

**Analysis and documentation of *The Baptism* by
Domenicos Theotokopoulos using non-destructive
physicochemical techniques II. A first comparison with
The Adoration of the Magi from the Benaki Museum.**

Aloupi, E.¹, Paschalis, V.², Stassinopoulos, S.², Aslani, I.¹, Karydas, A.G.³, Anglos, D.⁴, Gionis, V.⁵, Chryssikos, G.⁵

¹THETIS authentics Ltd, 41, M. Moussourou str., GR 11636 Athens, Greece, aloupie@thetis.gr, aslanii@thetis.gr

²Conservation Department, Benaki Museum, 6 Hesiodou str., GR 10674 Athens, Greece, paschalis@benaki.gr, stassinopoulos@benaki.gr

³Institute of Nuclear Physics – NCSR Demokritos, P.O. 60228, GR 15310 Agia Paraskevi, Greece, karydas@inp.demokritos.gr

⁴Institute of Electronic Structure and Laser - FORTH, Vassilika Vouton, P.O. Box 1385, GR 71110 Herakleion, Crete, Greece, anglos@iesl.forth.gr

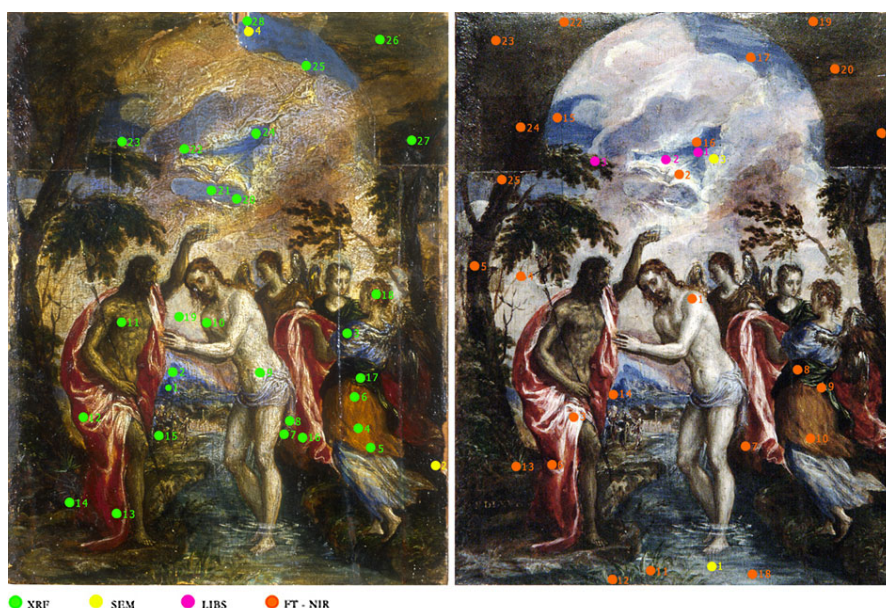
⁵Institute of Theoretical and Physical Chemistry – NHRF, 48 Vasileos Konstantinou Ave., GR 11635 Athens, Greece, vgionis@ieie.gr, gdchryss@ieie.gr

Introduction

The recent restoration of El Greco's "Baptism of Christ", carried out by the Conservation Department of the Benaki Museum¹, Athens, provided a unique opportunity to examine, analyze and document the material and technical aspects of the painting by use of non-destructive physicochemical² and micro analytical techniques³. The "Baptism of Christ", that bears a 1567 date, as established by the analysis before cleaning, was painted by El Greco soon after his arrival in Venice, where it is assumed that he joined Titian's workshop and became acquainted with the works of Tintoretto and the Venetian School⁴.

Following this, a similar analysis of El Greco's "Adoration of the Magi", most probably painted in Crete⁵, between 1565 and 1567 and also restored in the Conservation dept. of the Benaki Museum⁶, was

Figure 1a – 1b: The Baptism icon before and after conservation. The coloured spots represent the areas analysed by non destructive techniques, XRF (1a green), FT – IR (1b orange), LIBS (1b purple) and the microsampling for SEM/EDX (1a&b, yellow).



initiated. The detailed comparison of the two paintings will hopefully provide interesting insight into the way that El Greco's move to Venice affected his work.

This task is greatly aided by recent studies of the material and technical aspects of late 16th - early 17th century Venetian paintings⁷ that have brought to light specific information relating to materials and techniques of individual masters such as Titian, Tintoretto, Bellini, Lotto and others. As the analysis of the "Adoration of the Magi" is not yet complete we will present only a first comparison based on work in progress.

Description of the icons

The "Baptism of Christ" (Figure 1a and 1b), was acquired by the Municipality of Herakleion from Christies Sale 6967, on December 8th, 2004. Soon after its appearance in the market it was recognized as an unsigned work by El Greco. The icon, initially of an arched shape on top, lay on one side of the right wing of a triptych, with a similar



Figure 2: Detail from the lower left side of *The Baptism* after cleaning. IR imaging revealed the MDLXVII (1567) date and facilitated the conservator's work.

iconography to that of the Modena triptych⁸. Later, when separated from its reverse, it was embedded in a thin rectangular wooden panel (H. 23.6 cm x W. 18 cm). A detailed assessment of the icon⁹ suggests a date between 1567 and 1570, the first period of Theotokopoulos in Venice, after his move from Herakleion in 1567/mid 1568¹⁰. A detailed technical description¹¹ dealing with the present condition of the icon, overpaintings, additions, etc indicates that the setting of the icon on the thin wooden support (3-6mm) occurred in late 18th-early 19th century. During the cleaning process, the date MDLXVII (1567) was uncovered on the left lower side of the icon (Figure 2). The date is authentic since the inscription, in gold, lays under the overpainting and the original varnish. It follows the damage and the fine network of cracks of the painting.

