MA Thesis – Research into the Degradation of the Elements Inside the Cages of Two Birdcage Vases

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Summaries

English

Research into the Degradation of the Elements Inside the Cages of Two Birdcage Vases

For this master's thesis the degradation of the elements inside the cages of two 18th century Japanese birdcage vases owned by Stiltestichting Landgoed den Bosch was examined in depth in order to answer the research question: '*What aspects of the composition and construction of the mounted porcelain birds inside the cages have resulted in their detachment and damage?'* This research question was formulated in response to the poor condition of one of the pheasants and perches. Damages and old restorations are present on the porcelain upper body and metal leg of this bird and its perch has separated from the inner wall of the birdcage.

Literature and archival research were undertaken to better understand the history of these two vases as well as the context of this type of object more generally. The condition of the two porcelain vases and their birdcages was examined using visual analysis and UV imaging, and a variety of experts was consulted, including conservators who have previously worked with this type of object, art-historians with an in-depth knowledge of Asian porcelain, and an expert on urushi lacquer. The construction and condition of the elements of these two vases were compared to those of birdcage vases in other collections to determine in how far the elements and degradation patterns are consistent between the different examples of this type of object.

The cracking and lifting of the decoration on the inner wall of the cage as well as the detachment of the large branch element that supports the porcelain pheasants were determined to be common issues for this type of object and the combination of urushi lacquer and porcelain was identified as a conservation problem as the adhesion of urushi lacquer to porcelain is known to be poor.

To determine whether the inner wall decoration was indeed created using urushi lacquer and gain further insight into the structure of its layers, determine the extent of the restorations carried out on the different elements, and identify other potentially vulnerable components a combination of SEM-EDX, XRD, and Py-GC/MS analysis was used to examine the morphology and layer structure of samples taken from various areas in the cage and identify both the inorganic and organic components in the porcelain pheasants, their legs, their perches and the lacquer decoration on the inner wall.

Results of these analyses suggest the presence of filling materials and restoration paints on the perches and of filling materials and restoration paints and glues on one of the porcelain pheasants. The inner wall decoration was shown to contain Japanese urushi lacquer on a clay mineral containing ground layer and the branch was shown to have been fixed to the lacquered wall using an animal glue.

Knowing more about the materials that were used in its manufacture has been helpful in identifying the vulnerabilities of this type of object and may be useful for future decision-making surrounding their conservation and restoration.

Dutch

Onderzoek naar de Degradatie van de Elementen in de Kooien van Twee Vogelkooivazen

In deze scriptie wordt de degradatie van de elementen in de kooien van twee 18e-eeuwse Japanese vogelkooivazen uit de collectie van Stiltestichting Landgoed den Bosch in detail onderzocht om de volgende onderzoeksvraag te beantwoorden: *'Welke aspecten van de compositie en constructie van de gemonteerde porseleinen vogels in de kooien hebben tot hun onthechting en schade geleid?'* Deze onderzoeksvraag is geformuleerd naar aanleiding van de slechte conditie van één van de porseleinen fazanten en takken die zich in de kooien bevinden. Beschadigingen en oude restauraties zijn zichtbaar op het porseleinen lichaam en het metalen pootje van de vogel en de tak is losgekomen van de binnenzijde van de kooi.

De literatuur en archieven zijn doorzocht om een beter beeld te krijgen van de geschiedenis van deze vazen en de bredere context van dit type object. De conditie van de twee vazen en hun kooien is door middel van visuele analyse en UV-fotografie onderzocht, en een verscheidenheid aan experts is geraadpleegd, waaronder restauratoren die eerder met dit type object gewerkt hebben, kunsthistorici met een diepgaande kennis van Aziatisch porselein, en een expert op het gebied van urushilak. De constructie en conditie van de elementen is vergeleken met die van vogelkooivazen in andere collecties om vast te stellen of de elementen en het schadepatroon consistent voorkomen op dit type object.

Het is gebleken dat het scheuren en loskomen van de decoratie op de binnenste wand van de kooi en het loskomen van de takken veelvuldig voorkomt bij dit type object en de combinatie van urushilak en porselein is een bekend probleem gebleken binnen de restauratie van dit type objecten door de slechte hechting van lak aan porselein.

Om vast te stellen of de decoratie op de wand van de kooi inderdaad met urushilak vervaardigd is, meer te weten te komen over de lagen in de decoratie, vast te stellen in hoeverre de elementen gerestaureerd zijn, en vast te stellen in hoeverre er verdere kwetsbaarheden zijn is een combinatie van SEM-EDX, XRD en Py-GC/MS gebruikt om de morfologie en structuur van monsters genomen van verschillende delen van de kooi te onderzoeken en de anorganische en organische componenten die deel uit maken van de porseleinen fazanten, hun metalen poten, de houten takken, en de lakdecoratie te identificeren.

Resultaten van deze analyses laten zien dat er vulmaterialen en restauratieverven aanwezig zijn op de takken en dat de decoratie op de wand Japanse urushilak op een grondlaag met kleimineralen bevat. Ook is gebleken dat de tak met dierlijke lijm vastgezet is geweest.

De opgedane kennis over de materialen die gebruikt zijn in de vervaardiging van de kooien van deze vogelkooivazen heeft informatie opgeleverd die heeft geholpen bij het vaststellen van de kwetsbaarheden van dit type object. Dit kan in de toekomst helpen bij het nemen van beslissingen omtrent hun conservering en restauratie.

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Cover Image: Author

Br. 144,
Photograph:
Author

1 Introduction

This master's thesis, written for a Master's in the Conservation and Restoration of Cultural Heritage at the University of Amsterdam specializing in Glass and Ceramics, will give a diagnostic overview of a conservation issue presented by a pair of porcelain birdcage vases owned by Stiltestichting Landgoed den Bosch that have been in the storage of Museum Arnhem since 2004 (Inventory numbers Br. 144 & Br. 145). The two birdcage vases exhibit a number of conservation issues that might be investigated in more depth, including the loss of material from the four golden, textured lacquered panels that adorn each vase, questions of authenticity and significance surrounding the ornate metal handles that set this particular pair apart from all other examples of birdcage vases found so far, and the detachment of one of the bird-perch constructions that serve as the centerpieces of the intricately decorated gilded birdcages that encircle the middle of these large vases. Because the scope of this thesis is limited, and the amount of materials used to create these vases is quite large, this research has focused on the causes of the condition and damage inside the cages, notably the porcelain birds, their perches, and a branch that has detached from the porcelain vase. An analysis of the construction, condition, and stability will provide information that will aid the conservation and preservation decision-making for these vases as well as the preservation of other vases of this type. The reason why this focus was chosen over others is that the gilded panels have recently been the subject of an in-depth investigation by the Porzellansammlung of the SKD[1] in 2017[2] and to narrow down the research to topics more closely related to glass and ceramics. The main research question is: *'what aspects of the composition and construction of the mounted porcelain birds inside the cages have resulted in their detachment and damage?'*.

To answer this question the construction and condition of these two vases and of similar objects in other collections were examined and the vulnerabilities of the materials used in their construction were investigated. This was done by examining the literature that currently exists on the topic, through visual and microscopic examination of the materials, by consulting others who have worked with these objects or know more about the materials, and by carrying out relevant instrumental

[1] Staatliche Kunstsammlungen Dresden

[2] Staatliche Kunstsammlungen Dresden, Porzellansammlung & Independent Administrative Institution National Institutes for Cultural Heritage Tokyo National Research Institute for Cultural Properties, *The Report on the Cooperative Program for the Research of a Japanese Art Object in the Dresden State Art Collections, Porcelain Collection - The Birdcage Vase- (ドレスデン国立美術館陶磁器資料館所蔵の日本美術品共同研究事業報告書染付桂絵鳥籠装飾広口大瓶 一 The Birdcage Vase 一)*

analysis with the aid of the RCE.[3] Samples were taken where possible and examined using SEM-EDX to learn more about their morphology, layer structure (where applicable) and the composition of inorganic materials present in them, using XRD to identify crystalline materials, and using GC-MS to gain insight into the composition of the organic materials present. This has provided important information about the birdcage vases that will help conservators and owners make informed decisions to protect the condition of their collections. The thesis will give a brief overview of the (art-historical) background of these and of similar vases, their provenance and condition, previous research on topics relating to the degradation of such vases, and the instrumental analysis that was carried out.

[3] Rijksdienst voor het Cultureel Erfgoed (Dutch Cultural Heritage Agency)

2 History and Context

2.1 Porcelain & Lacquer

To understand the significance and context of the birdcage vases it is important to understand their background, starting with the collection of East Asian porcelain in Europe in the 17th and early 18th century. True porcelain[4] was not successfully manufactured in the West before the early 18th century and was an exotic material in high demand. Trading companies such as the Dutch East India Company (VOC) brought millions of pieces of Asian porcelain to Europe over the course of the 17th century.[5] While at first the wares imported were primarily Chinese, wars of succession[6] and pirating[7] complicated European-Chinese trade and made trading companies turn to Japan for more supplies.[8] While the Japanese initially traded with Portugal, they entered an exclusive trade deal with the Dutch in the mid-17th century to limit their interaction with the Western world and its religion. Although porcelain was initially scarce and reserved only for the wealthy, porcelain wares gradually changed into fashionable commodities that were collected and displayed in Europe on a large scale.[9] At the height of porcelain's popularity the appreciation and demand for porcelain culminated into the development of the so called 'porcelain cabinets' or 'porcelain rooms' among the nobility and royalty, rooms fully dedicated to the display of luxurious porcelain wares of every kind. Such rooms were often but not exclusively designed and decorated by royal women.[10] These collections of porcelain did not only serve as showcases of expert craftsmanship and beauty, but also served as markers of nobility, celebrating economic and political power.[11]

[4] Also known as hard-paste porcelain, true porcelain contains around 50% kaolin, 25% feldspar and 25% quartz or flint and is fired to up to 1400 ℃ unlike soft-paste porcelain, which contains more flux and is fired at lower temperatures leading to slight porosity and a more brittle body. (Buys and Oakley, *The Conservation and Restoration of Ceramics*, 16)
[5] Volker, *Porcelain and the Dutch East India Company*
[6] Alayrac-Fielding, *From the Curious to the 'artinatural': the Meaning of Oriental Porcelain in 17th and 18th Century English Interiors*, 2
[7] Chan S., *Foreign Trade, Commercial Policies and the Political Economy of the Song and Ming Dynasties of China,* 70
[8] Alayrac-Fielding, *From the Curious to the 'artinatural': the Meaning of Oriental Porcelain in 17th and 18th Century English Interiors*, 2
[9] Gerritsen and McDowall, *Material Culture and the Other: European Encounters with Chinese Porcelain, ca. 1650-1800,* 88
[10] Bischoff, *Women Collectors and the Rise of the Porcelain* Cabinet
[11] Ströber, *Representation and Taste in Baroque Court Culture: The Porcelain Collection of Augustus the Strong*

Similarly, the West developed a large interest in Japanese lacquerware over the course of the 17th century. Even more rare and expensive than porcelain, lacquerware, created with the sap of certain trees of the *Anacardiaceae* family unique to Asia[12], was valued very highly and was typically only accessible to royals and aristocrats.[13] While the West attempted to produce lacquerware of its own, the difficulty of transporting the raw and toxic materials needed for lacquering and the subsequent necessity of using other types of resins native to Europe meant that Western lacquerware or *japanned* ware, while popular and valued, could still not quite match authentic Asian lacquerware, with Japanese lacquerware or *urushi* in particular being considered to be of the highest quality and value.[14] In the 17th century lacquer rooms were similarly put together for the purpose of showing off significant collections of lacquered objects, and lacquerware was sometimes displayed alongside porcelain in luxurious displays of 'Asian' art.[15]

While lacquer was usually applied to substrates made out of wood and sometimes to substrates made out of bamboo, textiles, paper, leather or metals[16], the demand for both lacquer and porcelain led to the application of lacquer to porcelain substrates in a very limited amount of wares for the export market. This combination of porcelain and lacquer is not well-known and was generally reserved for wares to be displayed in elaborate baroque palaces.[17] Despite the limited number of urushi-lacquered porcelain wares in existence, the Porzellansammlung of the SKD in Dresden has a sizable collection, owning no less than 63 lacquered Imari vases in 2017[18]. Sadly, these are generally in very poor condition, and this is explained by the natural tendency of urushi to expand and contract in response to changing atmospheric conditions, which makes it a poor fit for the porcelain as this remains unaffected by such changes. Because of their degradation, the vases are mostly kept in storage.[19] Issues associated with the combination of lacquer and porcelain pose a conservation challenge that was described as far back as the 18th century, as inventories from Dresden around that time already mention damages and the detachment of decorative layers more specifically.[20]

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[12] Honda, *Analyses of the Kawari-nuri (Urushi Coatings Decorated with Various Materials) Parts of the Birdcage Vase,* 92
[13] Kleutghen*, Imports and Imitations: The Taste for Japanese Lacquer in Eighteenth-Century China and France*, 176
[14] Jörg, *Japanese Export Lacquer for the Dutch Market* , 43
[15] Bischoff, *Women Collectors and the Rise of the Porcelain* Cabinet, 173
[16] Lambooy, *Lacquer on Japanese Porcelain; a Case Study of Two Imari Vases with Urushi Lacquer Decoration from the Collection of the Rijksmuseum Amsterdam,* 1075
[17] Lambooy, *Lacquer on Japanese Porcelain; a Case Study of Two Imari Vases with Urushi Lacquer Decoration from the Collection of the Rijksmuseum Amsterdam,* 1075
[18] Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 66
[19] Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 66
[20] Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 66

2.2 Birdcage Vases

The birdcage vases are one such type of object combining Arita porcelain and urushi, being extravagant 'Asian' wares exported for the Western market at the start of the 18th century. These birdcage vases were brought to Europe and were mainly purchased by Augustus II the Strong[21] for prominent display in his 'Japanisches Palais'[22] in Dresden, a palace that was supposed to house his extravagant collection of some 24,000 porcelain objects.[23] Historical floor plans and inventories suggest at least 20 birdcage vases were purchased for this purpose[24] and another 50 imitation birdcage vases were commissioned from the Meissen Manufactory around 1730.[25] It would seem as though the Meissen Manufactory, however, was unable to fulfil this order and supplied only a very limited number of these objects. The few examples of Meissen birdcage vases[26] still in the collection of the SKD are of porcelain decorated in different colors and patterns with no urushi decorations and branches made out of porcelain, setting them apart from the Japanese export vases, although a fragment of a Meissen imitation that is said to resemble the Japanese examples quite closely is also kept in their collection.[27] Considering the Japanese policy on foreign trade the Japanese birdcage vases must have been imported by the Dutch East-India Company (VOC) and traded from the Netherlands, and indeed receipts have been found in the Dresden State Archives that detail Augustus the Strong's purchase of 5 birdcage vases from Dutch dealers in Asian art.[28] It is unclear exactly how many of these Japanese birdcage vases were created and imported and how many are currently in existence as it is difficult to tell them apart based on description and several have entered the art trade, or have been lost or destroyed over the centuries. It is possible that further in-depth archival research could lead to more information on this.

[21] Elector of Saxony, King of Poland, and Grand Duke of Lithuania
[22] Japanese palace
[23] Stöber, *Representation and Taste in Baroque Court Culture: the Porcelain Collection of Augustus the Strong*, 55
[24] Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 69
[25] Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 72
[26] Inv. Nr. PE 805, PE 806, PE 807, PE 3715 & PE 3716
[27] Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 72
[28] Simonis, *How to Furnish a Palace. Porcelain Acquisitions in the Netherlands for Augustus the Strong 1716-1718*, 10

3 The Vases

3.1 Description of Vases

The objects that are the focus of this research are a set of two birdcage vases owned by Stiltestichting Landgoed den Bosch and in the custody of Museum Arnhem, inventoried under Br. 144 and Br. 145. Please see Figure 3-1, Figure 3-2, Figure 3-3 and Appendix I – Additional Images of Birdcage Vases Br. 144 & Br. 145 for overview pictures of these objects. The vases are identical in design and have almost the same dimensions (Br. 144 is 50.5 cm in height and Br. 145 is 51.5 cm in height, both are 36 cm at their widest) and are trumpet-shaped of glazed porcelain and adorned with floral motifs and dragons chasing pearls in underglaze cobalt blue. Each of the two vases features four panels, decorated with golden, patterned decorations framed in a black relief. On two of these panels are ornate handles. A metal wire cage encircles the middle of the objects and fixed within these cages are two porcelain pheasants each perched on painted branches made from what is believed to be a wood- or papier mache-like material. The pheasants have painted metal feet and legs. In the branches there are small holes where imitation twigs with porcelain blossoms might previously have been present as observed in similar objects in the collection of the Rijksmuseum and the *Porzellansammlung* of the Staatliche Kunstsammlung Dresden. The inside wall of the cages is decorated with gold and black. Please see Figure 3-4 and Figure 3-5 for overview pictures of the birdcages.

Figure 3-1: Overview picture of Br. 144 & Br. 145. Photograph: Author

Figure 3-2: Overview picture of Br. 144. Photograph: Author

Figure 3-3: Overview picture of Br. 145. Photograph: Author

Figure 3-4: Overview pictures of Birdcage of Br. 144. Photograph: Author

Figure 3-5: Overview pictures of Birdcage of Br. 145. Photograph: Author

3.2 Provenance

The vases are currently in possession of Stiltestichting Landgoed Den Bosch, a legal entity set up by the late Dionysia Wilhelmina Everwijn[29] (Brummen, 1923 – Leuvenheim, 2011) and responsible for the maintenance and protection of her estate including her sizable art collection which consists of a significant amount of her own original work as well as nearly a hundred other collected art objects. These other objects, consisting of primarily porcelain and glass, are on long term loan to Museum Arnhem, including the two birdcage vases.

It is unclear when the vases came to be in the possession of the Everwijn family. It would appear the family had strong links to Dutch nobility and politics. [30] A representative for Stiltestichting Landgoed Den Bosch mentioned it is rumored the vases might be linked to van Oldenbarnevelt and that the family had ties to the royal family.[31] The Dutch key historical figure Johan van Oldenbarnevelt passed away in 1619 and while online databases do suggest a link between the Everwijn and the van Oldenbarnevelt name,[32] no evidence that confirms this information was found. It is possible the vases were indeed handed down through generations, but this has yet to be determined.

Research by Simonis into the background of Dresden's birdcage vases shows that professional Asian art dealers from the Hague served as middlemen in supplying Augustus the Strong with a number of birdcage vases around 1717.[33] Whether the set of birdcage vases to be examined was originally intended for Augustus the Strong or were purchased by a different collector entirely remains unclear. While some birdcage vases feature markings that allow them to be linked to one another in the form of numerical kanji[34] [35] no such identifying markings have been found on the two birdcage vases from Stiltestichting Landgoed den Bosch. It is therefore unclear exactly what the history of the vases is at this point. Perhaps further archival research could shed more light on this.

As the history of these two birdcage vases is still largely unknown, information on the climatic conditions they were kept under is quite limited. The vases have been in the care of Museum Arnhem since 2004 and were kept in the cellar of the Historical Museum in Arnhem until 2014 after which they were moved to a bunker built in WWII

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29 Also known as Denise Everwijn
30 https://www.geldersarchief.nl/onderzoek?trefwoord=everwijn (last accessed28/08/2021)
31 Ruud W Mooij, personal correspondence, 14/04/2021
32 https://www.kloek-genealogie.nl/Venne1.htm (last accessed28/08/2021)
33 Simonis, *How to Furnish a Palace. Porcelain Acquisitions in the Netherlands for Augustus the Strong 1716-1718*, 10
34 Ulbricht, *Historical Background and Design Features of the Birdcage Vase,* 72
35 Isabelle Garachon, personal correspondence 26/05/2021

and now used for storage. Both the building of the Historical Museum and their current storage space are presumed to not have any climate control[36] and were not designed with the storage of art objects in mind. No pictures of or reports on the condition of the vases or their storage conditions exist in the archives of Museum Arnhem,[37] and no relevant information was found in the archive of the Everwijn family.

3.3 Condition and Construction of Elements

The vases consist of a large variety of materials that each bring with them their own conservation challenges. As the contents of the birdcages will be the focus of this research, attention will be paid in particular to the porcelain pheasants, the metal legs that support them, the branches they are perched on, and what is presumed to be a gilded lacquer decoration on the porcelain inner wall of the cage, onto which the bird-perch structures are attached. Before the apparent construction and condition of these elements are individually described in detail, a very concise overview of damages will be given of the other parts of the birdcage vases to put the degradation of the interior of the cages in context.

Overview

The two vases each show damages and significant soiling. The adhesion of the patterned lacquer[38] relief to the unglazed panels is failing and parts of the decorations are missing (See Figure 3-6). Close inspection of the gilded reliefs shows differences in condition between different areas of the same panels, with some areas having more defined textures or showing more degradation than others. This difference in the appearance and condition of the materials might be the consequence of previous treatment(s). The black paint on the frame around the golden panels has flaked off in various areas and retouches appear to be present (See Figure 3-7, Figure 3-9). Very minor retouches are also present on the porcelain. One of the handles of birdcage vase Br. 144 is missing and an old adhesive appears to be present where it was previously situated (See Figure 3-8). The roofs of the cages have small holes and dents in them, and the metal bars of the cages show significant corrosion. Small tears

[36] Joanna Minderop, personal correspondence 17/05/2021
[37] Joanna Minderop, personal correspondence 26/05/2021
[38] In other objects of this type this patterned material has been assumed or proven to be a layer of urushi decorated with other materials. This is also known as 'Kawari-nuri' decoration. (Honda, *Analyses of the Kawari-nuri (Urushi Coatings Decorated with Various Materials) Parts of the Birdcage Vase*, 93

are visible in several areas of the cloud collars that decorate the metal cages. Parts of the black paint on the base of the vases have been lost. (See Figure 3-10)


Figure 3-6: Panel on Br. 145 Showing Significant Degradation of the Golden Decoration. Photograph: Author


Figure 3-7: Flaking Black Border on Br. 144. Photograph: Author


Figure 3-8: Missing Handle and Damages on Top of Cage on Br. 144. Photograph: Author


Figure 3-9: Cracks in Golden Decoration and Flaking of Black Frame of Br. 144, Possible Retouch on Upper Left Corner. Photograph: Author


Figure 3-10: Losses of Paint Visible on Base of Vase Br. 144. Photograph: Author

For more overview pictures see Appendix I – Additional Images of Birdcage Vases Br. 144 & Br. 145. For a short, written overview of and comparison between the porcelain, glaze, textured panels and handles of the two vases see Table 3-1.

Vase	**Br. 144**	**Br. 145**
Porcelain	The porcelain appears to be in good condition	The porcelain appears to be in good condition
Glaze	Glaze in good condition overall, minor retouches visible	Glaze in good condition overall, very minor retouch visible
Gilded Urushi Panels	Significant deterioration of panels. Cracks forming and appliqué crumbling. Differences in condition between panels as well as between areas of the same panel might suggest previous treatment. Black border flaking, losses of decoration. Visible retouches	Significant deterioration of panels. Cracks forming and appliqué crumbling. Differences in condition between panels as well as between areas of the same panel might suggest previous treatment. Black border flaking, losses of decoration. Visible retouches
Handles	Damages on surface handle, one handle missing entirely	Damages on surface of handles

Table 3-1: Overview of Condition of Porcelain, Glaze, Panels and Handles

Porcelain Pheasants

For pictures of the porcelain pheasants please see Figure 3-11 and for overview images and mappings of the condition of the interior of the birdcage vases see Appendix I – Additional Images of Birdcage Vases Br. 144 & Br. 145 and Appendix II – Condition Mappings of Cages respectively.

The porcelain pheasants appear to be made out of white hard-paste porcelain or 'true' porcelain and seem to be identical between the two vases in terms of shape and design. They each have glaze layers with detailed polychrome decorations. Both of the vases feature one noticeably more slender pheasant with a monochromous black head, breast, and underside, and white wings and tail painted with tan and dark brown colors to mimic feathers. The eyes of these dark birds are encircled in red and they have yellow beaks and eyes with small details added in black. The other pheasant present in both of the two cages has a head, breast, and underside decorated with small orange and tan lines suggesting a fine coat of feathers, and wings and a tail painted with orange and brown lines and dots to suggest the larger wing- and tailfeathers. These pheasants also have yellow beaks and eyes with small black details, but the areas around their eyes are dotted with a brown color instead. It is assumed the two pheasants are meant to represent a male and female green pheasant or *Phasianus Versicolor* as depicted in Figure 3-12 and Figure 3-13. The porcelain pheasants and their sides of the cages will be referred to as 'male' and 'female' for

Figure 3-11: Porcelain Pheasants on Br. 144. Photograph: Author

easier comparison. These birds are native to Japan and are traditionally associated with springtime.[39]

Figure 3-12: Male Green Pheasant. Photograph: Wikimedia User Alpsdake (Unaltered image used under CC BY-SA 3.0 licence)

Figure 3-13: Female Green Pheasant. Photograph: Wikimedia User Alpsdake (Unaltered image used under CC BY-SA 3.0 licence)

The tail of the male pheasant of Br. 145 has broken off entirely (See Figure 3-14) , possibly because the entire bird-perch structure has come away from the wall and is unsupported and able to be moved around in the cage, greatly increasing the risk of physical damage when the vase is moved. This tail has been kept separately. It is unclear exactly how well the fit between the two break edges is as a very significant amount of old adhesive is present on the break edges, but it appears as though no ceramic material was lost. Otherwise the glaze layer and ceramic body of each bird appear to be intact in as far as can be observed underneath the thick crust of brown dirt present on their entire surfaces. There seem to be no scratches in the decorations and no cracks or lacunae. Spot cleaning tests were undertaken to have an unobstructed view of the glaze and to determine what techniques were used to decorate the birds and whether the decorations are at risk of detachment. It would appear as though each of the colors are fused to the glaze layer and the dirt can easily and safely be removed by gently using cotton buds with acetone or water. See Figure 3-15 for a photograph of the dirt layer and a cleaning test and Appendix III – Cleaning Tests for a full overview of images taken of these tests.

[39] Christiaan Jörg, personal correspondence 29/03/2021

Figure 3-14: Male Pheasant of Br. 145 Missing
Tail. Photograph: Author

Figure 3-15: Detail of Dirt Layer and Cleaning Test on Female Pheasant
on Br. 144. Photograph: Author

Pheasants' Legs

The porcelain pheasants are each supported by legs made using metal wires, with what is presumed to be gesso, and paint. One side of the metal wires is believed to have been inserted into holes in the porcelain bodies of the pheasants, as observed on other birdcage vases in the porcelain collection of the SKD,[40] [41] and the other side is inserted into a hole in the perch the pheasants are situated on. Where the metal meets the branch, thinner wires have been added to suggest the toes of the pheasants. Where the metal meets the porcelain, a thick, three-dimensional layer of a white plaster-like material has been added and sculpted to suggest the upper leg of the pheasant. The exact composition of this material is unknown and no research into this has been found. The entire legs are covered with a paint layer that matches the color of the pheasant they are part of – black for the male pheasant and red lines on a lighter base for the female pheasants. As all of the pheasants' legs are covered in a thick layer of dirt it is unclear in how far the darkened appearance of the female pheasants' legs can be attributed to dirt and in how far this is the result of material changes caused by the degradation of the original material.

The condition of the legs varies quite significantly between the different birds. The leg closest to the cage of the male pheasant of Br. 145 is in considerably worse condition than most of the other legs. (See Figure 3-16) Almost no paint is present on the metal and large losses are visible on the upper leg. An unidentified brown material can be observed on the upper leg and might have been added as part of a restoration treatment. The metal wire has visibly corroded and is thought to be made of iron. The difference in condition between this pheasant and the others might again be explained by the separation of the bird-perch structure from the inner wall, as this makes it possible for the structure to me moved around, potentially leading to physical damages.

The paint layers on the upper legs of the female bird of Br. 144 appear to have been lost almost entirely (See Figure 3-17). It is unclear what has caused the adhesion between the paint layer and the ground layer to fail. The other legs each show minor losses of paint and corrosion of the metal wires.

[40] Araki and Miyata, *Structural Investigation of the Birdcage Vase Using X-Ray Computed Tomography*, 89
[41] Object PO 5176, "Birdcage Vase." Porzellansammlung. https://skd-online-collection.skd.museum/Details/Index/119944 (last accessed 16/06/2021)

Figure 3-16: Detail of Leg of Male Pheasant of Br. 145. Photograph: Author

Figure 3-17: Detail of Leg of Female Pheasant of Br. 144. Photograph: Author

Branches/Perches

Both pheasants are situated on painted perches secured to the inside wall that hold the pheasants in place. The male pheasants are standing on what appears to be a large wooden branch, while the female pheasants are standing on a smaller perch that is sometimes described as a rock[42 43] but decorated in the same manner as the large branch. A smaller rock is placed next to the female pheasant's perch but appears to serve no structural purpose. Losses of material are visible on each of the pheasants' perches, and wood is visible where the green-brown paint and white ground layer are missing. Again, the extent to which the different branches are damaged varies significantly, with the large branch on the male side of Br. 145 showing most damage as a result of having become separated from the inner wall of the cage. This separation makes it possible to observe the side of the branch normally stuck to the porcelain. Careful examination with a rigid borescope showed the back of the branch to be covered with thin boards of wood, giving the back an even surface. These boards of wood appeared to be coated with a thin layer of darkened resin. The adhesive layer that held the branch to the inner wall was still partially present on top of the coated wooden boards.

Information about the exact nature and composition of the materials used to create the perches has not been found in the literature. Japanese cedar or *sugi* and Japanese cypress or *hinoki* wood were both commonly used types of wood in Japan and might have been used for these perches.[44] The ground layer might again be a gesso. It is unclear what binding medium and pigments were used to paint the branches with.

Figure 3-18: Different Wooden Elements on Br. 144. Photograph: Author

[42] Jörg, *Fine & Curious, Japanese Export Porcelain in Dutch Collectons*, 270
[43] Ohashi, *The Birdcage Vase in Arita Porcelain*, 79
[44] Dave van Gompel, personal correspondence 30/03/2021

Lacquer on Inner Wall of Cage

The entire inner wall of the cage, including the area where the branch was situated, appears to be coated in what is believed to be Asian lacquer or *urushi* lacquer more specifically. This lacquer layer is decorated with black pine and bamboo motifs on a gilded background.[45] The black decorations are flaking off in several areas (See Figure 3-19) and this shows the black to have been applied on top of the gold, which would mean the entire lacquer layer was first gilded before the black was applied (with the exception of the areas where the perches were placed). This was likely done by applying gold powder to the urushi surface after polishing.[46] Lacquer could then be mixed with carbonaceous pigments and potentially with a filling material and be added on top for the pine and bamboo decorations.[47]

The entire decorative layer on the inner walls of the cages of both Br. 144 and Br. 145 is covered with a brown layer of dirt and shows cracks and surface scratches. Significant cracks run all along the bottom and the top of the decorative layer on both cages and flakes of lacquer are curling away from the substrate. The porcelain is visible underneath. The areas around the branches/perches of the pheasants are similarly affected with especially the area around the large branches on the male sides of the cages showing cracking and splitting of the lacquer layer and the detachment of significant areas (See Figure 3-20).The lacquer that previously held the large branch of Br. 145 in place is still present on some areas of the inside wall, while other parts of it are attached to the branch as discussed in the previous section.

[45] Christiaan Jörg, personal correspondence 29/03/2021
[46] Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 33
[47] Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 33

Figure 3-19: Loss of Black Decoration on Inside Wall and Crack Along the Bottom of the Cage of Br. 145. Photograph: Author

Figure 3-20: Lacquer Detaching from the Area Where the Large Branch of Br. 145 Was Previously Situated. Photograph: Author

3.4 Other Birdcage Vases

As part of the recent investigation in Dresden a list of all known Japanese birdcage vases was compiled.[48] This overview lists 17 full-sized vases of which the whereabouts are currently known and mentions several more vases of which descriptions or records have been found but of which the location is currently unclear. The birdcage vases owned by the Kyushu Ceramic Museum in Arita are also briefly touched upon but differ from the examples found in the West slightly in size and design. The two vases under examination are not mentioned in this publication and at the time of publication the author of the overview was not aware that the Stiltestichting had these two vases in their possession.[49]

Other (historical) sources that mention birdcage vases can be found, but it has sadly not proven possible to link the two vases in question to any specific sources, although the descriptions of the birdcages themselves and their materials do differ slightly between different sources. Unfortunately comparing these sources has not led to significant new information as the terminology used is varied and certain descriptions are visual, art-historical perspectives on the appearance of the materials while others are descriptions of the actual materials used in its construction (e.g. ' wood' to describe the perch the bird is situated on vs. ' wood' to describe the material the perch is made out of). A few mentions however stand out from the others. As mentioned in the 2017 publication on birdcage vases by the SKD and TOBUNKEN[50] a historical source by Gustav Friedrich Klemm detailing Augustus II the Strong's porcelain collection makes mention of 'Vases that are surrounded by a framework made out of golden wires, in which tree branches and trunks have been put, on which sit colorfully lacquered guinea fowl and other birds, some made out of wood, some made out of porcelain'.[51] [52] No other sources seem to mention wooden birds or other species of birds besides the green pheasants. in the 2017 publication this is claimed to suggest the Meissen Manufactory has made replacements for the birds after this description was written.[53] This, however, seems unlikely, as only the male and female green pheasant are present on each of the known examples of birdcage vases and this would suggest all these vases were altered by the Meissen Manufactory in Dresden. Another peculiarity is the mention of textile on the inside of the cage of a birdcage vase on the

[48] Ulbricht, *Historical Background and Design Features of the Birdcage* Vase, 71
[49] Heike Ulbricht, personal correspondence 22/02/2021
[50] Ulbricht, *Historical Background and Design Features of the Birdcage* Vase, 70
[51] Vase ist in der Mitte mit einem Stabwerk von vergoldetem Drath umgeben, innerhalb dessen man Baumzweige und Stämme angebracht hat, auf denen theils hölzerne, theils porzellanene Perlhühner u. a. Vögels sitzen, die sämmtlich in Lackfarbe bunt gemalt sind.Translated from German by author.
[52] Klemm, *Die Königlich-Sächsische Porzellan- und Gefässe-Sammlung*. 90 (last accessed 0/06/2021)
[53] Ulbricht, *Historical Background and Design Features of the Birdcage* Vase, 70

website of the Ashmolean Museum in Oxford.[54] It is unclear exactly why and how this textile was applied. As will be discussed in more detail it appears as though the interior of the cage of the vase in the collection of the Ashmolean Museum differs quite significantly from that of all the other birdcage vases known.

To gain a further understanding of the vulnerabilities and elements on the birdcage vases examples of birdcage vases in other collections were investigated. Where possible, the elements and the condition of their birdcages are described in the following sections.

Rijksmuseum, Amsterdam

The Rijksmuseum owns two birdcage vases[55] that were examined in person on multiple occasions. The interior of their cages matches that of the cages on the vases from the Stiltestichting very closely in terms of the placement and decoration of the elements but feature delicate twigs with small porcelain flowers and flower buds alongside the pheasants and their perches (See Figure 3-21). These twigs are inserted into small holes in the branches and rock elements. It is assumed similar decorations were previously present on the two vases from the Stiltestichting, as the perches that are part of these have small holes in the locations where the branches would be. (See

Figure 3-21: Porcelain Flowers Present on Rijksmuseum Birdcage Vase AK-NM-6654-A. Photograph: Author

[54]Object EA1992.144, "Birdcage Vase." Ashmolean. https://collections.ashmolean.org/collection/browse-9148/object/93389 (last accessed 01/06/2021)

[55] Inv. Nr. AK-NM-6554-A and AK-NM-6554-B

Figure 3-22) The flowers are believed to be plum blossoms, completing the 'Three Friends of Winter' motif common in Chinese and Japanese art, with the Three Friends of Winter being bamboo, pine, and plum and symbolizing resilience.[56]

Compared to the wooden perches of Br. 144 and Br. 145 the perches in the cages of the Rijksmuseum vases appear to be in a better condition and more finely painted, featuring dots and lines that suggest the bark of a tree. While each of these perches are attached to the inner wall, closer examination shows the lacquer on this inner wall to be coming away from the substrate around the perches as well as at the top and bottom rim. Gilding is also present on the bottom of the cage, while only very small areas of gilding can be found on the bottom of the cages of the vases from the Stiltestichting.

[56] Christiaan Jörg, personal correspondence 29/03/2021

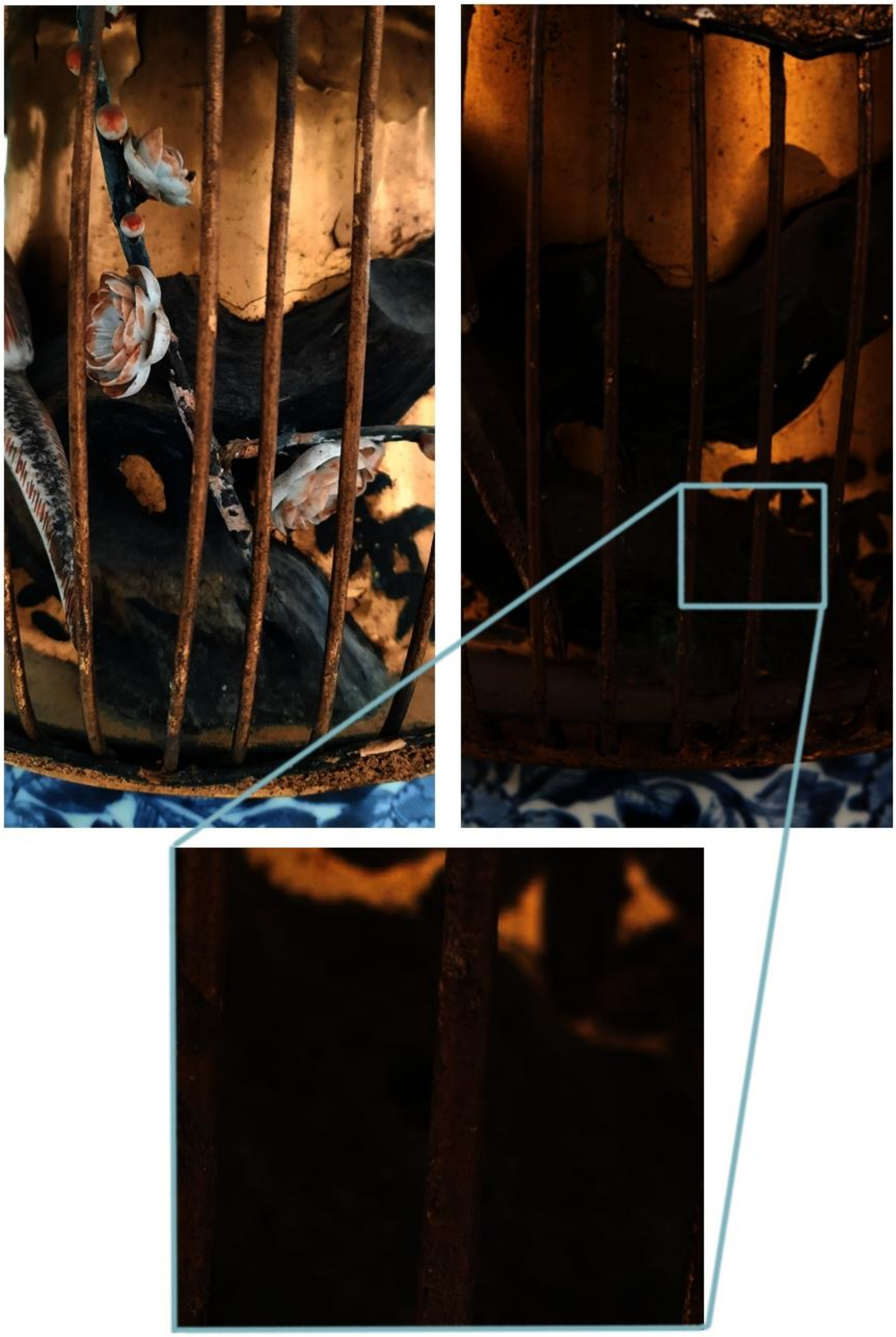

Figure 3-22: Top Left: Detail of Branch on Male Side of Rijksmuseum Vase AK-NM-6554-A. Top Right: Detail of Branch on Male Side of Stiltestichting Vase Br. 144. Bottom: Close-up of Hole in Branch. Image: Author

Staatliche Kunstsammlungen Dresden, Porzellansammlung, Dresden

The Porzellansammlung of the Staatliche Kunstsammlungen Dresden currently contains the largest known collection of birdcage vases, consisting of 9 complete objects.[57] Together with TOBUNKEN[58], the SKD has carried out significant research into the composition of the gilded, textured panels, the restoration of these objects, and their art-historical background. In this section only information related directly to the visible appearance and construction of the elements in the birdcages and their condition will be discussed.

