UNIVERSITY OF CALIFORNIA

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Piecing together the history of an 18th-century printed Armenian Prayer Scroll: The Study of Cultural Context and Manufacturing Techniques

A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Conservation of Archaeological and Ethnographic Materials

by

Colette Badmagharian

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ABSTRACT OF THESIS

Piecing together the history of an 18^{th} century printed Armenian Prayer Scroll: The Study of Cultural Context and Manufacturing Techniques

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Masters of Arts in Conservation of Archaeological and Ethnographic Materials

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Professor Ioanna Kakoulli, Chair

The use of prayer scrolls along with other religious art and literature has played a significant role in Armenian culture over several centuries. However, relatively little is known about the materials and techniques used to construct medieval illuminated religious Armenian texts and the risks involved for their preservation. To bridge this gap in our knowledge, a privately owned and heavily used eighteenth century Armenian prayer scroll has been investigated using a holistic and integrated approach combining humanistic and scientific research. Part of the text along with the miniatures has been interpreted and studied, and a technical investigation applying non-invasive and non-destructive techniques including analytical photography, fiber optic reflectance spectroscopy (FORS), X-ray fluorescence (XRF) and Raman spectromicroscopy (μRS) was employed for the characterization of pigments, colorants, ink, and the paper used to construct the prayer scroll. This study provides an overall understanding of the constituent materials, printing technique, religious significance, use, as well as the traditional practices in Armenian culture in the eighteenth century. Furthermore, the identification of the colorants/pigments and inks, manufacturing process and an in depth investigation of condition of this prayer scroll, helps inform preventive conservation measures ensuring the preservation of this important document.

This thesis of Colette Badmagharian is approved.

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Chapter 1 Introduction

This research examines an eighteenth century printed Armenian prayer scroll. Armenians would keep religious scrolls as amulets. Religious scrolls contained prayers, magical formulas, stories of healing and miracles from Gospels, prayers against sickness and protection against spells.

Figure 1. Detailed image in diffuse light of the 18th-century Armenian prayer scroll in this study showing wear and tear.

Figure 2. Detailed image in diffuse light of the 18th-century Armenian prayer scroll in this study showing an illustration representing *Crucifixion of Jesus Christ*.

A privately owned scroll was lent to the UCLA/Getty Conservation of Archaeological and Ethnographic Materials (CAEM) Interdepartmental Degree Program (IDP) in fragmentary and poor state of condition (Figure 1). Once unraveled and placed together, the scroll was deemed to be over 20-foot-long and about 4 inches wide. The printed scroll includes twenty-five pigmented miniatures[1], along with prayers and Gospel passages (Figure 2, Figure 3).

Figure 3. Detailed image in diffuse light of the 18th-century Armenian prayer scroll showing an illustration of the Twelve Apostles.

Manuscripts have long been a form of written documentation for various cultures and civilizations. Illuminated manuscripts act as a significant form of expression through visual media in Armenian culture. Armenian texts appear in the early fifth century with the invention of the Armenian alphabet by St. Mashtots which initially comprised of 30 consonants and 6 vowels (Sanjian 1996). In the twelfth century, two additional letters were later introduced. The invention of the alphabet allowed the Armenian people the opportunity to translate and author various texts. Today the total number of surviving Armenian manuscripts is estimated at approximately 31,000, but because many are still privately owned, this estimate cannot be fully confirmed (Mathews, Taylor et al. 1994).

1.1. Scope and significance

This research paper submitted in partial fulfillment of the requirements for the degree of Master of Arts at the UCLA/Getty Conservation of

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[1] Miniature: An independent illustration as opposed to a scene incorporated into another element of the decorative scheme such as a border or initial Brown, M. P. (1994). Understanding Illuminated Manuscripts: A Guide to Technical Terms. Los Angeles, Getty Publications.

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Archaeological and Ethnographic Materials (CAEM) Interdepartmental Degree Program (IDP), investigates the history, use and technology of production of an eighteenth century Armenian prayer scroll. The research is based on a holistic and integrated approach that includes a thorough investigation of the history, function and significance of the prayer scroll within its religious context along with a systematic non-invasive and non-destructive analysis for the characterization of constituent materials. The scientific study employs a multi-scale and multi-analytical approach from the macroscopic to the microscopic level for the identification of colorants/pigments, inks, paper and printing technique. It also investigates the risks associated with its preservation and implements preventative conservation measures to ensure the long-term sustainability of the fragmented prayer scroll.