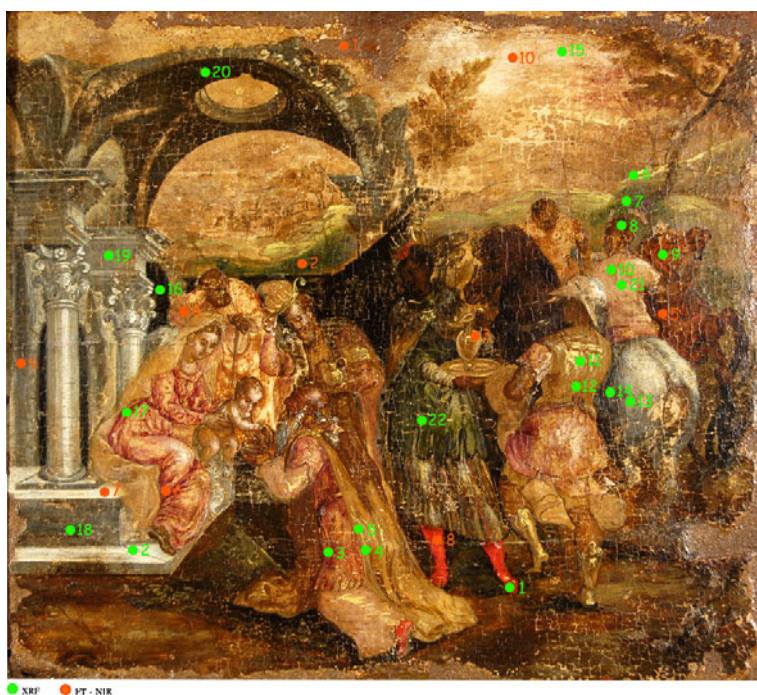


Figure 3: *The Adoration of the Magi* (MB Cat. No. 3048). The green and orange spots represent the areas analysed by XRF and FT-NIR respectively.

The “Adoration of the Magi” (Cat. No. 3048, Figure 3) is one of the two icons in the Benaki Museum Collection bearing Domenico Theotokopoulos signature (XEIP ΔΟΜΗΝΙΚΟΥ) (Figure 4); the



Figure 4: *The Adoration*, detail with El Greco's signature XEIP ΔΟΜΗΝΙΚΟΥ

second being "Saint Luke painting the Virgin". The "Adoration of the Magi", painted in Candia (Herakleion) on second hand boards initially used in the construction of a chest, dates between 1565 and 1567 and measures H: 56cm x W: 62cm. Both works in the Benaki Museum collection display similar technical features (under drawing, colour palette and handling of the brush-stroke) to the fully signed ΔΟΜΗΝΙΚΟΣ ΘΕΟΤΟΚΟΠΟΥΛΟΣ Ο ΔΕΙΞΑΣ icon of the "Dormition of Mary", discovered in 1983 in Syros. In all three early El Greco paintings, a range of Italian elements have been recognized to varying degrees¹².

Methodology: Non destructive Physicochemical Techniques



Figure 5a: Spot analysis of *The Baptism* with FT-NIR technique at NHRF.

The non-destructive techniques applied for the analysis of *the Baptism* involved the use of X-radiography (General electric Scenograph DMR, 25kV-6mA) and computer aided tomography (CAT Picker PQ2000, 120kV- 100mA and 210mA); multi-spectral (UV-Visible-IR) imaging (MUSIS HS FORTH photonics, 365-1100nm); detailed examination under a stereoscope (Olympus SZX9, Highlight 3100, CCD Sony Exwave HAD, magnification 10-150x); analysis by X-ray fluorescence spectroscopy (XRF)¹³; on 27 spots (spot area 3mm²) shown in figure 1a. (XRF: Rh anode X-ray tube, 50kV 1mA, PIN-Peltier cooled X-ray detector, anal. conditions 40kV filtered excitation, 15KV unfiltered). Following completion of the restoration, the painting was analyzed by Fourier transform near infrared spectroscopy (FT-NIR 4000-120000cm⁻¹, Vector 22N, Brucker Optics) (Figure 5a) on 28 selected spots and laser induced breakdown spectroscopy¹⁴ (LIBS, pulse laser Nd:YAG, 52nm, 15nsec, ICCD detector) on 4 spots (spot area 0,01



Figure 5b – 5c: Examination of *The Adoration* under the stereoscope, conservation dept. of the Benaki Museum; spot XRF analysis at NCSR Demokritos.

mm², 20mJ/cm²) all show in figure 1b. The application of digital holographic interferometry¹⁵ allowed a thorough structural examination of the icon with the identification of detachments, cracks and other damages underneath the surface and facilitated the conservator's work. The re-examination of the icon after the completion of restoration has provided the Conservation dept. with a strong documentary base for the future. The non destructive examination was complimented by optical microscopy, μ Raman, μ FTIR spectroscopy, high performance liquid chromatography (HPLC/DAD) on micro-samples¹⁶ obtained during the conservation process. Scanning electron microscopy combined with energy dispersive X-ray analysis (SEM/EDX, JEOL XSM-5310, Si(Li) detector) was also used on 4 selected microsamples (polished cross sections mounted in resin).

The analysis of *The Adoration*, according to the above methodology Figure 5b and 5c) is in progress. The spots analysed by XRF as shown in figure 3.



Figure 6: X-ray image of *The Baptism*. The original wooden substrate is free of tree rings; those depicted in the radiograph come from the wooden support of the late 18th-early 19th cent.

Analysis and documentation of *The Baptism* by Domenicos Theotokopoulos using non-destructive physicochemical techniques II. A first comparison with *The Adoration of the Magi* from the Benaki Museum.

Aloupi, E., Paschalis, V., Stassinopoulos, S., Aslani, I., Karydas, A.G., Anglos, D., Gionis, V., Chryssikos, G.

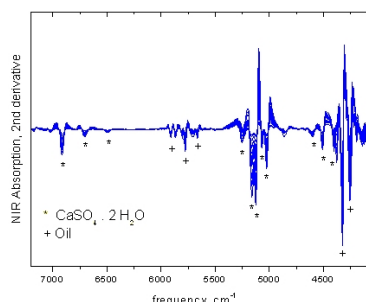


Figure 7: FT-nIR spectra from all 28 spots analysed on *The Baptism*, showing the presence of gypsum (*gesso* technique) and an oil medium.