Each of the cages of the nine vases appears to be identical in design to those of the two vases in possession of the Stiltestichting, with the exception of the presence of small imitation twigs adorned with small porcelain flowers and flower buds described as apricot blossoms[59][60] in some of the cages. Where present, these have been stuck in the perches that support the pheasants, adorning the right sides of the bird-perch constructions in a similar manner as those found on the examples from the Rijksmuseum. One of the vases (PO3801) appears to have a more intricate black decoration on the inner wall than the other vases in their collection and the vases from Stiltestichting Landgoed den Bosch, with thin, curving lines having been applied around the bamboo leaf decorations.

The condition of the interior of the birdcages appears to differ quite significantly between the nine vases. The vases are considered to be heavily damaged overall.[61] Most vases show obvious cracking and/or detachment of the lacquer layer on the inner wall to some degree. The extent of damages between these different vases ranges from small cracks and lifting flakes being visible to an estimated 50% of the inner wall decoration missing entirely. One vase of which the birdcage's interior is in particularly poor condition (PO5176) has a female pheasant that is missing its legs entirely, allowing the holes where the metal wires were previously inserted to be observed.

The branches of several of the vases have come away from the wall. As part of the research project birdcage vase PO5178 underwent a full restoration detailed in more detail in the accompanying publication. Here it is noted that the large branch that had detached from the inside wall had deformed significantly and no longer matched the contour of the vase.[62] This points towards the wood having been under a certain degree of tension while fixed in its previous position. Wood is known to warp or

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[57] Objects PO5174, PO5176, PO5177, PO5178, PO5181, PO5182, PO5183, PO5185, and PO3801" Birdcage Vases." Porzellansammlung
[58] Tokyo National Research Institute for Cultural Properties
[59] Yamashita*, Restoration of the Artefact* , 107
[60] Apricots and plums are very closely related and have similar flowers
[61] Yamashita, *Restoration of the Birdcage Vase (Urushi part)*, 98
[62] Yamashita, *Restoration of the Birdcage Vase (Urushi part)*, 99

deform in situations where moisture cannot be transferred to and from the air evenly on each side.[63]

The Peabody Essex Museum, Salem, Massachusetts, USA

The Peabody Essex Museum has one birdcage vase in their collection[64], the condition of which has been investigated in 2002 and again in 2018. Reports show the same pattern of degradation as found on the vases from Stiltestichting Landgoed den Bosch, including the dislocation and damage of the large branch element and the cracking and detachment of the gilded decoration on the inner wall, in particular around the top and bottom of the cage and around the bird-perch constructions. Treatment has been carried out to return the branch to its former position and consolidate the urushi decoration. The perches/branches appear to be more finely painted than those of the birdcage vases from Stiltestichting Landgoed den Bosch,

In addition to the elements it shares with these birdcage vases, the interior of the cage also features an additional, slender branch, brown in color, adorned with a significant amount of small porcelain flowers and flower buds. While the flowers themselves look similar to those found on the examples from the Rijksmuseum and the Staatliche Kunstsammlungen Dresden, they are fixed to one large branch element situated between the birds rather than to separate twigs inserted into their perches (See Figure 3-23)

[63] Museum International, Behaviour of Panels, 148
[64] Inv. Nr. AE85720 "Birdcage Vase." Peabody Essex Museum.

Figure 3-23: Birdcage Vase from the Peabody Essex Museum Collection, Inv. Nr. AE85720. Branch with Flowers Visible on the Left Side of the Cage. Photograph: Peabody Essex Museum, Salem, Massachusetts.

Ashmolean Museum, Oxford

The Ashmolean Museum was contacted to learn more about the condition of their birdcage vases, but they were sadly unable to provide further information on the objects in their collection.[65] All comparisons were therefore made using the pictures made publicly available on their website.[66]

Interestingly enough one of the two vases in their possession consists of only the porcelain vase without a cage or lacquer decorations.[67] As previously mentioned the other example in their collection is claimed to contain a textile.[68] This textile Is described as being wrapped around wires to suggest plant stems[69] for the porcelain flowers present. Indeed, images show the birdcage to contain a twig with a small porcelain flower. The positioning and design of it is like that of those on the Rijksmuseum and SKD birdcage vases, but it seems as though most of the flowers might have been lost. The branches/perches appear to be significantly more varied in color than observed on other examples, with bright orange-red and green spots on a dark brown base. The placement of the two pheasants differs from that of the pheasants on the other vases examined, with the male pheasant being placed on the small perch and the female pheasant being placed on the larger, more elaborate perch. It would seem as though this larger perch has come away from the inner wall of the cage entirely. Decoration on the inner wall appears to be flaking in several areas with most significant lifting and loss of the layer around the bottom. The black leaves on the gilded background differ from the other examples, appearing much less finely applied.

Château de Pau, Pau

While Château de Pau kindly shared a short written description of the vases from their archives as well as literature on the art-historical background of the birdcage vases, they were unable to share any reports on or pictures of the current state of the birdcage vases in their collection and the interior of their cages. Interesting, however, is the fact that the description of the vases in their archive mentions that one of the

[65] Ashmolean Museum (Conservation and Eastern Art departments), personal communication (11/05/2021, 12/05/2021)
[66] See https://collections.ashmolean.org/collection/browse-9148/object/93389 (last accessed 01/06/2021)
[67] Object EA1984.2 Unnamed. Ashmolean https://collections.ashmolean.org/collection/browse-9148/per_page/100/offset/95600/sort_by/random/object/93386 (last accessed 17/06/2021)
[68] Object EA1992.114 "Birdcage Vase." Ashmolean https://collections.ashmolean.org/collection/browse-9148/object/93389 (last accessed 01/06/2021)
[69] https://collections.ashmolean.org/collection/browse-9148/object/93389 (last accessed 01/06/2021)

birdcage vases only has one pheasant in it. This is surprising, as the pheasants should not typically be able to be taken out of the cage if it is intact.

	Porcelain Pheasant	**Pheasants' Legs**	**Branches/ Perches**	**Flowers**	**Inner Wall Decoration**
Stiltestichting Landgoed Den Bosch (Br. 144 + Br. 145)	Male and female porcelain pheasant present.	Legs present for each bird.	Painted in green-brown colors.	Not present, but holes present where they might have been.	Black bamboo and pine motifs on a gold background.
Rijksmuseum (AK-NM-6554-A + AK-NM-6554-B)	Male and female porcelain pheasant present.	Legs present for each bird.	More finely painted to suggest tree-bark.	Two small twigs covered in flowers and buds in each cage.	Black bamboo and pine motifs on a gold background.
Porzellansammlung, SKD (PO5174, PO5176, PO5177, PO5178, PO5181, PO5182, PO5183, PO5185, and PO3801)	Male and female porcelain pheasant present.	Painted legs missing from female pheasant of PO5178.	Color of branches appears to vary between the different vases.	Two small twigs covered in flowers and buds on some of the birdcage vases.	Black bamboo and pine motifs on a gold background. Additional painted leaves at the bottom of PO 3801.
Peabody Essex Museum (AE85720)	Male and female porcelain pheasant present.	Legs present for each bird.	More finely painted to suggest tree-bark.	One slender branch covered in flowers and buds.	Black bamboo and pine motifs on a gold background.
Ashmolean Museum (EA1992.114)	Position of male and female pheasant different from all other examples.	Legs present for each bird.	Coarsely painted with orange and green.	Parts of a single twig with a flower present.	Black bamboo and pine motifs on a gold background, appears to have been applied more coarsely.
Château de Pau (P83 + P86)	One porcelain pheasant is missing.	Unknown	Unknown	Not mentioned.	Unknown

Table 3-2: Overview of Differences in Appearance of Elements Between Birdcage Vases

4 Scientific Knowledge

4.1 Arita Porcelain and Glaze – Techniques and Constituents

Hard-paste porcelain was first made in Arita around 1615-1620[70] and was typically produced using a locally quarried white pottery stone consisting of α-quartz, sericite ($K_2O·3Al_2O_3·6SiO_2·2H_2O$), microcline feldspar ($K_2O·Al_2O_3·6SiO_2$), and kaolinite ($Al_2O_3·2SiO_2·2H_2O$)[71] and a small amount of iron (II) sulfide (FeS). This material, sourced from the Izumiyama deposit[72], was crushed and refined and could be used to create porcelain wares without having to add any other mineral additives.[73] The iron component gives the product a slight orange or salmon color[74] as observed on the unglazed parts of the birdcage vases (see Figure 4-1). This clay is known to be particularly strong and therefore well-suited for wheel-throwing large objects,[75] the technique for which was likely brought to Japan by Korean potters at the end of the

Figure 4-1: Loss of Decoration Showing Unglazed Section of the Birdcage Vase. Photograph: Author

[70] Sasaki, *The Birth of Japanese Porcelain*, 37
[71] Katsuki, et al., *Some Properties of the Early Arita Celadon,* 673
[72] Bartle and Watling, *Provenance Determination of Oriental Porcelain Using Laser Ablation-Inductively Coupled Plasma-Mass Spectometry (LA-ICP-MS)*, 341
[73] Katsuki, et al., *Some Properties of the Early Arita Celadon,* 673
[74] Lambooy, *Lacquer on Japanese Porcelain: a Case Study of Two imari Vases with Urushi Lacquer Decoration from the Collection of the Rijksmuseum Amsterdam,* 1076
[75] Impey, *The Early Porcelain Kilns of* Japan, 33

16th century,[76] and it is likely the birdcage vases were shaped in this manner.[77] Whether larger objects like the birdcage vase underwent a biscuit firing is unclear, with literary sources disagreeing on this topic.[78] The 2017 Dresden publication on the birdcage vases claims Arita ware was typically biscuit fired from the mid-17th century onward,[79] suggesting the birdcage vases would have undergone a firing prior to being decorated. For the decoration, peonies and dragons were painted on using cobalt (II) oxide, or *gosu* in Japanese,[80] imported from China. It is possible this *gosu* was used mixed with synthetic European pigments, a practice that was started in the mid-17th century to save on the cost of materials.[81] The vases were then covered with a glaze compatible with the hard-paste porcelain, likely produced using locally sourced glaze stones in combination with wood ash.[82] The panels that were to be lacquered later were likely covered in glaze first and then wiped clean using sponges, as suggested by glaze residues found on the surface of the porcelain body of one of the Dresden birdcage vases.[83] The vases were then fired.

To create the pheasants, two-piece vertical clay molds might have been used[84] to shape the clay. X-Ray Computed Tomography (CT) imaging undertaken in Dresden shows the pheasants on one of their vases were hollow with holes in the underside for the insertion of the metal legs they stand on.[85] After shaping the pheasants and allowing them to dry they were likely biscuit fired[86] before being coated with a transparent glaze and fired a second time.[87] It is likely that during this glazing and second firing the pheasants were supported using the holes or areas where the legs would later be inserted to prevent having visible support marks present on the finished product.[88] The overglaze color would then have been applied and a third firing at a lower temperature undertaken to fuse the colors together with the underlying glaze.

The black glaze on the male pheasants is very dark and has a high shine, and it is unclear exactly how this color was achieved. Around the start of the 18th century the Chinese used a technique for creating *famille noire* glazes that consisted of combining a layer containing cobalt and small amounts of manganese and iron with

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76 Impey, *The Early Porcelain Kilns of* Japan, 36
77 Ohashi, *The Birdcage Vase in Arita Porcelain*, 79
78 Lambooy, *Japans Porselein met Urushi-Lakdecoraties,* 38
79 Ohashi, *The Birdcage Vase in Arita Porcelain,* 76
80 Ohashi, *The Birdcage Vase in Arita Porcelain,* 79
81 Montanari, et al. *European Ceramic Technology in the Far East: Enamels and pigments in japanese Art from the 16th to the 20th Century and their Reverse Influence on China,* 6
82 Katsuki, et al., *Some Properties of the Early Arita Celadon,* 673
83 Yamashita, *Restoration of the Birdcage Vase (Urushi Part),* 97
84 Ohashi, *The Birdcage Vase in Arita Porcelain,* 79
85 Araki and Miyata, *Structural Investigation of the Birdcage Vase Using X-Ray Computed Tomography*, 89
86 Ohashi, *The Birdcage Vase in Arita Porcelain,* 76
87 Analytical Methods Committee, *X-Ray Fluorescence (XRF) Analysis of Porcelain: Background Paper*, 2371
88 Ohashi, *The Birdcage Vase in Arita Porcelain,* 79

copper green overglaze colors to achieve a glossy black glaze layer.[89] It is possible that a similar technique was used by the Japanese, but this has not yet been determined. Alternatively, black overglaze colors could potentially have been obtained by using one of various combinations of oxides, often including manganese, copper, iron, and cobalt.[90]

Yellow overglaze colors could be achieved using different recipes. From the mid-17th century onward, Japanese potters frequently used a combination of lead and iron oxides to create yellow overglaze colors. Over the course of the 18th century Japanese recipes were modified to include quantities of antimony and zinc, materials that were more prominently used in European recipes for yellow enamels.[91] Antimony used for this purpose was brought to Japan by the Dutch from the seventeenth century onwards.[92]

Red and tan colors were often obtained using hematite, or *bengara* in Japanese, a naturally occurring iron oxide compound that was also synthetically produced in Japan starting from the beginning of the 18th century.[93] Adding amounts of aluminum oxide to hematite can lead to a variety of red, tan, and brown colors and combinations of *bengara* and aluminum oxide could have been used to decorate the birds.

In order to determine exactly which colorants were used to achieve the decorations on the pheasants further instrumental analysis would have to be carried out.

4.2 Application, Identification and Degradation of Asian Lacquers

The East Asian art of decorating objects with Asian lacquer dates as far back as the prehistoric era[94] and a large variety of different decorative techniques have been developed over the thousands of years this art has been practiced. The raw material used for lacquering is obtained by tapping the bark of certain trees of the *Anacardiaceae* family unique to Asia.[95] [96] A milky-white tree sap is obtained from the

[89] Ink de Pree, personal correspondence 23/05/2021
[90] F. Casadio, A. Bezur, et al, *X-Ray Fluorescence Applied to Overglaze Enamel Decoration on Eithteenth- and Nineteenth-century Porcelain from Central Europe,* S66 & S70
[91] Montanari, et al., *European Ceramic Techniques in the Far East: Enamels and Pigments in Japanese Art From the 16th to the 20th Century and Their Reverse Influence on China*, 10
[92] Montanari, et al., *European Ceramic Techniques in the Far East: Enamels and Pigments in Japanese Art From the 16th to the 20th Century and Their Reverse Influence on China*, 9
[93] Asaoka, et al., *Reproduction of Japanese Traditional Pigment Based on Iron Oxide Powders with Yellowish Red Color*, 1
[94] Kuraku, *Origins of the Use of Urushi in japan and Its Development*, 45
[95] Honda, *Analyses of the Kawari-nuri (Urushi Coatings Decorated with Various Materials) Parts of the Birdcage Vase,* 92
[96] Snyder, Donald M. *An Overview of Oriental Lacquer*. 977

trees between June-October[97] and purified and processed for usage as a liquid coating.[98] The lacquer can be mixed with a variety of pigments to obtain different colors, with black being most commonly achieved by using carbonaceous materials as pigments.[99]

The three different trees that Asian lacquers are obtained from are the *Toxicodendron Vernicifluum* (also known as *Rhus Vernicifera*) from which the true Japanese *Urushi* lacquer is obtained, the *Toxicodendron Succedaneum* (also known as *Rhus Succedanea*) native to Taiwan and Vietnam, and the *Gluta Ushitata* (also known as *Melanorrhoea Usitata*), native to Thailand and Myanmar.[100] It is possible to use Py-GC/MS analysis to identify certain biomarkers to determine the exact species of tree a lacquer was obtained from, allowing one to determine the production area of the lacquer.[101] For an overview of the different components present in each of the three lacquers please see Figure 4-2.

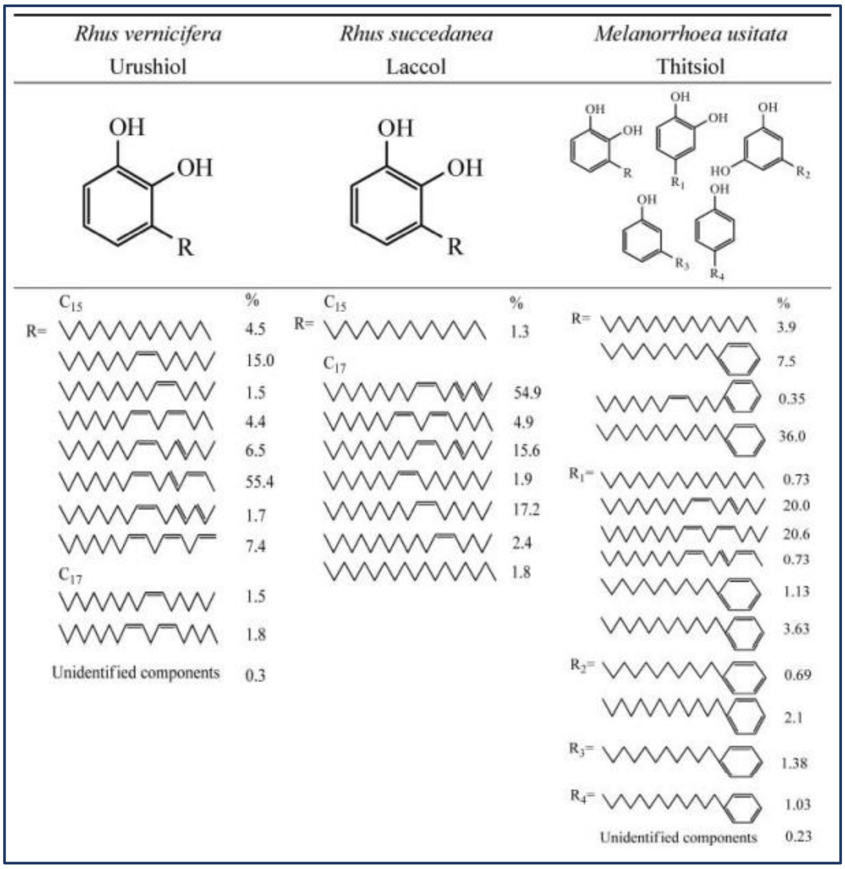

Figure 4-2: Components and Structures of Oriental Lacquer Sap. Image: Lu et al. From: *Oriental Lacquer: A Natural Polymer,* 158

97 Lu, et al., *Oriental Lacquer: A Natural Polymer,* 154
98 Snyder, Donald M. *An Overview of Oriental Lacquer*. 977
99 Derrick, et al., *FTIR Analysis of Authentic and Simulated Black Lacquer Finishes on Eighteenth Century Furniture,* 231
100 Honda, *Analyses of the Kawari-nuri (Urushi Coatings Decorated with Various Materials) Parts of the Birdcage Vase*, 92
101 Honda, *Analyses of the Kawari-nuri (Urushi Coatings Decorated with Various Materials) Parts of the Birdcage Vase*, 92

To create a lacquer coating on an object a ground layer is typically first applied in multiple (1-5) applications.[102] This ground layer or *shitachi* coating is very important for the adhesion between the lacquer and the substrate[103] and generally contains inorganic filling materials, often consisting of clay powders,[104] [105] combined with a binding medium to create a smooth surface for the lacquer to be applied on. Where multiple applications are added it is usual for fillers of various grit sizes to be used, with the first layers containing coarser fillers than the upper layers.[106] While Asian lacquer is traditionally used as the binding medium in the ground layer this material is costly and sometimes substituted or mixed with other, qualitatively inferior, binding mediums[107], examples of which include animal glues, starches, oils[108], persimmon juice[109], and animal blood[110]. Once the desired number of ground layers has been added the ground layer is smoothened, usually using a whetstone, and the lacquer layers are applied.[111] Drying oils are often added to the raw lacquer, in the first place to increase the gloss of the dried lacquer film so that it does not require final polishing, but also to increase the fluidity of the lacquer and decrease the overall cost of the material.[112]

The lacquer layer could then be decorated using a large variety of different decorative techniques. Most of these decoration techniques are carried out on an already polished lacquer surface. One well-known group of Japanese lacquer decorations is *maki-e*, a group of decorations made using techniques where metal powders are applied to the lacquer surface.[113] Gold is commonly used for this technique as it does not change in color when used in combination with the lacquer.[114] Most *maki-e* lacquerwares appear to be made with black lacquer and feature golden decorations on top of a black background rather than the black on gold observed on the birdcage vases. Reliefs can be formed on the lacquer layer and this technique can be combined with *maki-e* as in for example *taka-maki-e* decorations where raised surfaces are combined with metal decorations. These raised surfaces can be created using a

[102] Lu, et al., *Oriental Lacquer: A Natural Polymer,* 179
[103] Lu, et al., *Oriental Lacquer: A Natural Polymer,* 179
[104] Jonas Veenhoven, personal correspondence
[105] Lambooy, *Japans Porselein met Urushi-Lakdecoraties,* 41
[106] Lambooy, *Japans Porselein met Urushi-Lakdecoraties,* 41
[107] Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 32
[108] Heginbotham, *New Evidence for the Use of Southeast Asian Raw Materials in Seventeenth-Century Japanese Export Lacquer*, m
[109] Schellmann, *Observations on the Causes of Flaking in East Asian Lacquer Structures*, 2
[110] Miklin-Kniefacz, et al. *Searching for Blood in Chinese Lacquerware: zhū xiě huī 豬血灰,* 2016
[111] Lu, et al., *Oriental Lacquer: A Natural Polymer,* 179
[112] Heginbotham, *New Evidence for the Use of Southeast Asian Raw Materials in Seventeenth-Century Japanese Export Lacquer*, h
[113] Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 33
[114] Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 33

mixture of earthen powder and urushi or using the more stable and elaborate method of applying many layers of lacquer on top of one another.[115]

The primary drying mechanism of Asian lacquer is an oxidation-induced polymerization process, the final result of which is a coating that is extremely hard, durable, and solvent-resistant, but not excessively brittle.[116] This sets Asian lacquers apart from European lacquers as these typically dry through the evaporation of solvents.[117]

While Asian lacquer is considered to be a particularly durable material[118] the lacquer surface is susceptible to exposure to light,[119] with short wave ultraviolet radiation being the most damaging.[120] The effects of light-induced degradation can cause it to lose its deep gloss, make it more sensitive to polar substances, and lead to the material becoming hygroscopic. This can lead to more surface moisture, causing swelling which in turn leads to cracking and flaking of the lacquer layers.[121] Eventually damages caused by light can lead to the lifting of the urushi foundation layers from the substrate.[122]

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115 Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 33

116 Snyder, Donald M. *An Overview of Oriental Lacquer*. 977

117 Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 32

118 Lu, et al., *Oriental Lacquer: A Natural Polymer,* 180

119 Yamashita and Rivers, *Light-Induced Deterioration of Urushi, Maki-e and Nashiji Decoration*, 208

120 Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 34

121 Bézard, *Japanese Lacquer Bottles from the Schönbrunn Palace: Examination – Preservation – Presentation*, 34

122 Yamashita and Rivers, *Light-Induced Deterioration of Urushi, Maki-e and Nashiji Decoration*, 208

4.3 Urushi Lacquer Structures and Their Adhesion on Porcelain

While a significant amount of Western literature exists that describes the degradation and conservation[123] [124] of Asian lacquer as well as the specific issues associated with their layered structure and their adhesion to wooden substrates,[125] the amount of literature that pertains to lacquered porcelain specifically appears to be relatively limited, something that is expected considering the fact that the combination of porcelain and lacquer is unusual and not very well-known,[126] having been used almost exclusively for a small group of valuable wares for the export market (see Porcelain & Lacquer). Nevertheless, publications on urushi applications on other, more common substrates do give some insight into the adhesion between the different layers of the lacquer and the influence of the choice of substrate and binding medium on the stability of the urushi decoration.

The adhesion between individually applied layers of Asian lacquer is not typically considered a problem, but the cohesion and adhesion of foundation layers can differ and depends on the binding medium and additives used.[127] Schellmann points out that cohesion between the layers and a firm attachment to the substrate are required to mitigate the risk of delamination caused by the expansion and contraction of the lacquer layers.[128] She also notes that the addition of cheaper, weaker binding mediums in the ground layer, something that is frequently done in Japanese export lacquerware, can be detrimental to the stability of the lacquer structure as a whole.[129]

Not only are ceramics very different in terms of elemental composition and mechanical properties from urushi lacquer, the fact that porcelain and urushi were combined specifically for the export market means the grounds used for the urushi decorations on porcelain are likely to contain qualitatively inferior materials that can further increase the risk of damages.

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[123] Williams, *The Conservation of Asian Lacquer: Case Studies at the Asian Art Museum of San Francisco*
[124] Rivers, *Conservation of Japanese Lacquer in Western Collections: Conserving Meaning and Substance*
[125] Schellmann, *Observations on the Causes of Flaking in East Asian Lacquer Structures*
[126] Lambooy, *Lacquer on Japanese porcelain: a case study fo two Imari vases with urushi lacquer decoration from the collection of the Rijksmuseum Amsterdam*, 1075
[127] Schellmann *Observations on the Causes of Flaking in East Asian Lacquer Structures*, 2
[128] Schellmann *Observations on the Causes of Flaking in East Asian Lacquer Structures*, 2
[129] Schellmann *Observations on the Causes of Flaking in East Asian Lacquer Structures*, 2

An example of such damages can be found in a case study of two Imari vases discussed by Suzanne Lambooy.[130] Here the 'deterioration, cracking, exfoliating and loss of lacquer' on this pair of porcelain vases is investigated in depth. The lacquer is found to be matted, abraded, and crazed and this is found to be in line with what the Porzellansammlung of the Staatliche Kunstsammlungen in Dresden has noticed on their lacquered Arita porcelain. After examining this degradation more closely this exfoliating and loss of the lacquer layer is concluded to be primarily the result of the combination of porcelain and urushi being quite vulnerable to climatic fluctuations, which is explained as follows: 'Urushi is an organic material that changes dimensions with fluctuations in relative humidity, whereas the porcelain remains unaltered. Repeated changes in climate conditions will cause great tension and result in the lacquer film cracking and flaking.' Lambooy also notes the fact that the usage of cheaper binding mediums has further contributed to the degradation of the decoration, and that light might have worsened the condition of the lacquer layer by causing micro-cracks in the surface of the urushi.

Similarly, in her master's thesis on a lacquered porcelain Japanese offering dish Julia Wagner has linked losses of a decorative urushi layer on porcelain to poor adhesion and a difference in thermal expansion rate between the substrate and the urushi layer and notes that the fact the urushi decoration is applied to a curved surface leads to further tension.[131] What sets the Japanese offering dish apart from the Imari vases discussed by Lambooy is the fact that the urushi lacquer was partially applied to glazed surfaces, whereas the urushi lacquer on the object discussed by Lambooy as well as on the birdcage vases was applied to unglazed substrates. She notes lacquer applied to glazed sections appears affected to a larger extent but stresses that this does not necessarily indicate a stronger adhesion to unglazed sections as other factors such as proximity to the lacquer edge and exposure to light could also be responsible for the difference in condition.

It is expected that the urushi decorations on the birdcage vases have the same vulnerabilities described in the literature. The birdcage vases, like the offering dish and Imari vases, are export products where urushi lacquer is present on (curved) porcelain substrates which means that tensions will arise under the influence of fluctuations in relative humidity that can lead to delamination, especially in the likely event of a ground layer containing cheap binding materials.

[130] Lambooy, *Lacquer on Japanese porcelain: a case study fo two Imari vases with urushi lacquer decoration from the collection of the Rijksmuseum Amsterdam,* 1078-1079
[131] Wagner, *Research into the Deterioration of Lacquer Decoration on a Japanese Porcelain Bowl from Huis ten Bosch palace*, 62

4.4 Dresden Birdcage Vase Research

To date most research on this type of vase has been carried out by the Porzellansammlung of the Staatliche Kunstsammlungen Dresden[132] (SKD) as part of a joint project with the Tokyo National Research Institute for Cultural Properties (TOBUNKEN). In 2004 the SKD and TOBUNKEN started a joint research on urushi lacquered objects and the restoration of birdcage vases was chosen as a topic of research. In 2017 a full report on the project was published[133], as well as a poster[134] outlining some of the focal points and results. This publication includes an art-historical overview of the birdcage vases, information about the construction of the objects, chapters detailing Py-GC/MS and ED-XRF analysis of urushi samples, an X-ray computer tomography investigation of one of the birdcage vases, and an overview of the condition and restoration of a birdcage vase.

As explained in Application, Identification and Degradation of Asian Lacquers it is possible to use Py-GC/MS to determine the presence of Asian lacquer and the species of tree the Asian lacquer was taken from more specifically. This method of analyzing the lacquer was used to determine the production area of the lacquer used to decorate the four gilded panels on the birdcage vases of the SKD. Samples were taken from loose material kept in the storage of the SKD thought to be from the birdcage vase or from a similar object and were found to contain urushiol as well as carboxylic acids linked to palmitic acid and stearic acid, materials that were sometimes added in the form of drying oils to make the urushi lacquer glossier and easier to handle.[135]

The X-ray CT investigation shed some light on some of the elements that are part of the birdcage vases. A single vase was examined using a turntable-type X-ray CT apparatus. This investigation showed the bodies of the porcelain pheasants in the cage to be hollow to allow for the metal wires that make up their legs to be inserted into their bodies. While this has been done for three of the metal four legs present in the cage, one of the metal wires was found to be considerably shorter than the others and appears to end where it meets the porcelain. Furthermore, it was shown the porcelain of the vases is thinner at the top and thicker at the bottom.

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[132] Dresden State Art Collections, Porcelain Collection

[133] Staatliche Kunstsammlungen Dresden, Porzellansammlung & Independent Administrative Institution National Institutes for Cultural Heritage Tokyo National Research Institute for Cultural Properties

[134] (Kozar n.d.)

[135] Honda, *Analyses of the Kawari-nuri (Urushi Coatings Decorated with Various Materials) Parts of the Birdcage Vase*, 95

5 Analytical Research

5.1 Methodology

To gain more knowledge on the construction and composition of the elements inside the cage and ascertain the factors that may influence their damage and/or deterioration the different elements and their materials were studied first using visual methods of examination and later using various analytical techniques both destructive and non-destructive. These elements include the birds, their perches and legs, the adhesive layers between the branch and the inner wall and the decoration on the inner wall itself. Visual methods of examination included examination under visible light with the naked eye and UV light as well as examination with a rigid borescope to look at the back of the branch and the pheasants more closely. The findings of the initial visual examination are presented and discussed in The Vases. After this examination UV pictures were taken to help create an overview of the variety of materials present. Information gathered this way was used to decide on appropriate methods for further analytical research and the samples to be taken to carry these out. SEM-EDX[136] and XRD[137] analyses were decided to be valuable methods for obtaining more information about the inorganic materials (potentially) present in the porcelain pheasants, their legs, the lacquer layers, and the branch. To gain more insight into the composition of the organic binders and adhesives and the lacquer Py-GC/MS[138] analysis was carried out. The selection and preparation of samples and the individual methods of investigation will be further discussed in the following sections. SEM-EDX, XRD, and Py-GC/MS analyses were each conducted by and prepared for and discussed with Luc Megens of the RCE.

UV Photography

UV photography provides a non-invasive tool to discern differences in materials not easily noticed under visible light. The vases were photographed using a Nikon D750 SLR camera with an AF-S Micro NIKKOR 60mm lens and a Hoya HMC camera filter was used for the UV pictures. Two Helling GmbH ZERO 200/2 IP65 UV lights with an intensity of approximately 7000 μW/cm^2 at 400mm were set up on either side of the vases. An exposure time of 20 seconds was used to create clear images where the

[136] Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy
[137] X-Ray Diffraction
[138] Pyrolysis gas chromatography-mass spectrometry

distinct fluorescence of each element is visible without overexposure. Overview pictures were taken as well as close-ups of the birdcages.

Sampling and Sample Selection[139]

Samples were taken from six different sites and span a variety of materials present in the cage in order to learn more about the different elements of the constructions, in particular those of which the fragility and susceptibility to deterioration was unclear. All samples were taken from vase Br. 145. For a quick overview of samples taken see Table 5-1, and for a complete overview of sampling sites and microscopy images of the samples see Appendix IV – Samples. Samples were taken using a fine, pointed scalpel blade to cut away very small amounts of material. Where possible this was done around break edges or other areas that had previously been damaged. An attempt was made to take a sample from the metal component of the legs in the hopes of determining the composition of the metal but proved unsuccessful. All samples taken were first examined using an Olympus SZX7 stereo microscope and Hirox KH-7700 3-D Digital Microscope in order to capture images and examine the different layers and materials present more closely, and to make decisions about which samples would be suitable to prepare for SEM-EDX. It was decided to take material from samples 1, 2, 3 ,5, 6 (See Appendix IV – Samples) and a total of eight different pieces of material from these samples were separately embedded in Epofix 2-component epoxy resin and polished to ensure a clear cross-section, including the different layers of the samples where applicable. The samples were wet-polished using a polishing machine and silicon carbide paper of various grit sizes (P 500, P 800, P 1200, P 2000, P 4000) after which the samples were polished by hand using Micro-Mesh aluminum oxide polishing sheets. (P 6000, P 8000, P 12000) to create a smooth surface allowing for clear imaging.

Microscopy[140]

After polishing the embedded samples were again inspected and photographed using a Zeiss Axioplan 2 Imaging microscope equipped with a Zeiss Axiocam 506 color digital camera. The samples were inspected in incident polarized light, incident reflected light and fluorescence microscopy was performed using the Zeiss filter sets 01 (excitation filter BR 365/12 nm: emission filter LP 397 nm).

[139] Sampling and sample selection carried out together with Luc Megens (RCE)
[140] Microscopy images were taken by Luc Megens (RCE)

Sample (Group)	Location[141]	Type of Material	Analysis
1		Presumed to be ceramic and restoration materials, taken from the back of the male pheasant.	SEM-EDX and XRD to examine the constituents of the body and glaze, in particular the colorants used, and Py-GC/MS for the glue composition. 2 samples embedded for SEM-EDX.
2		Presumed to be a lacquer and ground layers, taken from the back of the dislocated branch.	SEM-EDX to find out more about the layered structure of the lacquer and its constituents, XRD for additional analysis of crystalline components, and Py-GC/MS to determine the type of lacquer used. 1 sample embedded for SEM-EDX.
3		Presumed to be wood and paint, taken from the front of the large imitation branch.	SEM-EDX to observe the layers in the sample and analyze the constituents, XRD for additional analysis of crystalline components. 2 samples embedded for SEM-EDX.
4		Presumed to be a painted, plaster-like material. Taken from the upper leg of the male pheasant.	XRD to determine the constituents of the plaster-like material as well as pigments in the paint.
5		Lacquer taken from the opposite side of sample 2 and presumed to be similar. Taken from the inner wall of the cage.	Same as 2. 1 sample embedded for SEM-EDX.
6		Composition unclear entirely. Looks like a feather and bits of adhesive. Taken from the upper leg of the male pheasant.	SEM-EDX to determine what type of material the sample is[142]. 2 samples embedded for SEM-EDX.

Table 5-1: Overview of Samples

141 Please see Appendix V – Samples for larger overview images and microscopy images
142 Further analysis was not considered helpful after examining SEM-EDX results.

Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDX)[143]

SEM-EDX analysis was conducted to investigate the internal morphology of the samples and identify their inorganic elemental composition. Better understanding the layered structure of the lacquer on the inner wall and the composition of its layers is important for understanding why the branch has separated from the wall. Furthermore SEM-EDX could shed some light on the composition of the ceramic body and glaze layer of the pheasant and the ground layer and paint layers of the branch. Information on their composition would be helpful in determining their fragility and indicating the presence and composition of restoration materials. The composition of sample 6, the feather-like material taken from the upper leg of the pheasant, was unclear entirely and it was assumed SEM-EDX might be able to lead to some insight into the nature of its material.

SEM-EDX measurements were carried out using a Jeol JSM-IT700HR scanning electron microscope at low vacuum mode of 30 Pa and 20kV with a WD of 10. Energy-dispersive X-ray Spectroscopy was undertaken using a ThermoFisher Scientific SDD Ultradry detector and Noran System Seven (NSS) software. Material was taken from samples 1,

2, 3 ,5, 6[144] after microscopy examination and embedded as described in Sampling and Sample Selection.

X-Ray Diffraction (XRD)[145]

To obtain further information on the composition of the samples non-destructive XRD measurements were taken of the samples. XRD enables for the characterization of crystalline materials and was considered a useful tool for determining elements and compounds that are present in the upper leg, the ceramic, the ground layers and potentially the paint. Samples 1,2,3,4,5 as well as the broken tail of the pheasant were analyzed after microscopic examination as outlined in Sampling and Sample Selection. For the XRD measurements a Bruker AXS D8 Discover microdiffractometer was used with a Vantec 2D detector. To integrate the 2D diffractograms into 1D diffractograms a general area detector diffraction system (GADDS) was used. The diffractograms were compared with the crystallography open database (COD) using the Bruker Eva software to identify components in the samples.

[143] SEM-EDX analysis carried out by Luc Megens (RCE)
[144] Please refer to Table 5-1: Overview of Samples and Appendix IV – Samples
[145] XRD analysis carried out by Luc Megens (RCE)

Pyrolysis-Gas Chromatography/Mass Spectrometry (Py-GC/MS)[146]

Py-GC/MS was used in order to analyze the organic materials present. Using py-GC/MS could potentially prove if the lacquer is indeed a Japanese urushi lacquer and will be useful in identifying the adhesive present on the bird. This might be useful for determining which materials were added by the restorer elsewhere. Samples 1, 2, and 5 were analyzed after microscopic examination as outlined in Sampling and Sample Selection.

Pyrolysis gas chromatography was carried out using a Frontier Lab 3030D pyrolizer. Pyrolysis temperature was 700°C and temperature of pyrolysis-interface was 290°C. A thermo Scientific Focus GC gas chromatograph and ISQ mass spectrometer were used. Pyrolysis unit was directly connected to a SLB5 ms (Supelco) 20m column with an internal diameter of 0,18 mm using a slip clutch. A constant flow (0,9 ml/min) of helium was used as a carrier gas. Temperature program was set to 35°C (1) – 16°C/min – 220°C – 10°C/min – 315°C (1). Column was connected directly to the ion source of the mass spectrometer. Temperature of the ion source was 250˚C. Mass spectra between 10 and 600 AMU were registered at a speed of 7 scans/second. Xcalibur 4.1 software was used to record and process spectral data.

[146] Py-GC/MS Analysis carried out by Luc Megens (RCE)

5.2 Results and Discussion

UV Photography

For a full overview of UV photographs see Appendix V - UV Images of Birdcage Vases Br. 144 & Br. 145.

The UV photographs taken show later additions to the object. Small fluorescent spots are present on the glaze of the vase itself, suggesting small areas of the vase have been painted over. This was possibly part of a restoration. The urushi panels are shown to made up out of at least four materials. A material with a yellow-golden fluorescence, a material with a more orange-gold fluorescence, a material with a strong white fluorescence and a material that does not show any fluorescence. This difference in fluorescence between areas corresponds to the difference in textures and condition mentioned in Overview. As some of the different materials are combined on a single panel it would seem as though this too can be attributed to a previous restoration effort. A material with a strong white fluorescence can also be observed around the area where the handle was previously attached on Br. 144. This matches an old adhesive likely used to attach the now-missing handle with. Within the cage we find fluorescence on each of the elements (Please see Figure 5-1 and Figure 5-2). The branches fluoresce green entirely. The cause of this is unclear, but it is possible this is caused by a binder or pigment present in the paint layer. The birds have a yellow fluorescence with some specks of non-fluorescence. These non-fluorescing spots match areas where the thick layer of dirt has flaked off and it is therefore likely that the yellow fluorescence originates from the dirt that obscures most of the pheasants' decorations. The leg of the male pheasant on Br. 145 shows strong blue fluorescence on the upper leg and a strong orange fluorescence around the metal part and the area where its tail has broken off (see Figure 15-1). Considering the condition the pheasant is in, the break edge, and the remnants of glue visible on it, it seems safe to assume that all of this fluorescence is caused by previous restoration(s) and retouching. The background shows a strong, even yellow-golden fluorescence on all golden parts that might be caused by the lacquer itself.

Figure 5-1: UV Photograph of Male Pheasant on Br. 145. Photograph: Author

Figure 5-2: UV Photograph of Male Pheasant on Br. 144. Photograph: Author

Microscopy and Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDX)

For an overview of the samples see Table 5-1 or Appendix IV – Samples and for a full overview of microscopy and SEM-EDX images see Appendix VI - Microscopy Images and SEM-EDX Results of Embedded Samples.

