EL GRECO. From Italy to Toledo.

TECHNICAL STUDY OF WORKS IN THE THYSSEN- BORNEMISZA COLLECTION

INTRODUCTION

On the occasion of the **400th anniversary of the death of El Greco** (Candia, 1541-Toledo, 1614), we are pleased to present the results of the technical study of the works in the Thyssen-Bornemisza Collection.

By using chemical analyses, X-rays and infrared imaging, we are able to conduct research that sheds new light on the artist's material and conceptual evolution in works from the two phases of his career under study—his years in Italy and in Spain—over the course of approximately two decades.

The results of this research confirm the development of his formal and material evolution from an early period conditioned and influenced by the Italian masters—as we can clearly see in the architectural composition revealed by X-rays and infrared imaging—to his Spanish phase, when underdrawings all but disappeared from his paintings, his brushstrokes were looser and more subjective, and he combined impasto and glazing in no apparent order. The work of his final years is the culmination of an unmistakably personal style characterised by elongated figures blurred with Impressionist touches, a reflection of El Greco's intellectual and technical maturity.

1.0.- INTRODUCTION

This chapter explains the techniques used to study an artwork. These techniques are complementary and their purpose is to obtain comprehensive information about every aspect of a painting. The infrared reflectography (IRR), X-ray image and chemical analyses for each work are shown below, and the most interesting details revealed by the different techniques are described to highlight the evolution in the artist's use of materials and conceptual approach.

1.1.- THE ANNUNCIATION ca. 1576

1.1.1- VISIBLE IMAGE

El Greco
The Annunciation, ca.1576
Oil on canvas. 117 x 98 cm
Inv. 172 (1975.34)

El Greco used architectural elements to spatially arrange his figures. The vanishing point where the lines of the flooring tiles converge is positioned on the imaginary vertical axis yet approximately 10 centimetres lower than the horizontal axis. This device has the effect of elevating the figures above the viewer's eye level. The academic canon and the extraordinary luminosity and colours are typical of this period. Curiously, the hand that the Virgin rests on the Scriptures is slightly out of proportion.

1.1.2- INFRARED IMAGE (IR)

The infrared reflectogram reveals a detailed preliminary drawing in which it is easy to identify the process followed by the artist in transferring the sketch or cartoon image to the final support. We can see the grid drawn to centre the composition and the most important lines for defining the volumes. The architecture in the background, where the window frame has vanished, is simpler in the final version and a new undefinable element has appeared on the horizon.

IR Details

Angels

The draughtsmanship is confident and firm on the infant angels crowning the clouds of glory. El Greco's circular strokes, used to define their anatomical features, are reminiscent of the work of Venetian masters like Titian and Tintoretto.

Virgin

The mantle covering Mary's head has been shifted slightly to the left, bringing the edges in and cinching the fabric at the nape of her neck. This gives the figure a more stylised bearing and heightens the impression of mobility.

Lectern

The geometric pattern of the floor tiles appears below the lectern/prayer desk which supports the book of scripture that the Virgin was reading moments before the Archangel Gabriel appeared. This may indicate that the lectern had not yet been defined in the preliminary drawing.

Floor

The presence of large semicircular strokes on the flooring tiles on the right side of the composition situates the shadow cast on to the floor by the angel floating on a cloud.

1.1.3- X-RAY IMAGE

This X-ray allows us to contemplate a very elaborate work. Even so, we can see that the painter make slight changes to the garments of the two central figures, the drape and the geometric pattern on the floor. He also covered the background in the central area, where we can make out a scene with houses and trees, perhaps believing that it might distract the viewer and detract from the importance of the primary scene.

With regard to the painting's condition, the X-ray reveals isolated losses on the paint layer but no major damage except around the edges, where the stress on the canvas is always highest and paint is often lost as a result of friction against the frame.

X-Ray Details (RX)

Lectern/prayer desk

In an earlier design, El Greco painted a prayer desk that was smaller than the final version. The tile floor fit these original measurements, but while executing the composition the painter decided to make the desk larger and therefore applied coats of paint over the tile to conceal the original composition. The same thing occurred with the Virgin's garments, where we see that the size and arrangement of the folds in the mantle and tunic were changed, which explains why they also cover part of the floor. The artist also altered the composition of the folds in the clothing and drapery, deciding to simplify the cloths in the definitive version. He did this by applying thin coats of paint to attenuate the sharper contrasts of light and shadow, though these are not thick enough to show up on the X-ray image.

The "twill" weave of the original canvas is clearly visible because it was impregnated with several coats of paint, *ground* and *primer*.

On the left side we see a lighter strip identified as the wooden stretcher, which serves to keep the canvas taut. The canvas, like the keys, is secured by metal tacks. As these tacks are made of a metal with a high atomic number, they appear as white spots because the X-rays cannot pass through them to the imaging plate. The same thing happens in parts of the stretcher where the wood has gnarls, as the material is harder and more compact in those areas and therefore more difficult to penetrate. In contrast, the areas with paint loss appear as darker patches due to the absence of matter.

Archangel Saint Gabriel

In this painting, El Greco worked with great confidence and freedom even while striving to stick to his original design, which is why we observe certain changes made during the process of painting. For example, on the right at the height of the wing, he "drew" white lines with his brush so that he would not stray from the design layout while painting. He also sketched a schematic outline of the wing and a few feathers in the darkest area.

We can also detect alterations in the position and size of the neck and head. El Greco initially painted the sky in the background, leaving a space for the head. He drew the head by sketching an oval, and after fixing the position of the face he finished the back of the head and the hair, eventually painting over part of the sky with loose strokes and a material easily penetrated by X-rays. He then added a final element: the staff that the archangel holds in his left hand.

The artist made several changes to this area of the work. For example, we see extra fingers on the archangel's right hand because the painter repeatedly corrected their size and position. He also reduced the size of the white fabric flowing from the angel's right sleeve, a colour he created using white lead pigment. As lead has a high atomic number, and the coats of paint in this area are very dense, X-rays cannot pass through, and it therefore appears in whitish tones on the X-ray image. The same is true of the archangel's yellow garment, painted using a lead-tin yellow pigment.

Background

The painter simplified the background in the final composition of this part of the work. He changed it from a small landscape featuring a town with houses and towers to a more schematic depiction with a small hill in the distance. The motifs we can make out were rendered in heavy strokes of paint that block radiation. But these ultimately disappeared under a new design, this time using materials with lower atomic numbers and therefore more easily penetrated by X-rays.

1.1.4- MATERIALS ANALYSIS

The materials analysis was carried out to determine the composition of the original materials used in the painting and how they are distributed in the various layers.

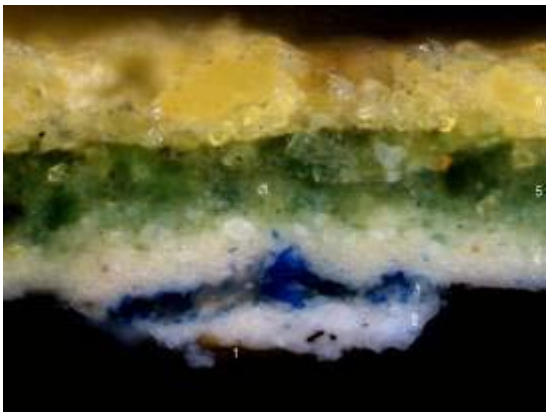
The information obtained from this analysis is useful for understanding the pictorial technique that the artist used and has helped to explain the different transformations that were effected during its execution.

The cross-sections of the microsamples analysed reveal the components of the paints from a perspective that would be impossible outside of a properly equipped analytical laboratory.