The Baptism - Results

The X ray examination (Figure 6) shows the use of a wooden substrate which is free of tree-rings, most possibly made of hardwood with an original thickness in the order of 6-8mm¹⁷.

The analytical results are summarized in table 1 where microphotographs from the stereoscope are combined with the data obtained from the analysis of this area by XRF technique. The identification of gypsum in the ground layer (Figure 7) reveals the application of the *gesso* technique¹⁸. By using the ratio of intensities for M and L lines of lead¹⁹ (Pb) from the XRF spectra, in combination with the X-radiography, it became clear that *lead white* was used for both the *imprimatura* layer and the highlights.

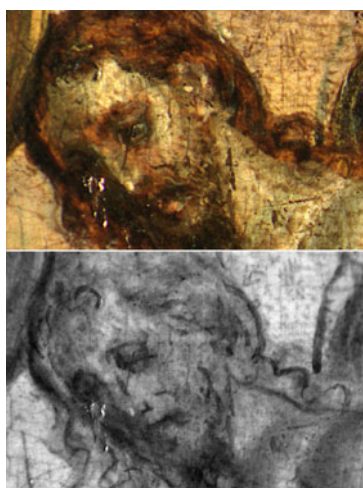


Figure 8b: *The Baptism*: detail of Christ (VIS and IR images).



Figure 8a: *The Baptism*: detail of the two angels on the right (VIS and IR images).

Analysis and documentation of *The Baptism* by Domenicos Theotokopoulos using non-destructive physicochemical techniques II. A first comparison with *The Adoration of the Magi* from the Benaki Museum.

Aloupi, E., Paschalis, V., Stassinopoulos, S., Aslani, I., Karydas, A.G., Anglos, D., Gionis, V., Chryssikos, G.

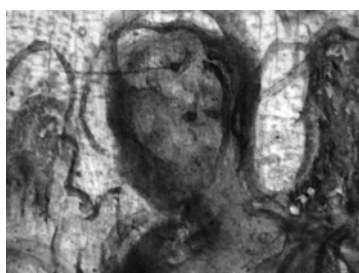


Figure 8c: *The Baptism*: detail of the left angel (IR image).

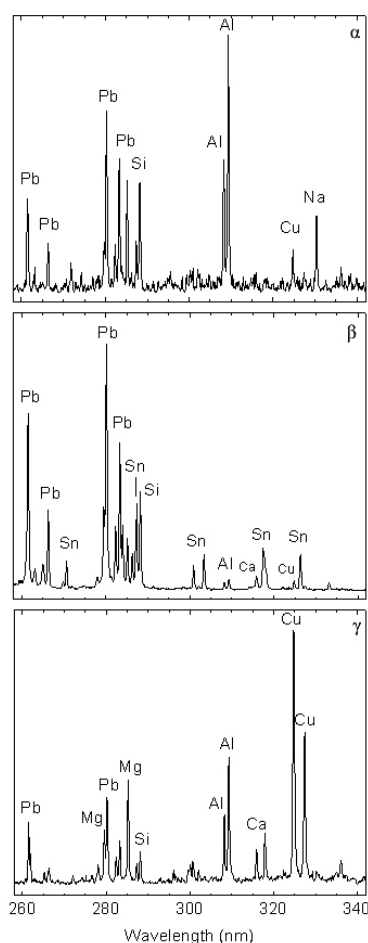


Figure 9: LIBS spectra from *The Baptism* a, lapis b, lead-tin yellow type II, c, Cu-based green (basic copper acetate in oil).

The IR imaging (Figure 8a, 8b and 8c) revealed a very detailed drawing of the figure of Christ which was made with a thin brush most probably with the use of organic *black and/or umber* (according to XRF, SEM/EDX data). On the other hand, Saint John and the Angels were not sketched with the same diligence. Detailed examination of the painting with the same technique revealed the existence of a *date* (MDLXVII) in the lower left part of the icon, hidden under the layers of subsequent overpaintings and retouchings subsequently revealed which was then uncovered during the restoration.

All FT-NIR spectra (Figure 7) are characterized by the presence of an oil substance which points to the direction of an oil medium. Slight differences in the FT-NIR spectra of the orange-yellow himation of the right angel and the observation of micro-craters under the optical microscope may also suggest the selective application of an *oil-egg emulsion*²⁰.

a. The pigments used for the blue were *lapis lazuli* identified by LIBS (Figure 9a), *smalt* a cobalt rich blue glass, identified by XRF for the light blue and probably *well crystallised azurite*²¹ for the dark blue of the sky (center of icon) and Christ's loincloth;

b. *gold paint* has been used for the details of the Christ's loincloth and the date;

b. *umber*, possibly mixed with *organic black*, for the brown and dark;

c. *arsenic sulfides* (orpiment and/or realgar) mixed with *umber and yellow ochre* for the orange himation of the right angel;

d. most probably *verdigris* (basic copper acetate) for the foliage of the trees and the green garment of the right angel which in an oil medium forms a copper glaze²² (Figure 9c);

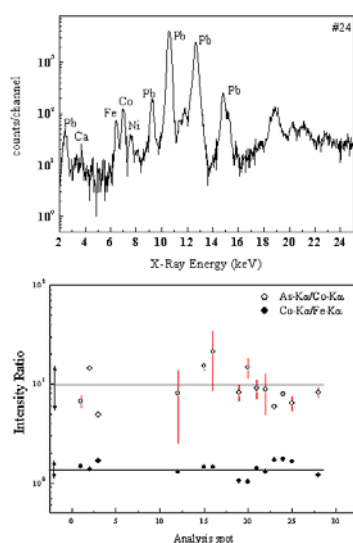


Figure 10: *The Baptism*: a. XRF spectrum from the sky (#24, 40 KV, 200s). Minor amounts of Fe, Co, As, Ni are indicative of the presence of glass used both as blue pigment and in the imprimatura; b. the Fe-Co-As correlation is clearly shown from the ratios AsKa/CoKa and CoKa/FeKa.