Microscopy images taken with the Zeiss Axioplan 2 Imaging microscope and SEM back-scattered images show 5a, a piece taken from what was presumed to be lacquering layers from the inside of the wall, to consist of three layers. (See Figure 5-3), A black organic upper layer (presumably the lacquer itself), a light brown interface layer, and a thicker, grainy, brown layer underneath (presumably the ground layer for the lacquer). EDX analysis of this brown layer has shown this layer to consist of primarily aluminum silicates, suggesting this layer is indeed a ground layer for the lacquer, as clay powder is a common filling material for lacquer ground layers.[147] Please see Figure 5-4, Figure 5-5 and Figure 5-6 for SEM back-scattered images and the EDX spectrum of the clay-containing layer.

Figure 5-3: Zeiss Axioplan 2 Imaging Microscope Overview of Sample 5a.
Image: Luc Megens (RCE)

[147] Lambooy, *Japans Porselein met Urushi-Lakdecoraties,* 41

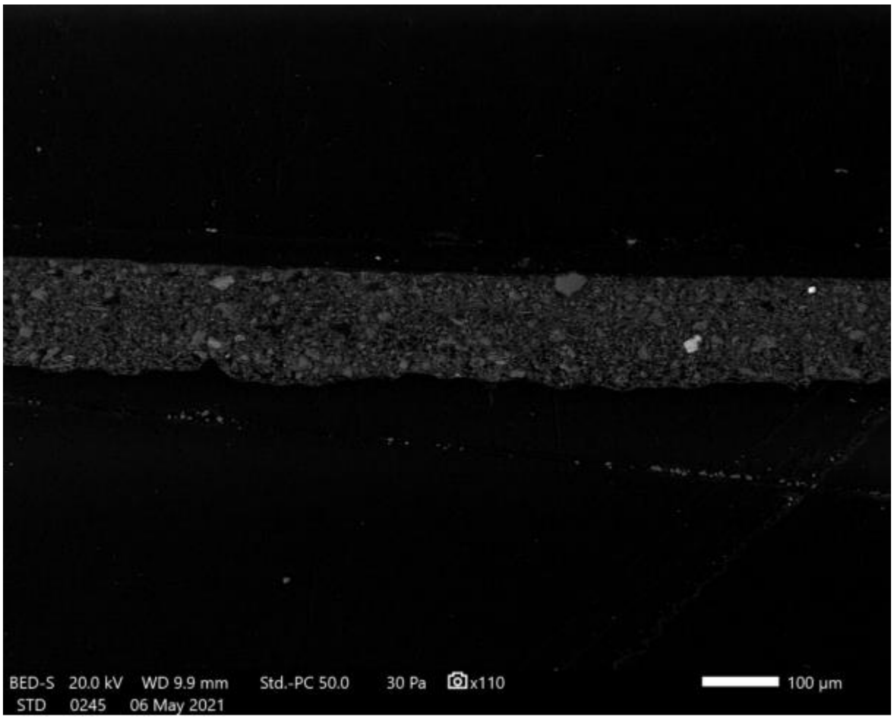

Figure 5-4: SEM Back-Scattered Image of Sample 5a. Image: Luc Megens (RCE)

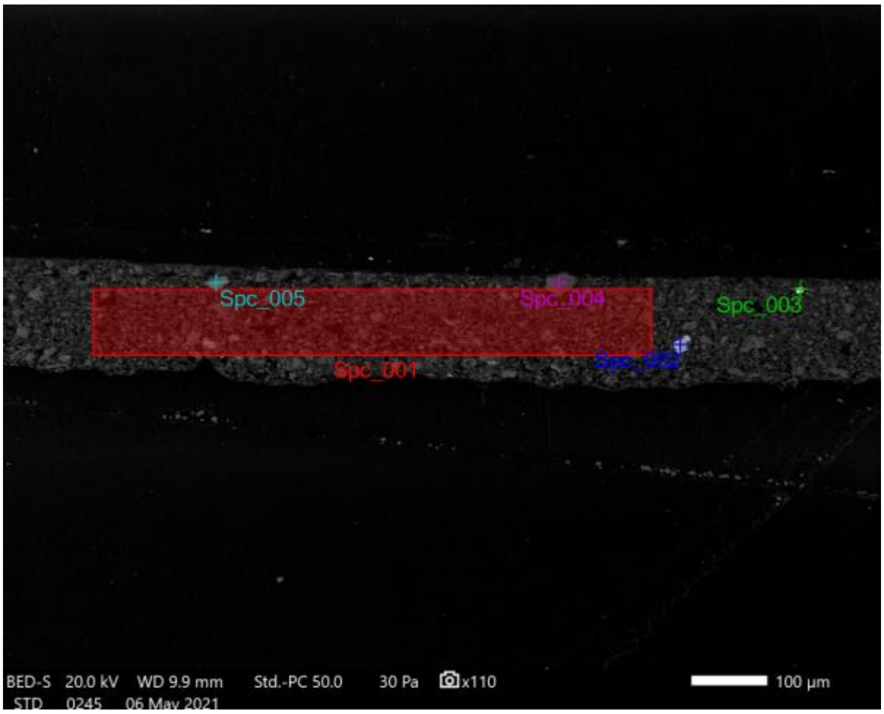

Figure 5-5: SEM Back-Scattered Image of Sample 5a Showing Areas Analyzed. Image: Luc Megens (RCE)

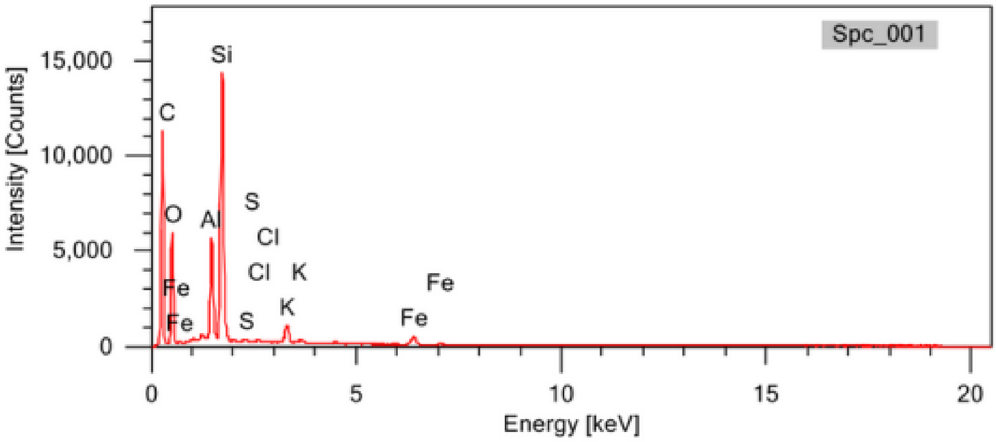

Figure 5-6: EDX Spectrum SPC_001 for Figure 5-5. Image: Luc Megens (RCE)

Similarly, sample 2a, taken from the back of the dislocated branch and also presumed to consist of lacquering layers, shows what appear to be two layers containing clay minerals but differs from sample 5a in that it has a thicker, slightly translucent organic layer (approximately 400 µm compared to 50µm for 5a) that shows a strong fluorescence (see Figure 5-7 and Figure 5-8). This suggests this thicker layer of organic material is of a different composition than the organic layer on 5a.

Figure 5-7: Zeiss Axioplan 2 Imaging Microscope Overview of Sample 2a. Image: Luc Megens (RCE)

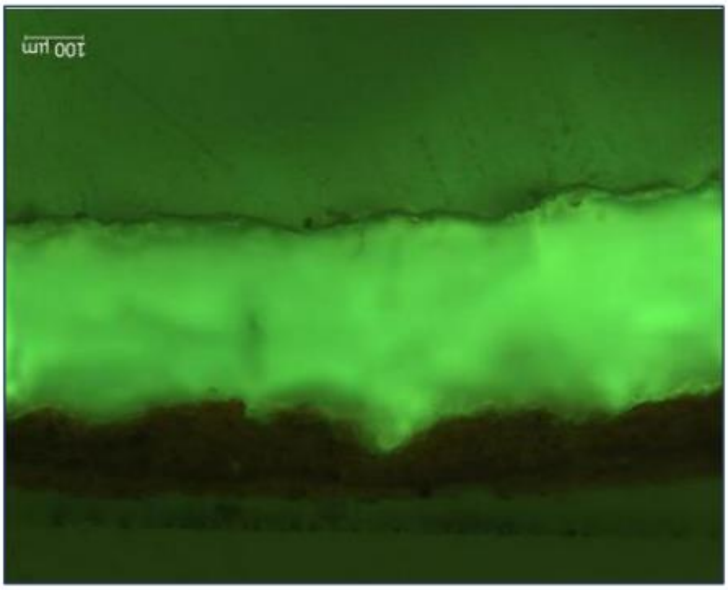

Figure 5-8: Zeiss Axioplan 2 Imaging Microscope Fluorescence Overview of Sample 2a. Image: Luc Megens (RCE)

Samples 1a and 1b, both taken from the back of the male pheasant on Br. 145, consist of several layers (see Figure 5-9) including a blue layer containing lead white, orpiment and an unidentified blue pigment[148], a thin, unidentified red layer of pigment, and a green layer consisting of barium sulfate and a small quantity of orpiment as well as an unidentified blue pigment[149]. Aluminum oxide was detected but is likely to be a contaminant from the process of polishing the embedded samples with the Micro-Mesh sheets. The structure of the samples and the barium sulfate and pigments present suggest retouching of the pheasant as part of a restoration. This is not completely unexpected as the pheasant has clearly been restored in the past as shown by the glue remnants and suggested by the UV pictures (See Appendix V - UV Images of Birdcage Vases Br. 144 & Br. 145). Also present in the sample is a small particle of calcium aluminum silicate on the underside, formed by high temperatures and pointing towards the underlying material being porcelain or glaze.

Embedded Samples 3a and 3b, both taken from the front of one of the branches, consist of a layer of calcium carbonate (assumed to be part of the gesso ground layer) covered with a blue-green layer containing lead white and an unidentified blue pigment[150]. On top of this layer we find a thin layer of orpiment and a discolored varnish layer, and a green layer containing barium sulfate on top. This again suggests

[148] This pigment is probably indigo as no chemical elements were detected by EDX that would explain the blue color otherwise
[149] See footnote 148
[150] See footnote 148

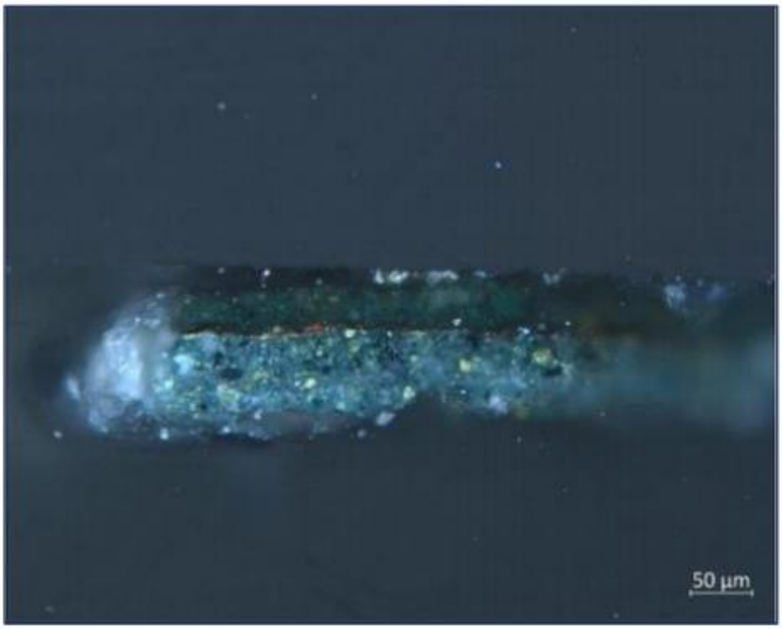

Figure 5-9: Zeiss Axioplan 2 Imaging Microscope Overview of Sample 1a . Image: Luc Megens (RCE)

restoration, as paint would not normally be applied over a varnish layer and the barium sulfate is present in other restorations found on the vase.

Sample 6a, which was taken from the upper leg and of which the composition was unclear was shown to consist purely of organic material and sulfur. This indeed points towards a small feather having gotten mixed up in the restoration material used on the leg. 6b could not be identified using SEM-EDX although a small particle of gypsum was observed as well as some aluminum oxides that likely came from the sample preparation process.

X-Ray Diffraction (XRD)

For an overview of the samples see Table 5-1 or Appendix IV – Samples and for an overview of all XRD images and measurements see Appendix VII - XRD Results.

XRD Measurements allowed for the identification of material in samples 2, 3, 4 and 5. A small flake of what appeared to be gilding found under the microscope was determined to be gold. Other crystalline materials identified in the bulk of the sample are calcite ($CaCO_3$), quartz (SiO_2) and gypsum ($CaSO_4 \cdot 2H_2O$) likely present in the ground layer. Sample 3 similarly contained calcite ($CaCO_3$) and quartz (SiO_2) as well as barium sulfate (BaSO4) in an organic matrix as shown by the SEM-EDX. These materials are common materials for creating fills with, again suggesting the branch has been restored in the past. The leg of the pheasant (sample 4) contains gypsum ($CaSO_4 \cdot 2H_2O$) likely as part of the gesso that shapes the upper leg and serves as a ground layer.

Pyrolysis-Gas Chromatography/Mass Spectrometry

For an overview of the samples see Table 5-1 or Appendix IV – Samples and for a full overview of Py-GC/MS results see Appendix VIII – Py-GC/MS Results.

Sample 1, taken from break edge of porcelain bird	Material found to consist primarily of shellac and contains oil, wax, and a very small amount of proteinaceous materials.
Sample 2, taken from back of branch	Material found to consist of mammalian animal glue.
Sample 5, taken from inner wall of cage where branch was previously located	Black layer contains urushi lacquer, oil, proteinaceous materials, and small quantities of other natural resins. Transparent part of sample consists of mammalian animal glue and fatty acids and oils,

Table 5-2: Results of Py-GC/MS analysis

The sample taken from the back of the broken porcelain pheasant consists of a variety of organic materials and it is unclear what the exact function of each of the components is. The shellac might have been used to glue the broken tail to the pheasant and the oil could potentially be the binding medium used for the restoration paint that was suggested to be present by the SEM-EDX analysis.

The sample taken from the back of the branch appears to be a mammalian animal glue. This layer of glue was applied between the thin wooden boards on the back of the branch and the lacquered inner wall of the cage.

The sample taken from the inner wall of the cage contains urushiol. This proves the decoration was made using true Japanese urushi lacquer obtained from the *Toxicodendron Vernicifluum* as explained in Application, Identification and Degradation of Asian Lacquers. The layer was also determined to contain a mixture of oils. This is consistent with the literature and it is likely oil was deliberately added to some or all of the layers to increase the workability of the materials.[151] Soot also appears to be present and was probably added as a pigment to obtain the black color of the lacquer.[152] It is not entirely clear where the proteinaceous component in the sample originates from and this material shows no clear correlation to any specific glue. It is possible the protein markers are present in the lacquer itself, as Asian lacquers are known to have a glycoprotein fraction.[153] Another possibility is the presence of animal derived binding mediums in the ground layer of the lacquer. Further instrumental analysis could potentially give more information about this material.[154]

A transparent flake present on the sample was analyzed separately and found to consist of proteinaceous matter, the markers for which most closely correlate to mammalian animal glue, and oils or fatty acids. It is likely this flake came from the glue used to attach the branch to the inside wall, with the oils or fatty acids having come from the lacquer or other layers.

151 Heginbotham, *New Evidence for the Use of Southeast Asian Raw Materials in Seventeenth-Century Japanese Export Lacquer*, h
152 Derrick, et al., *FTIR Analysis of Authentic and Simulated Black Lacquer Finishes on Eighteenth Century Furniture,* 231
153 Jonas Veenhoven, personal correspondence
154 Jonas Veenhoven, personal correspondence

6 Conclusion

A variety of research methods were used to gather information on the background, condition, and composition of the various elements of the birdcage vases with the aim of answering the research question that serves as the focus of this thesis: *What aspects of the composition and construction of the mounted porcelain birds inside the cages have resulted in their detachment and damage?* The combined information from the different methods of investigating the context, construction, condition, and composition of the different elements has shed some light on various factors that are believed to have led to their detachment and damage.

Instrumental analysis carried out on the lacquer taken from the inside wall of the cage provided valuable information on its layer structure and composition, showing there are at least three distinct layers and that these layers contain ground layer with a clay filler, Japanese urushi lacquer, oils, and unidentified proteinaceous materials.

As has been shown in previous research urushi lacquer applications on porcelain substrates are very prone to detaching. The reason for this has been determined to be twofold. Firstly, the lacquer has a natural tendency to react to changes in climate by contracting and expanding while porcelain remains unaffected, and this difference in coefficient of expansion can cause stresses that can lead to issues of detachment. Secondly, urushi was applied to porcelain substrates almost exclusively for the export market and cheap materials were commonly used as binding mediums in the ground layers used on export wares to keep their production costs down, leading to qualitatively inferior lacquer applications more likely to exhibit issues.

The display and storage history of the two birdcage vases from Stiltestichting Landgoed den Bosch is largely unknown, but considering the very high susceptibility of urushi-lacquered porcelain to climatic changes it is assumed that such changes have been a major factor in the deterioration of the lacquer on the inner wall. It is also possible the binding medium of the ground layer for the lacquer was not made with urushi, but with a cheaper alternative that increases the lacquer decoration’s risk of detachment, but to prove this further analysis would have to be carried out to determine whether the ground layer contains urushi or alternative binders like animal glues or blood. While the protein markers found in the samples could point towards such materials having been used, these could also have come from the urushi layer itself.

The reason why the urushi decoration detached from the area beneath and around the large branch specifically is possibly explained by the added stress from the wood that has been glued to the wall. A detached branch on one of the Dresden birdcage vases no longer fit the contour inner wall, showing there had been a certain amount of internal tension in the wood. The combined stress of this rather large structure placed on a variety of materials with different reactions to climatic changes might be the cause of the loss of the higher degree of damage to the area around the branch.

While the different elements in the cage should normally be protected from physical damage, being fixed in place and protected by the metal wires, the separation of the branch made it possible for the branch and the pheasant to move around during handling, and this is likely the reason why this specific pheasant and its branch show considerably more damage than any of the others.

Furthermore, instrumental analysis suggests the wooden perches were restored quite extensively. This could suggest there were problems with the original decoration. To determine whether this Is the case further research could be undertaken.

Many questions still remain, but the results of the analyses carried out as well as the information collected about the birdcages will provide a helpful starting point for further research and decision-making processes surrounding the conservation and restoration of these and similar objects in the future.

7 Acknowledgements

I am very grateful to all the people and institutions who have supported me and made this research possible by sharing with me their time, advice, and knowledge

These include:

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Stiltestichting Landgoed den Bosch and Museum Museum Arnhem, for loaning these interesting objects for research,

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Finally, I would like to thank fellow students and staff at the UvA for their support and guidance: Mandy Slager (UvA), Tonny Beentjes (UvA)

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9 Appendix I – Additional Images of Birdcage Vases Br. 144 & Br. 145

All photographs taken by author

Birdcage vase Br. 144

Figure 9-1: Overview Pictures of Br. 144


Figure 9-2: Overview Picture of Br. 144


Figure 9-3: Overview Picture of Br. 144

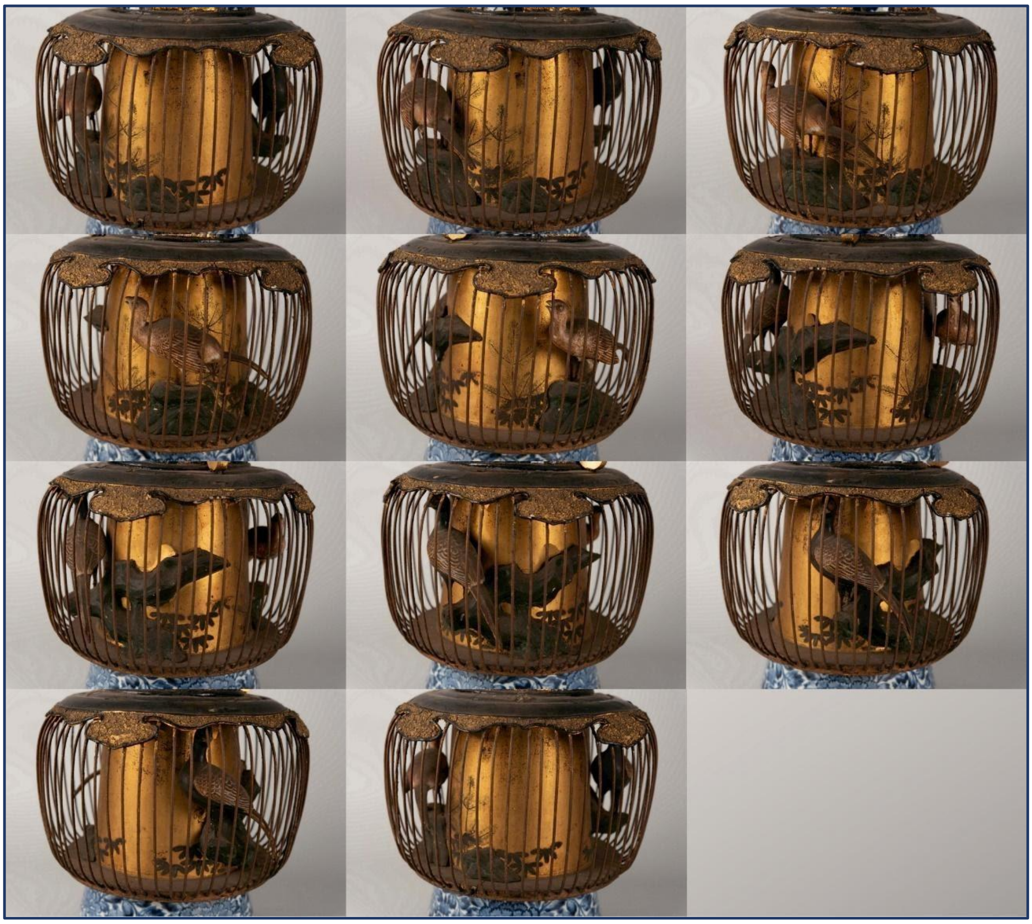


Figure 9-4: Overview of Cage of Br. 144

Figure 9-5: Gilded Panel on Br. 144

Figure 9-6: Overview of Cage of Br. 144

Birdcage vase Br. 145

Figure 9-7: Overview of Br. 145

Figure 9-8: Overview of Cage of Br. 145

10 Appendix II – Condition Mappings of Cages

All images created by author

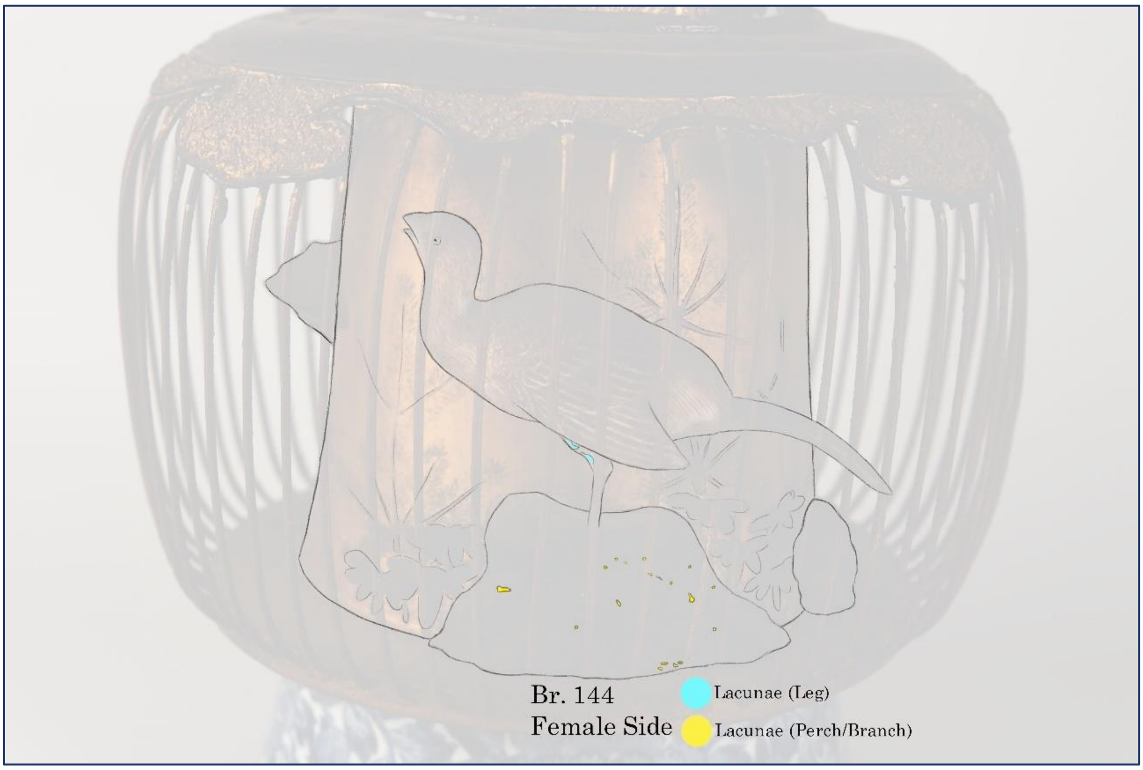


Figure 10-1: Condition Mapping of Br. 144 (Female Side)

Figure 10-2: Condition Mapping of Br. 144 (Male Side)

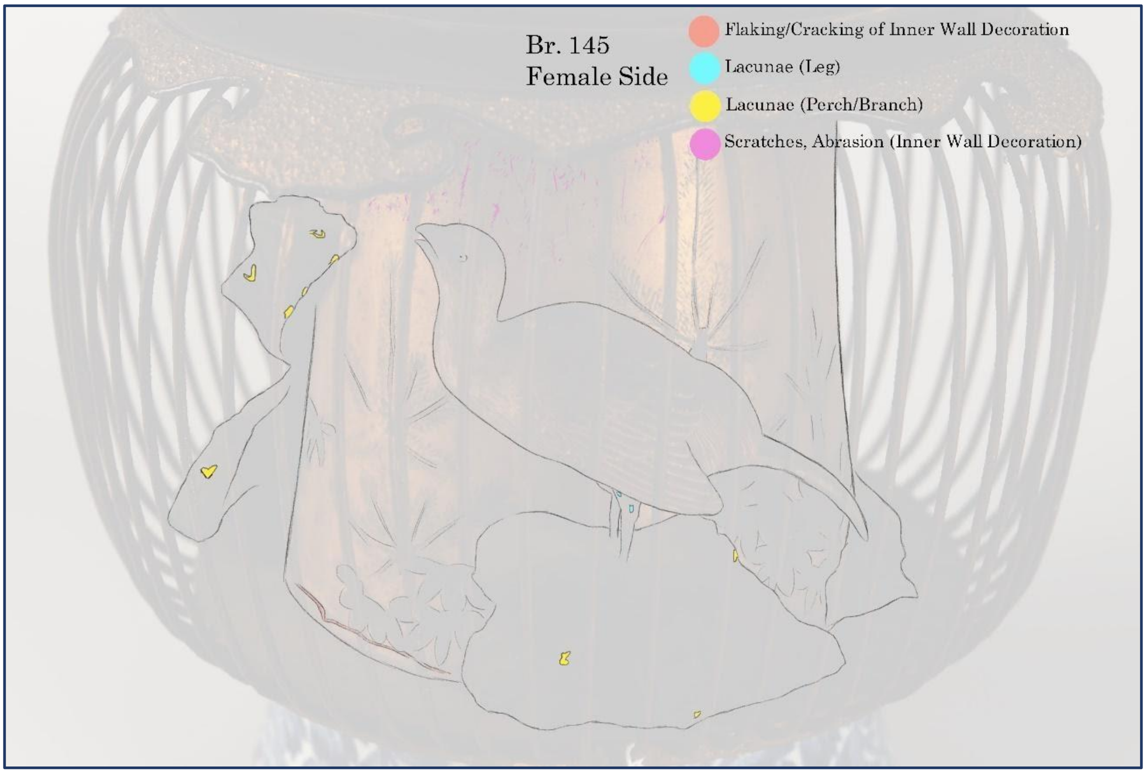


Figure 10-3: Condition Mapping of Br. 145 (Female Side)

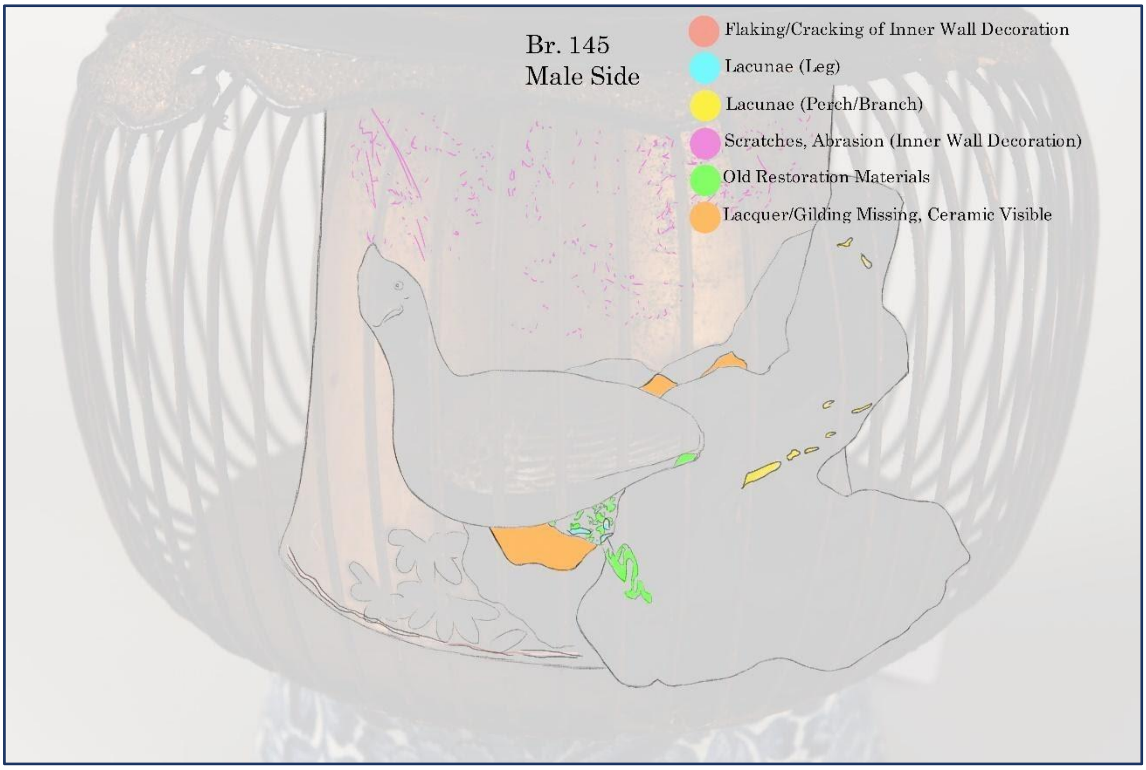


Figure 10-4: Condition Mapping of Br. 145 (Male Side)

11 Appendix III – Cleaning Tests

All photographs taken by author

Figure 11-1: Cleaning Test on Wing of Male Pheasant on Br. 145

Figure 11-2: Cleaning Test on Wing of Female Pheasant on Br. 145

Figure 11-3:Cleaning Test on Back of Male Pheasant on Br. 144

Figure 11-4: Cleaning Test on breast of Male Pheasant on Br. 144

12 Appendix IV – Samples

All images created by author

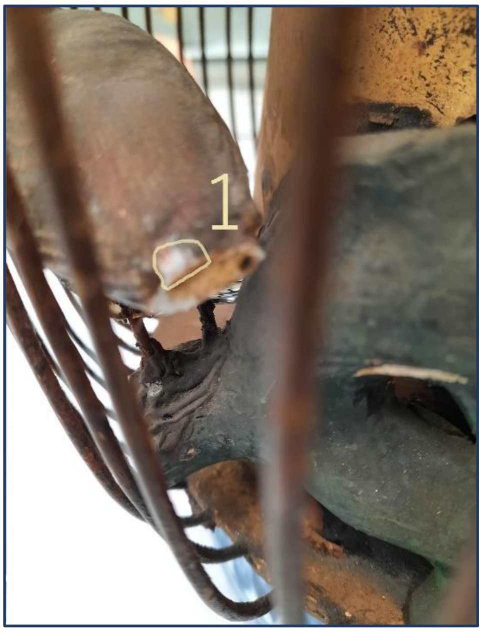


Figure 12-1: Overview of Sampling Site 1

Figure 12-2: Hirox KH-7700 3-D Digital Microscope Overview Image of Samples Taken from Sampling Site 1 (x20)

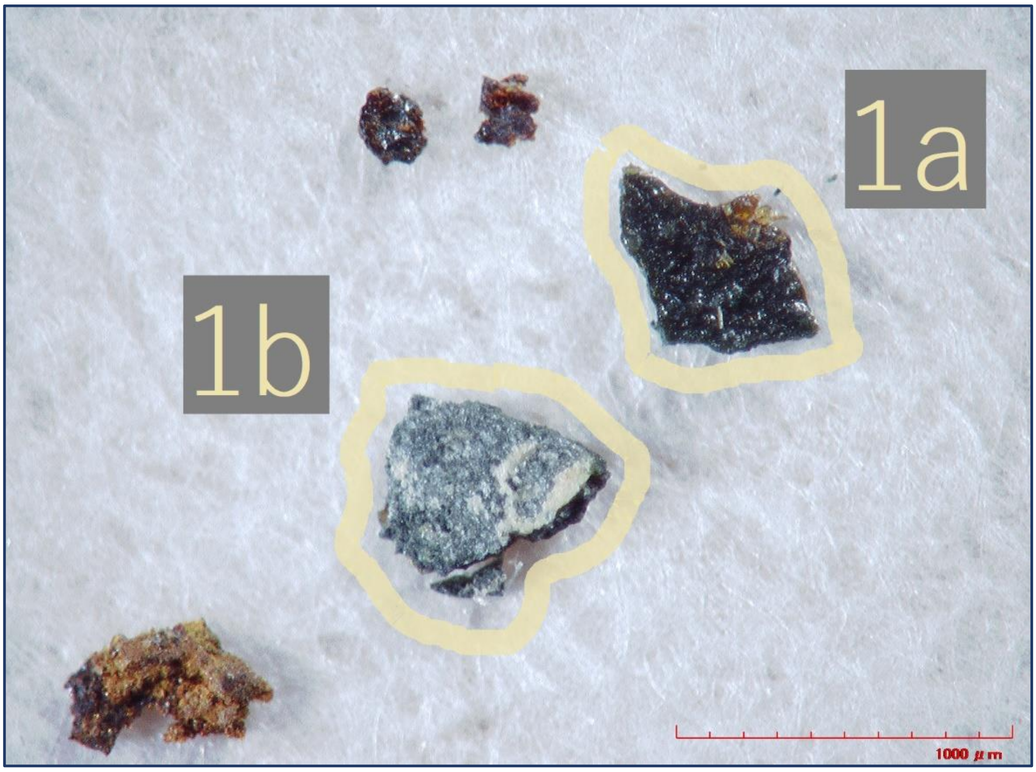


Figure 12-3: Hirox KH-7700 3-D Digital Microscope Overview Image of Samples Taken from Sampling Site One (x100), 1a and 1b selected for embedding

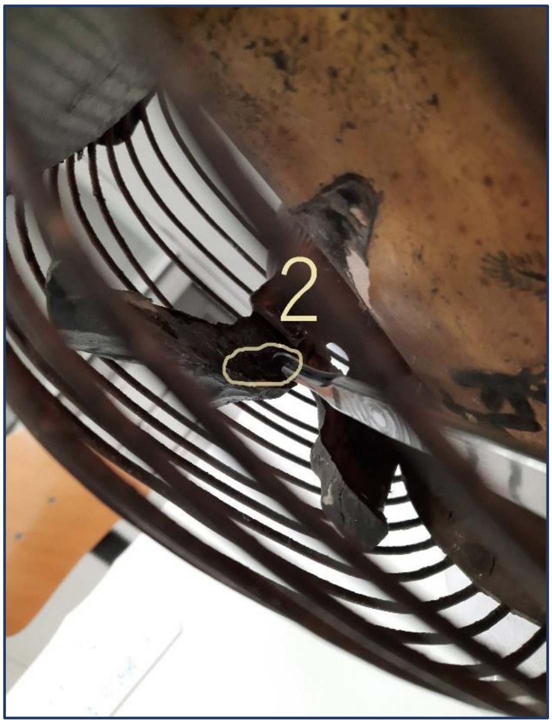


Figure 12-4: Overview of Sampling Site 2

Figure 12-5: Hirox KH-7700 3-D Digital Microscope Overview Image of Samples Taken from Sampling Site 2 (x20)

Figure 12-6: Hirox KH-7700 3-D Digital Microscope Image of Samples Taken from Sampling Site Two (x40), Sample 2a selected for embedding

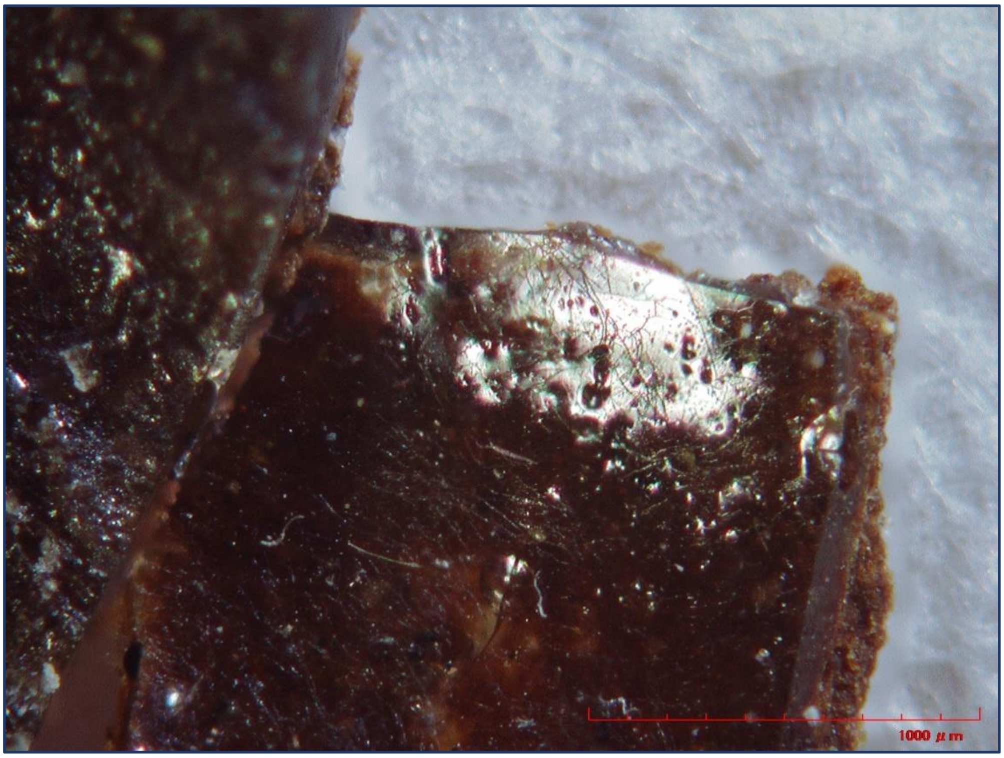


Figure 12-7: Hirox KH-7700 3-D Digital Microscope Detail of Sample Taken from Site 2 Showing Gold Flake (x160)

Figure 12-8: Overview of Sampling Site 3

Figure 12-9: Hirox KH-7700 3-D Digital Microscope Image of Samples Taken from Sampling Site Two (x40), Samples 3a and 3b selected for embedding

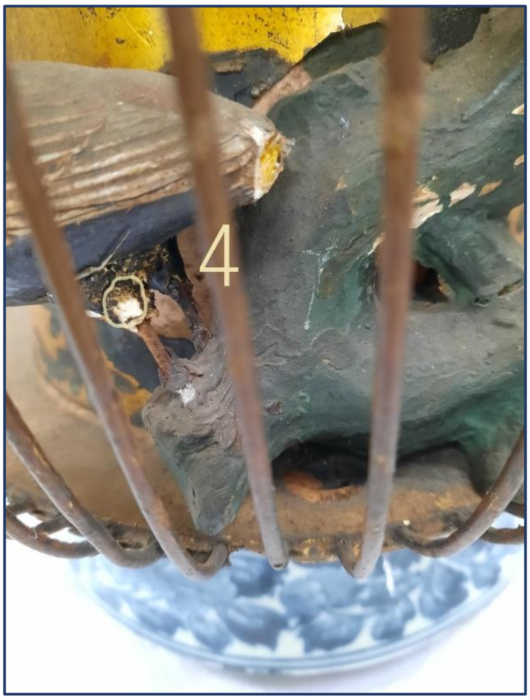


Figure 12-10: Overview of Sampling Site 4

Figure 12-11: Hirox KH-7700 3-D Digital Microscope Image of Samples Taken from Sampling Site Four (x40)