Cross-section Details

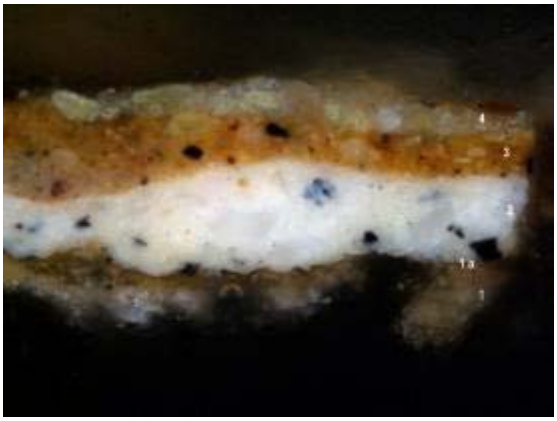
Green lining of the Virgin's mantle

In the cross-section we see a tiny fragment of the internal layer of gesso and animal glue (1) over which the greyish primer (2) was applied. The artist then painted the Virgin's blue tunic (3) and subsequently covered it in this area with white brushstrokes (4), possibly with the intention of preparing it to receive the bright green paint used for the mantle's lining, so that the blue underneath would not alter the tone of the green pigment. Before the green paint had dried he applied thick strokes with a high concentration of lead-tin yellow type II pigment granules mixed with white lead and calcium carbonate, which lend this layer a degree of transparency and allow it to blend with the green beneath.



Yellow of the angel's vestments

In the cross-section we can make out the thin layer of the underdrawing (1 a) that El Greco sketched on the gesso ground (1). This thin drawing layer was covered with a grey primer (3) made of white lead and calcium carbonate. The paint layers in this area were created by applying two series of strokes, an orangey-yellow tone subsequently softened with highly transparent yellow paint, thereby creating a strikingly luminous effect on the angel's garments.



1.1.5- SUPPORT - Back

The support of the work *The Annunciation* (ca. 1576) by El Greco consists of two superimposed canvases. The original is a twill weave typical of the Italian Renaissance and was chosen by the painter in accordance with the fashions of the time and place in which he painted the work. Years later, in the course of restoration work, a single piece of plain-weave canvas fabric was added to the back as reinforcement.

The characteristics of the original cloth could only be revealed by X-ray imaging, as it was concealed on both sides: on the front by layers of paint, and on the back by the lining. The canvas measures 117 x 98 cm.

The adjustable stretcher is made of pine and has two diagonal crossbars to ensure that the canvas maintains the proper tension. It has a key at each point where the central crossbar meets the stretcher and double keys in the corners.

Details of Information on the Back

Labels – These are located on the stretcher. They are used to document the provenance of the work or indicate museum venues where it has been exhibited.

Stamps – These are found on the stretcher and the lining canvas. In this case they serve the same purpose as the labels, providing information on the work's provenance or on museum venues where it has been exhibited.

2- THE ANNUNCIATION ca. 1596-1600

1.2.1- VISIBLE IMAGE

El Greco
The Annunciation, ca. 1596-1600
Oil on canvas. 114 x 67 cm
Inv. 171 (1954.1)

This work belongs to the author's Toledo period. By then his style had altered considerably: the figures are elongated and unusually elegant, the compositions are tighter, and the brushwork is increasingly swifter and impressionistic. Meanwhile, the architectural elements have disappeared and been replaced by neutral, dark backgrounds.

The palette is dominated by the dark tones of the grounds, visible on the paint layer in numerous areas and used as a pictorial device to achieve a grisaille effect. The coloured glazes applied over them are what lend this work its characteristic dazzling luminosity.

1.2.2- INFRARED IMAGE

The infrared reflectogram clearly illustrates the changes El Greco introduced in his technique after moving to Spain. The drawing has practically disappeared, or is difficult to identify due to the use of coloured ground layers in this stage of the process. Thicker, discontinuous lines to situate the figures are visible. The architecture in the background has disappeared, and the figures, in a narrower composition, seem to float in an undefined space.

IR Details

Virgin

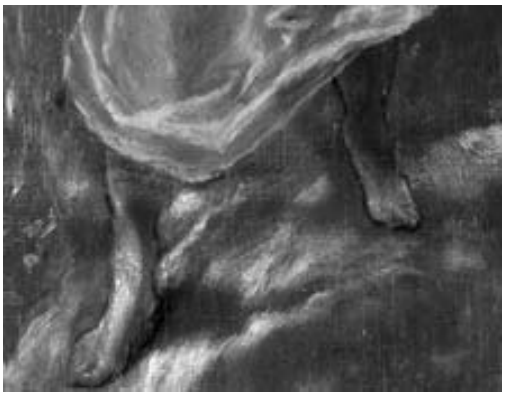
Thick lines, subsequently reinforced during the application of the paint, define the outline of the Virgin's face.

Archangel

The underdrawing is clearly visible in the profile of the face and the neck area, along the inner edge of the arm and on the outline of the wing of the Archangel Gabriel.

Archangel (feet)

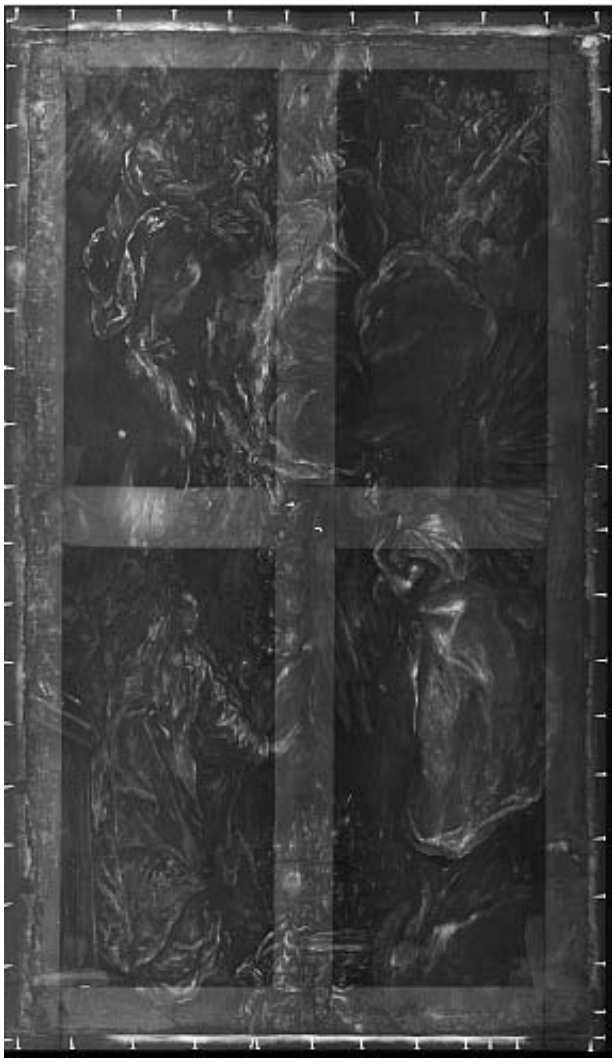
Sharply defined lines indicate the position of the archangel's feet descending on a cloud.



Musicians

Energetic strokes indicate the position of the principal elements in the group of musical angels.

1.2.3- X-RAY IMAGE



This X-ray confirms that the artist hardly made any changes while painting this work. As it is a smaller version of the same scene held at the Prado, El Greco did not work with his usual freedom because he was attempting to replicate a pre-existing model. The technical execution does not reveal the same elaborate effort put into his other paintings, which were altered during the painting process, and the X-ray image confirms this theory.

However, the X-ray also reveals a support that has sustained much more damage, especially around the edges, than the rest of the works in the museum's collection. This may be why patches from another piece of painted canvas were added all around the edges, and a thick ground layer was applied to make them even with the original paint layer. These edges were later covered with coats of brown paint, creating a kind of painted frame around the perimeter of the scene.

X-Ray Details

Virgin Mary

In the area of the figure of the Virgin Mary, we particularly notice the technical execution of the blue mantle, in a manner characteristic of El Greco: how he used brushes with thick bristles to drag impastos of light and create sharp contrasts which he later attenuated with very thin coats of paint, especially when he wanted to simplify the number of folds. To achieve this he used tinted glazes so thin that they do not appear on the X-ray. The precision and clarity of the scene in every area and the absence of pentimenti suggest that the artist was working from a predetermined concept.

Archangel Saint Gabriel

A noteworthy aspect in this figure is the simplification of the folds in the archangel's garments. At certain points the painter softened the sharp angles of the cloth, created using zigzag strokes of light and shadow, by applying glazes which are not visible in the X-ray image. On the other hand, the angel's beautiful face—still rendered with painstaking precision in this period of the artist's career—is highlighted around the edge by dark lines.