1.2. Outline of research

This M.A research focuses on the application of non-invasive and non-destructive analytical techniques to identify materials used to paint an eighteenth century printed Armenian prayer scroll. An understanding of the function, use and significance of the scrolls is coupled with material analysis to gain a holistic understanding of prayer scrolls. The following chapter (Chapter 2) provides a review of historic literature and research conducted on comparable illustrated manuscripts. Chapter 3 divides components such as: its use in history, the place of print, paper production, the text and miniatures, the intended owner and colophon and further discusses how these components reveal significant information about the printed scroll. Chapter 4 designates the analytical techniques used to identify the colorants/pigments, inks, and paper used on the scroll. Chapter 5 presents the results and discusses the findings. Chapter 6 illustrates the risks and details the preventative conservation measures performed. Lastly, Chapter 7 concludes with examination drawbacks, further ideas and future research.

Chapter 2 Armenian Scrolls, their function, materials and technology: Review of the literature

Illustrated manuscripts including rolls, codices, and scrolls are among the most cherished and respected forms of artworks. Ancient and medieval period illuminators and illustrators gained admiration not only through the use of brilliant color palettes but through beautifully depicted images and written text with the use of various calligraphic styles.

Today most of the surviving illustrated manuscripts are of religious nature (Mathews 1994). Manuscripts were written on papyrus, vellum or parchment and since the beginning of the late Middle Ages in Western Europe were written principally on paper. Before the advent of printing, two main types of inks were traditionally used for writing: lampblack (carbon black) or iron gall. As colorants in miniature paintings, they used natural or synthetic inorganic materials and/or organic compounds mainly of plant and animal origin (Table 1).

Pigments by Hue	Material	Manuscript	Collection	Origin/Date	Reference
Black	Carbon Black	Gospels of Queen Mlk'ē	San Lazzaro 1144/86	Armenia / 908-921	(Mathews, Taylor et al. 1994)
	Iron Gall	Armenian Prayer Scroll	UCLA/ YRL Special Collection	1608	(St. John 2013)
Brown	Organic brown	Trebizond Gospels	San Lazzaro 1400/108 &1925	Armenia / mid-11th century	(Mathews, Taylor et al. 1994)
	Iron Oxide	Gospels of Karapet of Urfa	San Lazzaro 888/159	Cilician-Urfa/ca.1200	(Mathews, Taylor et al. 1994)
Green	Organic Green	Gospels of King Gagik-Abas	St James 2556	Armenia /ca. 1050	(Mathews, Taylor et al. 1994)
		Shukhr Khandara Gospels	St. James 1924	Melitene Group/ 1064-66	
		Gospels fragment	Morgan M.789	Eastern Armenia/1296	
	Madder/alizarin	Adrianople Gospels	San Lazzaro 887/116	Armenia/1007	(Mathews, Taylor et al. 1994)
		Trebizond Gospels	1400/108 &1925	Armenia/ mid-11th century	
		Gladzor	UCLA	Eastern Armenia/ ca.	

Red		Gospels	Armenian MS1	1305	
		Gospels of T'oros the Priest	Walters 539	Cilician-Hromklay2/1261	(Mathews, Taylor et al. 1994)
	Vermillion	Gospels of Queen Mlk'ē	San Lazzaro 1144/86	Armenia/ 908-921	(Mathews, Taylor et al. 1994)
		Trebizond Gospels	San Lazzaro 1400/108 &1925	Armenia/ mid-11th century	(Mathews, Taylor et al. 1994)
		Gospels of Karapet of Urfa	San Lazzaro 888/159	Cilician-Urfa/ca.1200	(Mathews, Taylor et al. 1994)
		Gospels of King Gagik-Abas	St James 2556	Armenia/ca. 1050	(Mathews, Taylor et al. 1994)
		Shukhr Khandara Gospels	St. James 1924	Melitene Group/ 1064-66	(Mathews, Taylor et al. 1994)
		Gladzor Gospels	UCLA Armenian MS1	Eastern Armenia/ ca. 1305	(Mathews, Taylor et al. 1994)
		Armenian Prayer Scroll	UCLA/ YRL Special Collection	1608	(St. John 2013)
	Red lead	Armenian Prayer Scroll	UCLA/ YRL Special Collection	1608	(St. John 2013)
Yellow	Gamboge	Gospels of Karapet of Urfa	San Lazzaro 888/159	Cilician-Urfa/ca.1200	(Mathews, Taylor et al. 1994)
		Gladzor Gospels	UCLA Armenian MS1	Eastern Armenia/ ca. 1305	(Mathews, Taylor et al. 1994)
	Saffron	Gospels of Queen Mlk'ē	San Lazzaro 1144/86	Armenia/908-921	(Mathews, Taylor et al. 1994)
		Gospels of the Priests	Walters 537	Armenia/966	(Mathews, Taylor et al. 1994)
		Gospels of T'oros the Priest	Walters 539	Cilician-Hromklay/1261	(Mathews, Taylor et al. 1994)
		Gospels of Hohannes	Freer 44.17	Cilician-Hromklay/1253	(Mathews, Taylor et al. 1994)
	Orpiment	Trebizond Gospels	San Lazzaro 1400/108 &1925	Armenia/ mid-11th century	(Mathews, Taylor et al. 1994)
		Gospels of T'oros the Priest	Walters 539	Cilician-Hromklay/1261	(Mathews, Taylor et al. 1994)
		Gladzor Gospels	UCLA Armenian MS1	Eastern Armenia/ ca. 1305	(Mathews, Taylor et al. 1994)
		John Incipit Leaf	Metropolitan Museum of Art 38.171.2	Eastern Armenia/1300-1310	(Mathews, Taylor et al. 1994)
		Armenian Prayer Scroll	UCLA/ YRL Special	1608	(St. John 2013)