Figure 12-12: Overview of Sampling Site 5. Image: Author

Figure 12-13: Hirox KH-7700 3-D Digital Microscope Image of Sample Taken from Sampling Site Five (x40), Part 5a outlined here selected for embedding

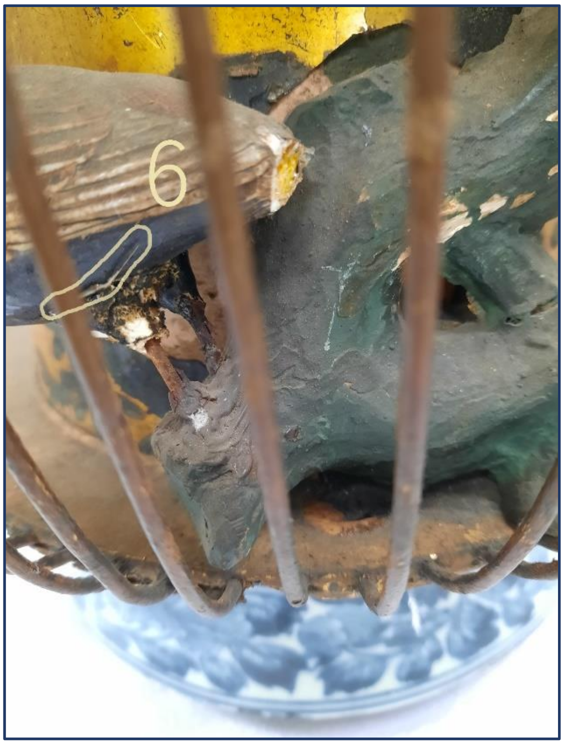


Figure 12-14: Overview of Sampling Site 6.
Image: Author

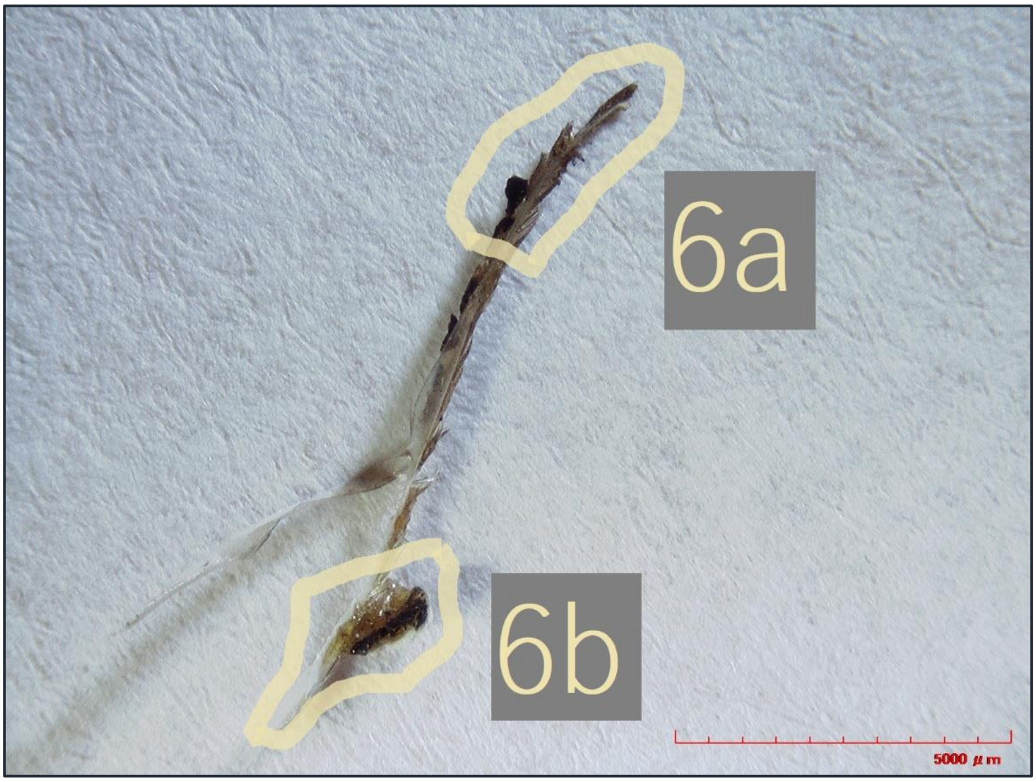


Figure 12-15: Hirox KH-7700 3-D Digital Microscope Image of Sample Taken from Sampling Site Six (x20)

13 Appendix V - UV Images of Birdcage Vases Br. 144 & Br. 145

All photographs taken by author

See UV Photography for information on the methodology

Birdcage vase Br. 144

Figure 13-1: UV Overview Pictures of Br. 144


Figure 13-2: UV Overview Picture of Br. 144


Figure 13-3: UV Overview Picture of Br. 144


Figure 13-4: UV Overview of Cage of Br. 144

Figure 13-5: UV Overview of Cage of Br. 144

Figure 13-6: UV Overview of Cage of Br. 144

Figure 13-7: UV Overview of Cage of Br. 144

Birdcage vase Br. 145

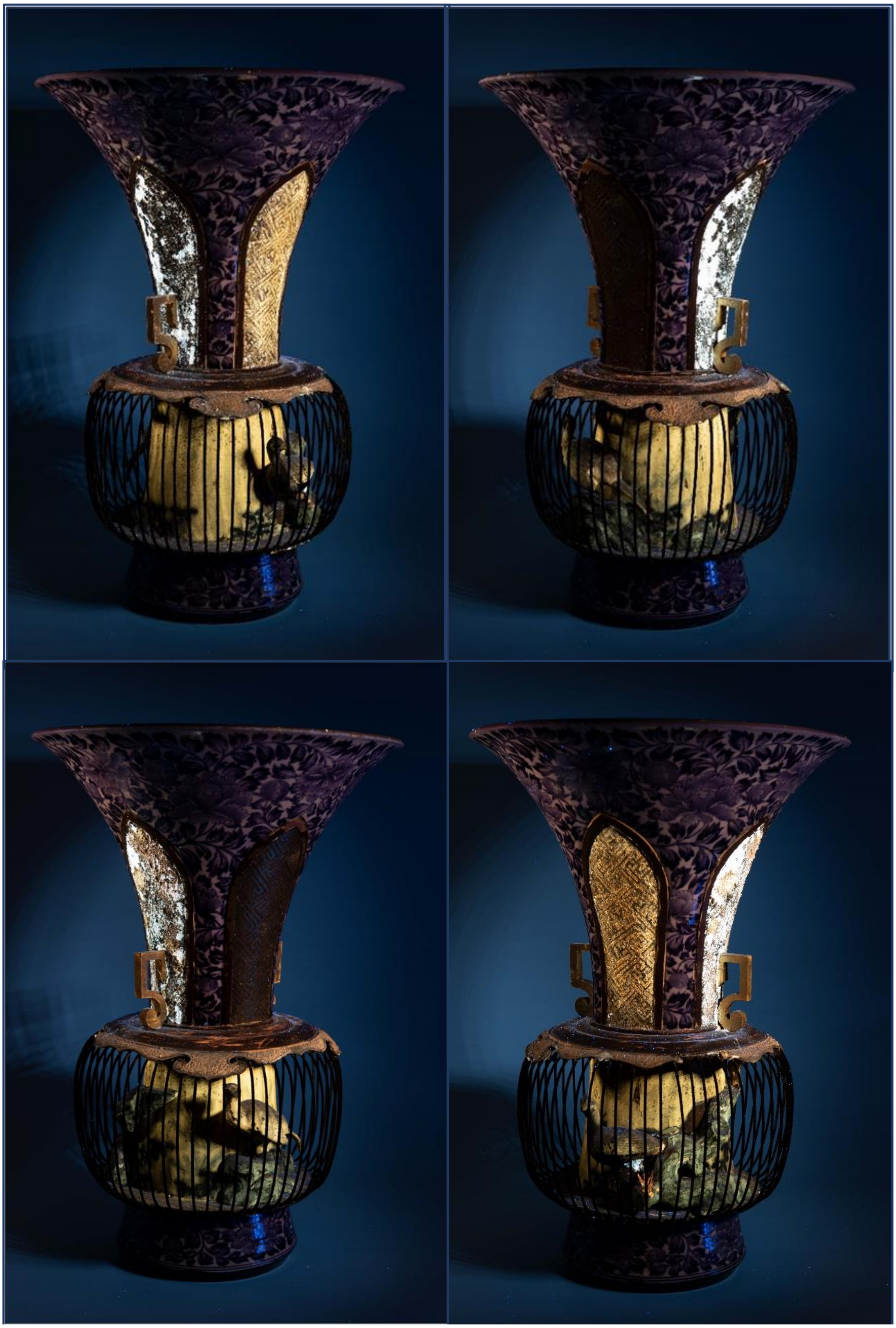


Figure 13-8: UV Overview of Br. 145

Figure 13-9: UV Overview of Cage of Br. 145

Figure 13-10: UV Overview of Cage of Br. 145

Figure 13-11: UV Overview of Cage of Br. 145

Figure 13-12: : UV Overview of Cage of Br. 145

14 Appendix VI - Microscopy Images and SEM-EDX Results of Embedded Samples

All images taken and results compiled by Luc Megens (RCE)

See Microscopy and Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDX) for information on the methodology

Sample 1a

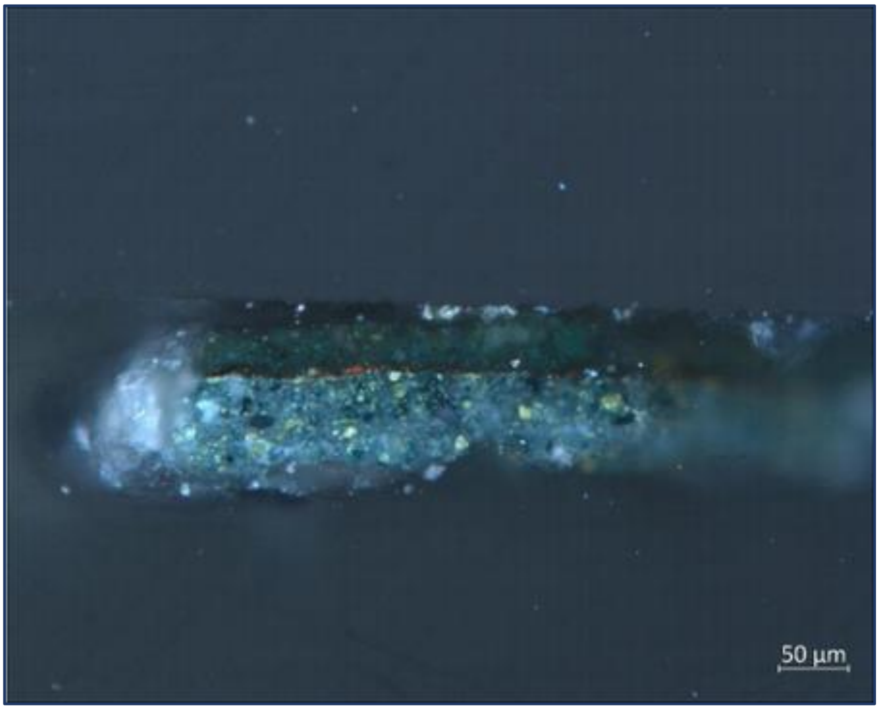


Figure 14-1: Zeiss Axioplan 2 Imaging Microscope overview of Sample 1a

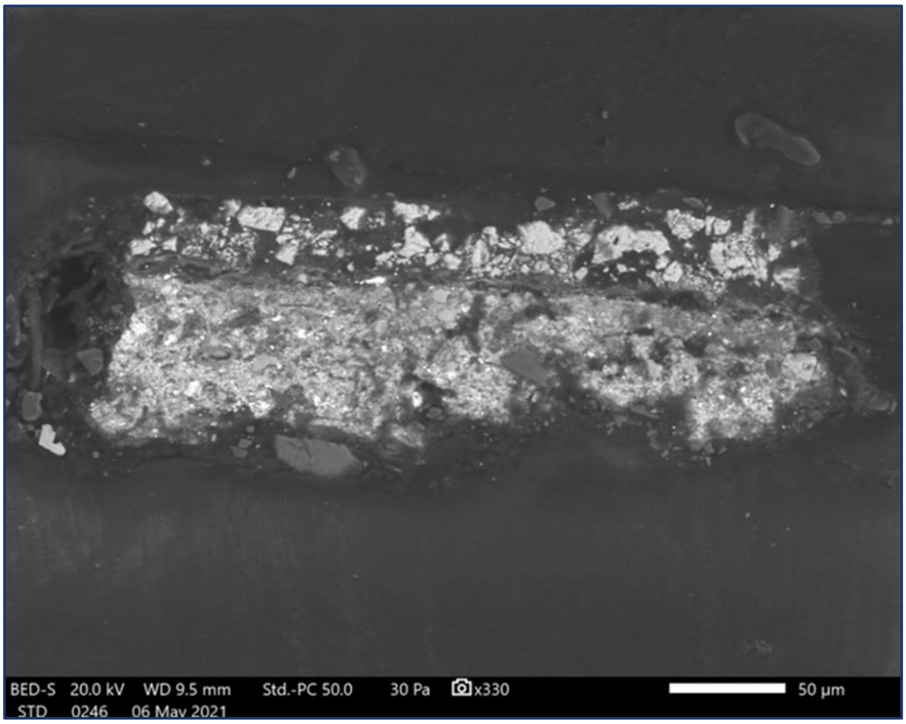


Figure 14-2: SEM back-scattered overview image of Sample 1a

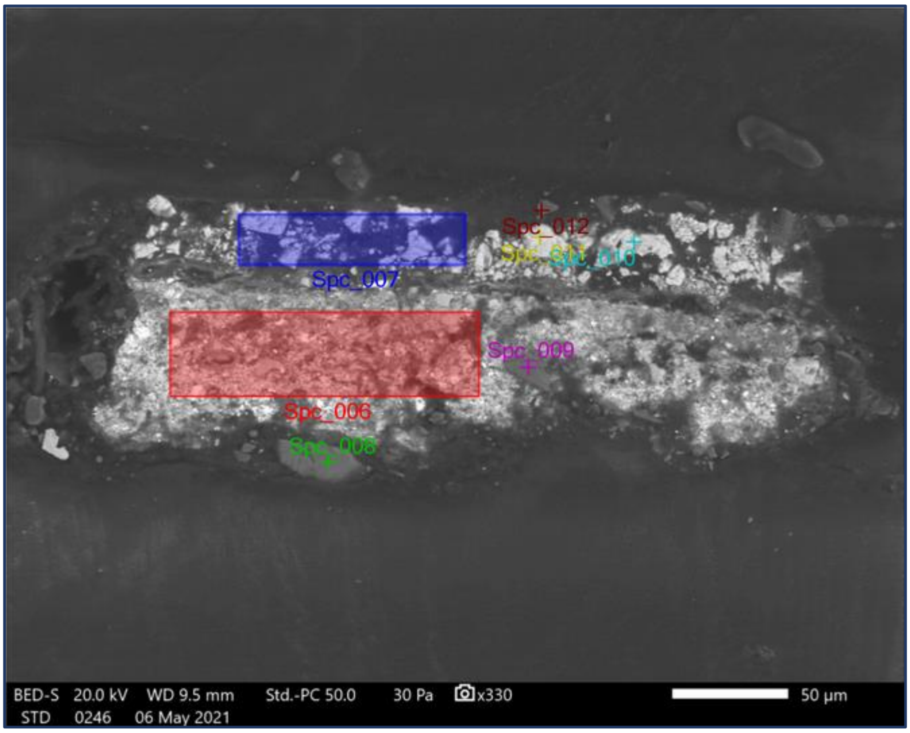
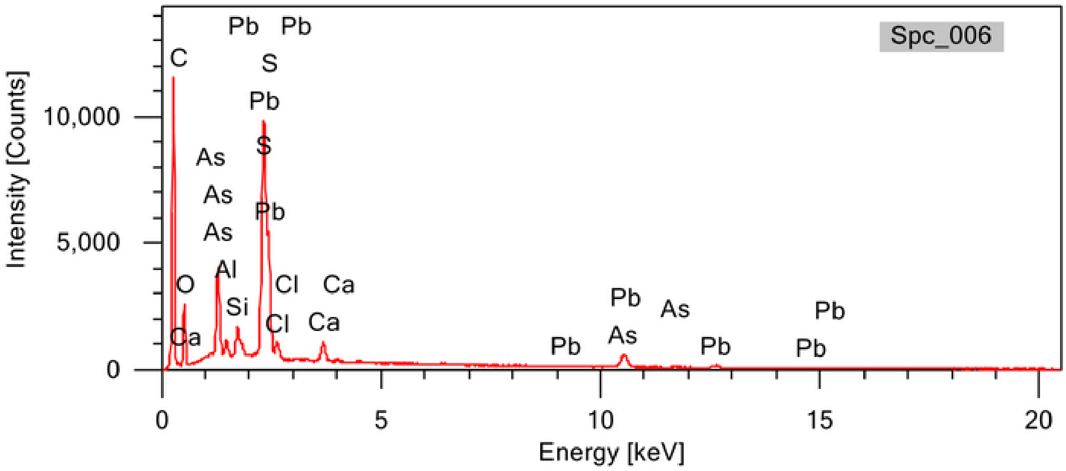


Figure 14-3: SEM back-scattered image of Sample 1a showing areas analyzed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Energy [keV]
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5,000
10,000
0
5
10
15
20
C
Pb Pb
S
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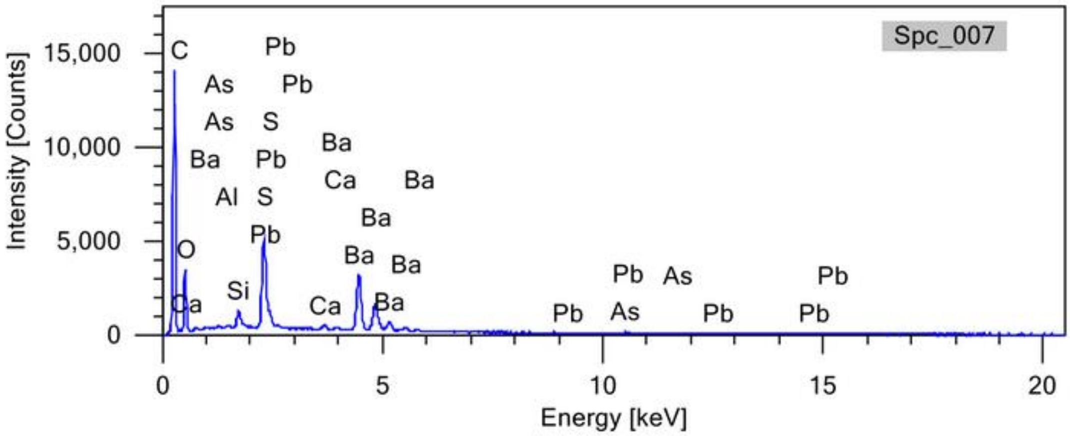
Pb
As
Pb
Pb
Pb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Intensity [Counts]
Energy [keV]
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5,000
10,000
15,000
0
5
10
15
20
C
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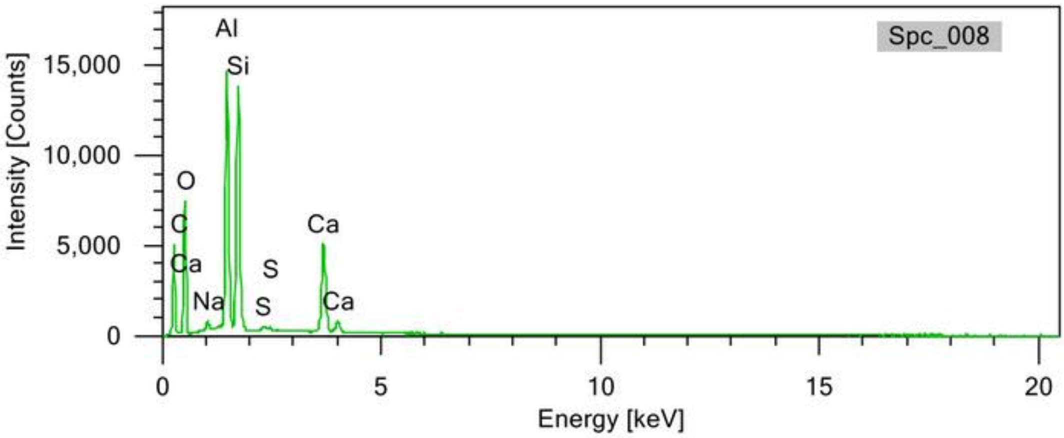
As
S
Ba
Ba
Pb
Ca
Ba
Al
S
Ba
Pb
O
Ba
Ba
Si
Ca
Ca
Ba
Pb
As
Pb
As
Pb
Pb
Pb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Intensity [Counts]
Energy [keV]
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10,000
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10
15
20
Al
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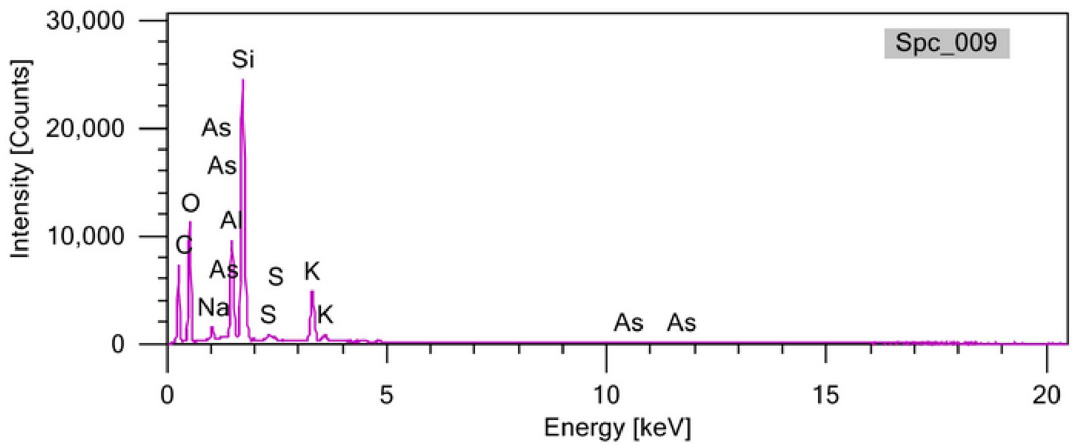
Ca
Na
S
S
Ca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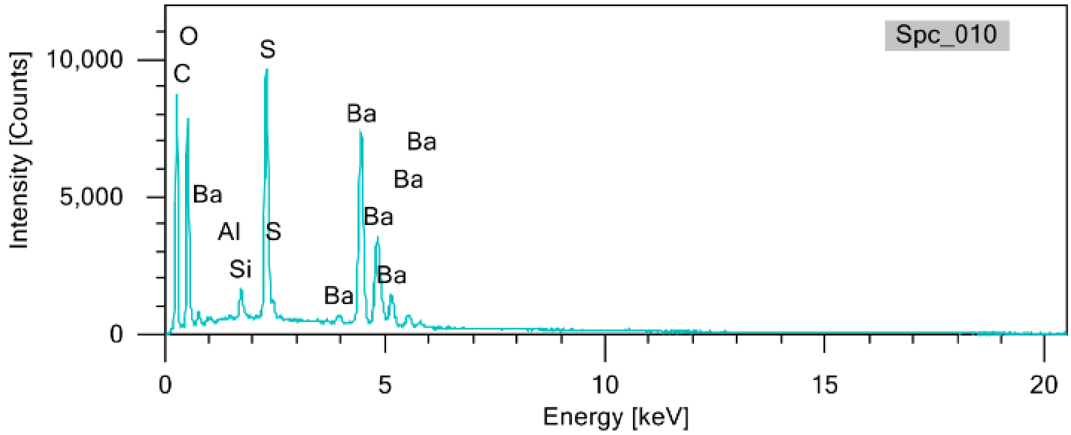
Intensity [Counts]
Energy [keV]
Si
As
As
O
Al
C
As
S
K
Na
S
K
As
As
30,000
20,000
10,000
0
0
5
10
15
20


Spc_010
Intensity [Counts]
Energy [keV]
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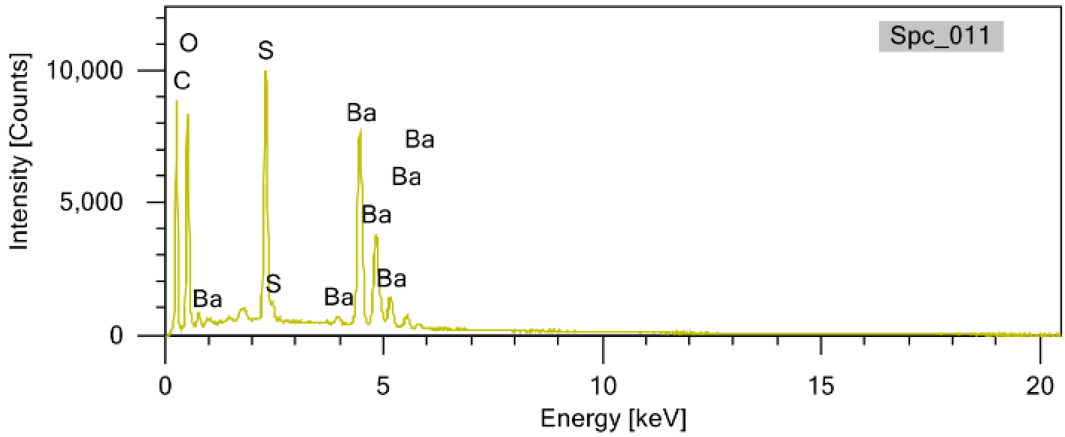
S
C
Ba
Ba
Ba
Ba
Ba
Al
S
Si
Ba
Ba
10,000
5,000
0
0
5
10
15
20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Intensity [Counts]
Energy [keV]
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S
C
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Ba
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S
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Ba
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5,000
0
0
5
10
15
20

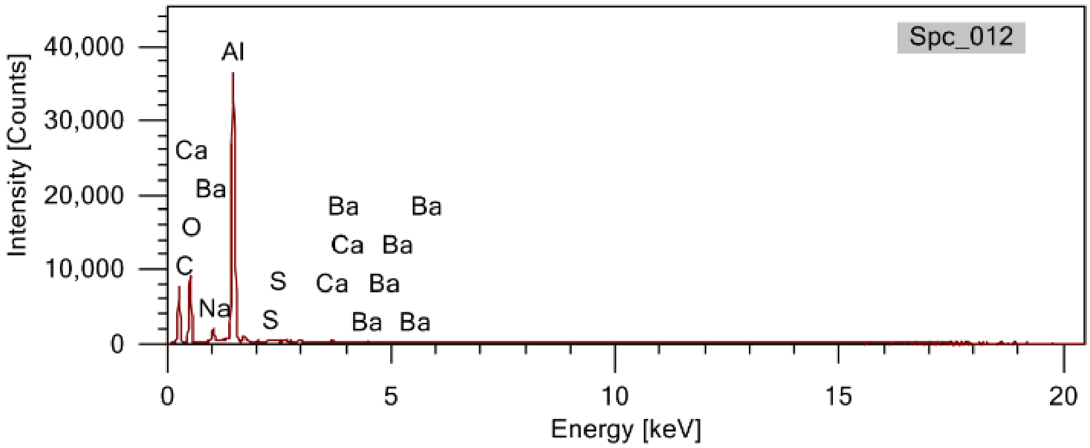


Figure 14-4: EDX spectrums for Figure 14-3

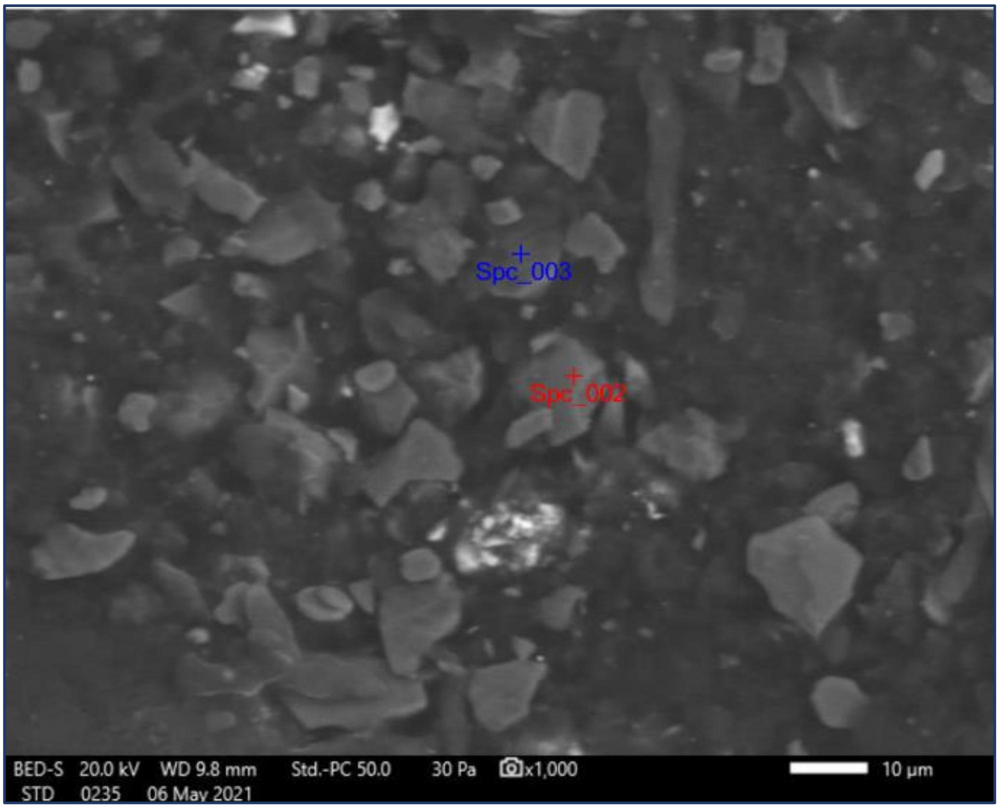


Figure 14-5: SEM back-scattered image of Sample 1a showing areas analyzed

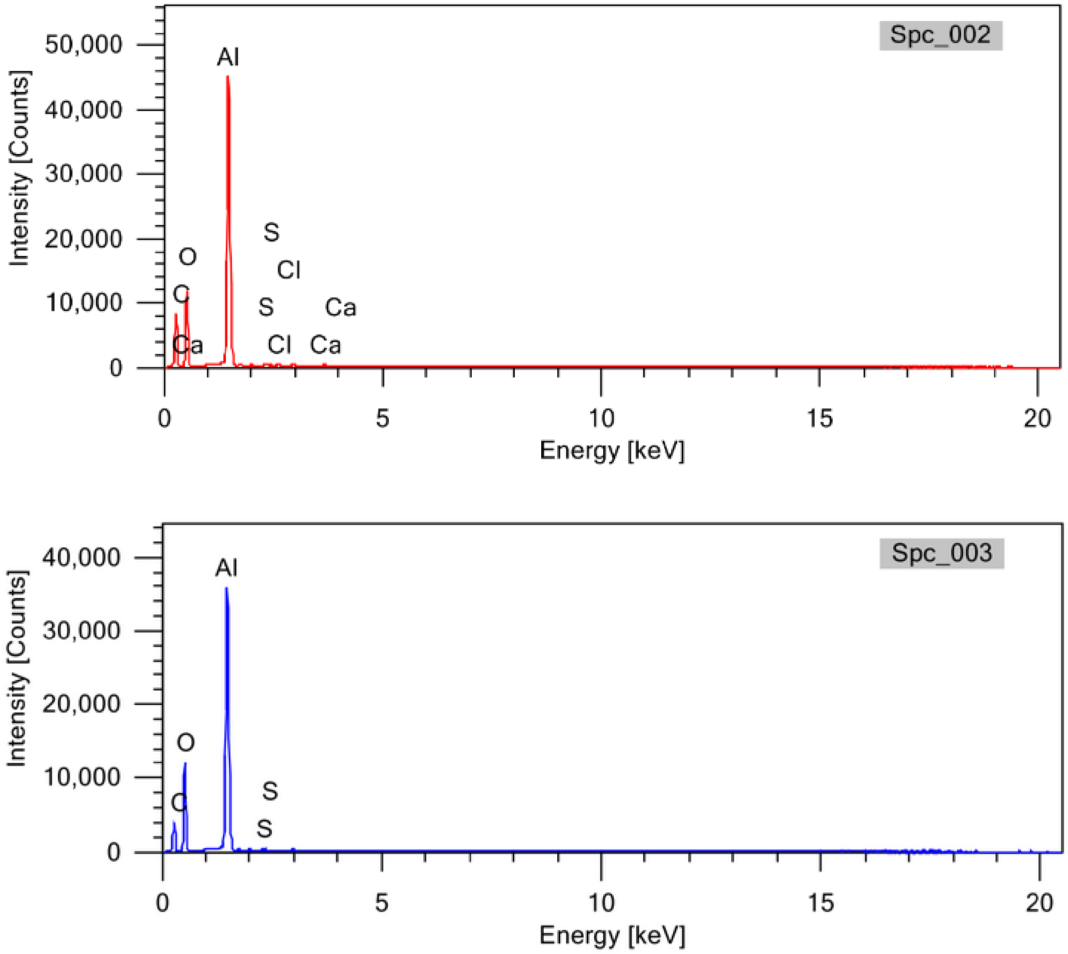


Figure 14-6: EDX spectrums for Figure 14-5

Sample 1b

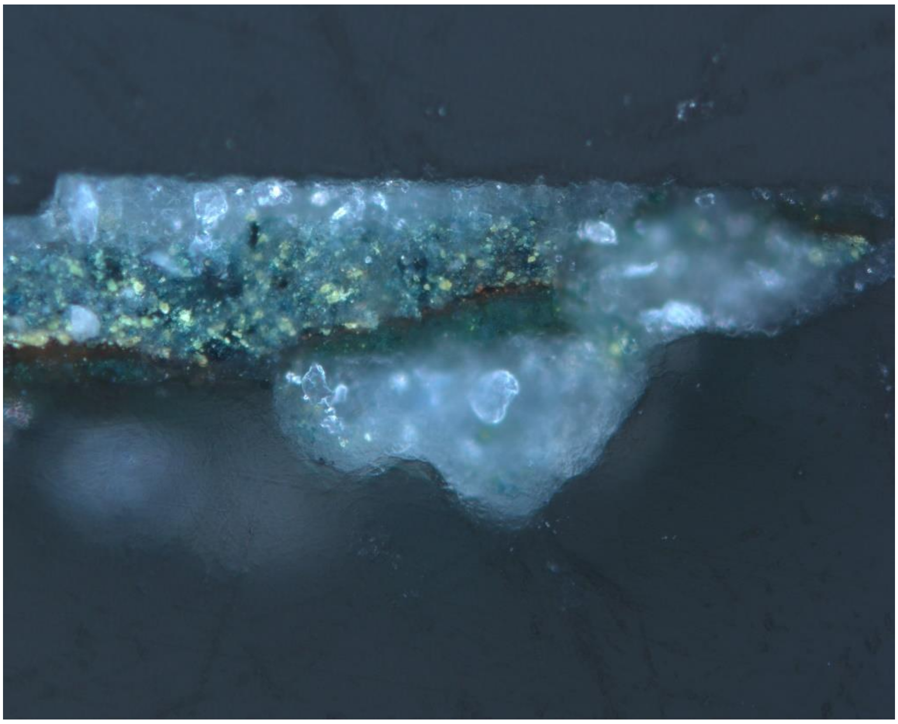


Figure 14-7: Zeiss Axioplan 2 Imaging Microscope overview of Sample 1b

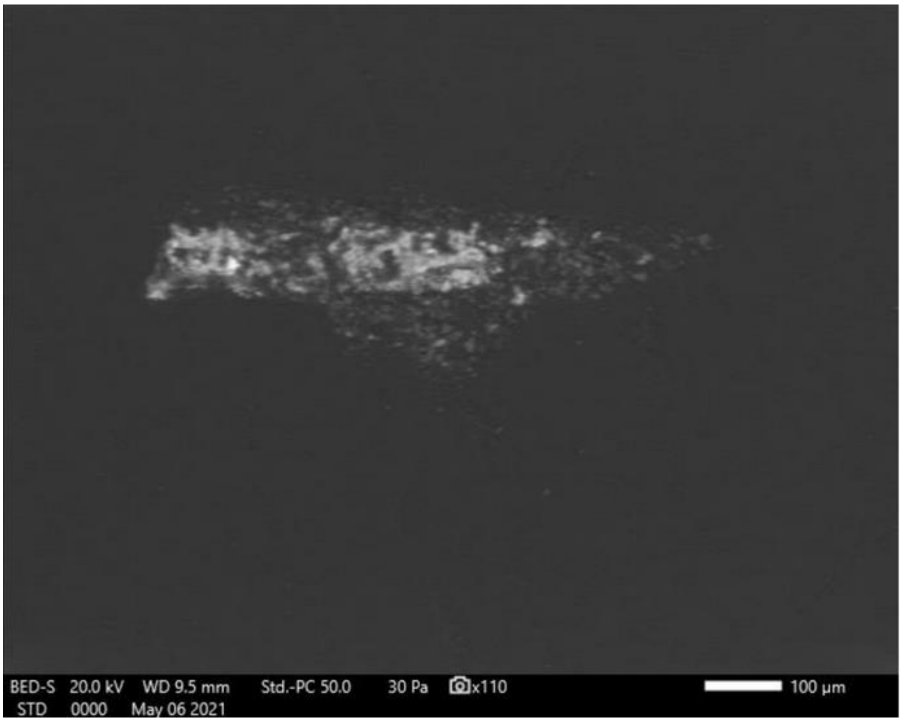


Figure 14-8: SEM back-scattered overview image of Sample 1b

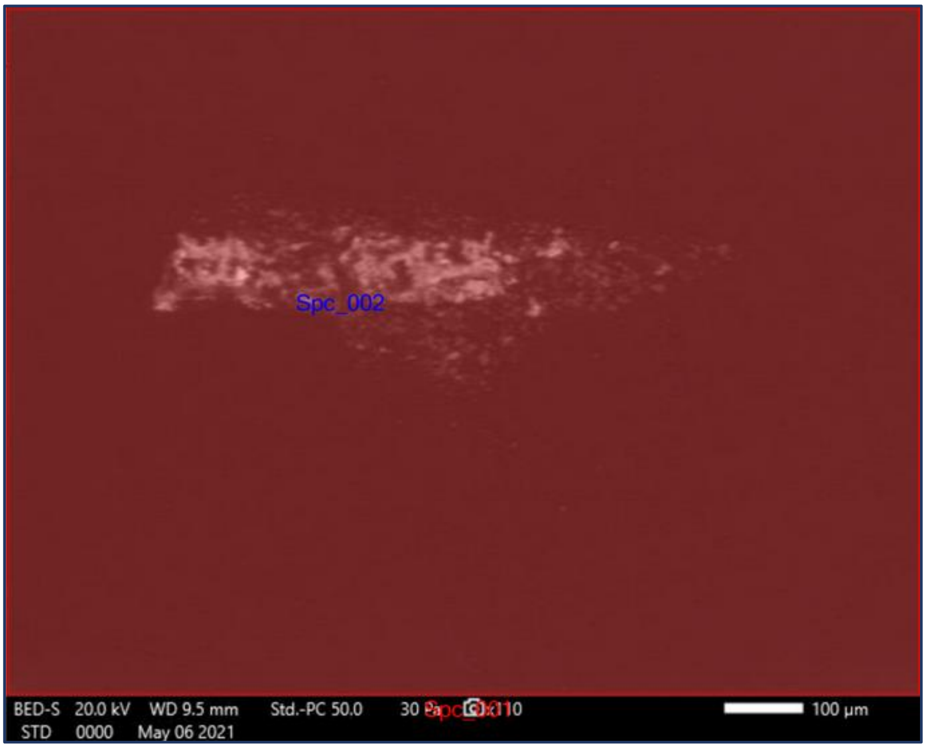


Figure 14-9: SEM back-scattered image of Sample 1b showing area analyzed

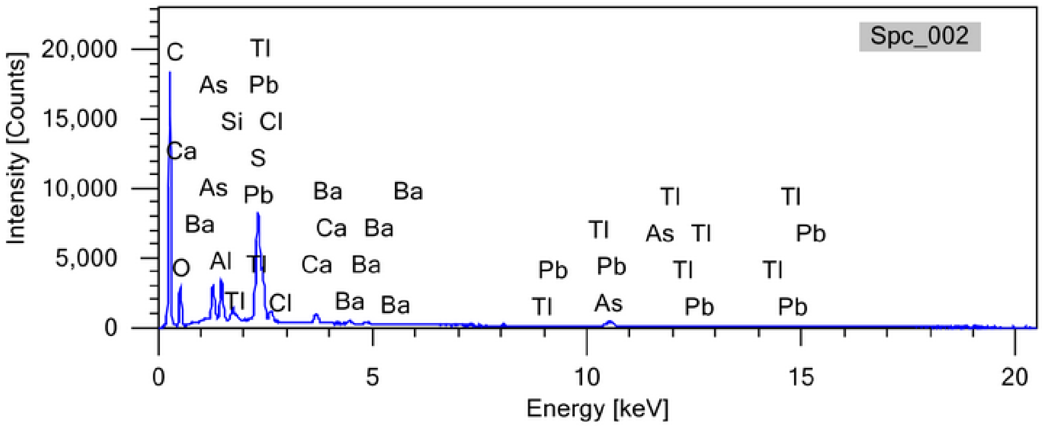


Figure 14-10: EDX spectrum for Figure 14-9

Sample 2a

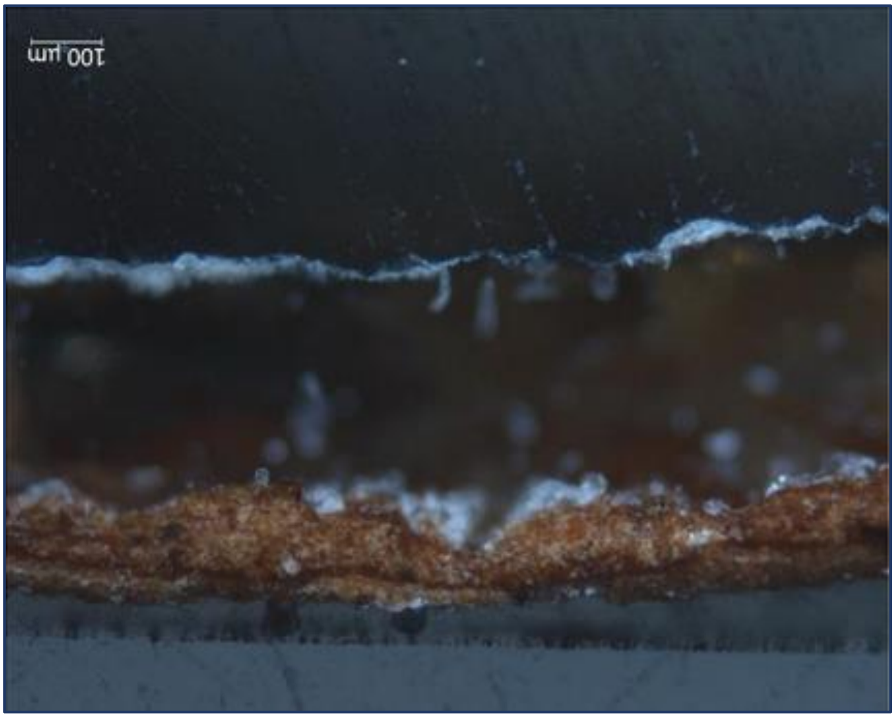


Figure 14-12: Zeiss Axioplan 2 Imaging Microscope overview of Sample 2a

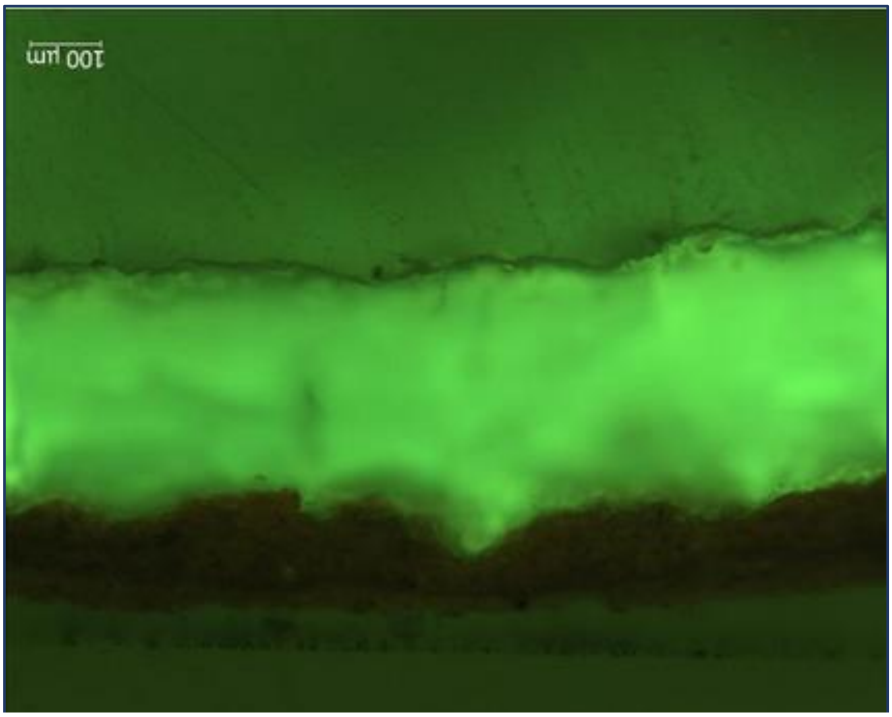


Figure 14-11: Zeiss Axioplan 2 Imaging Microscope fluorescence overview of Sample 2a (excitation filter BP 450-490 nm, emission filter 515 nm)