Finally, the technical composition of the wings is very precise, in part thanks to the fact that El Greco used a fine brush and white lead pigment to paint "layout" lines so that he would not lose sight of the underdrawing as he applied the coats of paint that make up the wing, situated in an area of the background reserved for this very element.

Musical Angel

Except for one correction concealed in the central area, we see no signs of hesitation in the layout of the composition. There are no extra fingers on the hands, nor any variation in the position of the faces or garments. The only change we see is located in the central area. An earlier opening in the clouds pierced by a beam of light was ultimately painted over with an instrument. However, as this was painted with white lead it blocks radiation, which is why it shows up clearly on the X-ray image.

1.2.4- MATERIALS ANALYSIS

The materials analysis was carried out to determine the composition of the original materials used in the painting and how they are distributed in the various layers.

The information obtained from this analysis is useful for understanding the pictorial technique that the artist used and has helped to explain the different transformations that were effected during its execution.

The cross-sections of the microsamples analysed reveal the components of the paints from a perspective that would be impossible outside of a properly equipped analytical laboratory.

Cross-section Details

Yellow on the cloak of the angel on the left side of the scene

This cross-section only penetrated as far as the top paint layer (1). The microsample clearly reveals one of the defining characteristics of the brushwork in this painting: the richness and precision in the use of varying quantities of different colour pigments, with which El Greco was able to achieve perfectly gauged nuances by blending brushstrokes (in this case he combined white lead, lead-tin yellow type I, minium, carmine lake, yellow ochre and calcium carbonate, with linseed oil as a binder).

Green on the tunic of the angel on the right side of the scene

The cross-section_of the microsample taken from the angel's green tunic shows the layers of the gesso and animal glue ground (1) followed by a layer of brown primer (2) made by blending white lead and earth pigments; we can also make out small fragments of colour pigments carried over from residue on the painter's palette (azurite, carmine lake, smalt blue, carbon black and minium). The top stratum is the paint layer (3) which in this case was applied as a single coat, blending green and yellow brushstrokes with a varying concentration of copper resinate and lead-tin yellow type I, attenuated with white lead and carbon black granules. The resinous material identified in the copper pigment is colophony resin with a low proportion of linseed oil.

1.2.5- SUPPORT – Back

The support of the work *The Annunciation* (ca. 1596-1600) by El Greco is also a lined canvas, like the preceding work. The original canvas is not of the type usually employed in Italy. El Greco came to Spain and began to use a plain-weave cloth more typical of the Renaissance period in this country. In this case the fibres are hemp, which is unusual as flax was normally used to make canvases. Like the rest of the works in the Thyssen-Bornemisza Collection, this piece was lined during restoration with a single piece of plain-weave canvas attached to the back.

The original edges have been lost, and we therefore do not know the work's original measurements as its deteriorating condition required the addition of the aforementioned lining canvas. The original canvas currently measures 110 x 62 cm, but with the additions the dimensions of the entire work are 114 x 67 cm.

The characteristics of the original cloth could only be revealed by X-ray imaging, as it was concealed on the front by layers of paint, and on the back by the lining.

The adjustable stretcher is made of pine and has two diagonal crossbars, a key at each point where the central crossbar meets the stretcher and double keys in the corners.

Details of Information on the Back

Labels - These are located on the stretcher. They are used to document the provenance of the work or indicate museum venues where it has been exhibited.

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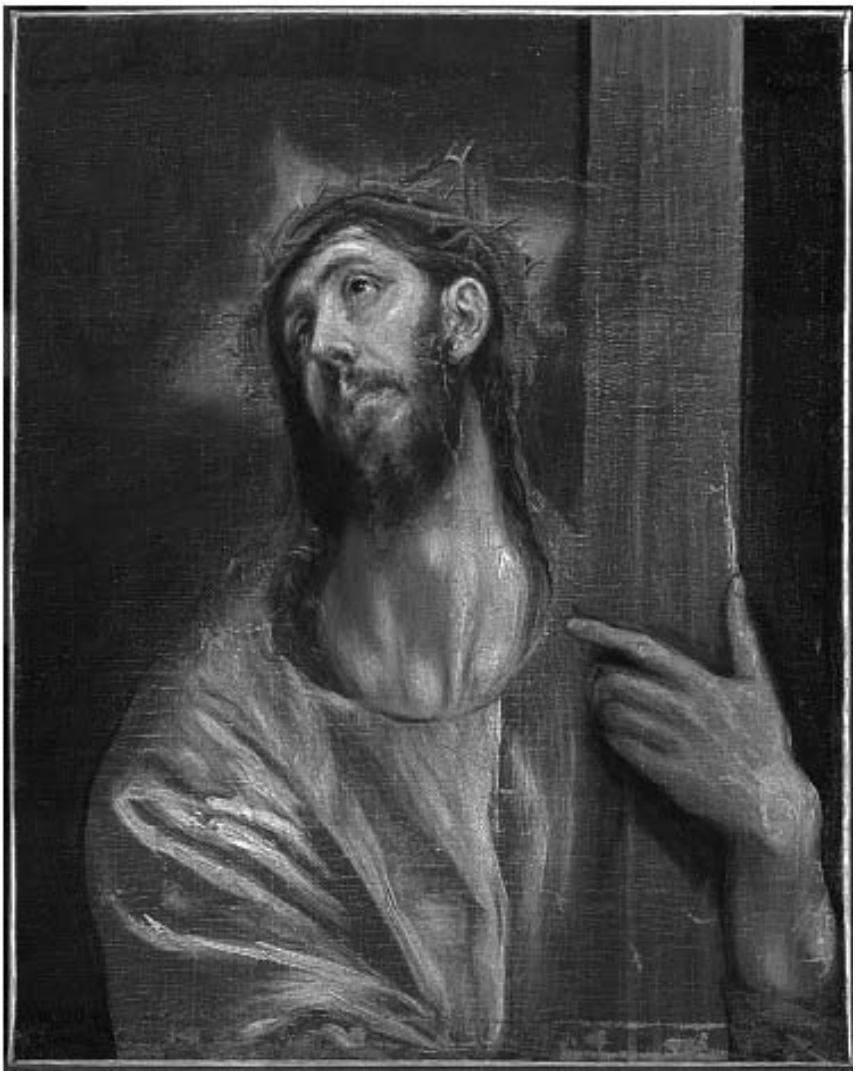
1.3- CHRIST WITH THE CROSS ca. 1587-1596

1.3.1- VISIBLE IMAGE

El Greco
Christ with the Cross, ca. 1587-1596
Oil on canvas. 66 x 52.5 cm
Inv. 169 (1930.28)

Cristo with the Cross depicts a theme from the Passion of Christ. All narrative elements have been eliminated from the scene, focusing solely on the figure of Christ, whose bust fills practically the entire pictorial surface. Wearing a crimson tunic and accompanied only by the cross and the crown of thorns, he is the image of the Son of God, gazing heavenward and conversing with the Father, which also makes this rendering a metaphor for Redemption and Salvation. Against a dark neutral background, the light falls strongly on Christ's face and hands, both executed with great skill. The numerous different versions of this devotional image produced by El Greco's workshop indicate that this type of scene was very popular with his clients. Some scholars have identified a work by Sebastiano del Piombo on the same theme, now held at the Museo del Prado, as a precedent for this painting.

1.3.2- INFRARED IMAGE



Infrared radiation does not shed much light on this work as the use of reddish-brown ground layers makes it difficult to identify clearly defined lines. However, there are a few traces in the area of the face, hair, neck and hand, as we can see in the details shown.

IR Details

Face

Very subtle sketched lines mark the position of the head, the locks of hair, the hand and the edge of the tunic in *Christ with the Cross*..

Hair

The drawing concealed beneath the paint shows that the artist changed his mind about the design of the neck area. He also corrected the arrangement of the hair to make the curling locks longer.

Hand

In the underdrawing, the fingers of the hand are drawn in a different position. El Greco later corrected them in the final painting.