e. *organic red* (lake)²³ for St John's garment, the cloth offered to Christ and the red tints in the sky;

f. *cinnabar* for the miniature orange-red figure standing out on the bank of the Jordan river (between St John and Christ); *cinnabar*, most possibly in thin underlying layers, has also been used for the flesh of Christ²⁴ while the shadows are worked with *umber*;

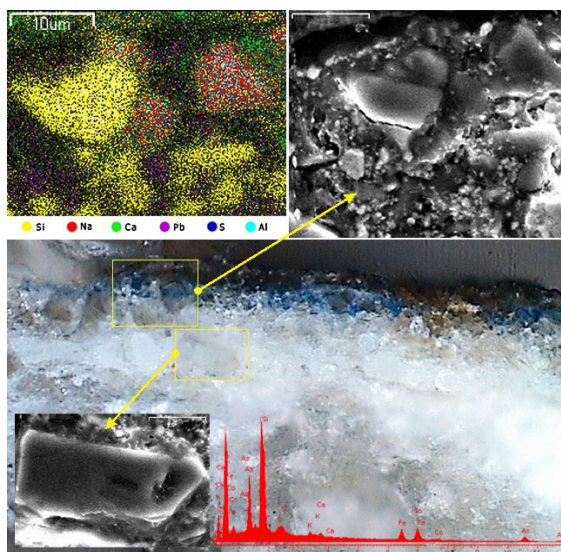
g. *lead tin yellow type II* (mixed with *lead-tin type I*) (Figure 9b) has been used selectively for the yellow leaves of the trees and the yellow highlights of the sky around the Holy Spirit;

h. *poorly crystallized azurite, ochre and gypsum* have been used for the painting of the wooden substrate (on both sides of the arch) into which the icon was laid after its separation from the original triptych;

i. *titanium oxide* and a blue that is non-identifiable with the XRF (lapis?) were used for an extended retouching on the sky in an attempt to cover cracks and craquelure, clearly visible under UV imaging; *titanium oxide* has also been used for the most recent retouching either before or on the occasion of the recent appearance of icon in the market.

An interesting feature revealed by the XRF analysis in most of the spots tested was a characteristic pattern between *Co-Fe-As* (with occasional presence of Ni) expressed as stable ratios between the elements (Figure 10). The results from SEM/EDX technique (Figure 11) verified the presence of *cobalt* glass inclusions in the preparation layer of imprimatura, which are colourless or vary in colour from grey-blue to pale grey. The tint of the glass does not present any correlation with the chemical composition and can be probably attributed to discoloration.

Figure 11: *The Baptism*: SEM and OM micrographs of a cross-section from the sky (Fig.1b, SEM4). The layer of imprimatura with colourless glass inclusions (inset SEM photo) mixed with lead white. On top, lapis and blue glass (smalt) are used for the blue (elemental mapping for Si, Ca, Pb, Na, Al, S).



Another interesting feature in the Baptism is that the proportion of glass inclusions over lead white in the layer of imprimatura varies greatly. We note the use of almost pure glass mixed with small quantity of lead white in the underlying transparent layer (Figure 12), for the depiction of the clear waters of the Jordan River and for the sky in the upper part of the icon. The atomic ratio Si/Pb which is usually 2.8-3 in the layer of imprimatura increases to 6.5-7 in these areas. *Smalt* or *blue cobalt glass* of the same composition has been used mixed with *lapis lazuli* for the blue of the sky (Figure 10).

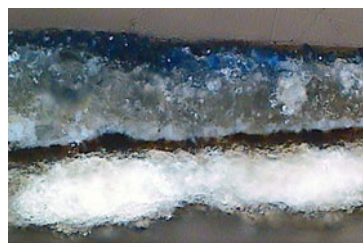


Figure 12: Cross-section from the Jordan River waters (Fig.1a, SEM1). From top to bottom: lapis and smalt are used for the blue; a transparent layer of 15µm mainly containing glass over a thin layer of lead white; a thin dark umber layer applied directly on the gypsum preparation.

The presence of *Fe*, with simultaneous detection of *Ni*, as trace element, points to the use of minerals in the series of *arsenopyrite-smaltite*, such as *cobaltite* $(Co,Fe)AsS$ and *erythrite* $[Co,Ni]_3[AsO_4]_2 \cdot 8H_2O$ for the production of *zaffer*²⁵, parent material of smalt, both found in Central Europe (Saxony and Bohemia) and in North Italy. Also, in view of the significant amount of iron²⁶ which usually results in green hues, the blue-grey colour of the glass inclusions can be attributed to the presence of FeII ions as a result of the procedure followed for the glass making technique²⁷. The materials

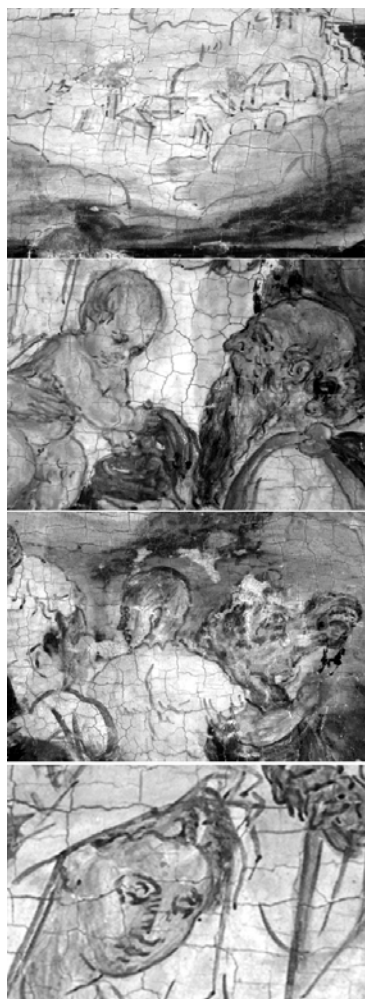


Figure 14a – 14d: Details from
The Adoration, IR images 900-
 1200nm.

detected are in agreement with those recently revealed by the re-analysis of samples of paintings by Bellini, Giorgione, Titian and Tintoretto and clearly show that Greco, soon, after his arrival in Venice, incorporated in his work the “Venetian palette” as well as materials and colorants not specifically designed for use in oil paint (i.e. glassy materials-“smalti”²⁸, lead tin type II, blue smalt).