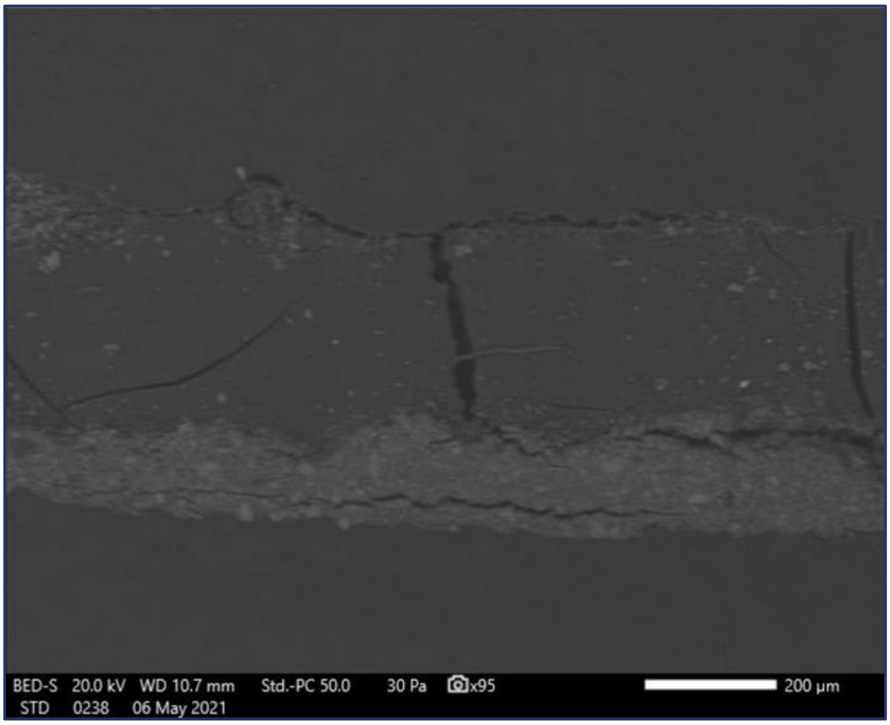


Figure 14-13: SEM back-scattered overview image of Sample 2a

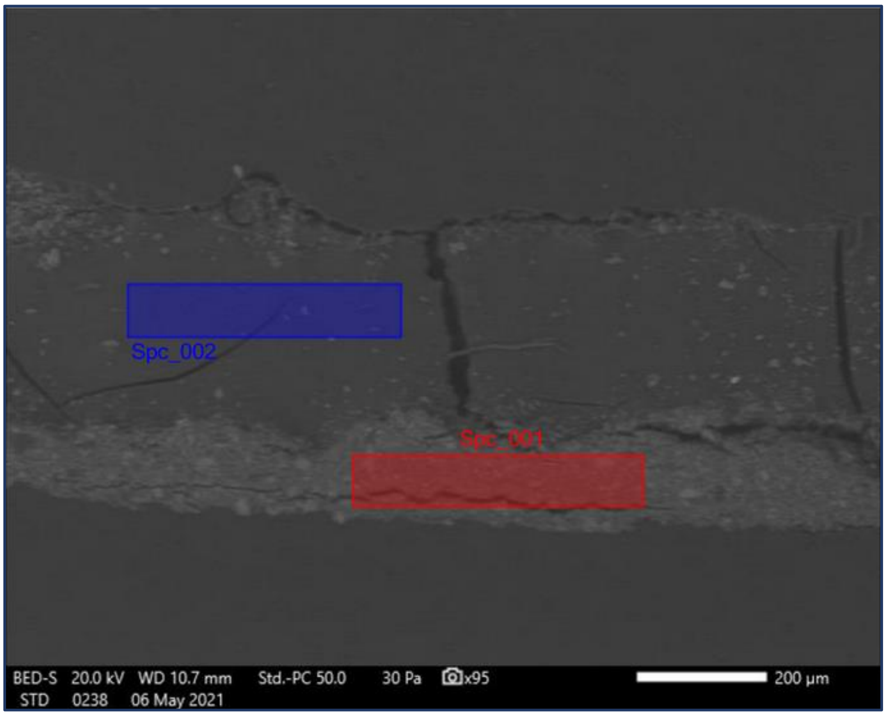


Figure 14-14: SEM back-scattered image of Sample 2a showing areas analyzed

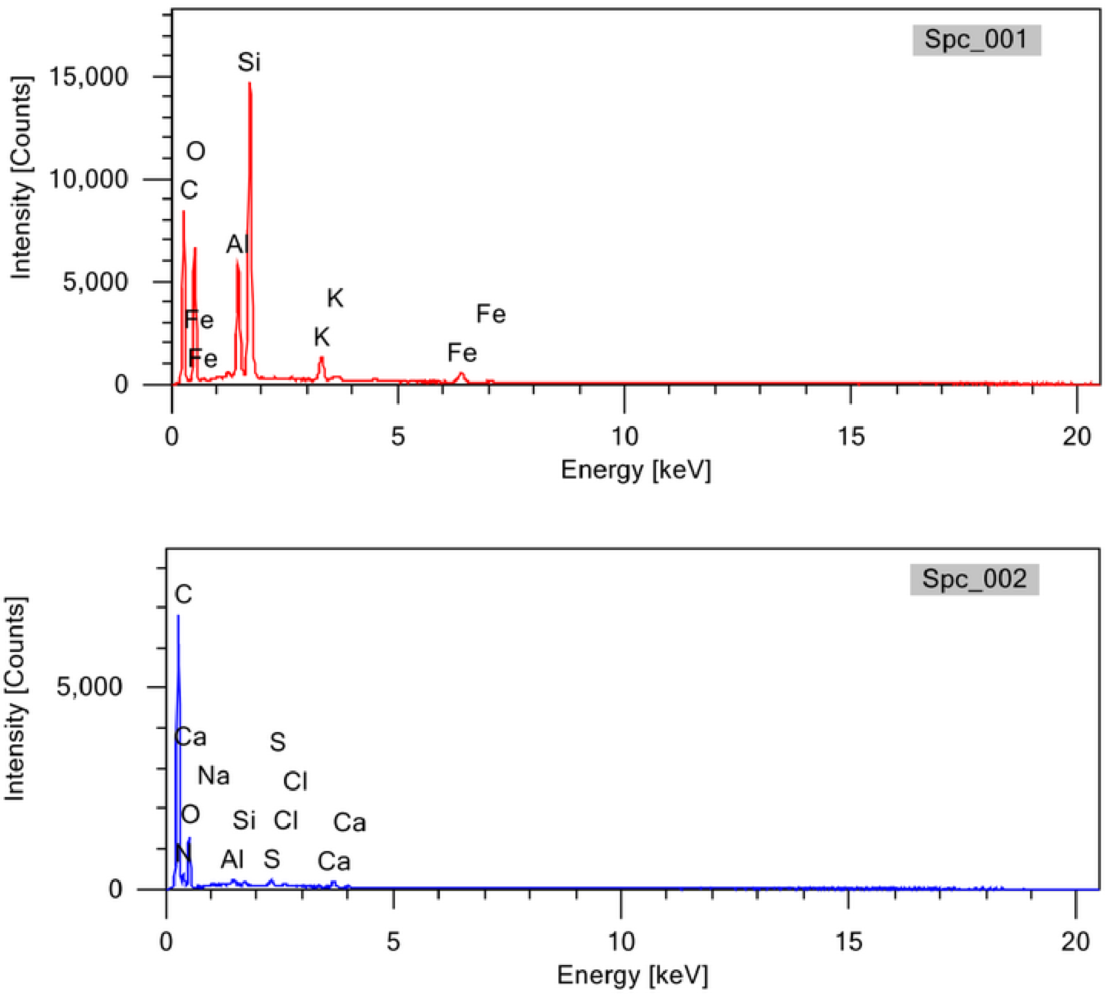


Figure 14-15: EDX spectrums for Figure 14-5

Sample 3a

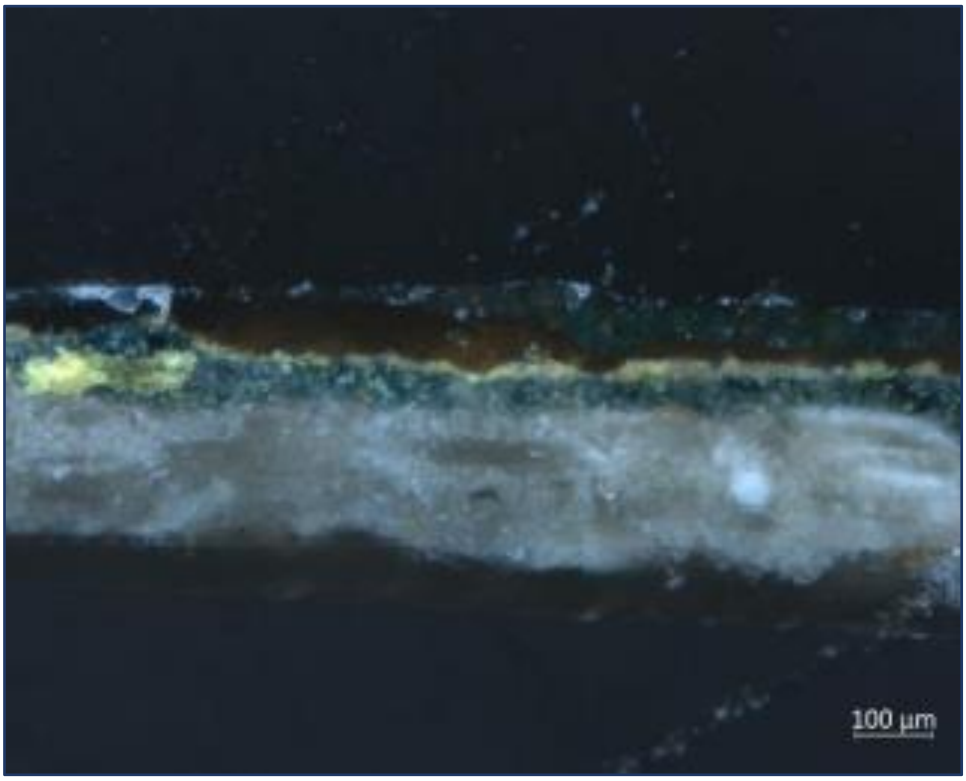


Figure 14-16: Zeiss Axioplan 2 Imaging Microscope overview of Sample 3a

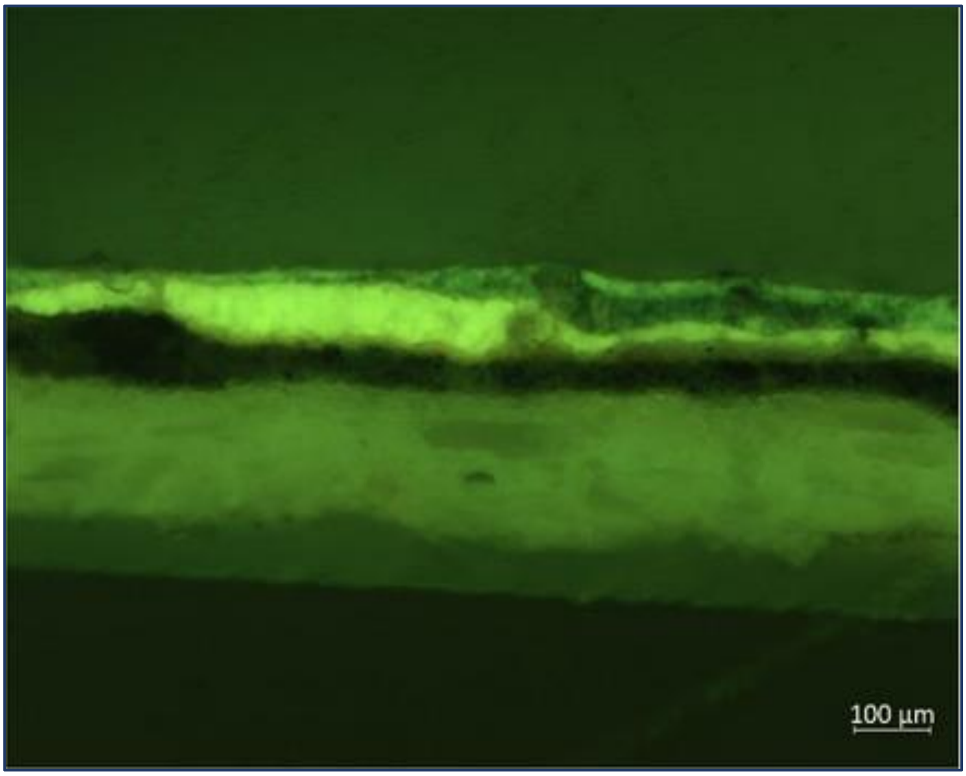


Figure 14-17: Zeiss Axioplan 2 Imaging Microscope fluorescence overview of Sample 3a (excitation filter BP 450-490 nm, emission filter 515 nm)

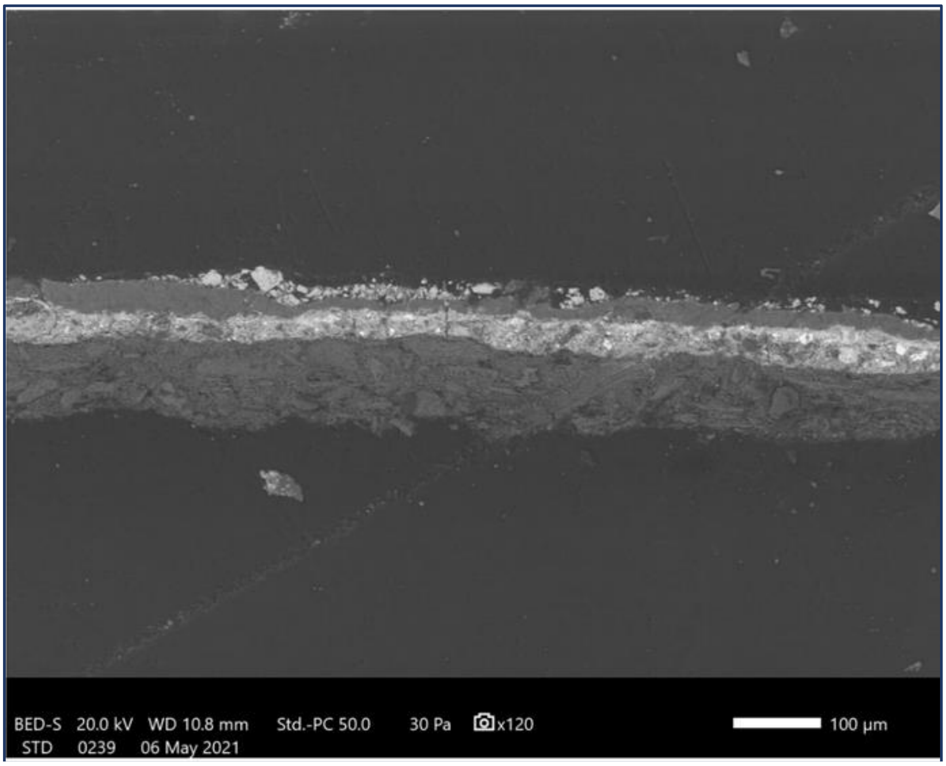


Figure 14-18: SEM back-scattered overview image of Sample 3a

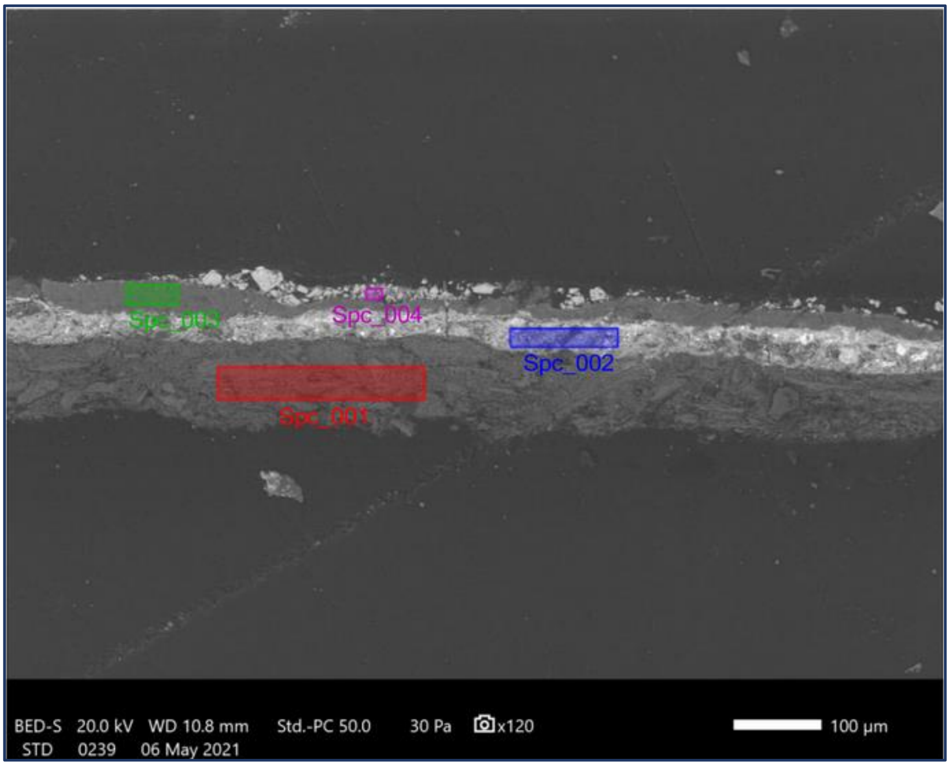
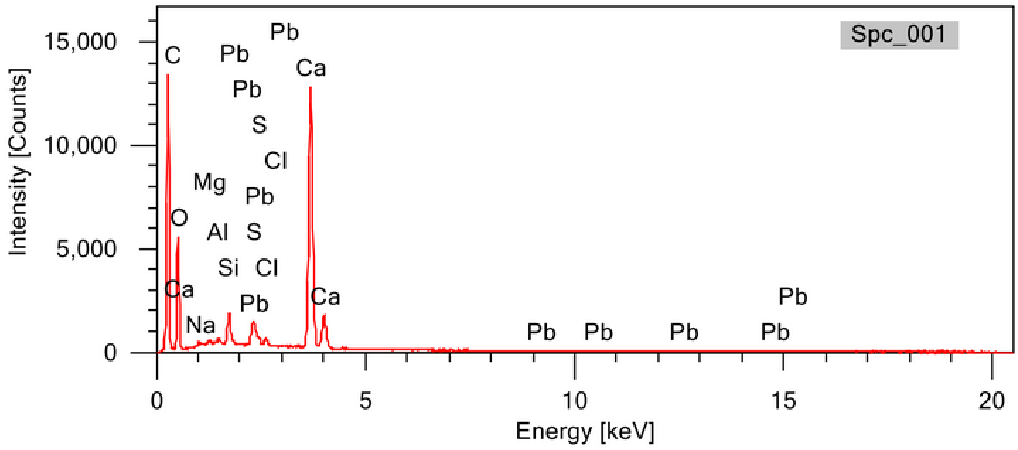
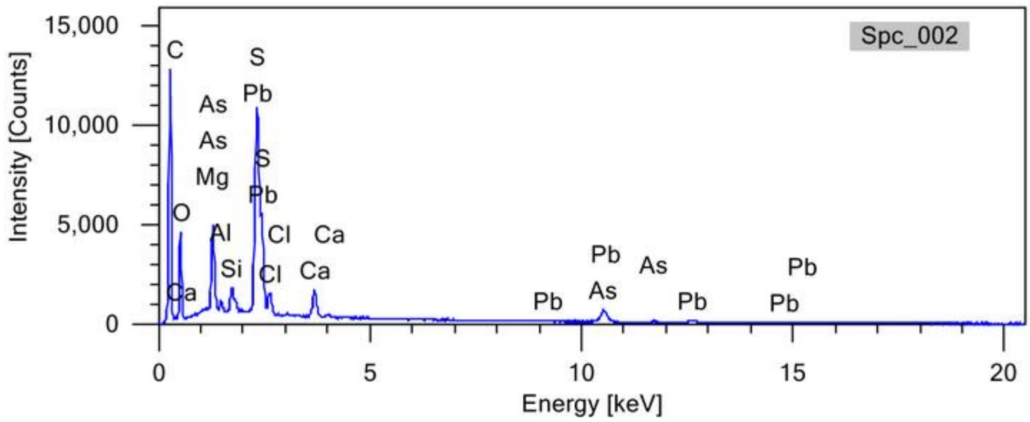
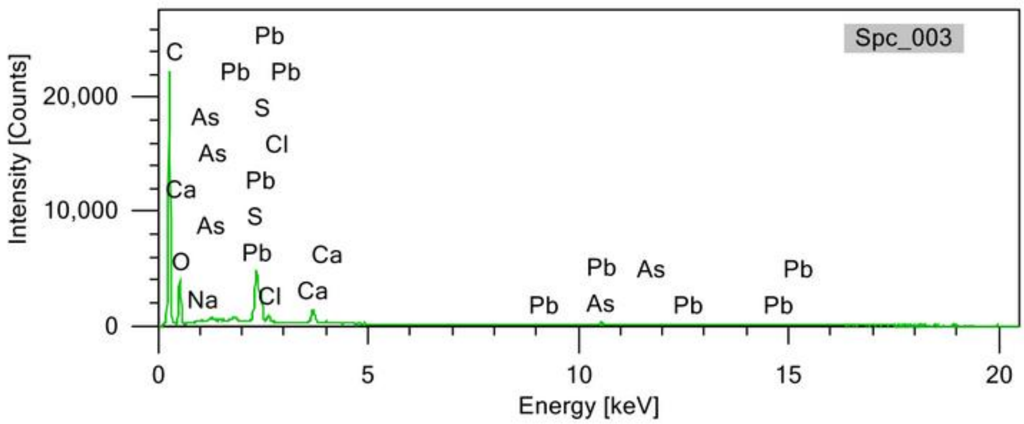


Figure 14-19: SEM back-scattered image of Sample 3a showing areas analyzed


Spc_001
Intensity [Counts]
15,000
10,000
5,000
0
C
O
Ca
Na
Mg
Al
Si
Pb
S
Cl
Ca
Energy [keV]
0
5
10
15
20


Spc_002
Intensity [Counts]
15,000
10,000
5,000
0
C
O
Ca
As
Mg
Al
Si
S
Pb
Cl
Ca
Energy [keV]
0
5
10
15
20


Spc_003
Intensity [Counts]
20,000
10,000
0
C
Ca
O
Na
As
Pb
S
Cl
Ca
Energy [keV]
0
5
10
15
20

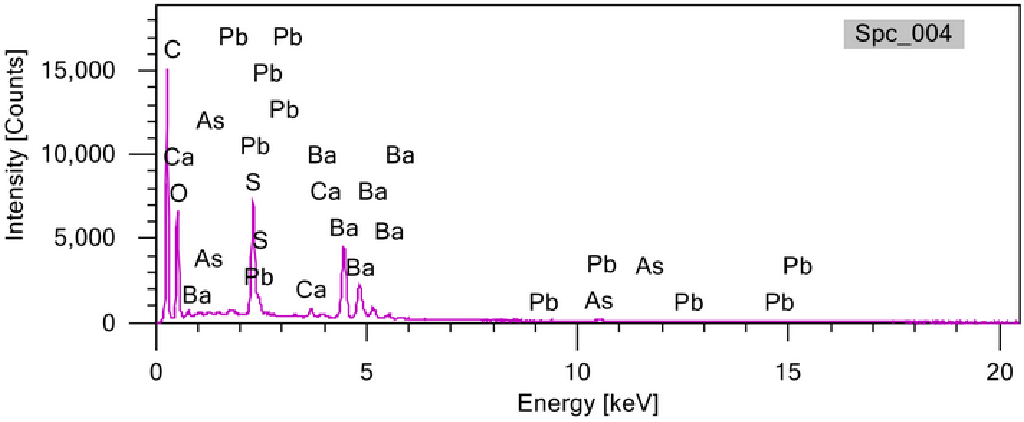


Figure 14-20: EDX spectrums for Figure 14-19

Sample 3b

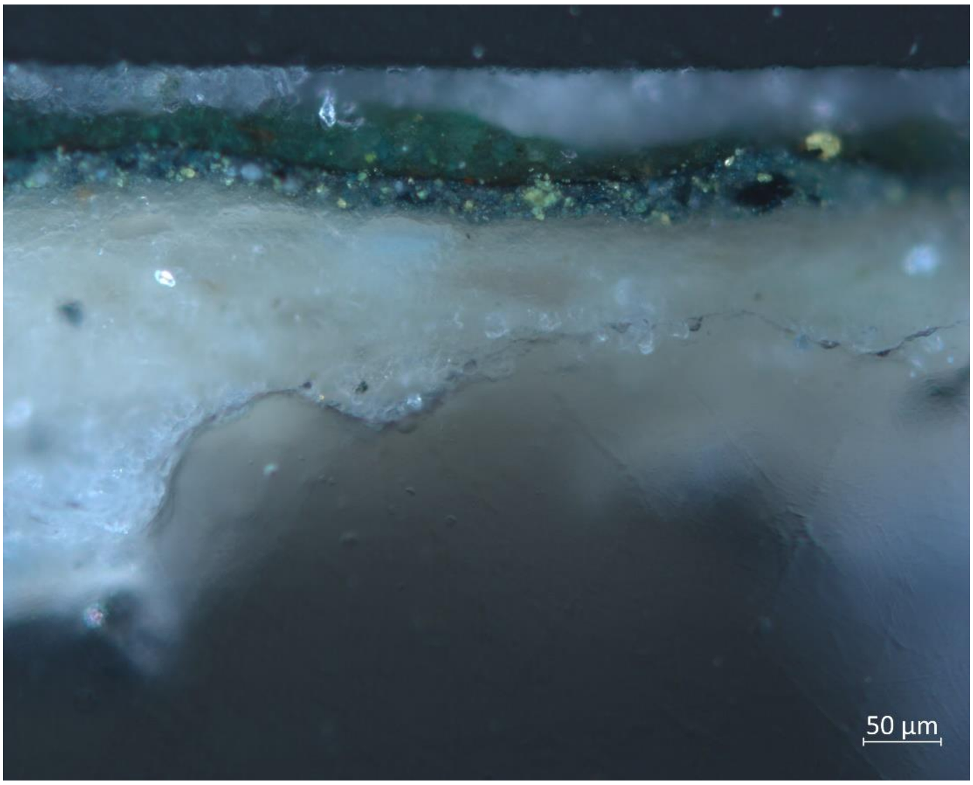


Figure 14-21: Zeiss Axioplan 2 Imaging Microscope overview of Sample 3b

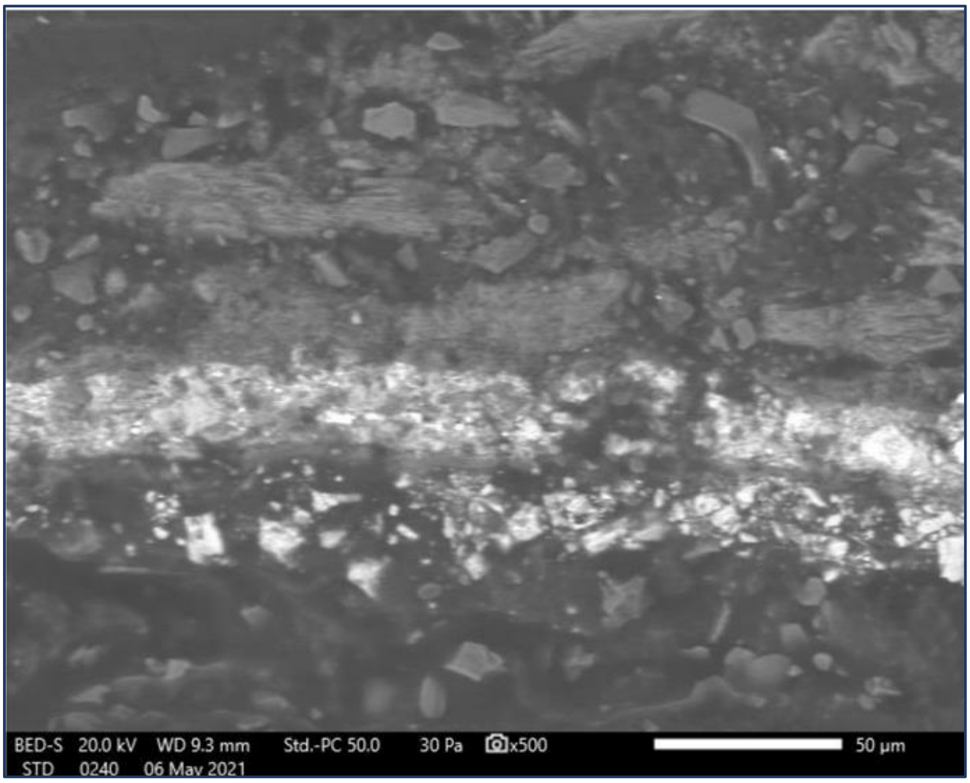


Figure 14-22: SEM back-scattered overview image of Sample 3b

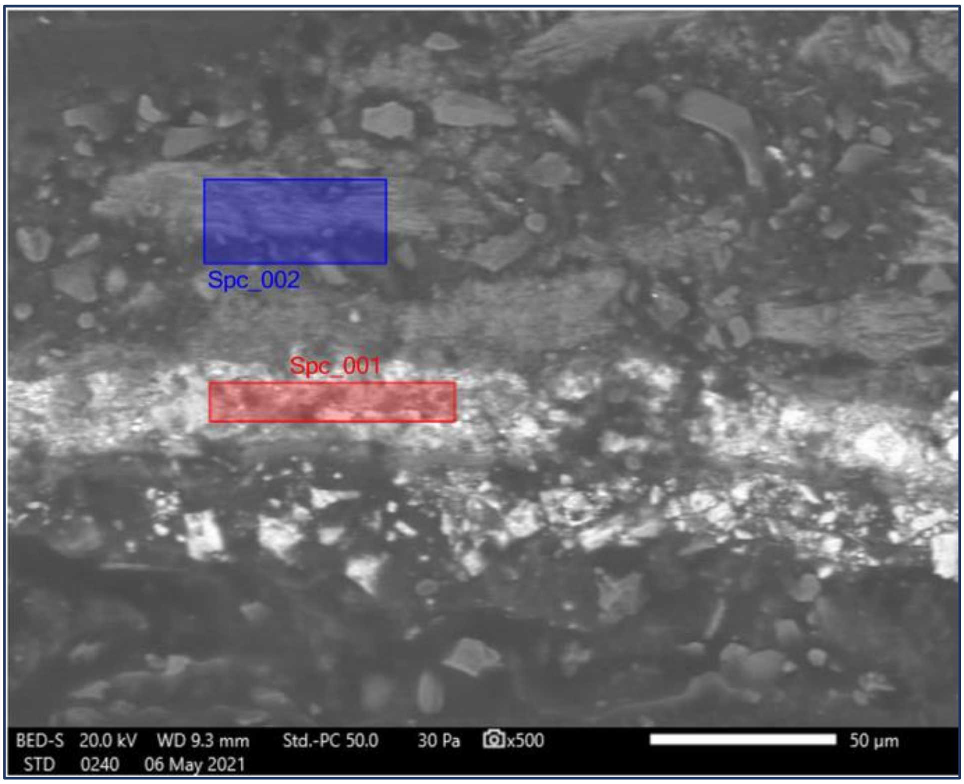


Figure 14-23: SEM back-scattered image of Sample 3b showing areas analyzed

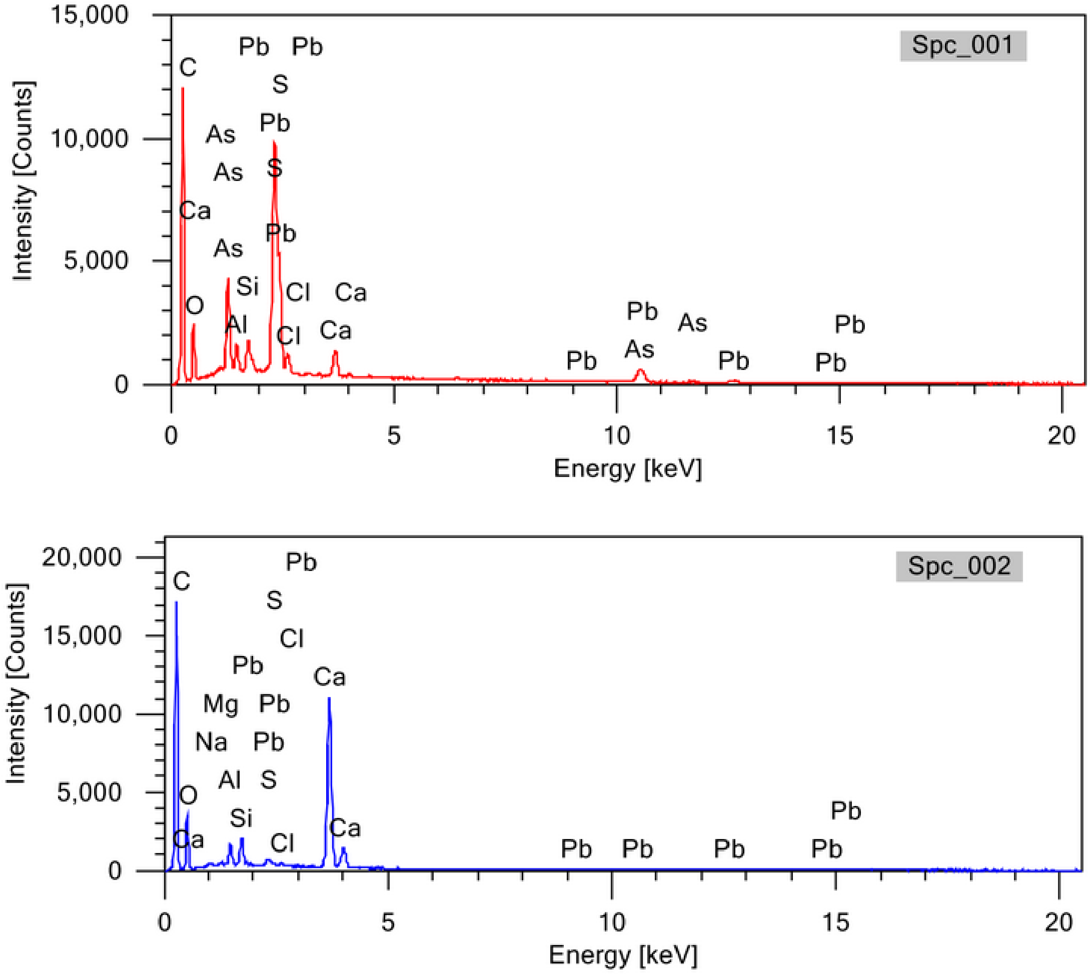


Figure 14-24: EDX spectrums for Figure 14-23

Sample 5a

Figure 14-25: Zeiss Axioplan 2 Imaging Microscope overview of Sample 5a

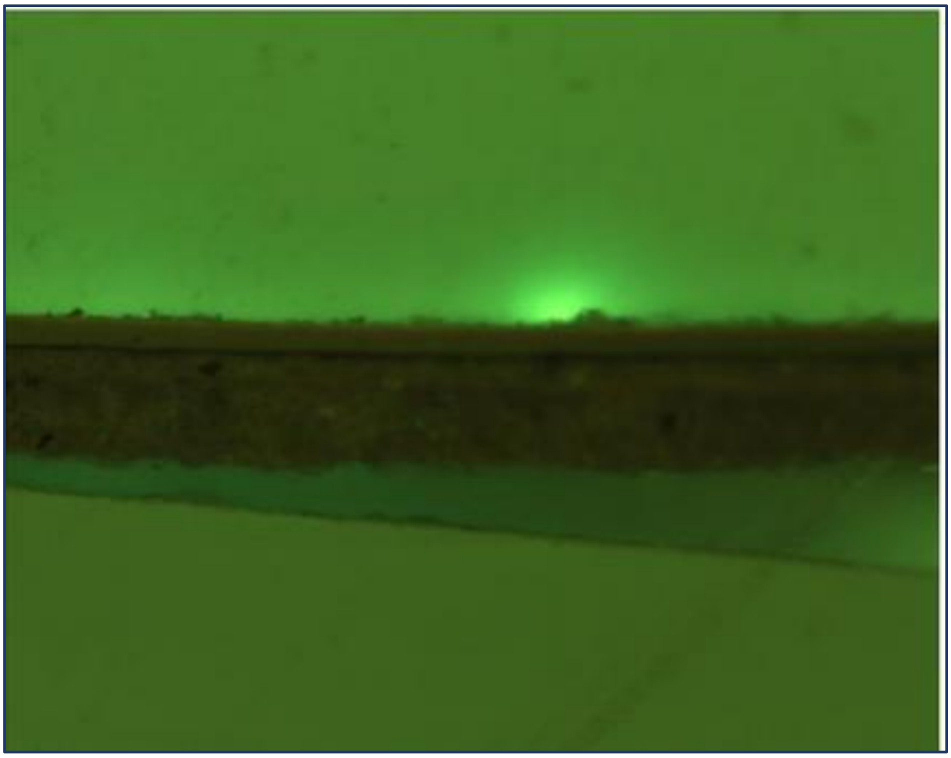


Figure 14-26: Zeiss Axioplan 2 Imaging Microscope fluorescence overview of Sample 5a (excitation filter BP 450-490 nm, emission filter 515 nm)