1.3.3- X-RAY IMAGE

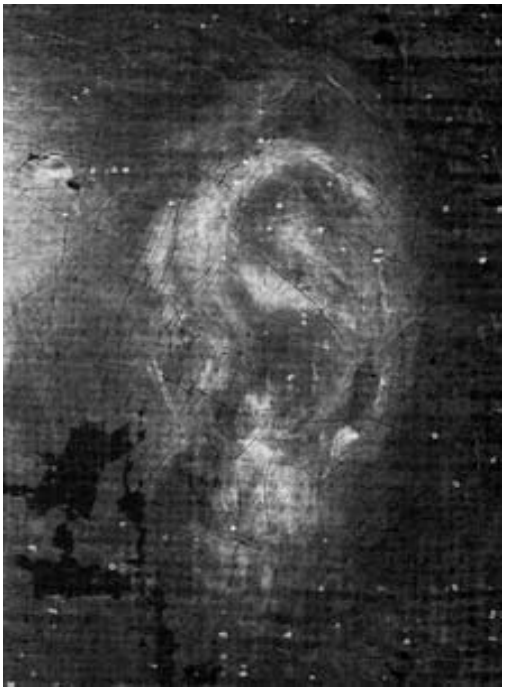
The X-ray image of this work reveals signs of past interventions in the canvas support. First the original size of the canvas was reduced at the top; this is why we see a dark line where the original painted cloth was folded over, and the holes where the original tacks secured it to a smaller stretcher (now lost). During a second intervention the original canvas was enlarged by unfolding the top and bottom edges and grafting on two patches from another piece of painted canvas, giving it the size we see today. Finally, the entire support was lined with a single piece of new canvas.

The work's overall condition is good, although there is considerable paint loss below the face and a cross-shaped tear in the central part of the canvas.

X-Ray Details

Face

It is a treat to observe the freedom with which El Greco painted this work, and how he executed a quasi-Impressionist face with swift, sure, loose brushstrokes. Making hardly any changes, he made the dark background come alive with vigorous lines of light, managing in a few deft strokes to create the perspective of a face so elongated that its dimensions would seem impossible if executed by any other painter, and yet in El Greco are truly brilliant.



Ear

The artist made minor alterations in the placement of the ear, moving it to the proper position for a face in three-quarter view. Beside the ear we see old damage to the original paint layer, which appear on the X-ray image as dark areas.

1.3.4- MATERIALS ANALYSIS

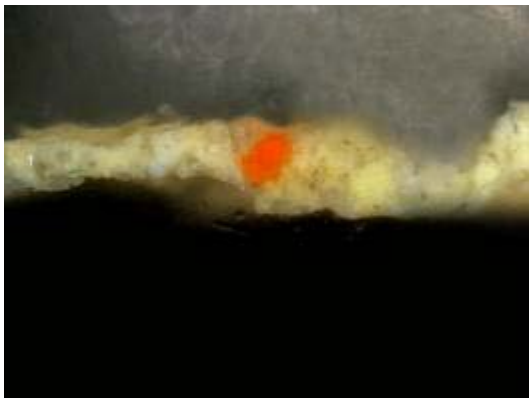
The materials analysis was carried out to determine the composition of the original materials used in the painting and how they are distributed in the various layers.

The information obtained from this analysis is useful for understanding the pictorial technique that the artist used and has helped to explain the different transformations that were effected during its execution.

The cross-sections of the microsamples analysed reveal the components of the paints from a perspective that would be impossible outside of a properly equipped analytical laboratory.

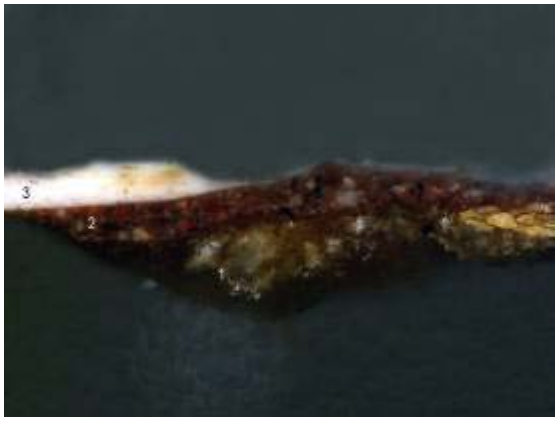
Cross-section Details

Yellow in Christ's halo



This cross-section only penetrated as far as the top paint layer (1). The blend of pigments identified in this layer matches the treatment observed in other El Greco paintings that have been analysed, in which he achieves yellow and orange tones by mixing lead-tin yellow (type I in this case) with minium or, when he wanted to add a reddish tinge, carmine lake. The base of this paint layer is white lead, and a small amount of calcium carbonate has also been detected.

Flesh of the hand of Christ



The lowest layer is the ground of gesso and animal glue (1), followed by a reddish-brown primer (2) in which the red ochre and white lead pigments that form the base are enriched with umber and carbon black pigments and contain traces of residue from the palette (vermillion, carmine lake and azurite identified in this area). The darkening of the reddish primer in this section seems to be linked to the base tone applied where the artist later intended to paint the vertical beam of the cross, and to the dark brown background used throughout the work. In the paint layer corresponding to the flesh (3) we identified white lead mixed with a few granules of vermillion, lead-tin yellow and carmine lake. The primer was bound with linseed oil, yet analyses of the binder in the flesh area suggest that walnut oil was used there.

1.3.5- SUPPORT - Back

The support of the work *Christ with the Cross* (ca. 1596-1600) by El Greco consists of two canvases. The original is a plain-weave cloth (typical of the Spanish Renaissance), and during restoration the work was lined with a single piece of canvas, also a plain weave, added to the back for reinforcement. Two patches of painted canvas were also added to the top and bottom of the painting.

The characteristics of the original cloth could only be revealed by X-ray imaging, as it was concealed on the front by layers of paint, and on the back by the lining.

The adjustable stretcher is made of pine and does not have a central crossbar, as it was considered unnecessary to maintain canvas tension given the picture's small size (66 x 52 cm). It has four simple keys, one in each corner.

Details of Information on the Back

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1.4- THE IMMACULATE CONCEPTION ca. 1608-1614

1.4.1- VISIBLE IMAGE

El Greco y Jorge Manuel Theotokópoulos
The Immaculate Conception, ca. 1608-1614
Oil on canvas. 108 x 82 cm
Inv. 170 (1930.29)

The execution of this work clearly shows that by this time El Greco had developed a much freer style of painting. The brushstrokes are much looser and less defined, applied swiftly to create dramatic textures. The colour palette is darker and metallic with bursts of light, like lightning bolts in a stormy sky, which illuminate the colours and electrify the glazes.

The characters seem to be in a state of permanent levitation. He simplifies the garments by arranging the folds geometrically, which has the effect of synthesising the end result.

El Greco set a clear precedent and has been a source of inspiration for countless generations of artists.

1.4.2- INFRARED IMAGE

As in the previous cases regarding the works producing during his Spanish period, the use of coloured ground layers makes it difficult to identify what may have been a complete drawing. Much more evident are the thick discontinuous lines which, in certain areas, coincide with firm brushstrokes applied to define the more important volumes and the outlines of the figures. The use of known models and the artist's mature command of his skills, manifested in a great freedom of execution, may also explain why the preliminary drawing is so simple.

IR Details

Angels (group)

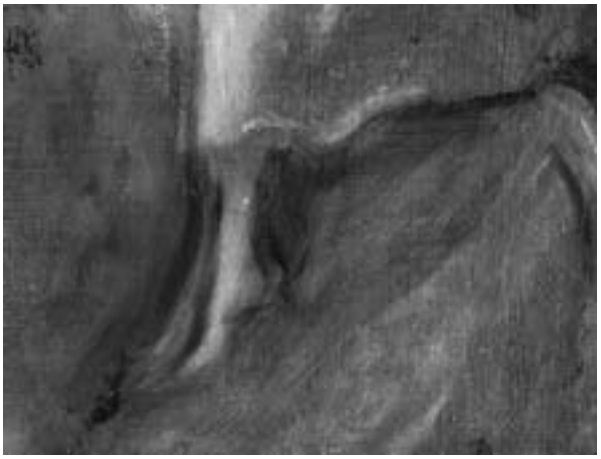
The drawing beneath the paint layers is precisely executed and its compositional design coincides perfectly with that of the final painting.