A first comparison with ‘*The Adoration of the Magi*’

As the analysis of the “Adoration of the Magi” is not yet complete, only certain features of the painting technique and of the materials and pigments used will be discussed here. The colour palette of the icon and the results from the spot XRF analysis (figure 3) are summarised in table 1 in an attempt to achieve a direct comparison with the respective data from *the Baptism* presented above.



Figure 13: X-ray image of *The Adoration of the Magi*.

Analysis and documentation of *The Baptism* by Domenicos Theotokopoulos using non-destructive physicochemical techniques II. A first comparison with *The Adoration of the Magi* from the Benaki Museum.

Aloupi, E., Paschalis, V., Stassinopoulos, S., Aslani, I., Karydas, A.G., Anglos, D., Gionis, V., Chryssikos, G.

The technique – materials and pigments

The X-ray image of “The Adoration of the Magi” reveals structural details of the icon some of which are also visible to the eye, i.e. the use of a canvas substrate applied on a fine wooden panel constituted by two parts and the two wooden battens on the back. Well identified tree-rings and gnarls as well as some transversal nails are revealed in Figure 13. The IR imaging (Figure 14 and 15) uncovers an underdrawing made with a thin brush, more detailed and accurate in the Virgin and Christ (Figure 14b and 14d) and rather vague in the heads of the soldiers (figure 14c). On close examination of the drawing and colouring details in the two icons we note the similarities between the contours of the head of Christ in *The Baptism* and the face of Virgin in *The Adoration* (figure 8b and 14d).



Figure 15: *The Adoration*: Detail of a soldier; inserted IR image.

The abundant presence of Ca points to the probable use of gypsum that covers the whole substrate indicating the use of the *gesso* technique. This will be tested by the forthcoming FT-NIR analysis. Lead white is used as an underpainting layer (*imprimatura*?) and for the highlights, but in a different manner than that used for the Baptism. The pigments identified are ochres, umber, organic black, red lake, copper based green (most probably basic copper acetate), cinnabar and lead-tin yellow. It is remarkable to note the detection of proportionately correlated Co and As in most of the areas analysed as shown in the diagram of Figure 16. Co and As as well as the accompanying traces of Ni and Bi²⁹ are indicative of the presence of glass inclusions in the lead white layer. The Fe-Co-As correlation diagram that was used in the case of *The Baptism* was not applicable in *The Adoration* due to the abundant use of Fe rich yellow-orange ochres.

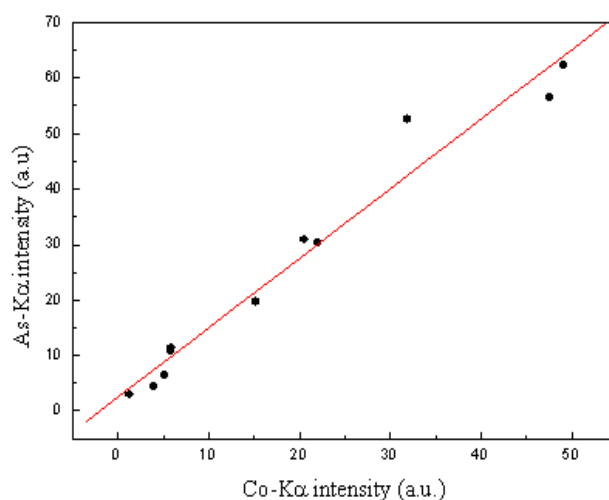


Figure 16: Diagram showing the proportional correlation of Co vs As, according to XRF data. (*The Adoration*).

From the comparison of the microphotographs obtained under the stereoscope, the IR images and the materials identified so far we can put forward a number of features that differentiate the *Adoration* from



Figure 17: Detail from *The Baptism*. A human figure that stands out from the crowd on the left bank of the Jordan River; rendered with three brushstrokes of cinnabar.

the *Baptism*. We note:

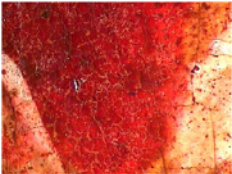





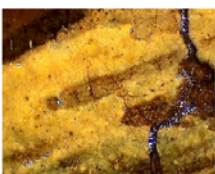

1. The absence of precious pigments like lapis, azurite, orpiment and gold in *The Adoration*.
2. The absence of blue colour for the rendering of the sky in *The Adoration*, with the simultaneous lack of all blue pigments like lapis, azurite and smalt, as opposed to the vividly blue sky of *The Baptism*.
3. The extensive use of pure cinnabar, in the case of *The Adoration* (thick layer on the boots of the Magi, thin brushstrokes for the red head-cover of the black Magus and for the reins of the right horse) as opposed with the very localised use in *The Baptism* (fine red figure that stands out from the crowd on the bank of Jordan River - Figure 17). Following a long tradition in Byzantine painting, cinnabar is also found mixed with ochre in the orange garment of the kneeling Magus, in *the Adoration*.
4. The extensive use of organic black, which when mixed with white gives a variety of shades from black and dark grey on the left part of the icon to bluish-grey on the back of the horse on the right side. Such use of organic black is common in Byzantine icons but is absent in *The Baptism*.

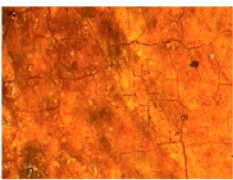

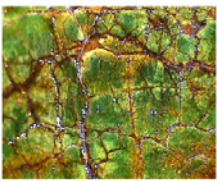
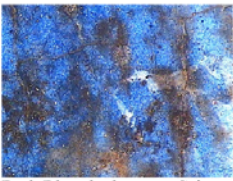
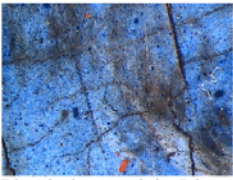
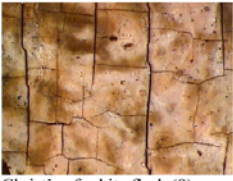
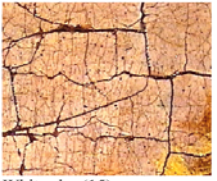
Lead-tin yellow, found in both icons was probably imported from Venice and could be easily found in Crete as shown from the recent analysis of icons belonging to the Cretan School³⁰.