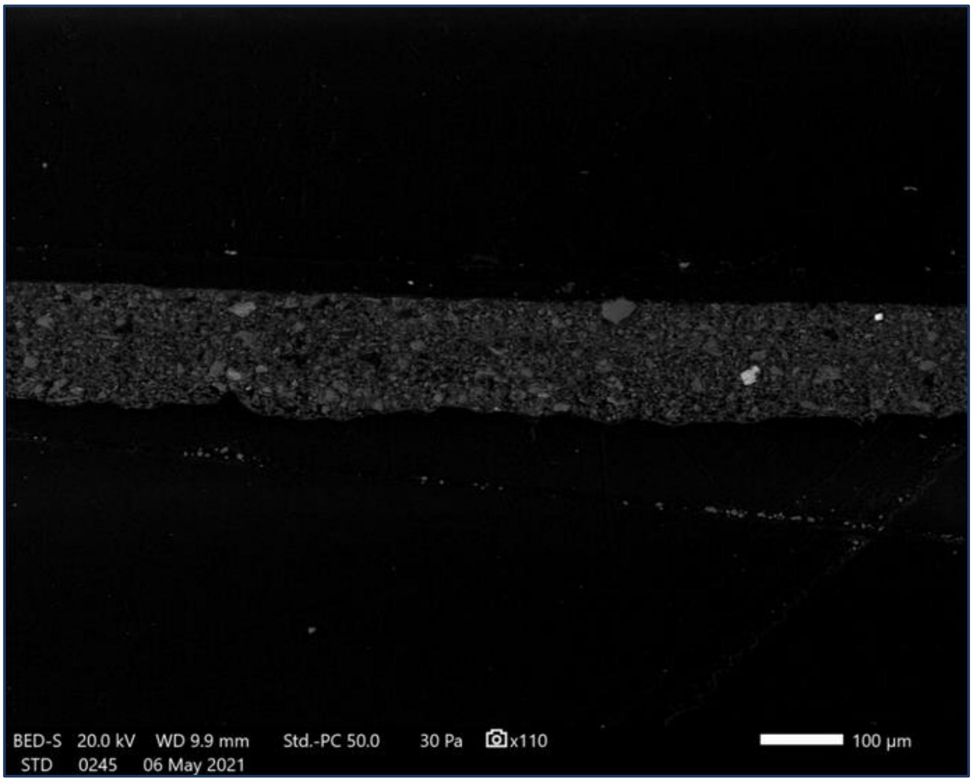


Figure 14-27: SEM back-scattered overview image of Sample 5a

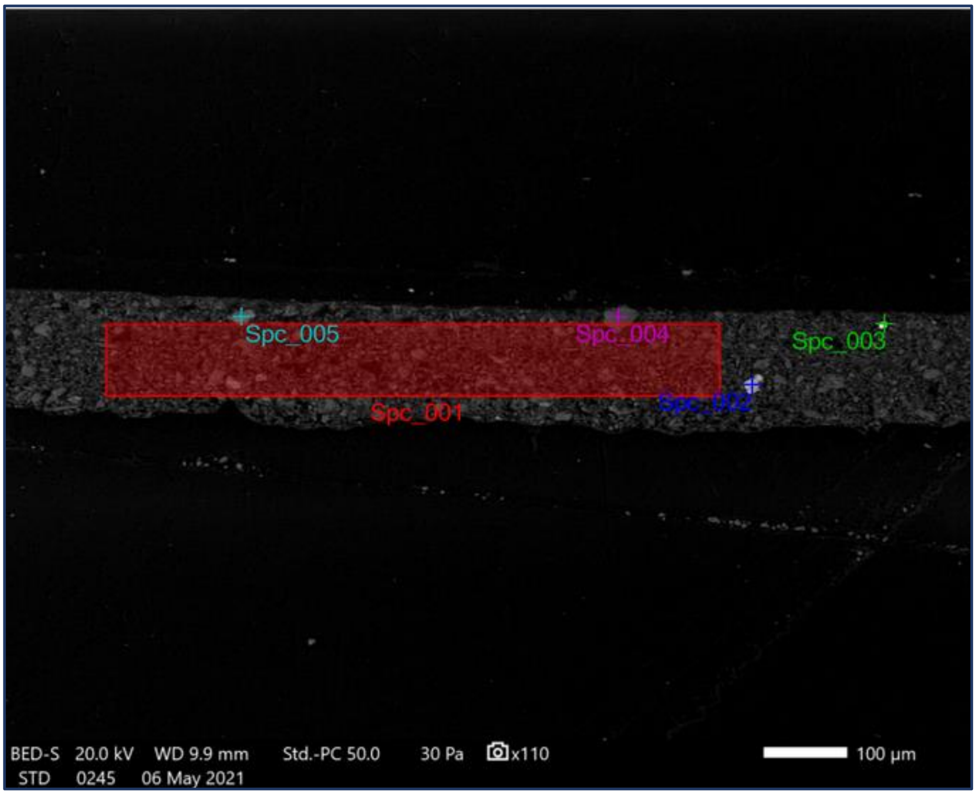
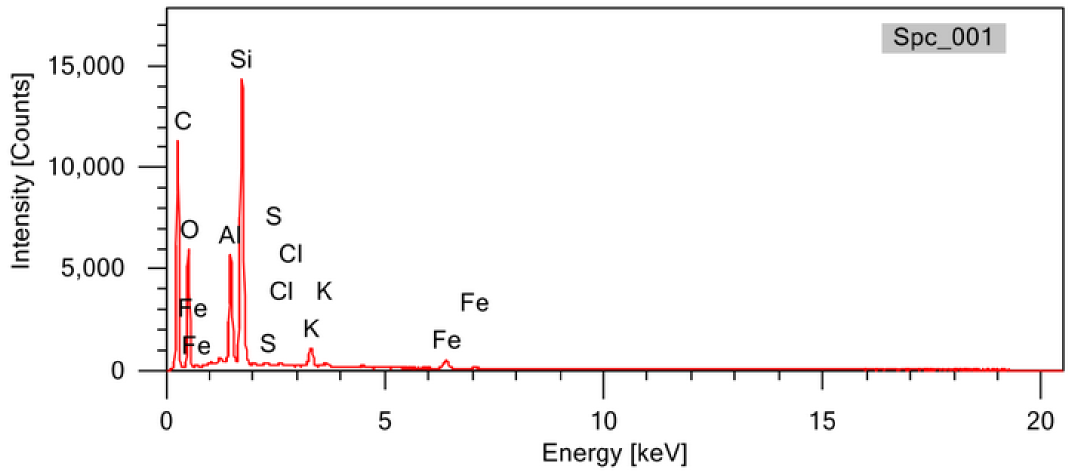


Figure 14-28: SEM back-scattered image of Sample 5a showing areas analyzed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Intensity [Counts]
Energy [keV]
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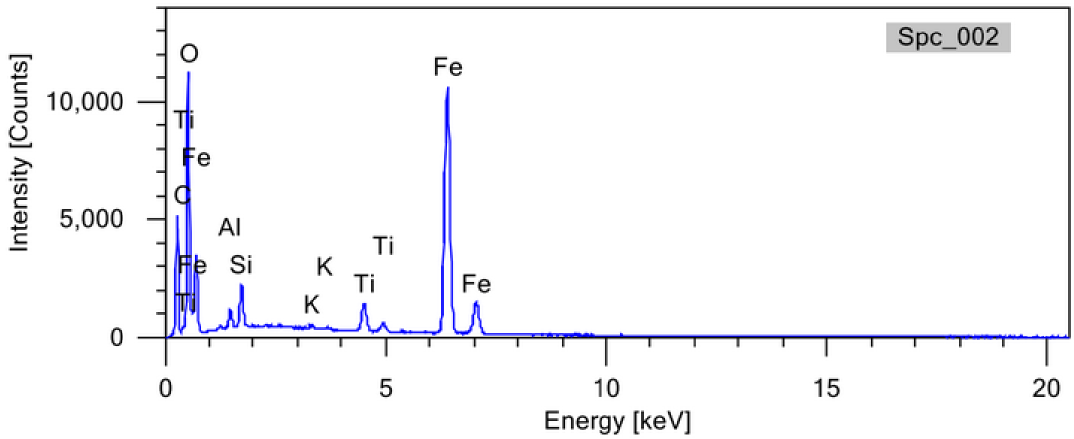
O
Fe
Fe
Al
Si
S
Cl
Cl
S
K
K
Fe
Fe


Spc_002
Intensity [Counts]
Energy [keV]
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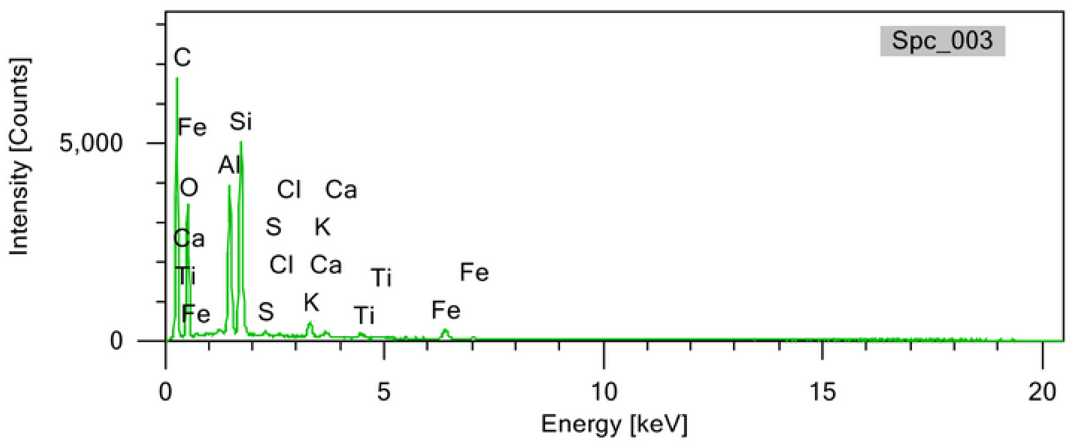
Ti
Fe
C
Fe
Ti
Al
Si
K
K
Ti
Ti
Fe
Fe


Spc_003
Intensity [Counts]
Energy [keV]
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Si
Al
O
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Ti
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K
Ti
Ti
Fe
Fe

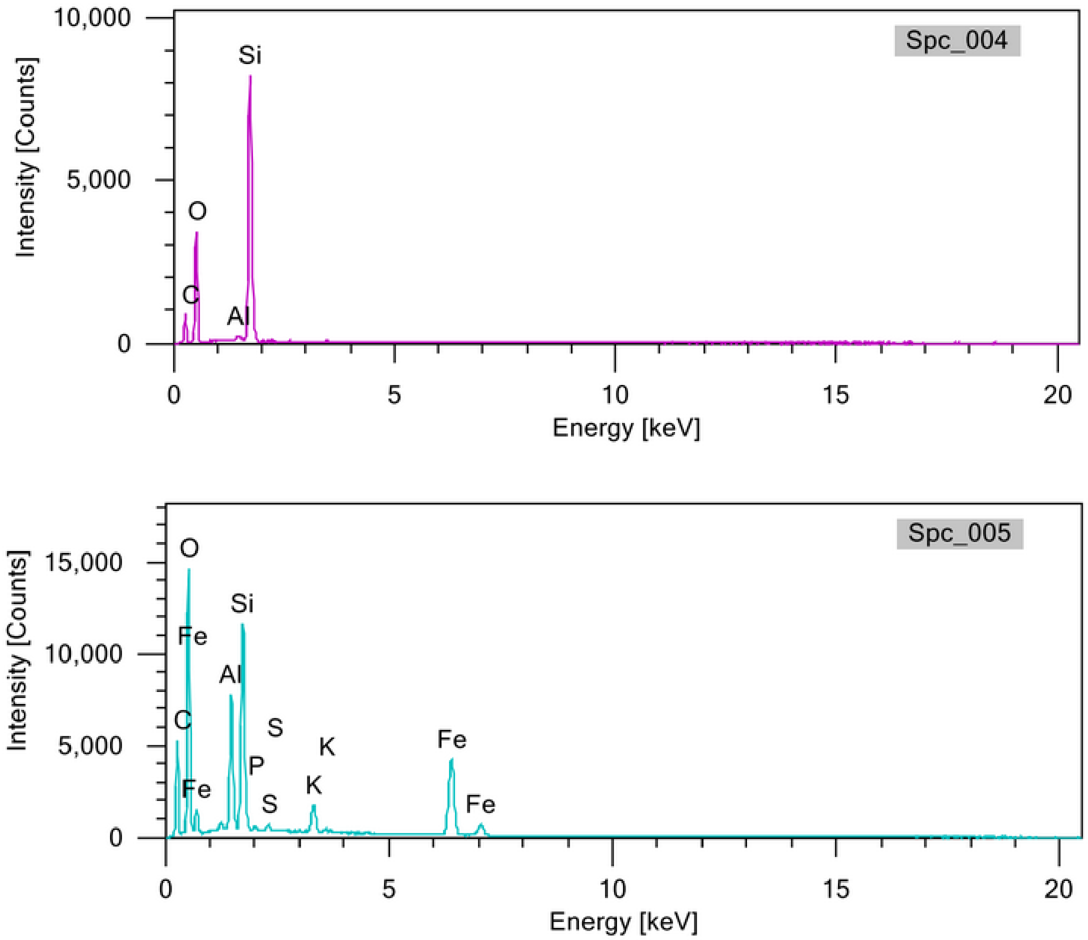


Figure 14-29: EDX spectrums for Figure 14-28

Sample 6a

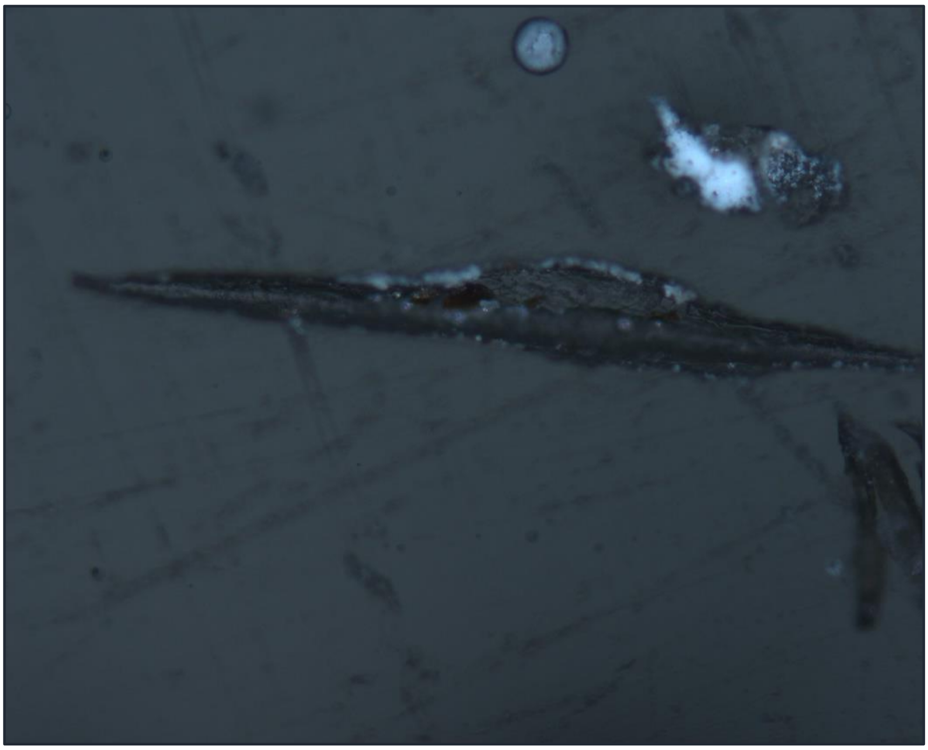


Figure 14-30: Zeiss Axioplan 2 Imaging Microscope overview of Sample 6a

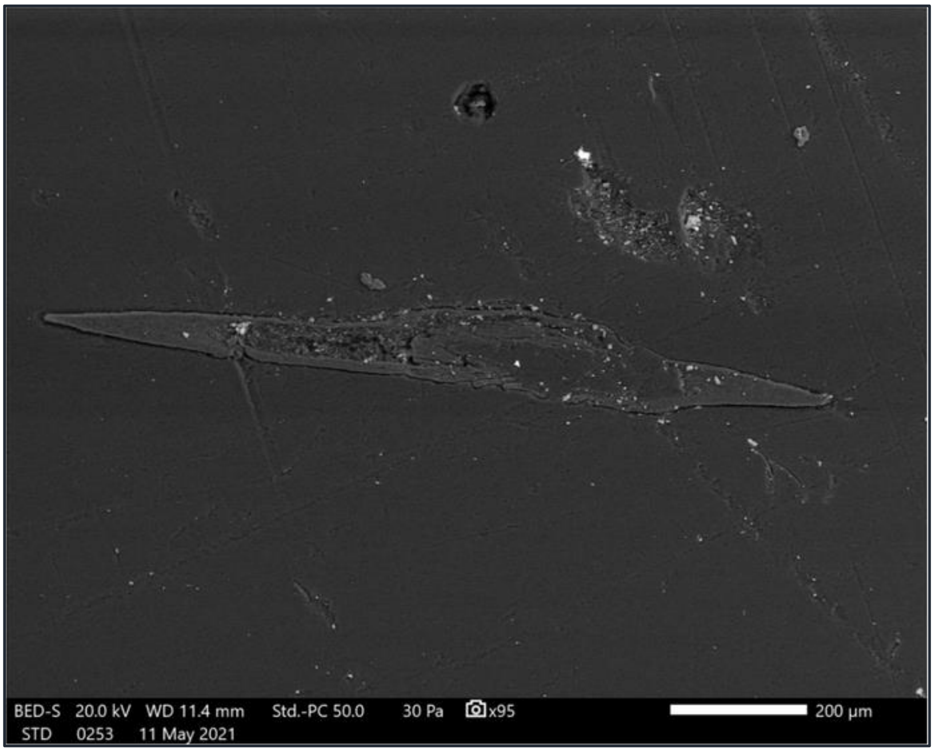


Figure 14-31: SEM back-scattered overview image of Sample 6a

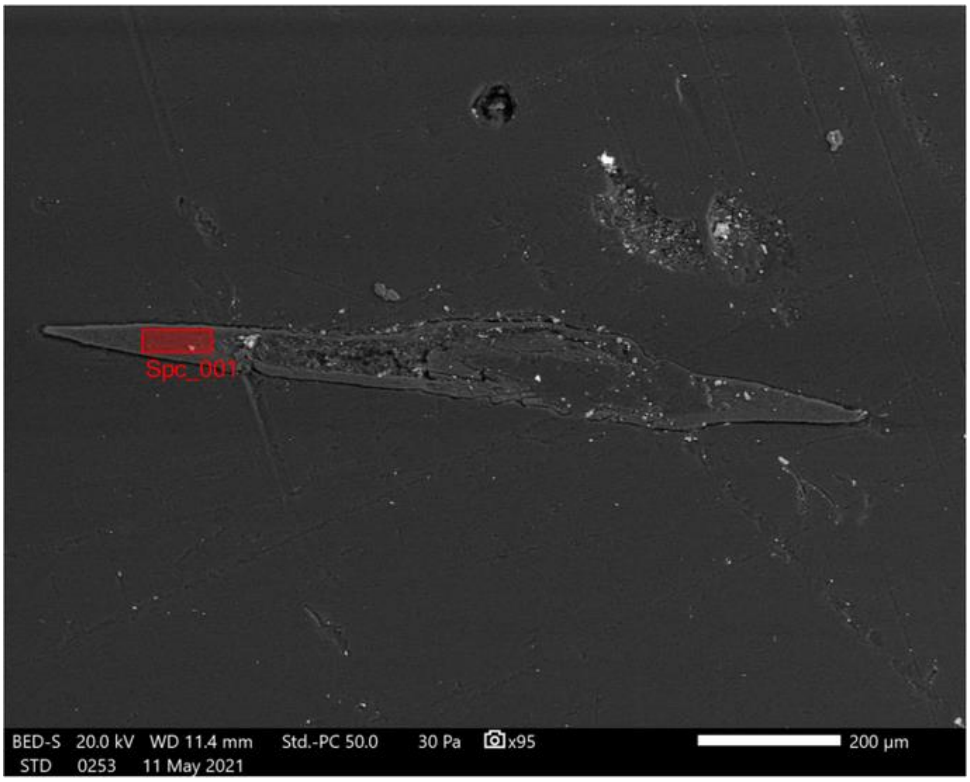


Figure 14-32: SEM back-scattered image of Sample 6a showing area analyzed

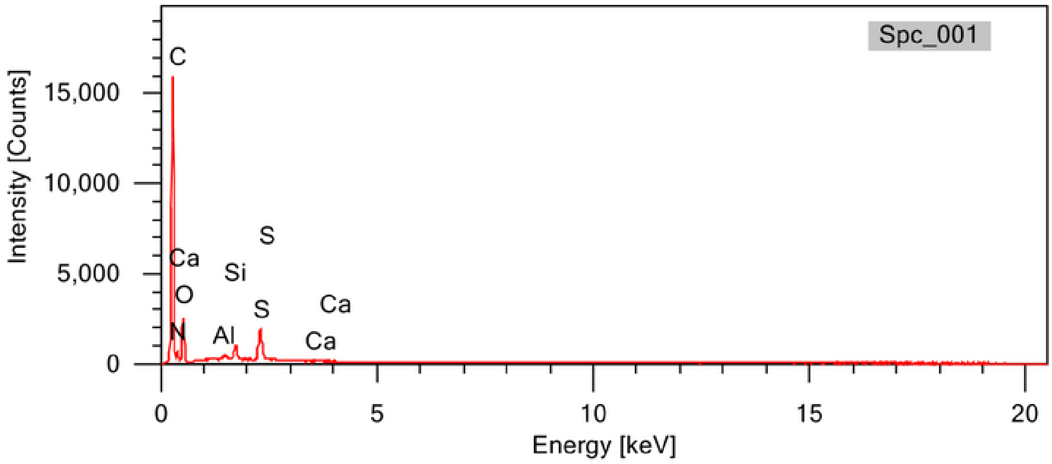


Figure 14-33: EDX spectrum for Figure 14-32

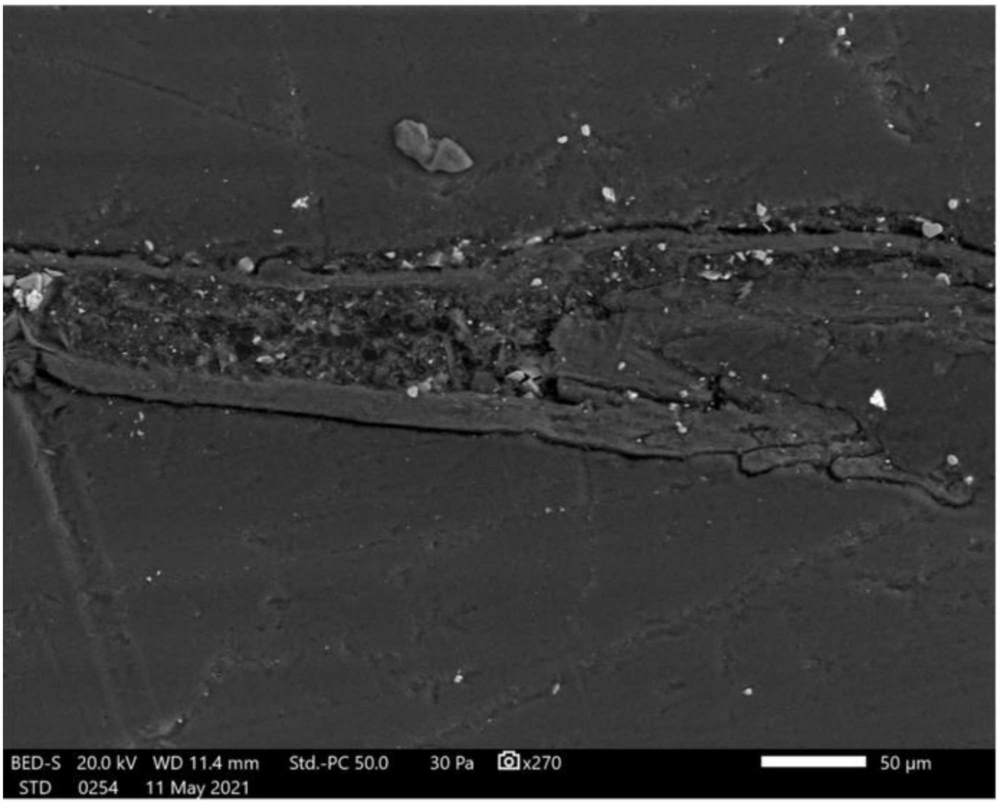


Figure 14-34: SEM back-scattered image of Sample 6a

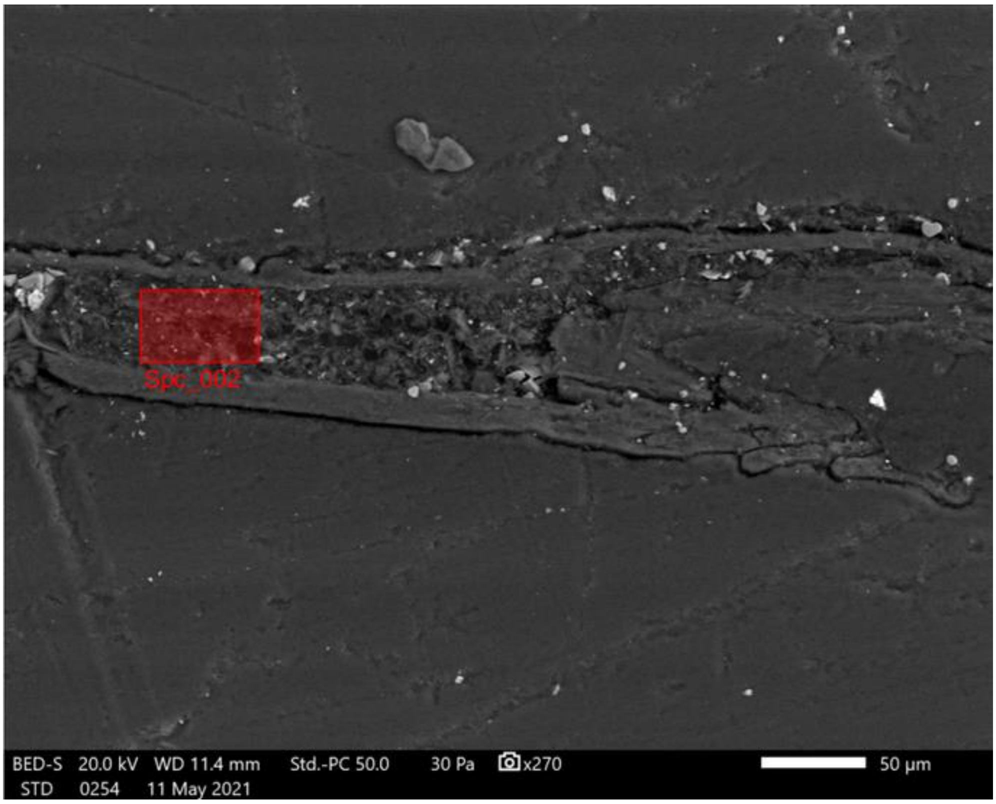


Figure 14-35: SEM back-scattered image of Sample 6a showing area analyzed

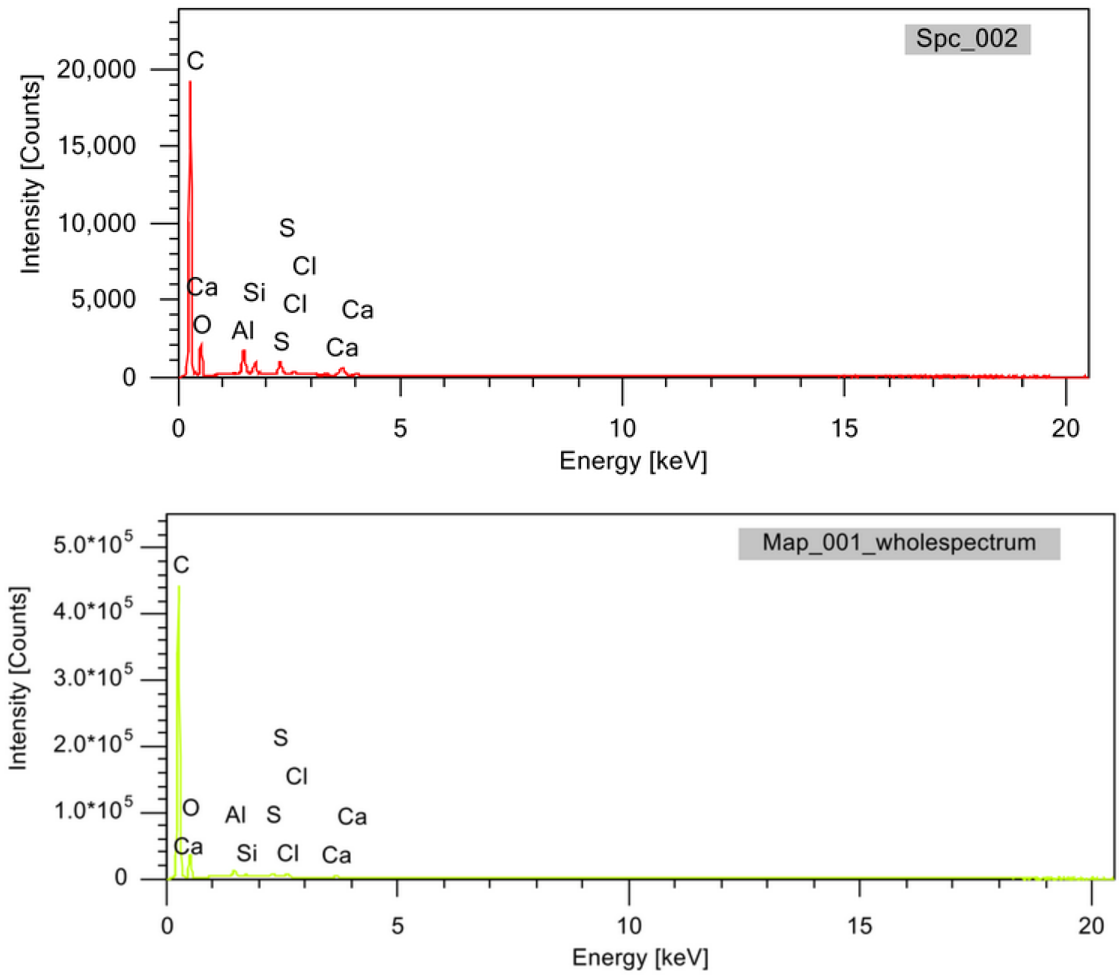


Figure 14-36: EDX spectrum for Figure 14-35

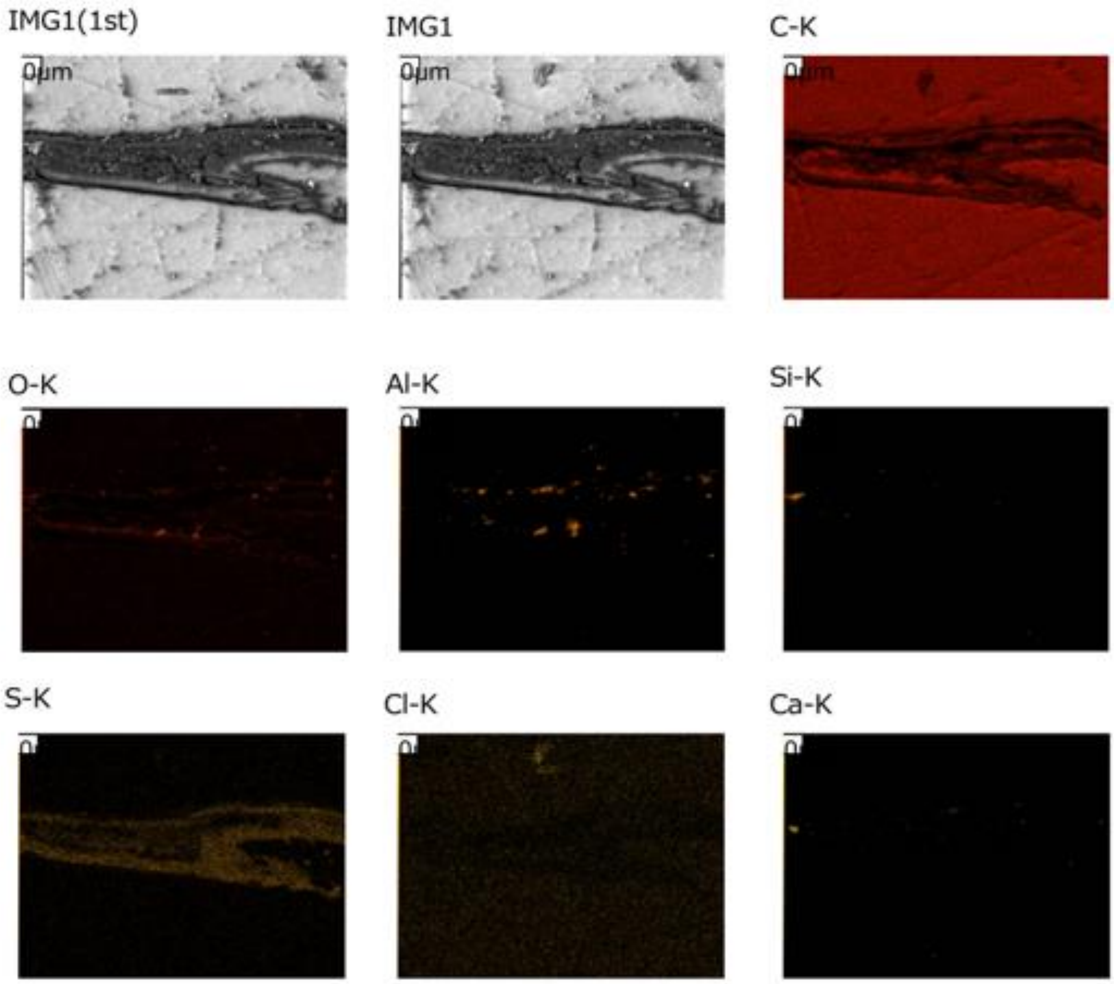


Figure 14-37: EDX calculated images of sample 6a

Sample 6b

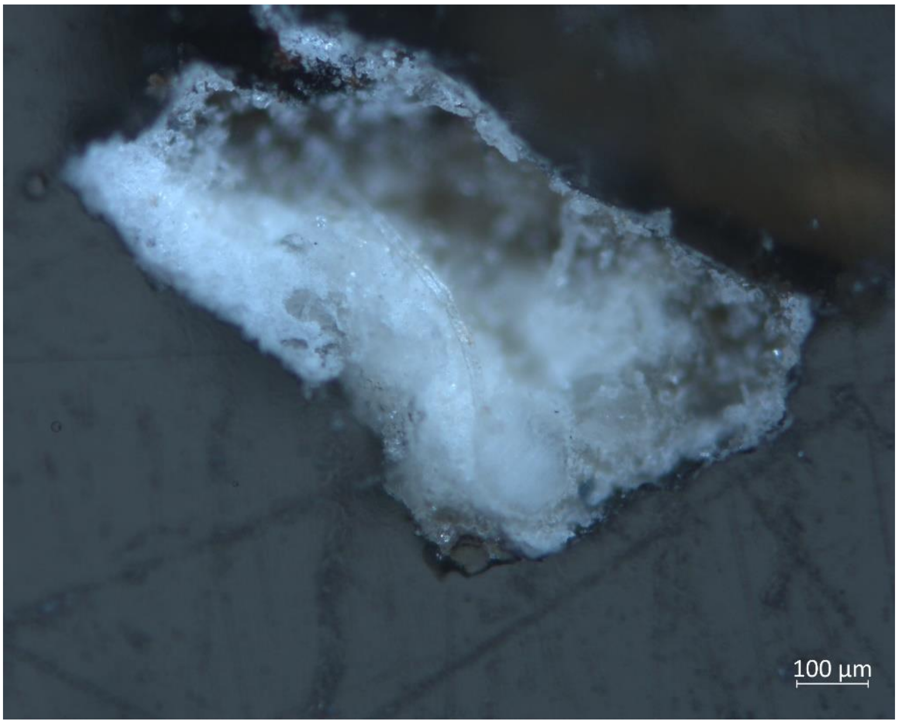


Figure 14-38: Zeiss Axioplan 2 Imaging Microscope overview of Sample 6a

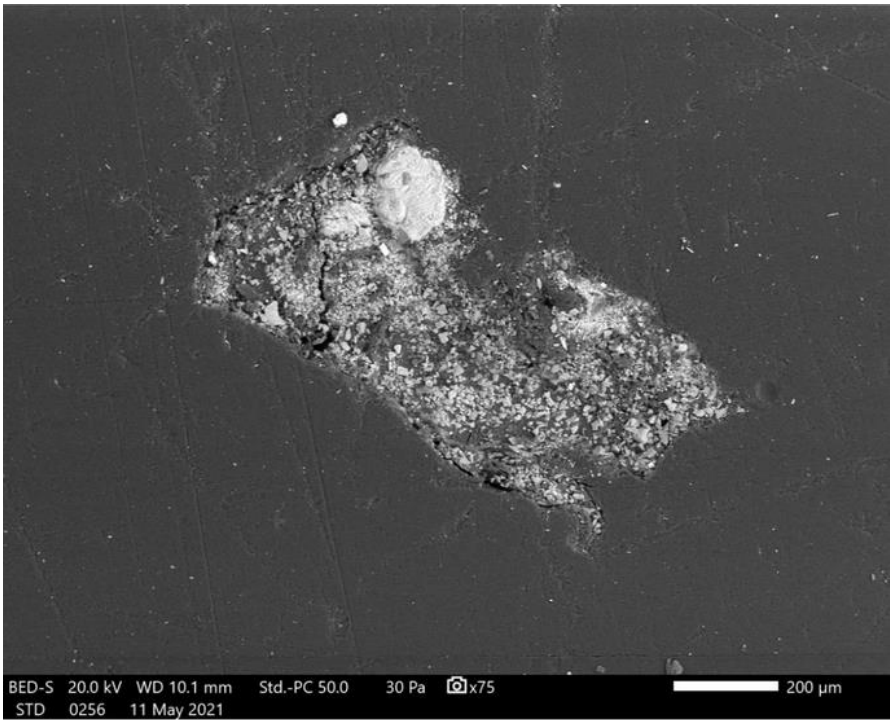


Figure 14-39: SEM back-scattered image of Sample 6b

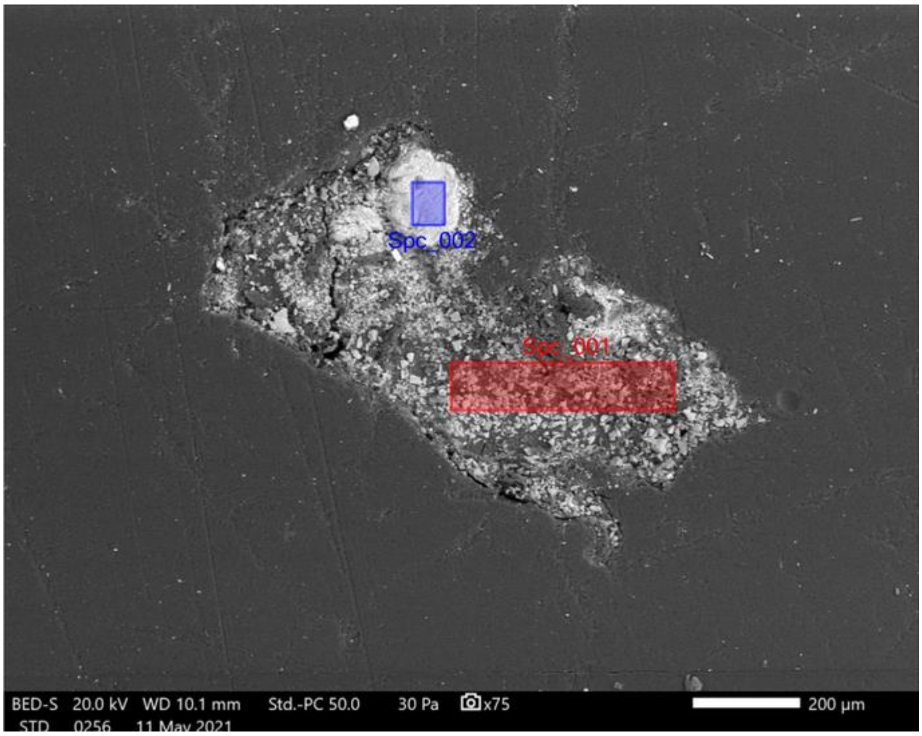
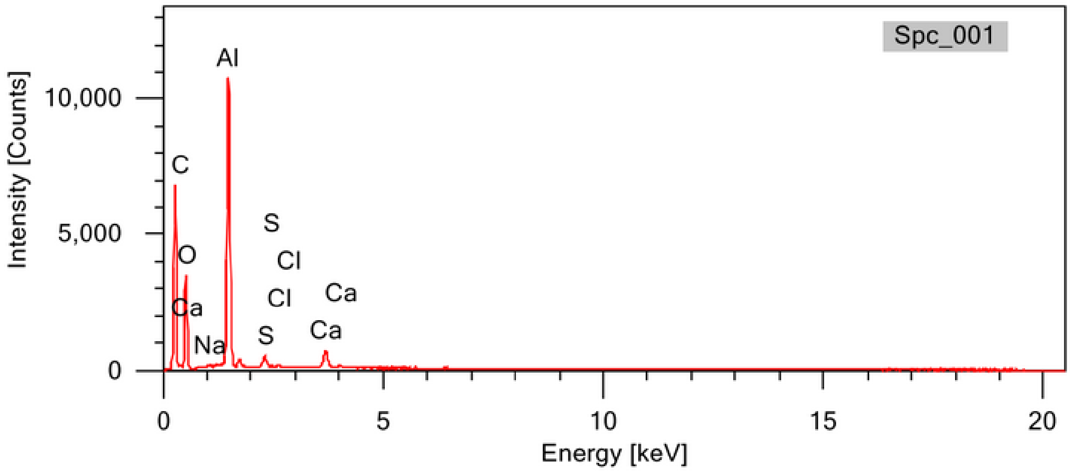