Musical angel

The draughtsmanship of the underdrawing for the musical angel figure is freer and more spontaneous than in other areas of the painting.

Angel (foot)

The sketch of the angel's foot hints at the movement that frames the composition around the Virgin Mary.



1.4.3- X-RAY IMAGE

The artist divided the composition into two parts: an upper and a lower register, clearly differentiating between the human and divine realms. Although both are very illuminating, we will focus on the upper register as it contains the most important figures in the composition and the X-ray of this part revealed a greater number of remarkable details.

The technical quality of this work is magnificent, the culmination of a lifetime of work that could only have been produced by a true master of painting. The figures are drawn with tremendous freedom and all the elements were composed with loose brushstrokes, but always after outlining the figures to avoid straying from the original layout. The marked contrasts we see in the X-ray image are a product of the artist's bold, generous use of paint. Shadows and highlights are sharply defined, and the midtones give way to an intense battle between dark and light colours, using copious amounts of X-ray absorbent materials like white lead.

The X-rays reveal that the painting's condition is stable, although there are isolated paint losses in different parts of the picture, particularly along the edges.

X-Ray Details

Angels on the right

El Greco painted this group with rapid brushstrokes, blurred in the anatomy of the hands and face yet simultaneously accentuating the light that radiates from the Virgin and is reflected in the faces and garments with thick layers of white lead. Light and dark tones are combined with great skill, ultimately resulting in a less elaborate appearance than that concealed beneath the surface of the work.

If we zoom in on this detail of the musical angel, we can see how the genius broke up the profile—a typical feature of this painter's style, especially in his later years. El Greco's masterful handling of the brush allowed him to achieve pictorial expressionism.

Angels on the left

In this group, we again see how El Greco created the figures in one swift stroke. His swift, confident brushwork constructed the faces and anatomy of these characters.

He began by staining the background to create an atmosphere, leaving an empty space for the heads. He then slightly altered the position of the face of the angel in the background. If we zoom in on this X-ray detail, the area of the angel in the foreground bowing respectfully to the Virgin, we can clearly see the freedom with which the artist executed the hands and garments.

The X-ray also reveals damage and losses in the paint layer and dark lines indicating the presence of craquelure in the original paint.

1.4.4- MATERIALS ANALYSIS

The materials analysis was carried out to determine the composition of the original materials used in the painting and how they are distributed in the various layers.

The information obtained from this analysis is useful for understanding the pictorial technique that the artist used and has helped to explain the different transformations that were effected during its execution.

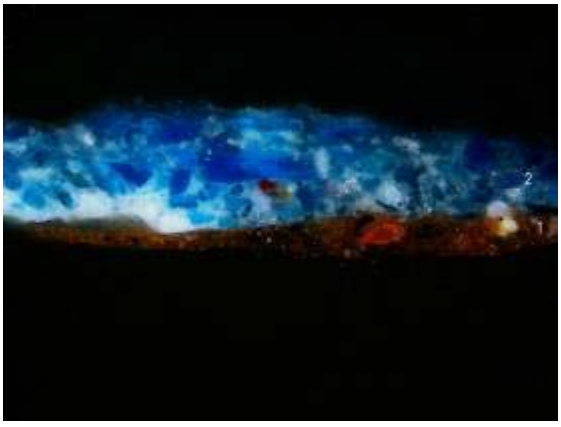
The cross-sections of the microsamples analysed reveal the components of the paints from a perspective that would be impossible outside of a properly equipped analytical laboratory.

Blue of the Virgin's mantle

This cross-section only penetrated as far as the primer layer (1), whose intense reddish-brown colour is owing to the abundance of red ochre, the tone of which was deepened by adding umber and carbon black pigments. In this case, trace residue from the palette is also present, though in smaller proportions than the previously analysed works. Above the red primer we see the layer of blue paint corresponding to the Virgin's mantle (2) in which azurite pigments were mixed with granules of lapis lazuli in a base rich in white lead (on the mantle's highlights). This layer is remarkable for its thickness and the coarse-ground texture of the exceptionally pure pigments used to create the colours.

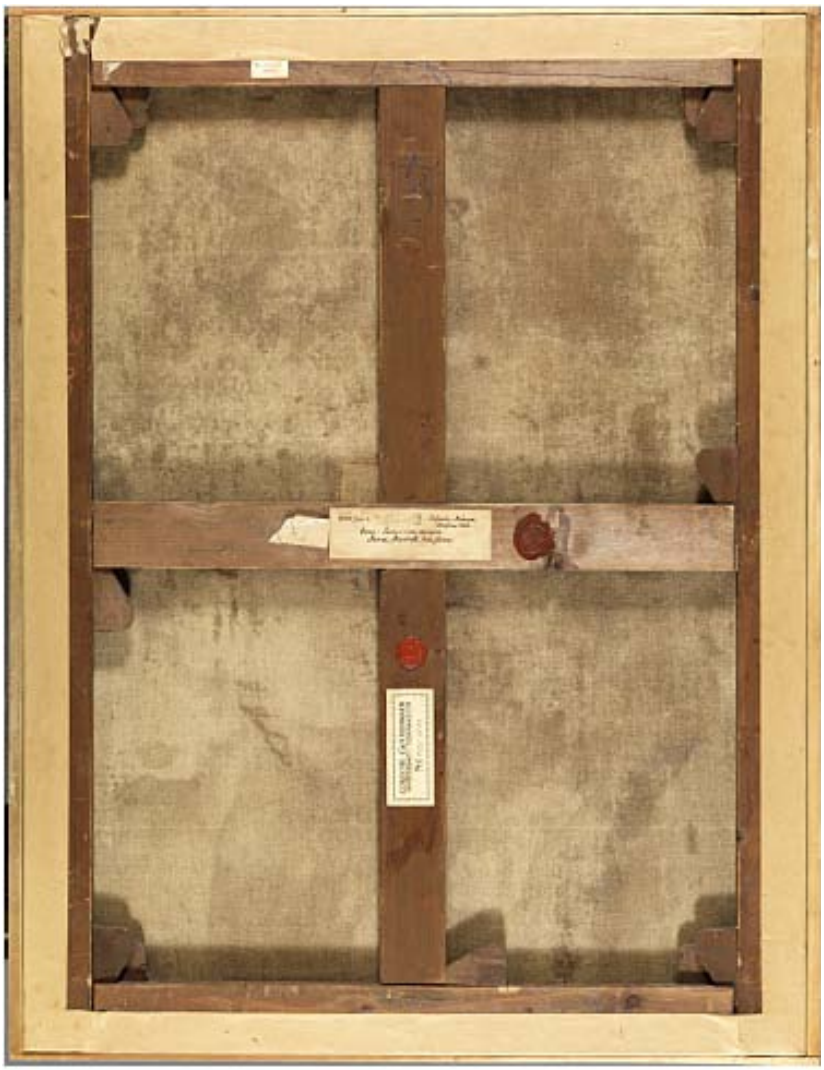
Green of the plants on the right side of the scene

The lowest layer is the ground of gesso and animal glue (1), followed by a red primer (2) tinged in this area with umber, carbon black and minium that lend it a slightly orangey tone. Minium is not present in all of the microsamples taken from this work, meaning that the colour of the primer varies from reddish to orangey in different parts of the painting. This aspect is also influenced by the variety of tones found in the palette residue that El Greco nearly always added to his primers, as the analysis of the three works painted in Spain has revealed.



The plants were created by applying a single coat of paint (3) of considerable thickness with a remarkable abundance of pigments. The materials analysis has identified this as a blend of verdigris, lead-tin yellow (type I) and small amounts of carbon black and ochre pigments, all added to a base of white lead and bound with linseed oil.

1.4.5- SUPPORT – Back



The support of the work *The Immaculate Conception* (ca. 1608-1614) is a plain-weave canvas typical of the Spanish Renaissance, with a lining added to the back during restoration consisting of a single piece of plain-weave canvas.