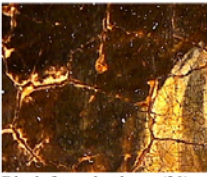
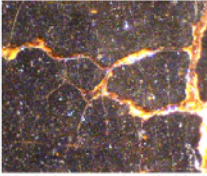


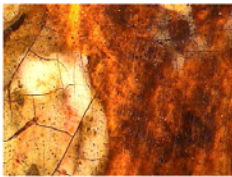


Conclusions

The article puts forward a new methodological approach for the examination of paintings based on the combined use of visual, structural and analytical non-destructive techniques.

Table 1. The colour palettes for *The Baptism* (G1) and *The Adoration of the Magi* (G2). Microphotographs from the examination under the stereoscope are combined with the data obtained by spot X-ray fluorescence spectroscopy for the characterisation of the materials used. The “detected elements” are arranged in three rows following a semi-quantitative hierarchy to major (first row), minor (second row) and trace (third row) elements. The numbers in brackets next to the area description represent the spot analysed (Figures 1a,b and 3).

Color	The baptism of Christ (G1)	The adoration of the Magi (G2)	Detected Elements Characterization	
Red – orange red			G1: Ca Pb Fe, Co, As, Sr	G2: Ca, Pb Fe, Co, As Sr
	Saint John's red garment (12)	Madonna's red chiton (17)	Major constituents based on lead and calcium. Minor amounts of iron-based pigments. possible presence of an organic material. Traces of cobalt and arsenic due to glass. -red lake, ochre, lead white, glass, gypsum.	
			G1: Ca, Pb Hg, Fe, Co, Cu, As Mn, Sr	G2: Ca, Hg Fe, Pb Cu, Sr
	Small red - orange figure in the background (15)	Magus' red boot (1)	Main constituents based on lead and calcium. Presence of mercury - based pigment. Minor amounts of iron and copper-based pigments. Trace amounts of manganese in G1. Cobalt and arsenic contained in G1. -cinnabar, lead white, glass (G1), ochre, umber (G1), gypsum.	
Yellow / Orange				G2: Pb, Ca, Fe Hg Sr
		Horse's red head (9)	Main constituents based on lead and calcium. Major amounts of iron-based pigment. Presence of mercury based pigment. - ochre, cinnabar, lead white, gypsum	
			G1: Ca, Pb Fe, Co, As, Sn Sr	G2: Pb, Ca, Cu, Sn Fe, Co, Ni, Zn, As Sr
	Yellow from the Holy Spirit (22)	Yellow from the skylight on the right (6)	Calcium present in large amounts. Major amounts of lead, tin and iron based pigments. Minor amounts of cobalt and arsenic due to glass. G1 contains zinc, nickel and copper. -lead-tin yellow, lead white, glass, ochre, gypsum	
Yellow / Orange				G2: Pb, Ca, Fe Mn, Hg Sr
		Yellow-orange cloak of the kneeling Magus (4)	Main constituents based on lead and calcium. Major amounts of iron based pigments. Minor amounts of manganese and mercury. - umber and/or ochre, cinnabar, lead white, gypsum	

			G1: As, S, Ca K, Fe Mn, Cu, Pb	
	orange himation of the right Angel (4)		Main constituent based on calcium. Major amounts of arsenic - sulphur based pigment. Minor amounts of manganese - iron based pigments. Traces of lead and copper. <i>- orpiment or realgar, umber and gypsum</i>	
Green			G1: Ca, Cu, Pb Ca, Fe Mn, Sr	G2: Pb, Ca, Cu Fe, Co, Ni, Zn, As Sr
	Green garment of the right Angel's (17)	Green from the horizon at the right (7)	Main constituents based on lead and calcium. Major amounts of copper based pigment. Minor amounts of iron based pigments. G1 contains traces of manganese. G2 contains minor amounts of cobalt, nickel, zinc and arsenic characteristic of glass inclusions <i>- copper green (malachite or verdigris), umber (G1), ochre, lead white, glass (G2), gypsum</i>	
Blue			G1: Ca, Pb K, Fe, Co, Cu, As Ni, Sr	
	Dark Blue sky between Saint John and Christ (1)		Main constituent based on lead and calcium Copper- based blue pigment. Minor amounts of iron, cobalt and arsenic signifying the presence of glass <i>- azurite and smalt, non identifiable blue (lapis), lead white, gypsum</i>	
			G1: Ca, Pb K, Fe, Co, As Ni, Sr	
	Blue sky between Saint John and Christ (2)		Main constituent based on lead and calcium Blue pigment non identifiable by XRF Minor amounts of iron, cobalt and arsenic. <i>- smalt, (lapis), lead white, gypsum,</i>	
White			G1: Pb Fe, Hg Cu, Sr	G2: Pb, Fe, Ca Fe, Co, Ni, As Sr
	Christ's off-white flesh (9)	White sky (15)	Major pigment based on lead. Minor amounts of iron. Presence of mercury in G1 and calcium in G2. G2 also containing minor amounts of cobalt, nickel, and arsenic due to glass inclusions <i>- lead white, ochre, cinnabar (G1), gypsum (G2), glass (G2)</i>	

