removed, the old restorations to the enamel have been removed, and the lacunas were filled and retouched. © Albertine Dijkema/Rijksmuseum

lacunas were filled with a variety of materials such as Modostuc, acrylic paint, and Paraloid B72, to mimic the enamel while acknowledging the restoration material's addition, covering most of the tin-lead solder repairs (Figure 10). The conservation treatment of the aigrette was more elaborate than described above. A full conservation and scientific research report can be provided upon request.

Discussion

The most invasive treatment options considered were the removal of the frame, the sleeve, and the replacement of the gemstones. In all cases, the original appearance of the aigrette was known. Ultimately, only the sleeve and frame were removed. The decision to remove the frame and not replace the gemstones with alternating dark and light-coloured ones was more straightforward than the decision regarding the sleeve. Removing the frame was deemed acceptable because it could be detached without causing damage, and both the sleeve and frame were identified as later additions. In contrast, replacing the gemstones would have involved altering the original material, which strongly influenced the decision to exclude this option from the treatment protocol.

A crucial factor in the decision to remove the sleeve was the information obtained from the μCT scan. Without this detailed structural insight, the sleeve might not have been removed. Why remove a well-executed repair and undertake a high-risk conservation treatment if no original enamel remained beneath? The μCT scan provided evidence of underlying original material, justifying the removal of the sleeve as part of the conservation process, relying on the tacit knowledge and skills of the conservator (Otero 2024).

It comes as no surprise that the decision-making based on the structural condition of the aigrette proved more challenging than decisions driven by aesthetic considerations, such as the removal and replacement of the restorations to the enamel. This difference was largely due to concerns about reversibility. Aesthetic treatments, often being reversible, could be undone in the future, while structural interventions were permanent. Interestingly, both types of treatments significantly influence the appearance of the piece. This underscores the prioritisation of structural integrity and the minimisation of potential damage to the object when designing a treatment protocol.

A guiding principle throughout the conservation process was to restore the jewel closer to its original appearance. While previous repairs and restorations tell their own story, they also obscured the original craftsmanship and aesthetic of the piece. By justifying and documenting each step of the decision-making process, scientific research and conservation treatment, the history of the object is preserved (Appelbaum 2007, 387).

Conclusion

The ethical considerations involved in the conservation treatment of this magnificent piece were numerous. The understanding that the conservation treatment would once again modify the object's history was outweighed by the value placed on bringing it closer to its original appearance. The use of μCT analysis was pivotal in the decision-making process, providing the conservator with the confidence to undertake extensive and invasive treatment safely, bringing the aigrette closer to its former glory, peeling back layers that had obscured its authentic appearance and reflecting the maker's original intention.

Scientific analyses not only informed the decision-making process but also enhanced understanding of the manufacturing techniques and materials used in both during manufacturing and subsequent conservation treatments. Combining archival research, scientific analysis, and hands-on examination have given a better understanding of the full history of this object. This holistic approach ensures that the story of this extraordinary piece is preserved for future generations, and museum visitors can now fully appreciate the exceptional quality of this unique piece of 17th-century jewellery.

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Ellen van Bork-Koopmans initially trained as a gold and silversmith. After a year of museum studies, she specialized in metal conservation at the Cultural Heritage Agency (RCE) in Amsterdam, from which she graduated in 2009. She worked as a metal conservator for the British Museum in London, as a lecturer and coordinator for the Metal Conservation and Restoration course at the University of Amsterdam, and founded her metal conservation studio. She subsequently returned to the Rijksmuseum, where her main focus is on (gilded) silver and jewellery, their manufacturing techniques, the associated deterioration processes and novel treatment options.

Hanco Zwaan joined Naturalis Biodiversity Center, Leiden, the Netherlands, in 1995, as curator of minerals and gems, and became head of the Netherlands Gem Laboratory soon thereafter. He has a PhD from Free University of Amsterdam on Geology, specialising on the formation of emeralds. Apart from this focus on emeralds, he published articles on a variety of other gemmological and mineralogical topics, among which on copper-bearing tourmaline, sapphire, diamond and pearls. He is involved in teaching gemmology, in association with Gem-A, London, and is also involved in education leading to the European Gemmology diploma (FEEG). He is currently president of the World Jewellery Confederation (CIBJO) Gemmological Commission, dealing with nomenclature issues and laboratory best practices.

Dirk van der Marel has been with the Naturalis Biodiversity Center since 1990, where he primarily focuses on geological research within the laboratory. Additionally, he supports studies in the biological sciences. He brings extensive experience from his work with the Netherlands Gem Laboratory, a division of Naturalis, where he has applied advanced analytical techniques such as UV-VIS spectroscopy, FTIR, ED-XRF (including micro-spot X-ray analysis and mapping), and both 2D and 3D X-ray imaging, among others. His most recent specialisation involves operating the XRADIA Versa 520 micro-CT scanner, providing comprehensive support for both internal and external research initiatives.

Suzanne van Leeuwen works as a curator and conservator of jewellery at the Rijksmuseum in Amsterdam since 2014. She completed most of her education at the University of Amsterdam, where she initially studied Art History before switching to Classical Archaeology. She then pursued a programme in conservation and restoration of cultural heritage, specialising in metal and jewellery. She further qualified as a gemmologist at Netherlands Gem Laboratory (NEL) and is now a Fellow of the Gemmological Association of Great Britain (FGA). In her work, van Leeuwen combines art-historical and archival research with material-technical research, to study the Rijksmuseum's jewellery collection.

Materials list

- Modostuc white and ebano (Labshop)
- Paraloid B72 (Labshop)
- Golden Varnish acrylic paint (Van Beek Art Supplies)
- Araldite 2020 (Labshop)
- Galdehydharzlösung (Kremer Pigmente)