The characteristics of the original cloth could only be revealed by X-ray imaging, as it was concealed on the front by layers of paint, and on the back by the lining. The work measures 108 x 82 cm.

The adjustable stretcher is made of pine and has two diagonal crossbars, a key at each point where the central crossbar meets the stretcher and double keys in the corners.

Details of Information on the Back

Labels – These are located on the stretcher. They are used to document the provenance of the work or indicate museum venues where it has been exhibited.

Stamps – These are found on the stretcher and the lining canvas. In this case they serve the same purpose as the labels, providing information on the work's provenance or on museum venues where it has been exhibited.

2.- ANALYSIS OF PICTORIAL TECHNIQUE

El Greco, a painter accustomed to constant change since his early days as an icon painter, had no difficulty adapting his style to assimilate new techniques.

He decided to leave Crete in order to learn more about western European painting. That innate curiosity and ability to evolve led him to develop a unique language of his own when he settled in Spain.

During his Italian period, he used white or light grey grounds that lent luminosity and freshness to the general tone of his colour palette.

After moving to Spain, he used layers of primer or reddish-brown grounds with a darker tinge, one of the methods he had undoubtedly learned in Venice.

His working method consisted in layering colours mixed with a significant amount of white (white lead) or even pure white in the most brightly-lit areas, and applying tinted glazes to the figures and elements he wished to emphasise, allowing the tone of the primer or ground layer, which is visible in many areas, to create a pictorial effect.

The following sections describe our study of El Greco's pictorial technique, analysing the distribution and composition of the materials and how they evolved through the four works by the artist in our collection.

In order to understand the end result of his efforts, we must learn how he painted and the methods he used when working, and the best way to do this is by determining how and when each layer was applied to his paintings.

2.1 EVOLUTION of MATERIALS: COMPOSITION AND DISTRIBUTION

2.1.1. PRIMER LAYER

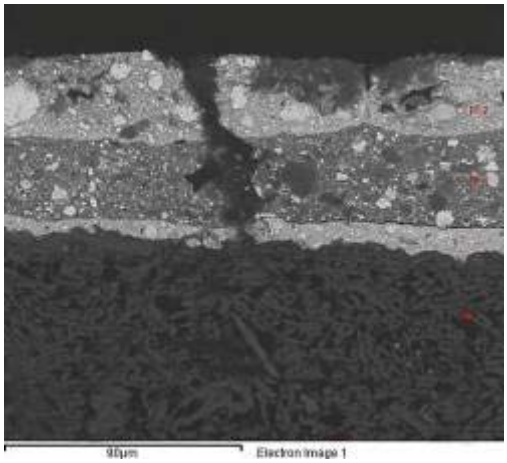
The analysis of the materials and the sequence of layers found in the works by El Greco reveal certain elements that are repeated in all four and others that appear to have changed over time. Three factors seem to have been largely responsible for these changes: the influence of the painting method used in the places where the works were made, the use of local materials, and modifications in pictorial technique as a result of the artist's natural evolution.

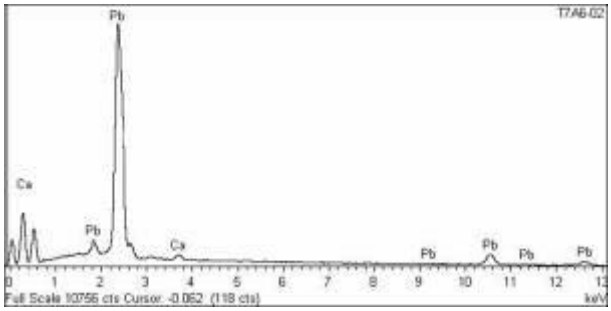
Examples of these observations are found in the materials used on the innermost paint layers and in the composition of certain pigments. In all of the works we analysed, the artist covered the panel with a ground layer of gesso mixed with animal glue, thereby achieving a flat, uniform surface on which to paint. Next, the painter applied a coat of primer, whose colour is different in each of the four paintings.

The general tone of the primer used in the first work, *The Annunciation* (ca. 1576), painted in Italy, is a very light grey. It is made of white lead mixed with granules of charcoal to give it a subtle greyish tinge and a very small amount of calcium carbonate, probably to make the primer slightly transparent. El Greco borrowed this method of preparing the canvas from Italian artists. When painters in Italy began to use oils, many preferred to apply light layers of oil under the paint, mixed with drying pigments like white lead, in order to seal the absorbent ground layer of gesso and animal glue. White primers were often attenuated with small amounts of coloured pigments like carbon black or ochre granules. Italian artists adapted this practice to the medium of oil on canvas, borrowed from the 15th-century masters of northern Europe, with the supports and materials used in this region at the time.

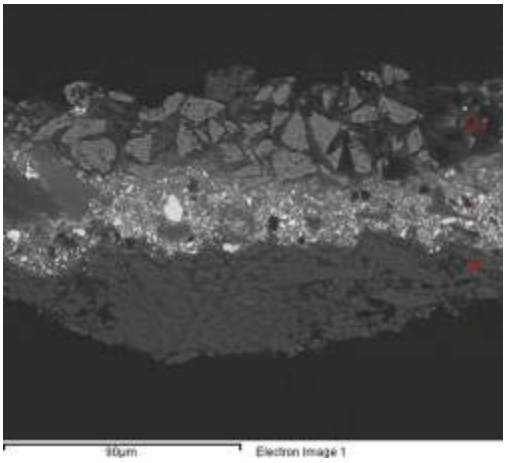
In the next three paintings analysed—*The Annunciation* (ca. 1596-1600), *Christ with the Cross* and *The Immaculate Conception*—the primers have a brown tone that becomes increasingly reddish, culminating in the deep red found in *The Immaculate Conception*. In these three works, the artist added ground residue scraped off his palette to this layer, thereby attenuating the reddish hue of the primers, which he undoubtedly used to enhance the overall effect of the finished paintings. Curiously, this undercoat contains traces of high-quality pigments such as smalt, lapis lazuli, azurite, lead-tin yellow and rose madder lake, whose presence in this layer can only be explained in the manner described above. Nevertheless, it is important to bear in mind that the heterogeneous origins of palette residue meant that the blend of pigments scraped off and used would not always have a uniform tone, which may explain why different areas of the primer coat present slightly different hues in the same painting. In all likelihood, incorporating these palette scrapings was a deliberate decision made

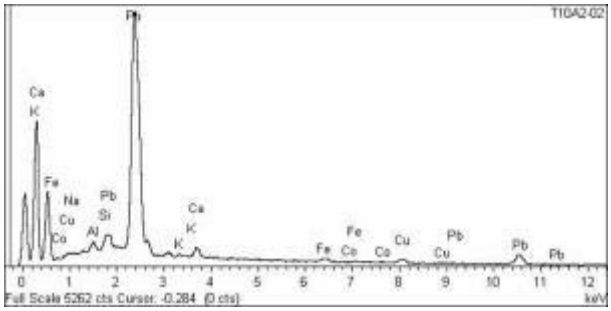
to subtly enhance the nuances in this layer, so critical for achieving the desired end result, rather than a rational determination not to waste painting materials.



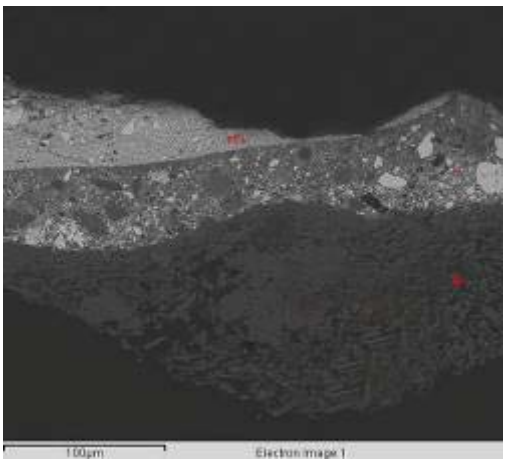


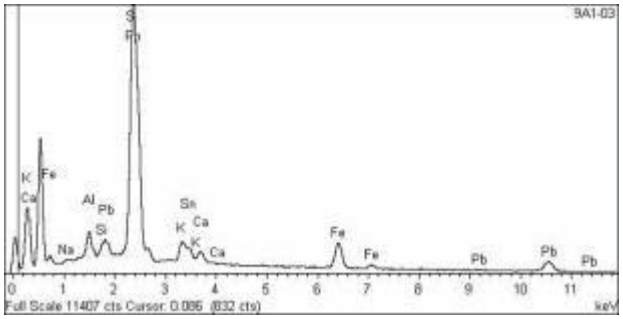
The Annunciation (ca. 1576). Cross-section seen under a scanning electron microscope [SEM] of a microsample taken from the reddish area of the floor tile (G: ground, P: primer, PT: paint layer). Right, the EDS spectrum obtained after analysing the primer layer (I) in which only white lead (Pb) and a small amount of calcium carbonate (Ca) are detected.