Gray / Black				G2: Pb, Ca Fe, Co, Ni, Cu, As Sr
		Black from the dome (20)		Main constituents based on lead and calcium. Minor amounts of iron and copper based pigments. Minor amounts of cobalt, nickel and arsenic. - ochre, organic black(?), lead white, glass, gypsum
				G2: Pb, Ca Fe, Co, Ni, As Sr
Brown				Main constituents based on lead and calcium. Minor amounts of iron based pigment. Minor amounts of cobalt, nickel and arsenic. - ochre, organic black(?), lead white, glass, gypsum
				G2: Pb, Ca Fe, Co, Ni, As Sr
		Grey right column (19)		Main constituents based on lead and calcium. Minor amounts of iron based pigment. Minor amounts of cobalt, nickel and arsenic. - ochre, organic black(?), lead white, glass, gypsum
Brown			G1: Ca, Fe, Pb Mn, Hg, Cu Sr	
	Saint John's flesh (11)			Main constituents based on lead and calcium Main pigment based on iron and manganese Minor amounts of copper and mercury - umber, ochre, lead white, gypsum traces of cinnabar
			G1: Ca, Pb Fe Mn, Sr	G2: Pb, Fe, Ca Mn, Cu, Hg Sr
Gold				Principal substances based on calcium and lead. Varying amounts of iron and manganese based pigments Minor amounts of mercury and copper found in G2 - umber, ochre and cinnabar (G2), lead white, gypsum
			G1: Ca, Fe, Au Mn, Cu, Pb, Sr	Gold. Minor amounts of iron and manganese based pigment. Traces of copper and lead based pigments. Presence of organic material. - gold (powder), umber, gypsum, lead white and organic red, non identifiable blue(lapis)

Analysis and documentation of *The Baptism* by Domenicos Theotokopoulos using non-destructive physicochemical techniques II. A first comparison with *The Adoration of the Magi* from the Benaki Museum.

Aloupi, E., Paschalis, V., Stassinopoulos, S., Aslani, I., Karydas, A.G., Anglos, D., Gionis, V., Chrysikos, G.

The comparison of the two icons suggests that though the early El Greco works in Crete manifest an Italian influence³¹, the techniques and materials used lie firmly in the Byzantine tradition.

The recent discovery³² of glass inclusions in the works of Venetian Renaissance painters (also found in *The Baptism*) indicates a cross-fertilization of painters' colors by materials used by other artisans. Pigment manufacturers, and color sellers, or *vendecolori*³³, served a multitude of trades including painters, glassmakers, potters and textile dyers. The presence of a characteristic Co-As correlation in the lead white of *The Adoration* also suggests the presence of "Venetian" glass inclusions. If the presence of glass is directly confirmed by the forthcoming SEM-EDX microsample analysis we may draw some interesting conclusions about the extent of this practice and the trade of painting materials across the Venetian realm.

Future work involving the analysis of *St Luke* icon from the Benaki Museum and *the Dormition of Mary* in Syros, in comparison with other Cretan icons will complete our understanding of the early El Greco period.

Acknowledgments

The "Adoration of the Magi" icon was analyzed in the framework of the research project "Development of in-built/incorporated elemental tagging techniques in cultural materials, funded by GSRT and EU (PEP ATT_29/ 2006-2008). Partners: NCSR Demokritos, Benaki Museum, Thetis Authentics Ltd.

- ¹ S. STASSINOPOULOS, (2005), The Baptism of Christ by Domenikos Theotokopoulos : description-condition-conservation (in greek), *Μουσείο Μπενάκη* 5, pp: 71-85.
- ² E ALOUPI – V. PASCHALIS – S. STASSINOPOULOS – V. TORNARI – A. ANGLOS – A.G. KARYDAS – V. GIONIS – G. CRYSSIKOS, (2005), Analysis and documentation of the *Baptism* by Domenikos Theotokopoulos using non-destructive physicochemical techniques (in greek), *Μουσείο Μπενάκη* 5, pp:87-114.
- ³ SISTER DANIILIA – K. ANDRIKOPOULOS– S. SOTIROPOULOU – I. KARAPANAGIOTIS, (2005), Analytical investigation of the painting techniques used in Domenikos Theotokopoulos' *Baptism of Christ* (in greek), *Μουσείο Μπενάκη* 5, pp: 115-134.
- ⁴ M. VASSILAKI–R. CORMACK, (2005), The recent acquisition of the Municipality of Herakleion: Domenikos Theotokopoulos' *The Baptism of Christ* (in greek), *Μουσείο Μπενάκη* 5, pp:55-70.
- ⁵ M. CONSTANDOUDAKI – KITROMILIDES, (1995), Italian influences in El Greco's early work, in N. HADJINICOLAOU (ed.), *Proceedings of the International Symposium –Iraklion, Crete 1-5 September 1990*, Municipality of Iraklion, pp: 97-118.
- ⁶ The "Adoration of the Magi" icon was restored in 1987, at the Icons Conservation Laboratory of the Benaki Museum.
- ⁷ B.H. BERRIE – L.C. MATTHEW, (2005), Material innovation and artistic invention: new materials and new colors in Renaissance Venetian paintings, in: *Scientific Examination of Art: Modern Techniques in Conservation and Analysis*, Proceedings of the National Academy of Science PNAS, pp: 12-26.
- ⁸ It has been argued (VASSILAKI-CORMACK, see n.4) that *The Baptism* icon formed one side of the right wing of a triptych that displayed on its left wing the "Adoration of the Shepherds" presently in the Agnes Etherington Arts Center collection, Queens University, Canada.
- ⁹ VASSILAKI – CORMACK, see n. 4
- ¹⁰ M. CONSTADOUDAKI, (1975), Dominicos Théotokopoulos (El Greco) de Candie à Venise. Documents inédits (1566-1568), *Thesaurismata* 12, pp: 292-308; N. PANAYOTAKIS, (1995), Un nuovo documento del periodo cretese di Dominikos Theotokopoulos, in N. HADJINICOLAOU (ed.), *Proceedings of the International Symposium –Iraklion, Crete 1-5 September 1990*, Municipality of Iraklion, pp: 133-140.
- ¹¹ STASSINOPOULOS, see n. 1
- ¹² CONSTANDOUDAKI – KITROMILIDES, see n. 5
- ¹³ A.G. KARYDAS - X. BRECOULAKI - TH. PANTAZIS - E. ALOUPI - V. ARGYROPOULOS - D. KOTZAMANI - R. BERNARD - CH. ZARKADAS - TH PARADELLIS, (2005), Importance of in-situ EDXRF measurements in the preservation and conservation of Material Culture, στο: *X-Rays for Archaeology*, Edited by M. Uda, G. Demortier and I. Nakai, Springer, pp:27-53; J. L. FERRERO - C. ROLDÁN - D. JUANES - E. ROLLANO - C. MORERA, (2002), Analysis of pigments from Spanish works of art using a portable EDXRF spectrometer, *X-Ray Spectrometry* 31, pp: 441-447.
- ¹⁴ E. TOGNONI - V. PALLESCHI - M. CORSI - G. CRISTOFORETTI, (2002), Quantitative micro-analysis by laser-induced breakdown spectroscopy: a review of the experimental approaches, *Spectrochimica Acta B* 57, p.1115; D. ANGLOS - S. COURIS - C. FOTAKIS, (1997), Laser Diagnostics of Painted Artworks: Laser Induced Breakdown Spectroscopy of Pigments" *Appl. Spectrosc.* 5, p.1025; D.