Figure 14-40: SEM back-scattered image of Sample 6b showing areas analyzed



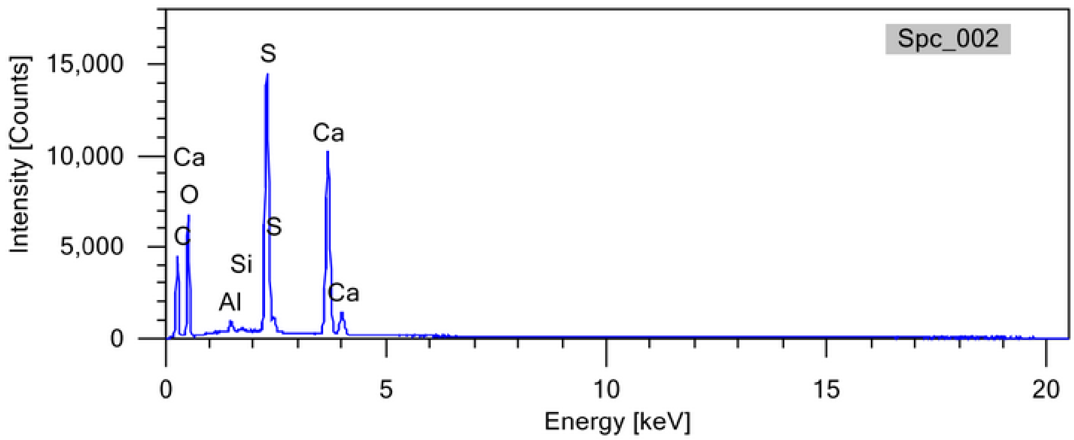


Figure 14-41: EDX spectrums for Figure 14-40

15 Appendix VII - XRD Results

All images taken and results compiled by Luc Megens (RCE)