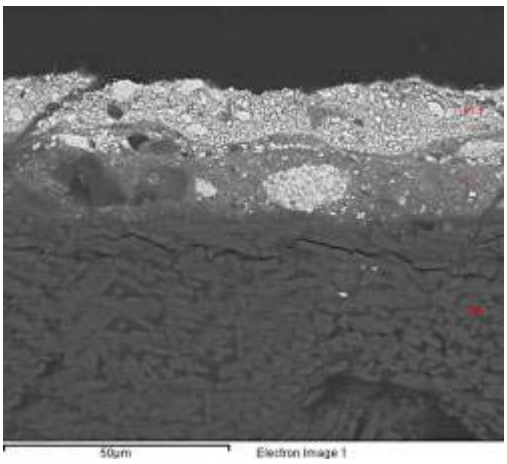


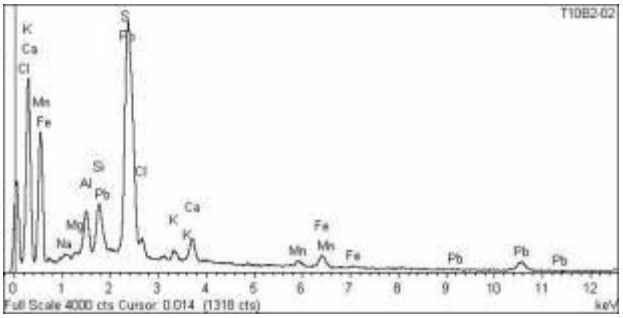
The Annunciation (ca. 1596-1600). Cross-section seen under a scanning electron microscope [SEM] of a microsample taken from the Virgin's blue mantle (G: ground, P: primer, PT: paint layer). Right, the EDS spectrum obtained after analysing the primer layer (I) in which we detect elements like cobalt (Co) and copper (CU) from the smalt and azurite added as palette residue, along with the elements Fe, Ca, K, Si, Al and Na present in ochres.





Christ with the Cross (ca. 1587-1596). Cross-section seen under a scanning electron microscope [SEM] of a microsample taken from the flesh of Christ's hand (G: ground, P: primer, PT: paint layer). Right, the EDS spectrum obtained after analysing the area around a yellow granule in the primer layer (I) in which we detect the elements Fe, Ca, K, Si, Al and Na from ochre pigments and Pb and Sn from the lead-tin yellow pigment scraped off the palette.





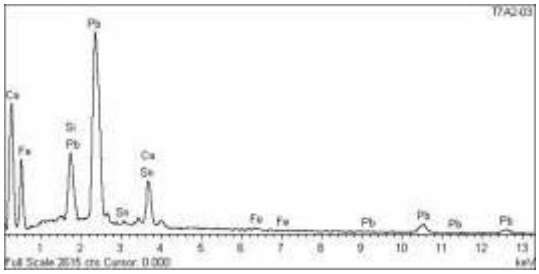
The Immaculate Conception (ca. 1608-1614). Cross-section seen under a scanning electron microscope [SEM] of a microsample taken from of the right wing of the dove (G: ground, P: primer, PT: paint layer). Right, the EDS spectrum obtained after analysing the primer layer (I) in which we detect the elements Fe, Mn, Ca, K, Si, Al and Na from ochre pigments. We also detected the presence of umber (Mn) in this work, which lends the red primer a darker tinge.

2.1.2- PAINT LAYER

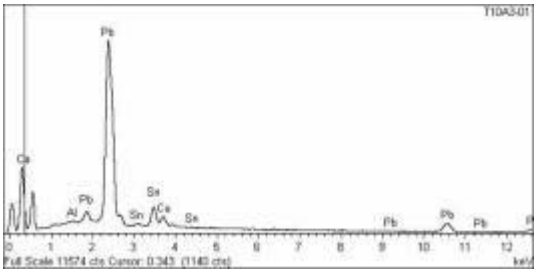
The identification of two different types of lead-tin yellow points to a significant change, which can probably be attributed to the local materials of the region where El Greco painted the work. Lead-tin yellow is a synthetic pigment that was widely used from the 14th to 18th centuries, and its two known varieties have different stoichiometric ratios and origins. Lead-tin yellow type I is a double oxide of lead and tin whose formula is Pb_2SnO_4, and lead-tin yellow type II is another type of oxide that follows the general formula $Pb(Sn,Si)O_3$. Type II can be obtained by fusing lead-tin yellow type I with silica at a temperature of 800-950ºC. Different analytical studies have proven that type I is the most commonly used variety, although type II is older and has been identified quite frequently in works from Florence, Venice and Bohemia, suggesting that it may have originated in connection with the glass industry. Chemical analyses performed on Spanish paintings suggest a greater tendency to use lead-tin yellow type I.

Scanning and transmission electron microscopy are both effective techniques for classifying these pigments. However, with the latter the compound's crystal structure can also be studied, allowing us to determine the variety of the pigment with greater accuracy.

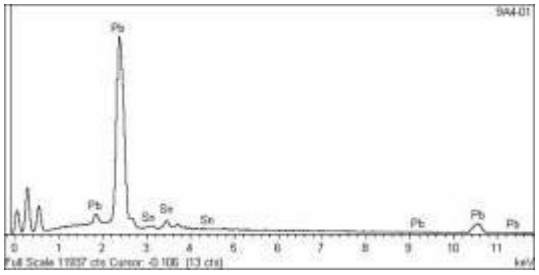
In the scanning electron microscopy (SEM-EDS) analysis performed, we detected a significant spike of silicon (Si) in the lead-tin yellow granules used in the painting *The Annunciation* (ca. 1576), which El Greco painted in Italy, suggesting the use of type II; however, silicon (Si) was not detected in the other three works made in Spain, indicating that he used lead-tin yellow type I.



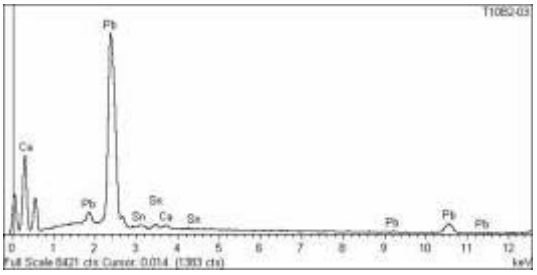
The Annunciation (ca. 1576). EDS spectrum obtained after analysing the lead-tin yellow pigment in a microsample taken from the angel's yellow tunic. Notice the significant presence of silicon (Si).



The Annunciation (ca. 1596-1600). EDS spectrum obtained after analysing the lead-tin yellow pigment in a microsample taken from the angel's garments. No silicon (Si) was detected in the composition of the lead-tin yellow pigment.



Christ with the Cross (ca. 1587-1596). EDS spectrum obtained after analysing the lead-tin yellow pigment in a microsample taken from the yellow of the halo. No silicon (Si) was detected in the composition of the lead-tin yellow pigment.



The Immaculate Conception (ca. 1608-1614). EDS spectrum obtained after analysing the lead-tin yellow pigment in a microsample taken from the angel's wing. No silicon (Si) was detected in the composition of the lead-tin yellow pigment.