ANGLOS, (2001), Laser-Induced Breakdown Spectroscopy in Art and Archaeology, *Appl. Spectrosc.* 55, p. 186; I. BORGIA - L. M. F. BURGIO - M. CORSI - R. FANTONI - V. PALLESCHI - A. SALVETTI - M. C. SCUARCIALUPI - E. TOGNONI, (2000), Self-calibrated quantitative elemental analysis by laser-induced plasma spectroscopy: application to pigment analysis *J. Cult. Heritage* 1 S281; L. BURGIO - K. MELESSANAKI - M. DOULGERIDIS - R.J.H.CLARK - D. ANGLOS, (2001), Pigment identification in paintings employing Laser Induced Breakdown Spectroscopy (LIBS) and Raman microscopy, *Spectrochim Acta* B56, p. 905.

¹⁵ ALOUPI –ET AL., (see n.2).

¹⁶ SISTER DANIILIA - ET AL. (see n. 3).

¹⁷ This is assumed by the current thickness of the work which is 2,5-3 mm.

¹⁸ the use of animal glue for the gesso technique was identified by μ -FTIR (SISTER DANIILIA - ET AL., see n. 3).

¹⁹ ALOUPI –ET AL., (see n.2).

²⁰ A. MASSING, (1988), The examination and restoration of El Greco's El Espolio. The first ten years, in IAN MCCLURE (ed.) *The examination and conservation of paintings 1977 to 1987, The Bulletin of the Hamilton Kerr Institute* 1, pp: 76-81. Cambridge: The Hamilton Kerr Institute of the Fitzwilliam Museum. University of Cambridge; S. PAULI, Two Paintings by El Greco: Saint Martin and the Beggar. Analysis and Comparison (forthcoming publication, Conservation Department Papers, National Gallery of Art).

²¹ The use of azurite is usually related with greenish-blue hues on the originally blue areas of a painting, which is not the case for *the Baptism*. On the other hand, well-crystalised azurite turns to dark blue in an oil medium. This is a plausible explanation for the presence of a dark blue Cu-based pigment in *the Baptism*; R.J. GETTENS - E.W. FITZHUGH, (1993), Azurite and Blue Verditer, in: *Artist's Pigments. A handbook of their history and characteristics* 2, ASHOK ROY (ed.), p.25.

²² For a detailed discussion on the use of verdigris in an oil medium vs copper resinate see M.VAN EIKEMA HOMMES,(2004), *Changing Pictures, Discoloration in 15th-17th Century Oil Paintings*, Archetype Publications Ltd. London ISBN: 1-873132-39-5.

²³ Identified as cochineal lake on the red garment of the right angel by HPLC/DAD technique (SISTER DANIILIA - ET AL., see n. 3).

²⁴ Following a technique similar to the one suggested by BERRIE - MATTHEW (see n.6). for the depiction of the flesh in Lotto's "St Catherine", based on the analysis of micro-samples under the SEM/EDX.

²⁵ B. MUHLETHALER - J. THISSEN, (1993), Smalt, in: *Artist's Pigments. A handbook of their history and characteristics* 2, ASHOK ROY (ed.), pp:113-130; J. HARTWIG, (2001), Production and use of Safr or Zaffera (cobalt) and Smalte by glassmakers from 16th to 18th century, *Verre* (Versailles, France) 7(14), pp:40-48.

²⁶ S. DAVISON, (2003), *Conservation and Restoration of Glass*, pp:76-77;

²⁷ SEM/EDX data showed the absence of Mn from the analysis of glass inclusions that might have played a role of a decolorant; Analytical comparison of Roman and Byzantine glass artifacts from Torcello present similar glass compositions: J. MASSA-AMMERMAN- J.A. HUNT, (2001), Archaeological exploration with the electron microprobe: the early history of glassmaking in the Venetian lagoon, *American Laboratory* April 01, pp: 52-55; see also above n.2

²⁸ According to BERRIE- MATTHEW (see n. 7) although the term "smalt" is used today to describe only blue glass pigment, reading the contemporary documents

shows that artists of the sixteenth century used the term “smalti” to describe numerous other colored glasses, including yellow, white, green at least some of which may have been used by painters.

²⁹ Bismouth has been found in late-fifteen and early –sixteenth Venetian enamels and in fifteenth century cobalt blue enamels and smalt in south German painting (BERRIE- MATTHEW, above n.7); nickel is also characteristic for the origin of zaffera (HARTWING, n.25)

³⁰ K. MILANOU, E. VRANOPOULOU, A. KALLIGAS, C. VOURVOPOULOU Study of icons signed by Cretan 15th cent. Painter “Angelos”, (work in progress) at the Conservation dept. of the Benaki Museum.

³¹ CONSTANDOUDAKI – KITROMILIDES, see n. 5.

³² BERRIE- MATTHEW, see n.7

³³ L.C. MATTHEW, (2002), Vendecolori a Venezia: the reconstruction of a profession, *The Burlington Magazine* CXLIV 1196, pp:680-686.