See X-Ray Diffraction (XRD) for information on the methodology

Sample 1

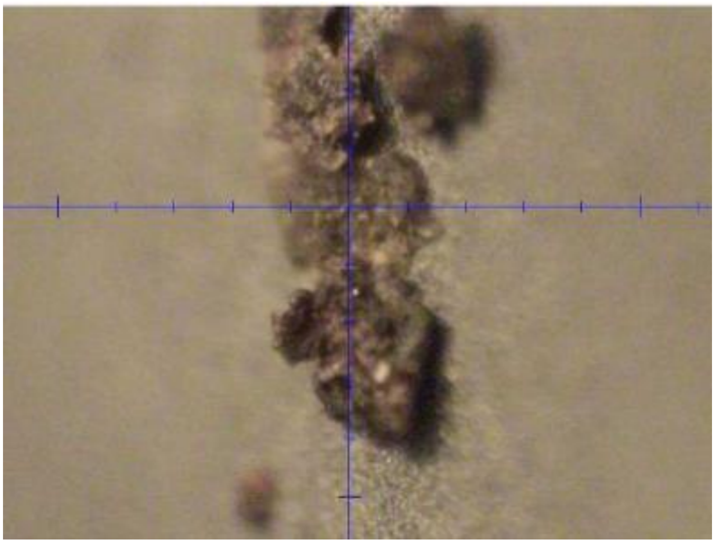


Figure 15-1

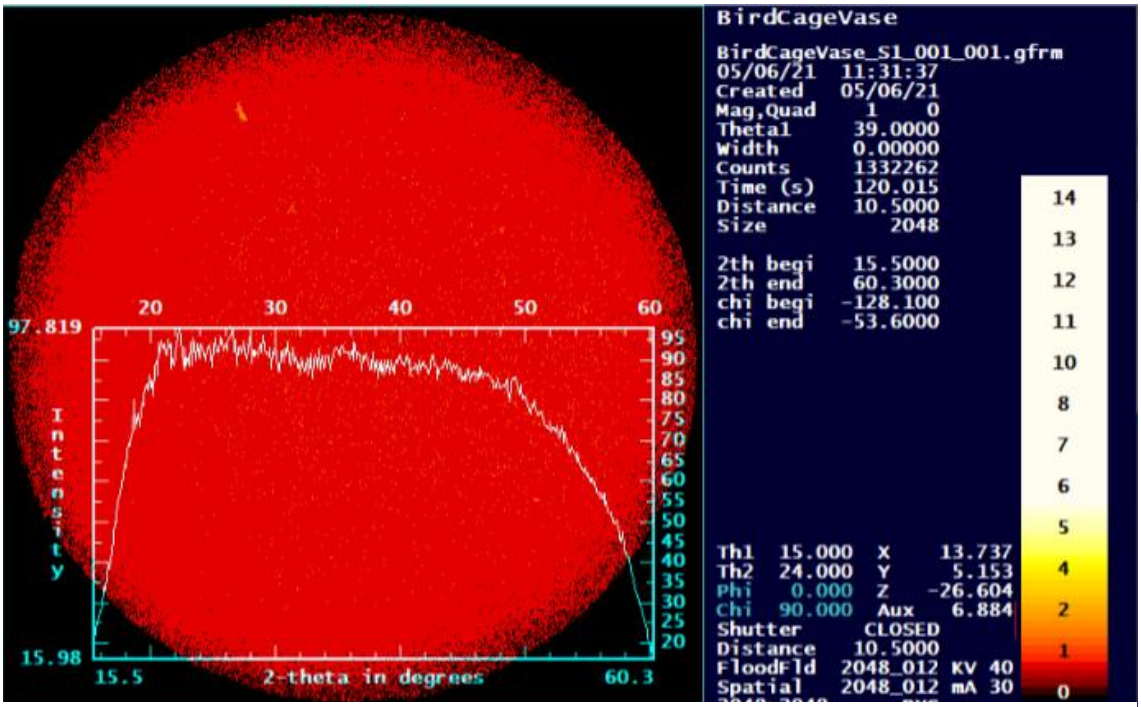


Figure 15-2: XRD Spectrum for Figure 15-1

Sample 2

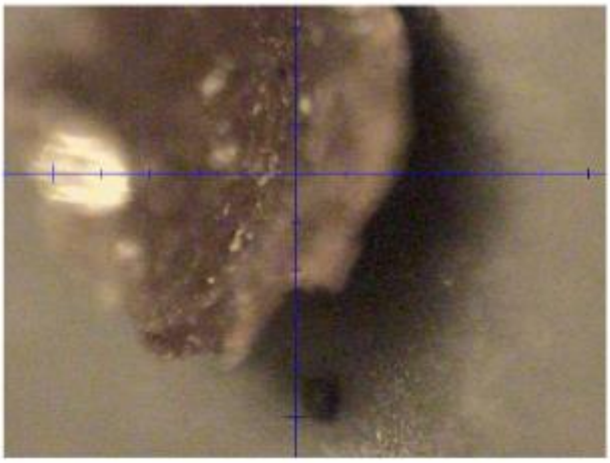


Figure 15-3

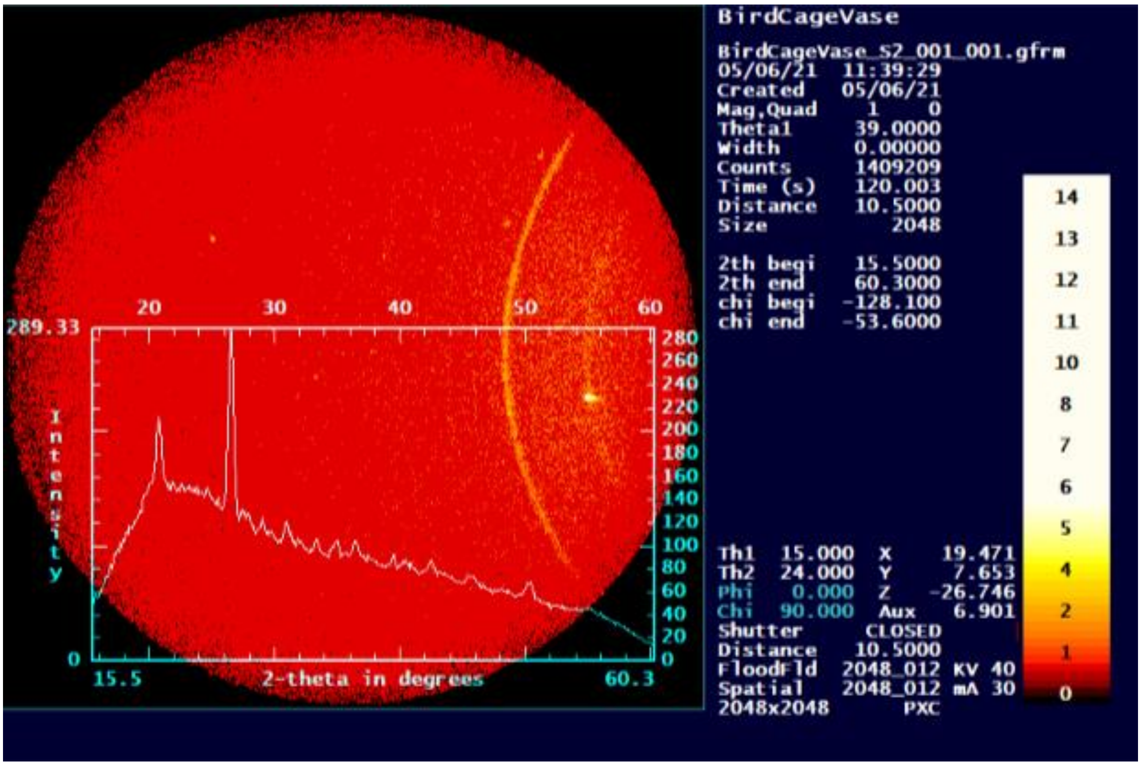


Figure 15-4: XRD Spectrum for Figure 15-3

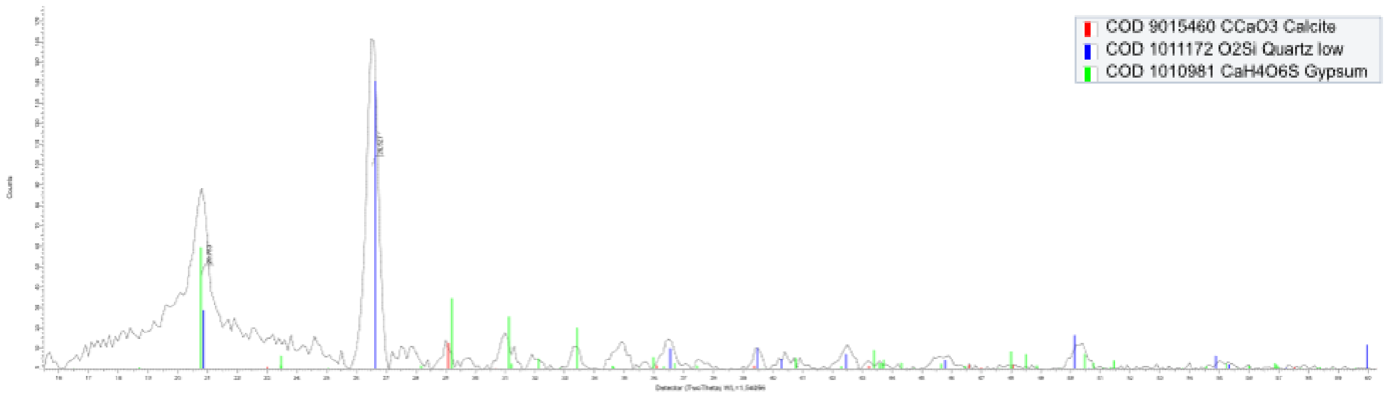


Figure 15-6: XRD Spectrum with Identification for Figure 15-3

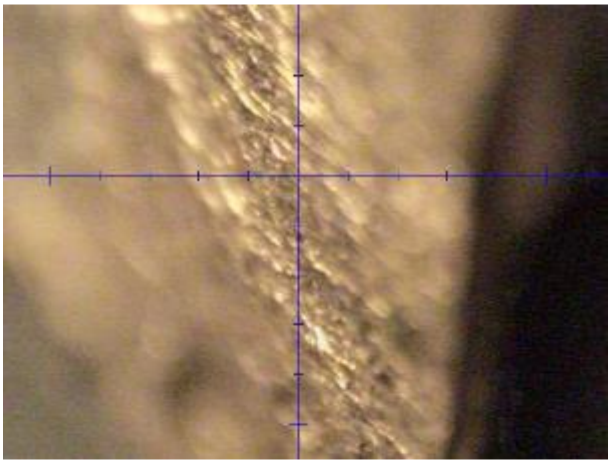


Figure 15-5

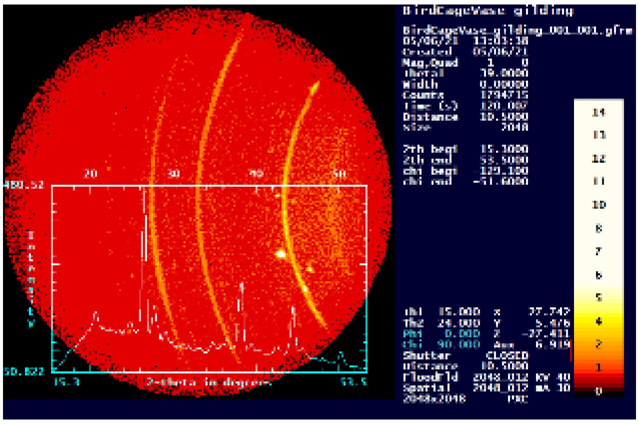


Figure 15-7: XRD Spectrum for Figure 15-5

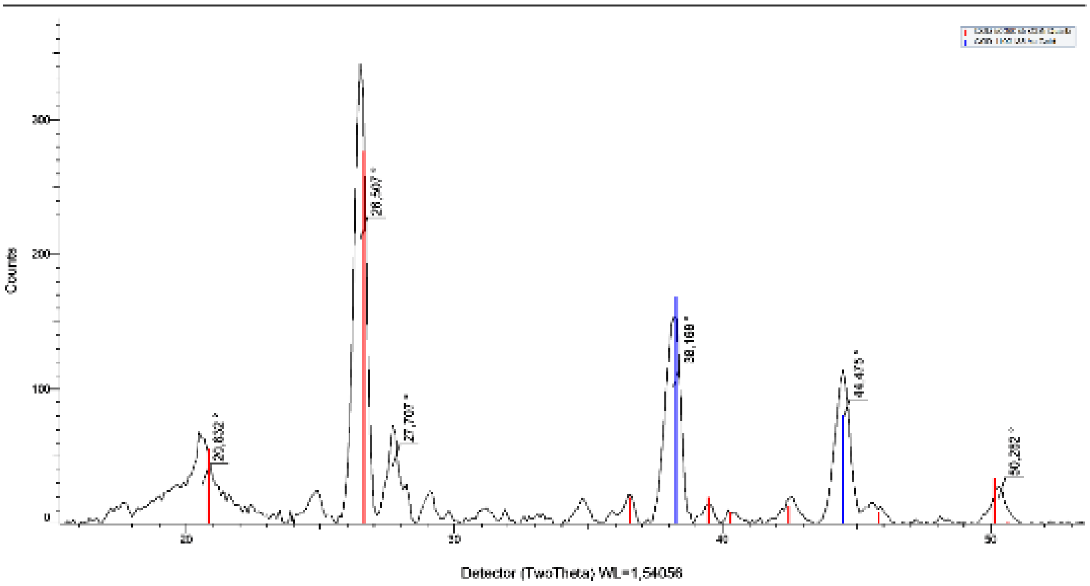


Figure 15-8: XRD Spectrum with Identification for Figure 15-5

Sample 3

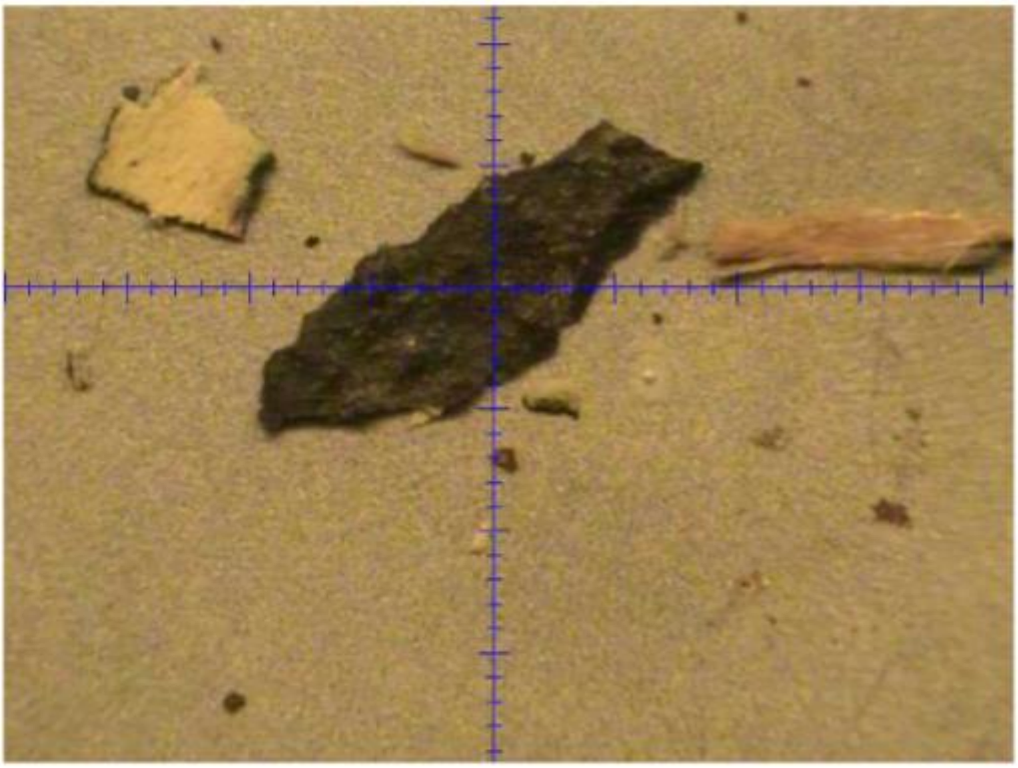


Figure 15-9

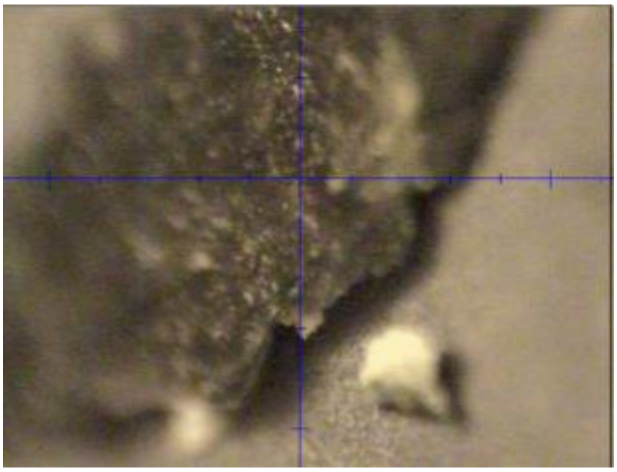


Figure 15-10

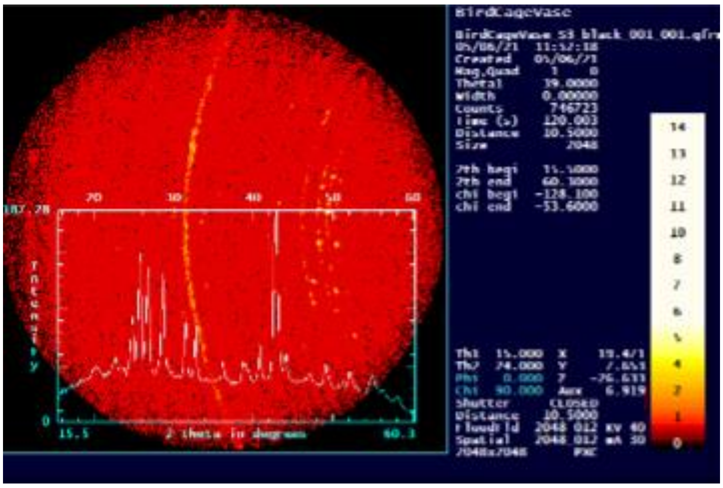


Figure 15-12: XRD Spectrum for Figure 15-10

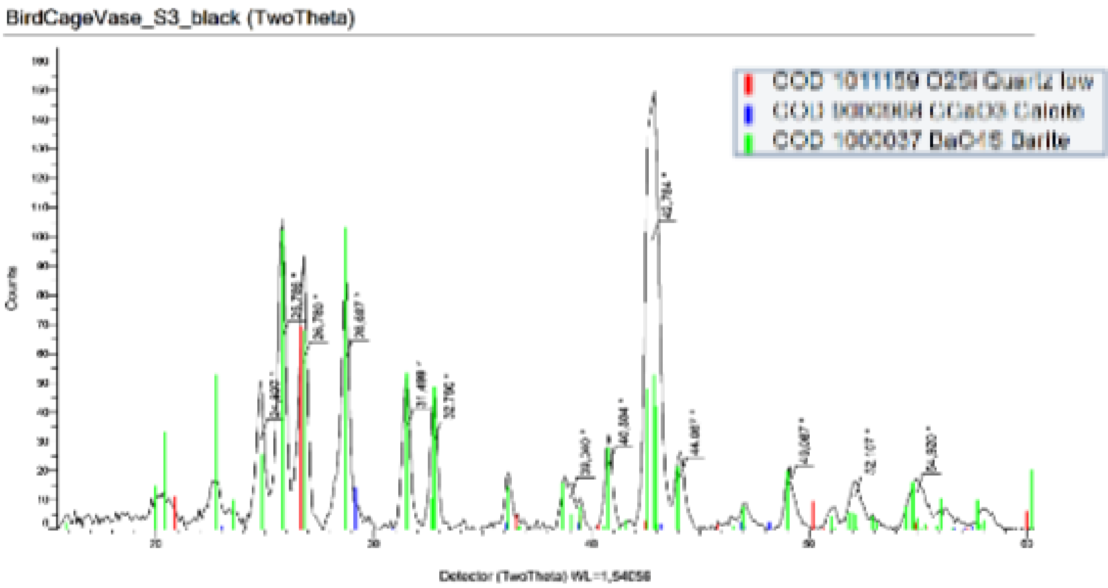


Figure 15-11: XRD Spectrum with Identification for Figure 15-10

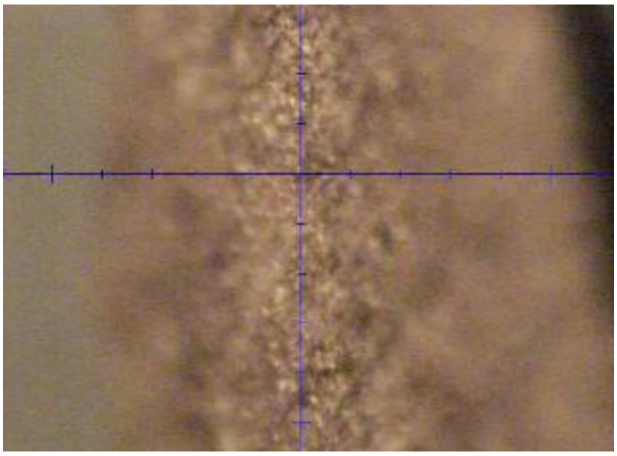


Figure 15-13

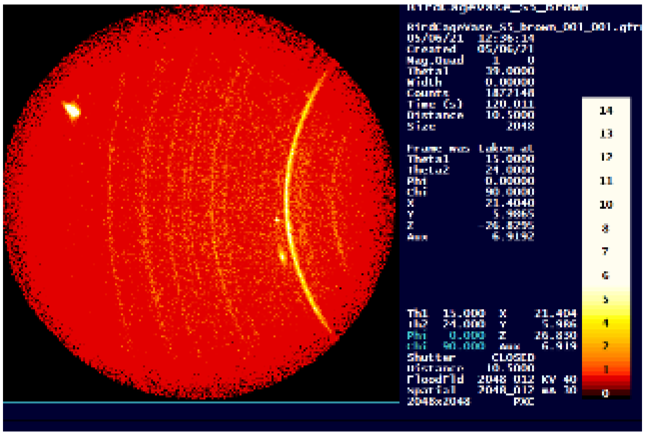


Figure 15-14: XRD Spectrum for Figure 15-13

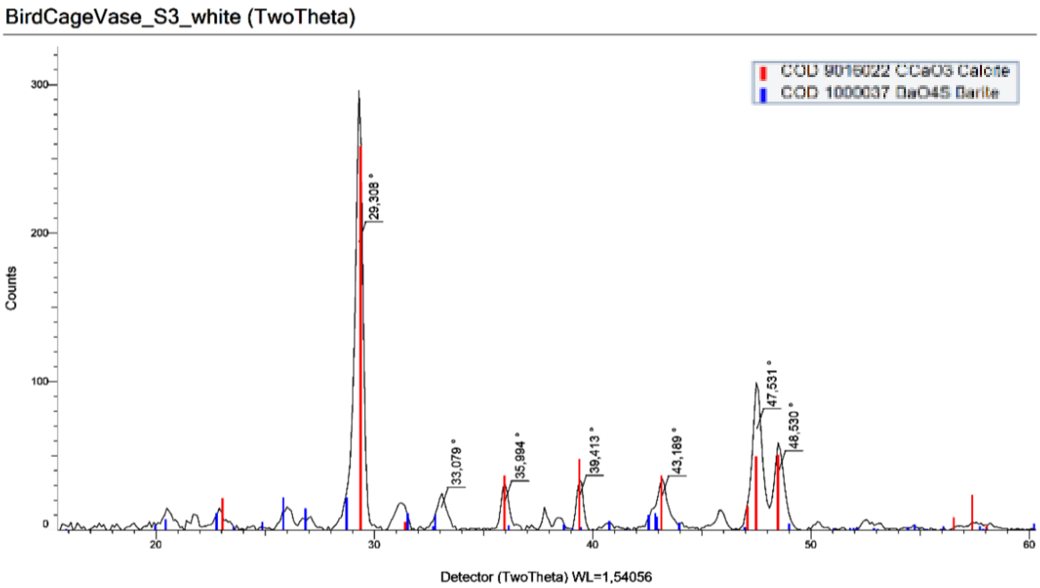


Figure 15-15: : XRD Spectrum with Identification for Figure 15-13

Sample 4

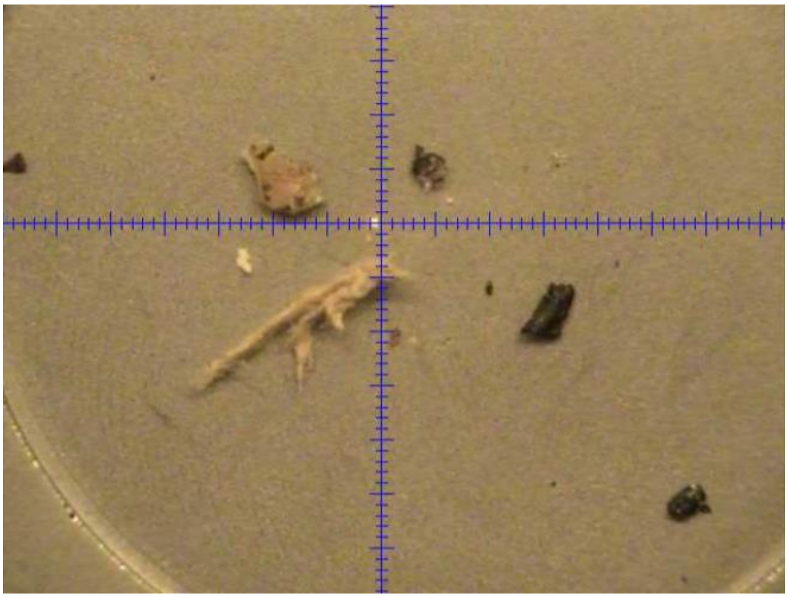


Figure 15-16

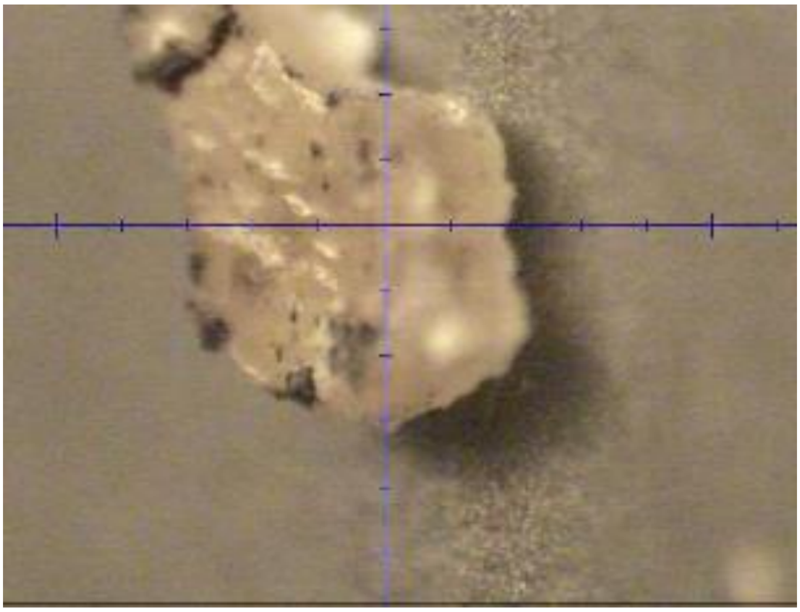


Figure 15-17

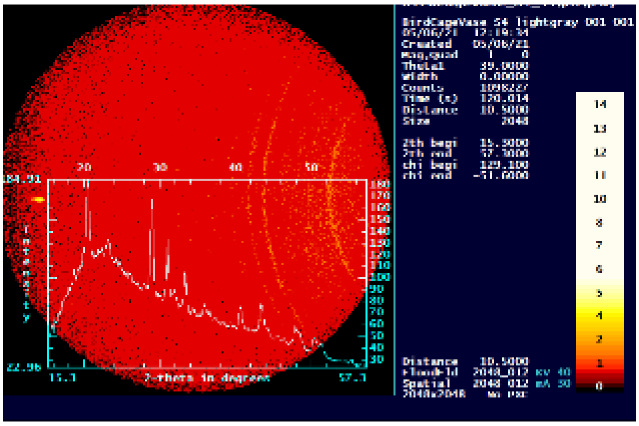


Figure 15-18: XRD Spectrum for Figure 15-17

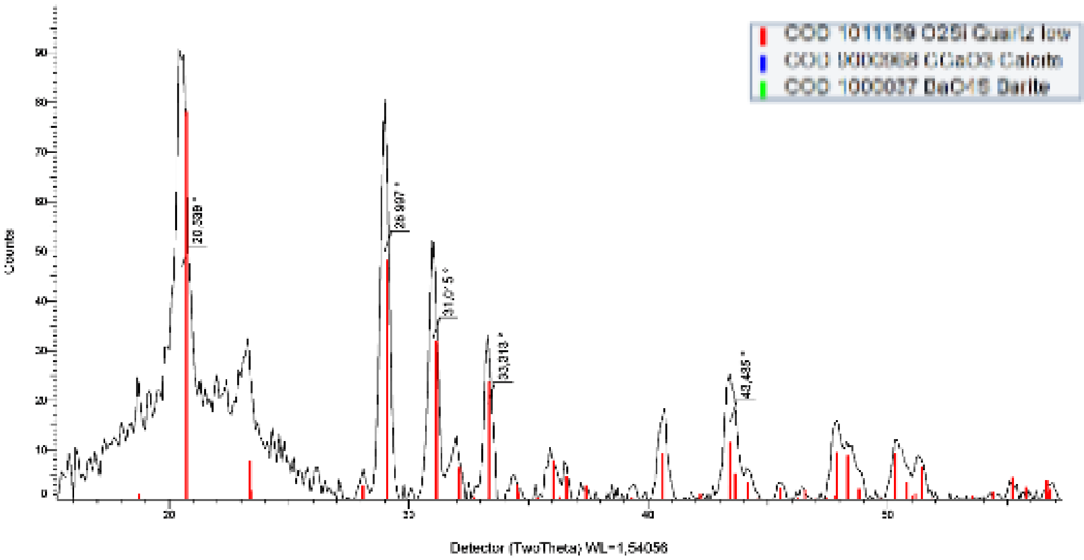


Figure 15-19: XRD Spectrum with Identification for Figure 15-17

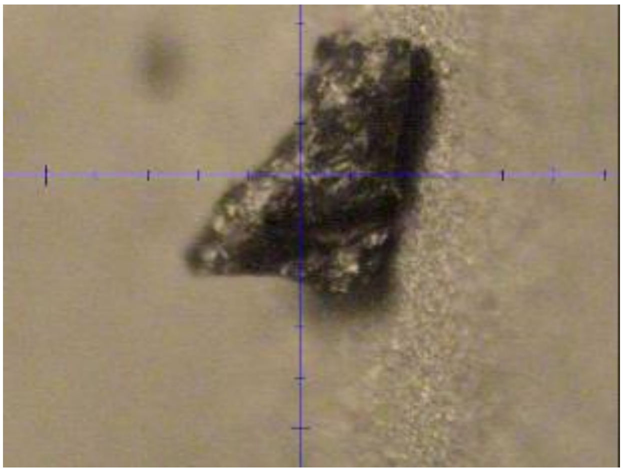


Figure 15-20

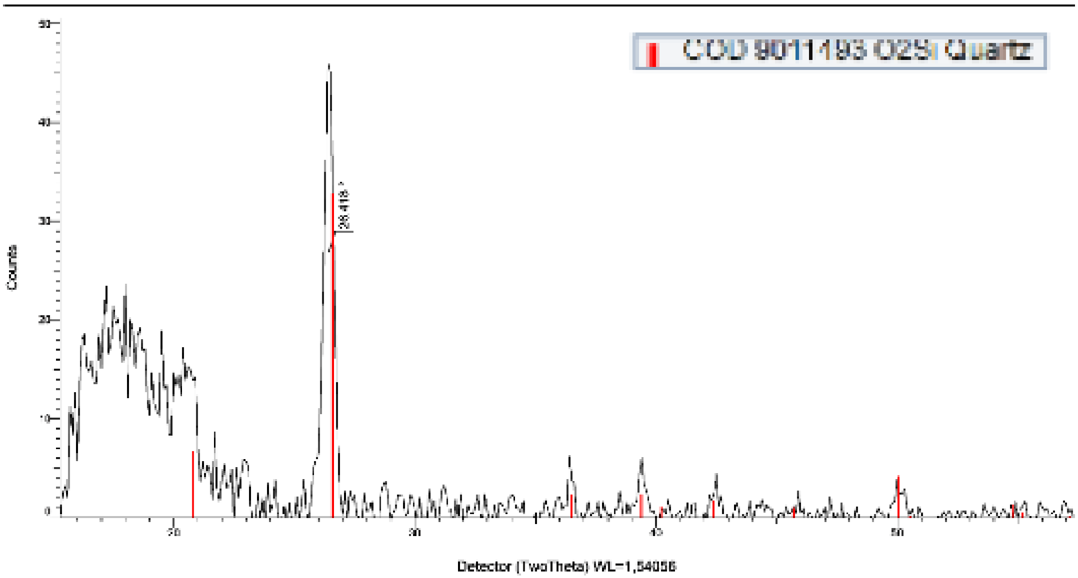


Figure 15-21: XRD Spectrum with Identification for Figure 15-20

Sample 5

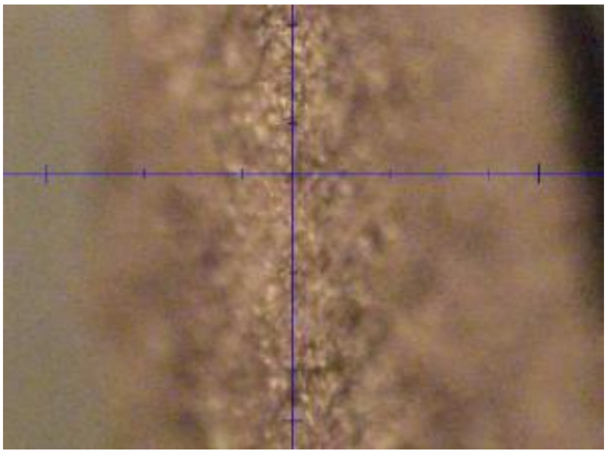


Figure 15-22

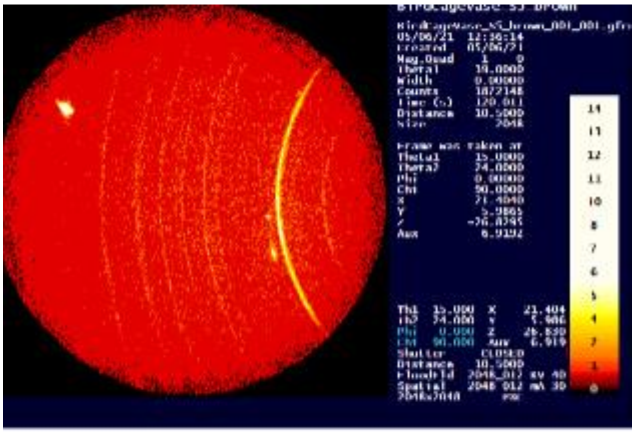


Figure 15-23: XRD Spectrum for Figure 15-22

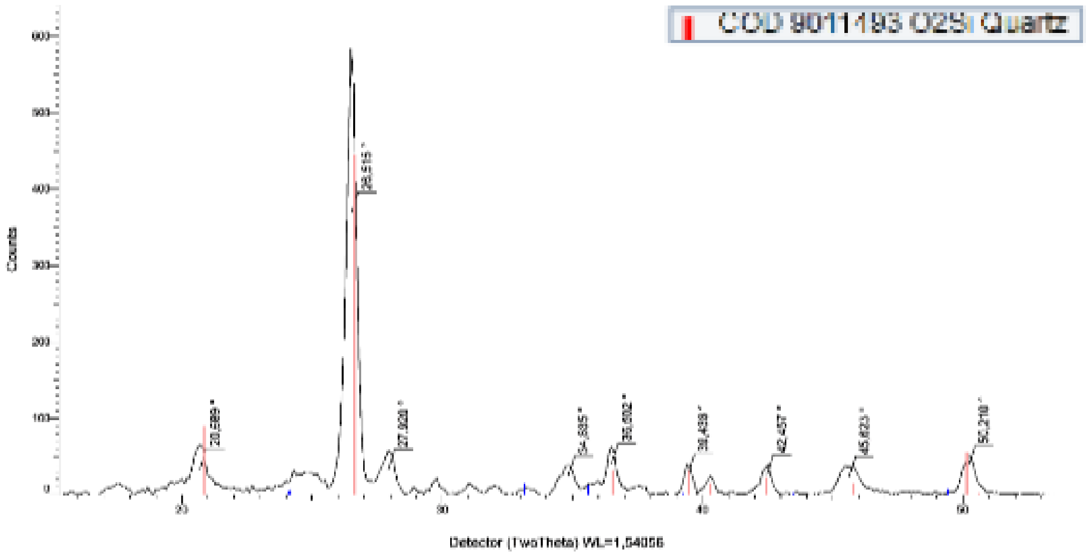


Figure 15-24: XRD Spectrum with Identification for Figure 15-22

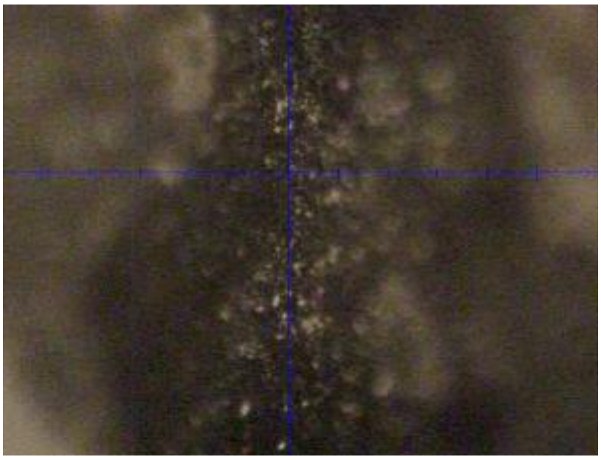


Figure 15-25

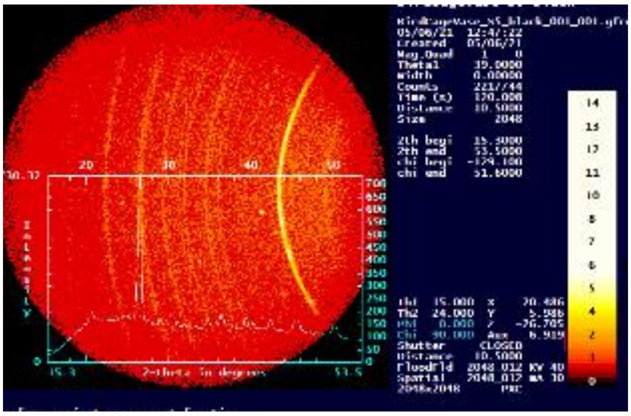


Figure 15-26: XRD Spectrum for Figure 15-25

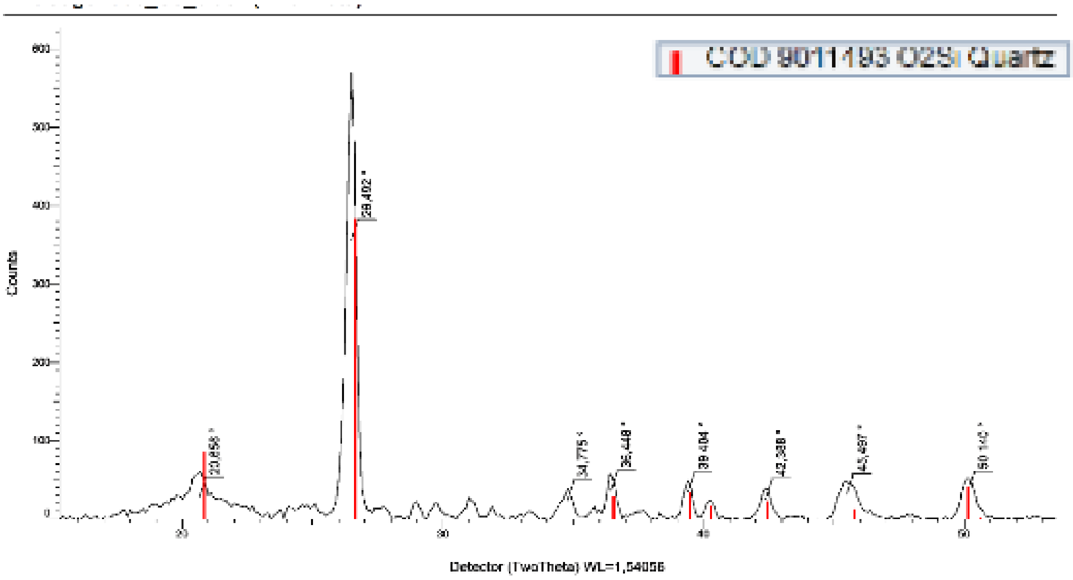


Figure 15-27: XRD Spectrum with Identification for Figure 15-25

16 Appendix VIII – Py-GC/MS Results

All results compiled by Luc Megens (RCE)

See Pyrolysis-Gas Chromatography/Mass Spectrometry (Py-GC/MS) for information on the methodology

Sample 1

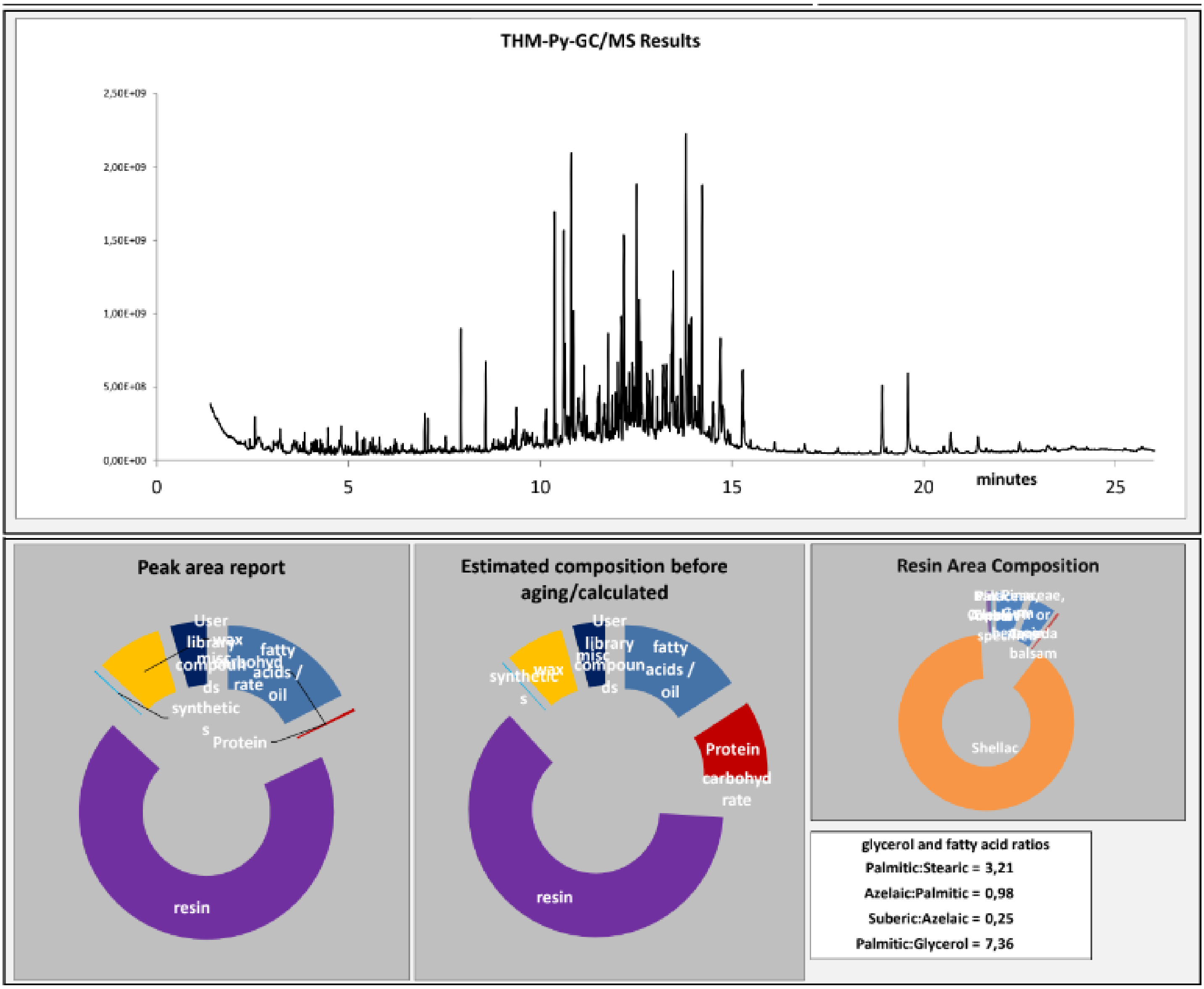


Figure 16-1: Py-GC/MS Results for Sample 1

Sample 2

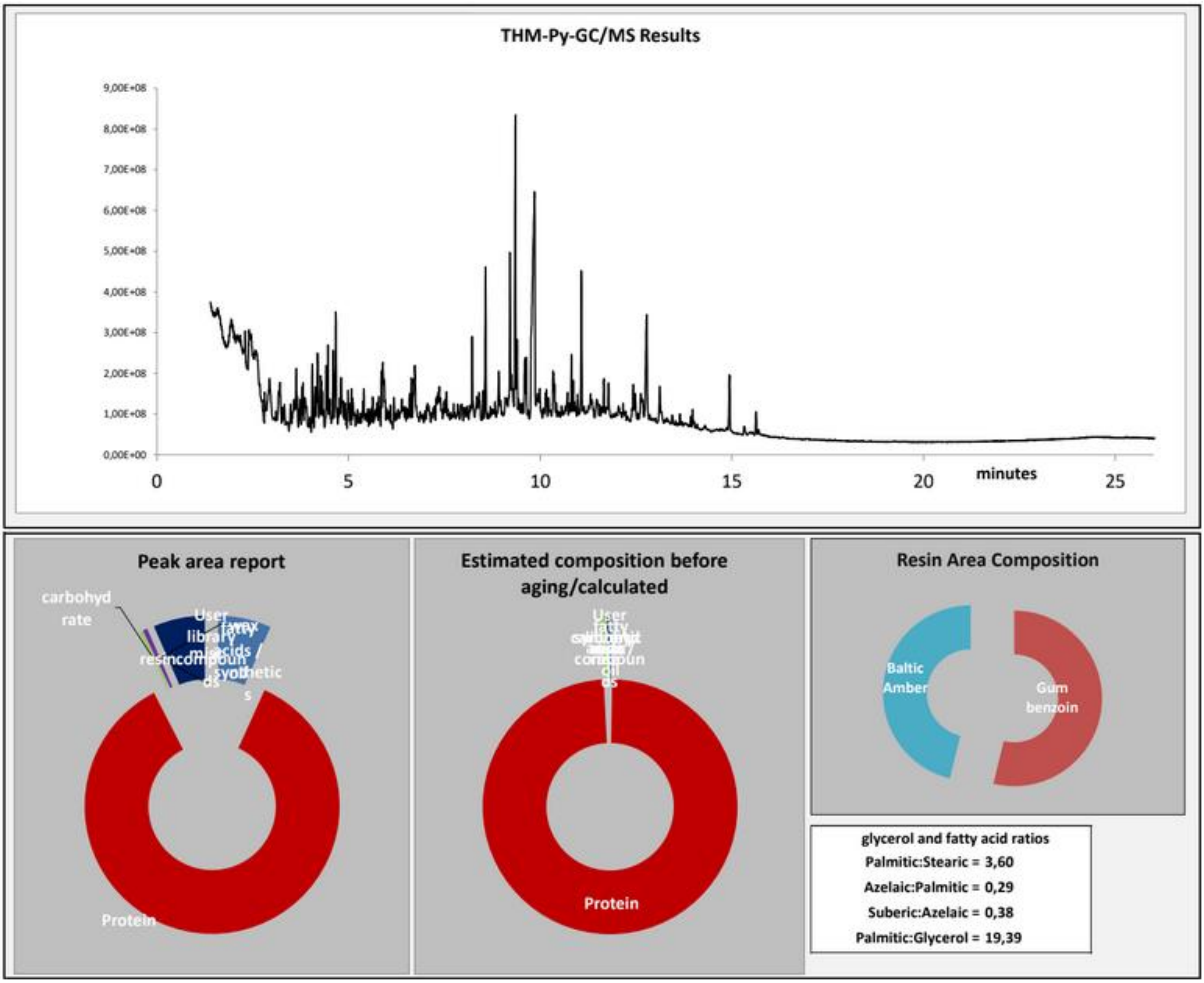


Figure 16-2: Py-GC/MS Results for Sample 2

Sample 5 (Transparent Flake)

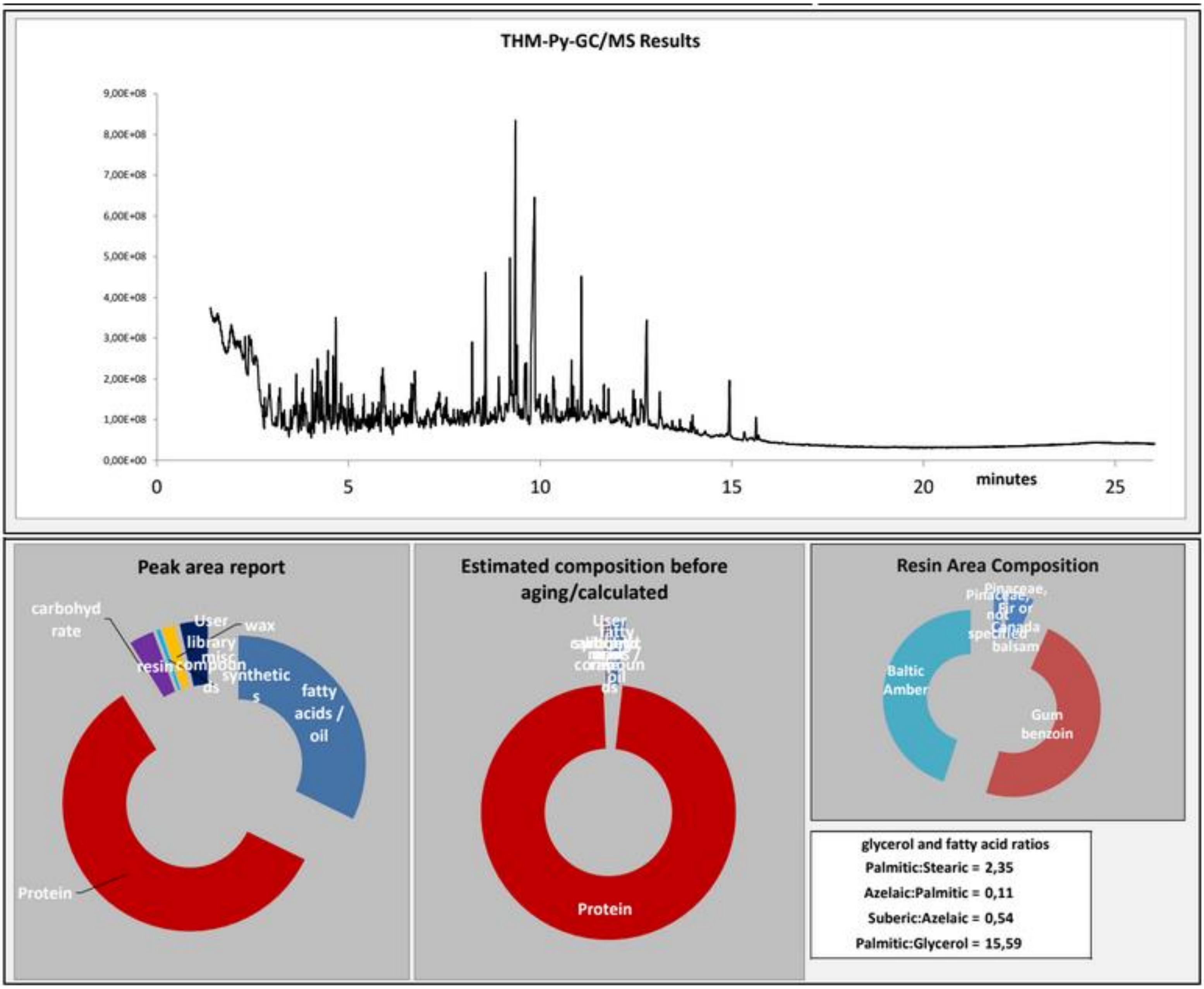


Figure 16-3: Py-GC/MS Results for Sample 5 (Transparent Flake)

Sample 5 (Lacquer Layers)

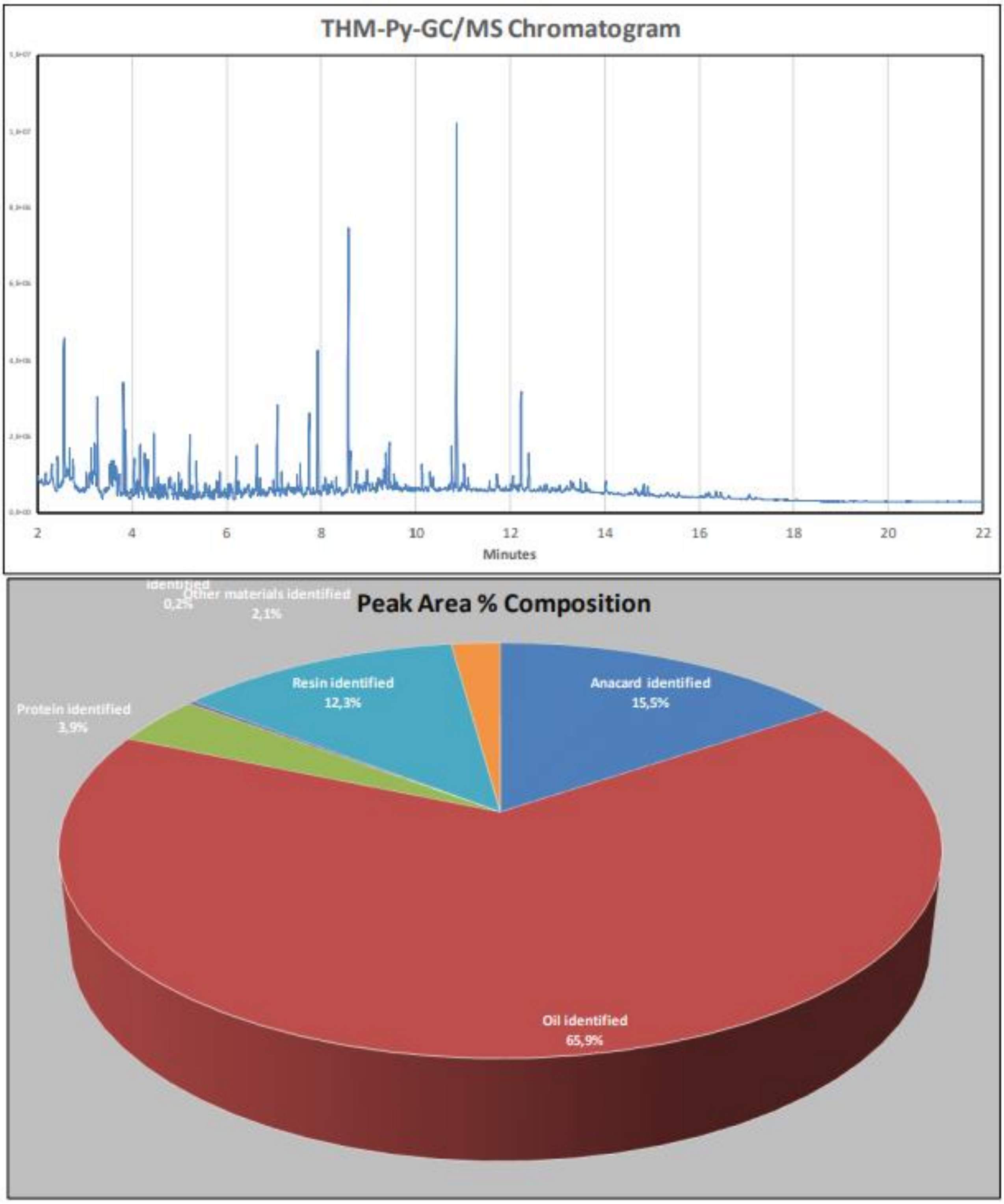
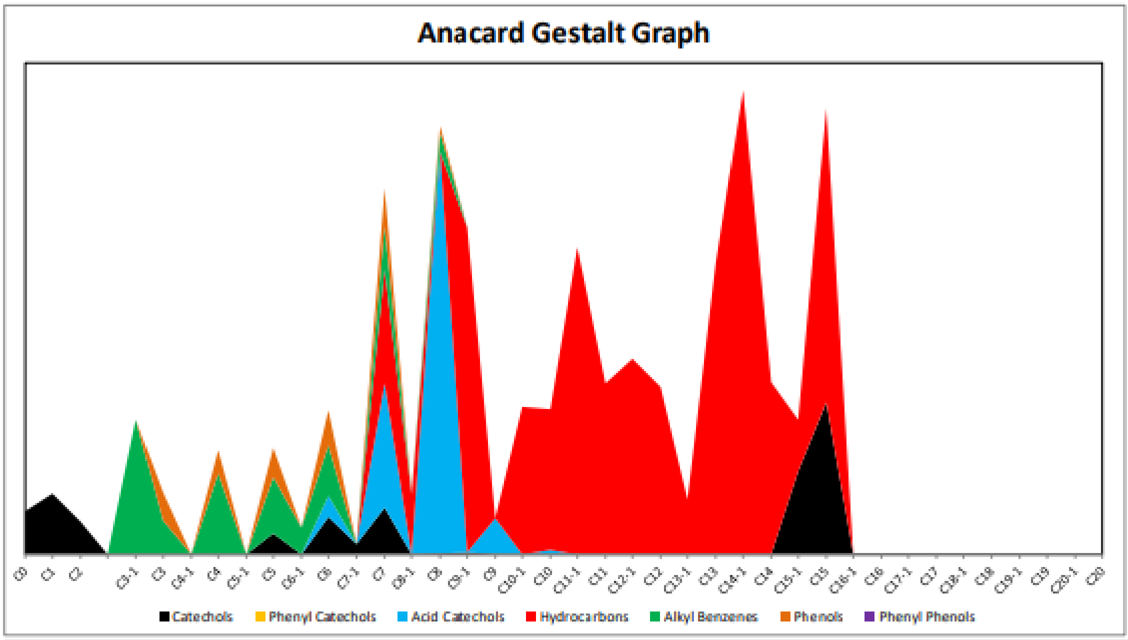
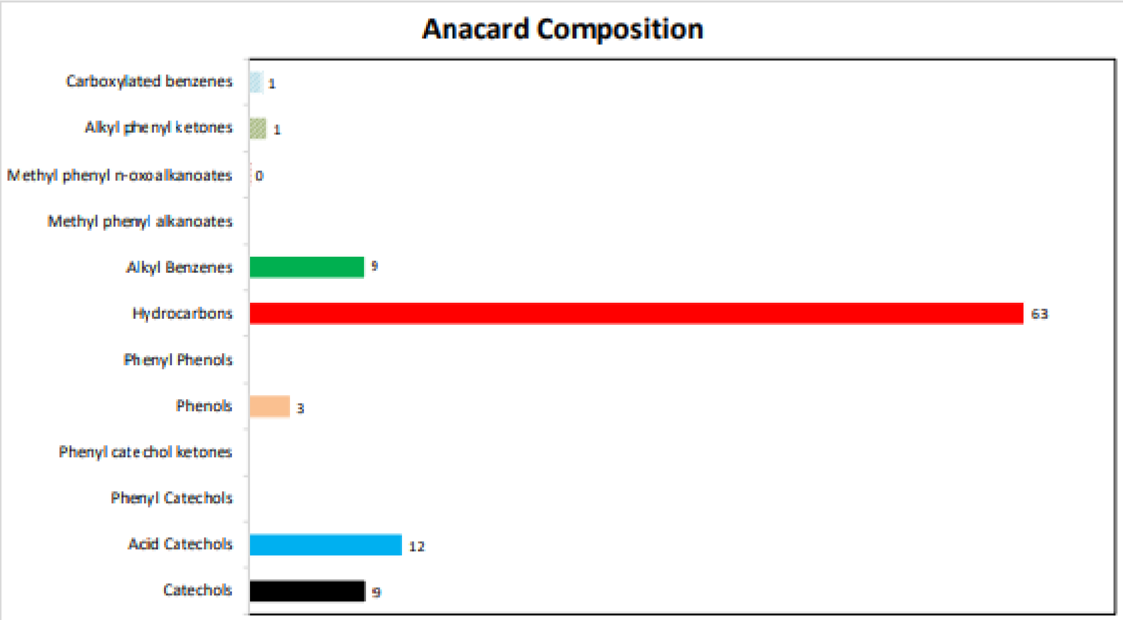
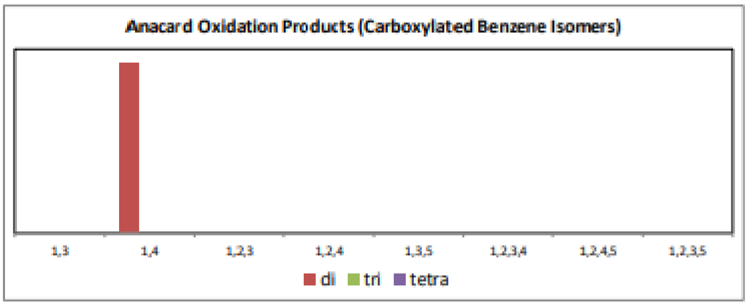


Figure 16-4: Py-GC/MS Results for Sample 5 (Lacquer Layers) (1/5)



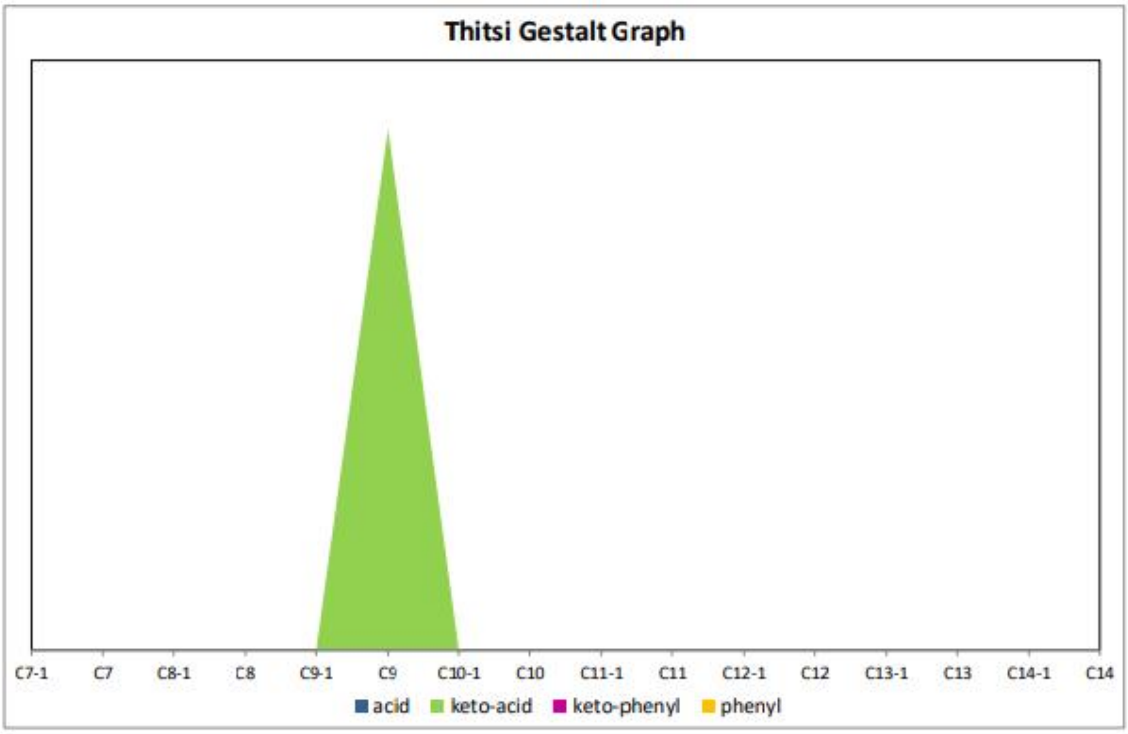




Anacard Aging Indices	
Unsaturated/Saturated	0,54
Acid Catechols/Saturated	3,87
Carboxylated Benzenes/Saturated	0,33
Thitsi Oxidized/Neutral	0,00

Derivatization Efficency	
Palmitate	100,0
C15 catechol	76,6
C17 catechol	###########

Figure 16-5: Py-GC/MS Results for Sample 5 (Lacquer Layers) (2/5)



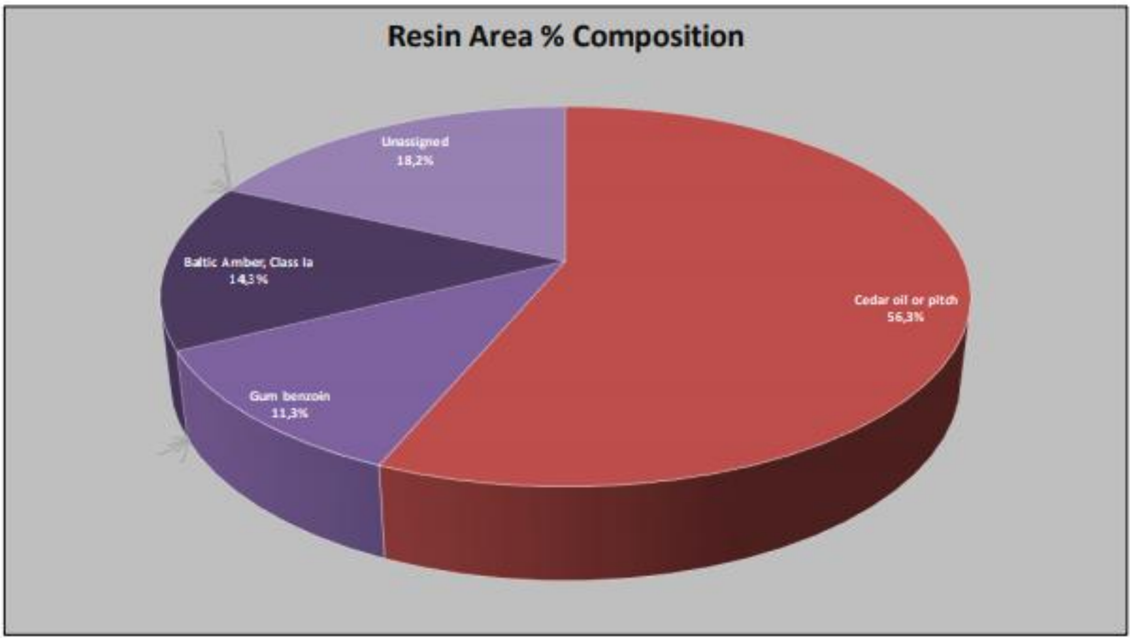
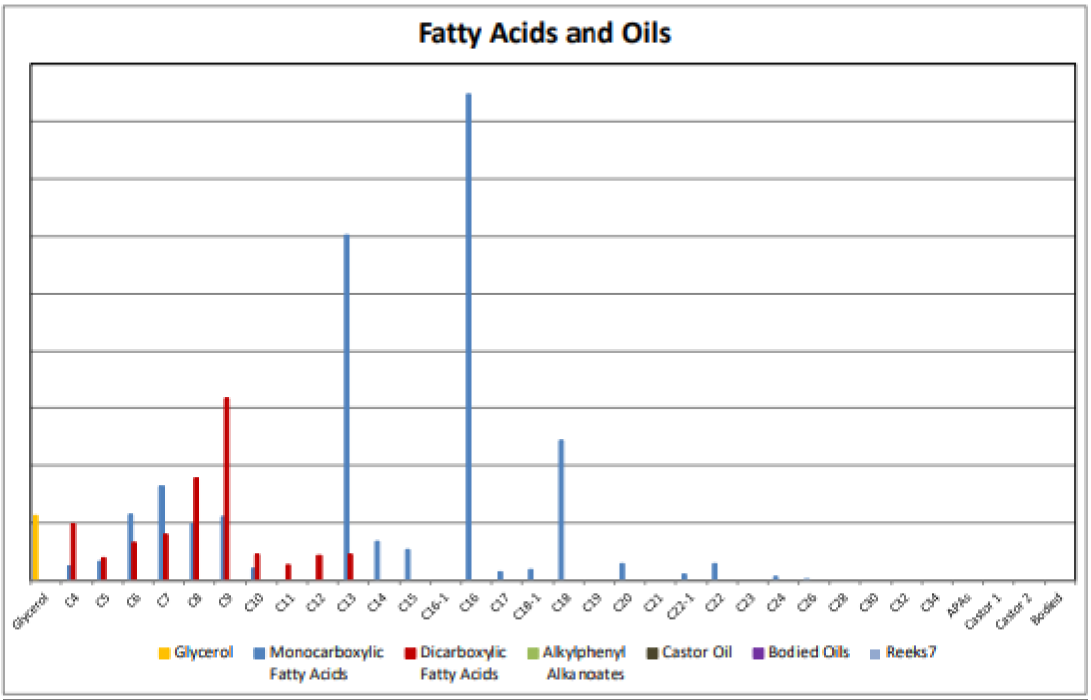


Figure 16-6: Py-GC/MS Results for Sample 5 (Lacquer Layers) (3/5)



Fatty Acid Ratios					
P/S	3,48	C8di/C9di	0,56	ΣFA/G	31,13
A/P	0,37	C13di/C8di	0,25	A/G	2,82
ΣDi/ΣMono	0,38	ΣAPA/ΣMono	0,00	P/G	7,52

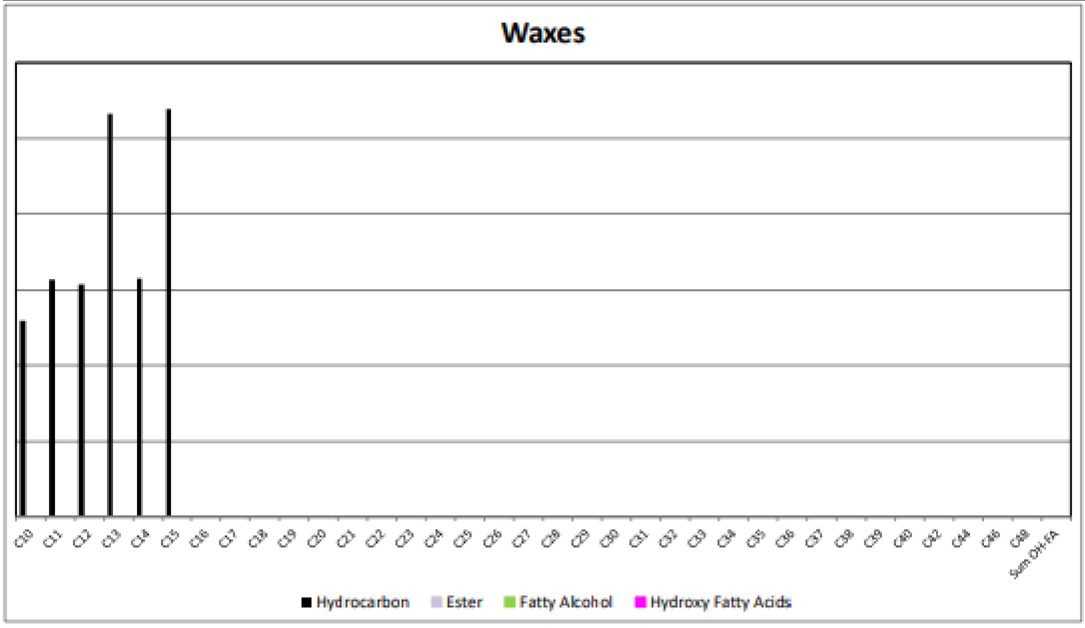


Figure 16-7: Py-GC/MS Results for Sample 5 (Lacquer Layers) (4/5)

			Protein Reference Materials										
Correlation Coefficient (1.0 is perfect match)			0,14	0,36	0,48	0,66	0,49	0,20	0,04	0,11	-0,21	0,23	0,30
Protein Marker Compound	*RI*	CHARLOTTEWIECHMANNS5RESINBACKGROUNDBLACK2	Blood (average of V&A samples)	Glue & red ochre light aged (GCI)	Fish glue & kaolin (GCI)	Glue (average of V&A samples)	Hide glue & urushi (Webb)	Whole egg & red ochre light aged (GCI)	Egg white (RCE)	Egg yolk (RCE)	Whole egg & urushi (Webb)	Casein (RCE)	Tofu & urushi (Webb)
Blood - unverified 5	1336	8,9	26	4,3	2,0	1,6	0	22	36	18	0	10	0
Blood - unverified 6	1435	0,0	24	1,2	1,2	1,9	0	18	15	28	0	20	0
Protein 1 - tofu and blood	1699	25,1	21	8,6	10	7,3	0	32	16	27	0	36	57
Blood - unverified 7	1815	0,0	5,6	0	0	0,2	0	4,3	5,9	0	0	0	0
Blood - unverified 9	2269	0,9	3,9	0	0	0,3	0	0	0	0	0	2,9	0
1H-Indole, 1,3-dimethyl-	1371,5	0,0	4,3	0	0	0	0	0	6,0	11	0	0	17
Protein 3 - blood & glue	1702	28,7	1,9	14	13	32	23	0	0	0	0	2,8	0
1H-Pyrrole, 1-methyl-	736	0,0	3,2	43	28	25	39	1,4	0	0	25	0	26
hydroxyproline	1223	1,5	0,5	2,2	4,1	5,7	2,4	0	0	0	0	0	0
Glue marker (fish glue 126/158)	1520	0,0	0,9	1,0	6,7	1,4	0	0	0	0	0	0	0
Glue marker (fish glue 126/158-2)	1535	0,0	0,2	1,2	3,9	1,0	0	0	0	0	0	0	0
d-Proline, N-methoxycarbonyl-, methyl ester	1380	4,4	1,2	2,6	10	2,7	0	0	0	3,7	0	1,9	0
Glue - unverified 3	1871,1	30,5	1,3	22	21	21	36	0	0	0	0	0	0
egg yolk RI=1420	1420	0,0	0	0	0	0	0	16	0	13	75	0	0
protein 131-160 (casein, egg white)	1718	0,0	5,7	0	0	0	0	6,6	21	0	0	26	0

Other Major Components % Composition	
Cashew Nut Shell Liquid	14
Gall	0
Tannins	86
Wax (HCs, alcohols, OH-Fas)	0

Carbohydrate % Composition	
Starch	36,0
Tofu	0,0
Anacards	0,0
Paper	64,0

Miscellaneous Materials	
Trimethyl phosphate	0
Sterols	0
Sulfur compounds	9866552
Caffeine	0
Crown 18 (resin)	0
Dyes & Pigments	492910349
Methyl hexadecenoate	0
Squalene	0
Fatty Amides	0

Figure 16-8: Py-GC/MS Results for Sample 5 (Lacquer Layers) (5/5)