2.1.3- COLOUR PALETTE PALETTE OF PIGMENTS AND BINDERS IDENTIFIED

PIGMENTS	The Annunciation (ca. 1576)	The Annunciation (ca. 1596-1600)	Christ with the Cross (1587-1596)	The Immaculate Conception (1608-1614)
WHITES AND TRANSPARENT PIGMENTS				
gesso	*	*	*	*
calcium carbonate	*	*	*	*
silicates	*	*	*	*
aluminium oxide (substrate in lake pigments)	*	*	*	*
white lead	*	*	*	*
BLUES				
smalt		**	**	
azurite		*	**	*
lapis lazuli	*	*		*
GREENS				
verdigris	*			*
copper resinate		*		
YELLOWS				
lead-tin yellow type I		*	*	*
lead-tin yellow type II	*			
yellow ochre pigments		*	*	*
ORANGES				
orange ochre pigments	*	*	*	*
minium	*	*	*	*

REDS				
vermilion	*	*	*	*
red ochre pigments	*	*	*	*
rose madder dye	*			
carmine dye		*	*	*
BROWNS				
ochre pigments (umber)			*	*
BLACKS				
charcoal	*	*	*	*
bone char			*	*
** only detected in the primer layer as bits of palette residue				
animal glue as gesso binder	*	*	*	*
linseed oil as paint binder	*	*	*	*
walnut oil in flesh layers			*	
rosin in the copper resinate layer		*		

2.2- EVOLUTION of PICTORIAL TECHNIQUE

2.2.1.- FACES



El Greco created drawings and small sculptures to serve as models and used them repeatedly in his works, as the faces of the angels and the Virgin clearly show.

His ground evolved from light to dark, and in areas where the paint was applied less heavily the ground layer shows through, lending the surface a violet hue that enhances the sensation of depth. He applied subtle white and crimson highlights to the inner corners of the eyes, which intensified the gaze and achieved the watery pictorial effect that characterises his style and makes his figures seem so lifelike.

For the flesh areas, he began to use a combination of colours and stains created with glazes beneath which the underdrawing gradually disappeared.

Over time, the faces became increasingly white and luminous, abandoning naturalism in favour of an idealised ethereal beauty.



2.2.2. – HANDS

The brushwork on the hands became increasingly loose and less defined as El Greco's style evolved.

We can see how the solid hands of his early period give way to more schematic forms, skilfully rendered with inconclusive brushstrokes.



He outlined his figures more boldly and deliberately disrupted the continuity of their silhouettes to underscore the contrast between one area and the next. To achieve this pictorial effect, he used a subtractive method. After modelling the ground layer in reddish-brown tones, he applied layer upon layer of glazes that allowed him to heighten or subdue the light in the areas he wished to emphasise.

2. 2.3- GARMENTS



The folds of the garments, rendered with glazes, convey the sensation of volume and movement that El Greco wanted to achieve. In his Italian period the fabrics hugged the bodies, but over time his treatment of the draperies became more rigid, giving the impression of stiffly starched cloth.

His brushstrokes draw our attention to the texture of the fabric, applying numerous folds in a zigzag pattern that he later simplified in the final layers.

His mastery of the colour palette allowed him to construct the details of the garments by means of angular, intricate folds. The initial compositions gradually gave way to a geometric, almost Cubist simplification, with textures that seem to vibrate in the painting.



3.-CONCLUSIONS

The four works in the Thyssen-Bornemisza Collection are oils on canvas. In the case of the oldest one, *The Annunciation* (ca. 1576), the original support is made with simple twill, in keeping with the customs of the day and the place where the work was painted, but all of the others were painted on a plain-weave fabric. The original canvas dimensions of the *Christ* and *The Annunciation* from 1596 have been altered by the addition of patches of painted canvas around the edges, and all of the works have been reinforced with a lining, added during an earlier intervention.

All four canvases were primed with a layer of gesso and animal glue, followed by another primer layer whose colour varies. In the oldest painting analysed, the primer is grey, like the one used by the Italian masters of the day, while in the Spanish works this layer is brown, mixed with an increasingly deeper reddish tone. Moreover, the three paintings produced in Spain all contain traces of palette residue in the primer, used to attenuate the reddish background, which appears to have had a notable influence on the final effect of the painting.

The analysis of the materials analysis and sequence of paint layers reveals certain characteristics that appear in all four works studied, such as the broad palette of pigments and binders made of linseed and walnut oil. However, other characteristics suggest a change or evolution over time, clearly influenced by the region where the painting was produced, the use of local materials and the artist's natural technical evolution. For example, in the Italian work we were able to confirm the use of lead-tin yellow type II, which is often found in paintings produced in Florence, Bohemia and Venice due to their connections with the glass industry. And in this painting, the red dye found in the palette residue is rose madder lake, whereas in the works produced in Spain carmine and lead-tin yellow type I are more common.

With regard to the painting method observed in the works in the collection, we may conclude that while during his Italian period El Greco created his compositions with great skill and clearly inspired by local influences, he subsequently evolved towards greater abstraction and a much more personal style, as manifested in the Spanish works.

The X-rays have revealed that he painted the faces and anatomy of the figures with swift, firm and meticulous strokes, using a fine brush and white lead pigment to draw lines so that he would not stray from the design layout while painting, and on top of this he applied layers of colour to create the definitive shapes of the figures and the architectural elements. He occasionally began by staining the background to create the desired atmosphere, leaving an empty space for the figures which he gradually filled in to achieve the end result. All the paintings studied denote an obvious freedom and precision in their execution, particularly evidenced in the hands and garments.

In general, the X-ray study reveals strokes applied with brushes with thick bristles to drag impastos of light and create sharp contrasts which he later attenuated with very thin coats of paint or glazes, especially when he wanted to simplify the final composition. The precision and clarity of these scenes and the absence of pentimenti in the four works suggest that the artist

was working from a predetermined concept. The marked contrasts we see in the X-ray image are a product of the artist's generous use of paint. The highlights are sharply defined and the midtones give way to an intense battle between light and dark colours, especially in the later works in the collection.

All of these technical and material characteristics observed in the four works analysed illustrate the transition from a distinctly academic representation of figures, deeply influenced by the Italian Renaissance, to the idealisation and stylisation of the canon. For example, whereas in the Italian period the garments are tight fitting and hug the body, in the paintings produced in Spain they are much looser and seem to float, giving the impression of stiffly starched cloth. Furthermore, infrared reflectography clearly reveals that in the Spanish period the precise preliminary drawing (based on a grid system) has disappeared, as have compositional devices such as the use of architectural and decorative elements to situate the figures spatially. The technical study of these works confirms that the artist sought to create an immediate effect through his brushstrokes rather than clearly defined forms, and demonstrates an evolution in his painting style that was greatly admired by critics and artists of the late 19th and early 20th-century movements and avant-gardes, who regarded it as a very modern approach.

4.- TECHNICAL DATA

Laboratory Equipment of Material Analysis

Optical microscope with polarized light and fluorescent ligth OLYMPUS BX51

MicroFTIR (Fourier Transform Infrared Spectroscopy) NICOLET iN10 (4000-400 nm)

Gas cromatograph- Mass spectrometry (6990N-59-73)

Scanning electron microscopy -Energy Dispersive X- Ray Spectroscopy . Jeol JSM-6390 LV

Variable pressure

XR Equipment

Yxlon Smart 160 E/0,4

XR Parameters:

The Annunciation (ca. 1576)	11´ 45 Kv 6mA 6m.
The Annunciation (ca. 1596)	10´ 45 Kv 6mA 6m.
Christ with the Cross (ca. 1587-1596)	10´ 45 Kv 6 mA 6m.
The Immaculate Conception, ca. 1608-1614	13´ 45 Kv 6 mA 6m.

Scanner:

300 x 400 mm plates scanned at 8 bits, 80 mm, actual-size resolution 318 ppi.

Scanner: Array Corporation Model 2905 Laser Film Digitizer.

Infrared Equipment

Osiris Camera

Opus instruments Ltd

Infrared Digital Camera.

16 mg pixeles

CREDITS

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Andrés Sánchez. Study of Materials Analysis

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Ana Arreaza. Management/ Administration Production Assistant

Old Master Curator Department

Mar Borobia and Mª Eugenia Alonso. Historic Study

Web Department

Ana A. Lacambra y Francisco Navarro. Web.

Collaboration

Acilia. Web Design

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