			Collection		
	Yellow Ochre	Gospels of Queen Mlk'ē	San Lazzaro 1144/86	Armenia/ 908-921	(Mathews, Taylor et al. 1994)
		Adrianople Gospels	San Lazzaro 887/116	Armenia/1007	(Mathews, Taylor et al. 1994)
	Massicot	Gladzor Gospels	UCLA Armenian MS1	Eastern Armenia/ ca. 1305	(Mathews, Taylor et al. 1994)

Table 1 Historic list of colorants (organic and inorganic) and inks used in Armenian manuscripts.

Manufacture of Armenian scrolls is attested from the sixteenth century. Prayer scrolls in particular, are regarded as magical amulets with prophylactic powers (Bausi, Borbone et al. 2015). During the seventeenth century there was a transition from manuscript copying to print (Bausi, Borbone et al. 2015). Prayer scrolls, or *hmayils* in Armenian, were either hand-written or printed in one column on paper and generally measured approximately 6 to 10 cm in width and at times reached more than 20 m in length. Scrolls contained written/printed prayers, which were generally hand-illustrated with miniature paintings. These scrolls were made to be highly portable and easy to carry when rolled. They were often hung in rooms for the protection and wellbeing of sick family members (Bausi, Borbone et al. 2015). Scrolls were elaborately illuminated[2] with miniature paintings using various pigments or modestly painted using only a few pigments. Illuminated miniatures consisted of imagery referenced in the written text above or below them.

[2] Definition of Illumination: The embellishment of a manuscript with luminous colors especially gold and silver ibid.

The prayer scrolls considered in this study may be compared to three scrolls that date to the seventeenth century. The first is housed at the Young Research Library Special Collections at the University of California, Los Angeles (UCLA), the second is located in the Special Collections at The Hunterian Museum at Glasgow University, and lastly the third is from the Near East section of the African and Middle Eastern Division from The Library of Congress.

The scroll fragments housed at UCLA combine to a staggering 7-meter-long hand written scroll in black/brown ink on sheets of white chain and laid paper (St. John 2013). Each gospel/prayer is distinguished with a stylized drop cap[3] as a multi-colored (green, yellow, and purple) crane. The scroll consists of ten miniatures generally between 9 cm to 14 cm in length with a standard width of 7 cm (Figure 4).

Figure 4. Detailed image of hand written Armenian prayer scroll from the Young Research Library Special Collections at the University of California, Los Angeles (UCLA).

[3] Drop cap: An enlarged capital letter at the start of the paragraph that drops down a specific number of lines into it. Drop caps can be highly decorated and colored or simply an enlarged letter of font a text is set in. Ambrose, G. and P. Harris (2010). The Visual Dictionary of Typography. Worthing, United Kingdom, AVA Publishing.

The images depicted in the scroll have scenes from the Holy Scripture such as Christ, the Crucifixion, the Cross, and the Twelve Apostles. The colorants used for the miniatures were analyzed (St. John 2013) using a portable X-ray fluorescence (pXRF) spectroscopy by Dr. David A. Scott, a UCLA professor in the Art History Department and Conservation of Archaeological and Ethnographic Materials IDP. The results suggested two types of yellow coloring compounds. The first used to paint the background revealed a presence of arsenic (As) and was interpreted as orpiment (an arsenic sulfide pigment, As_2S_3). The second found in the halos behind the heads of holy figures showed a high concentration of lead (Pb), sulfur (S), calcium (Ca), tin (Sn), iron (Fe), and zinc (Zn). The green colorants contained As, Fe, copper (Cu) and Zn. The spectra also revealed photon emission energies characteristic of As. These elements may correspond to the use of orpiment (similar to the yellow colorant found in the background paint) mixed with another color (blue) to obtain the green hue. Lastly, the red colorants showed photon emission energies characteristic of mercury (Hg), As and Pb. The presence of Hg is indicative of vermillion (HgS-mercury sulfide pigment) which is a common pigment in manuscript illumination (Bersani, Lottici et al. 2006). Analysis of the dark brown ink revealed the presence of Fe, suggesting the use of iron gall ink. The paper was also

Figure 5. Detailed image of hand written Armenian showing prayer for travelers from the Speical Collections at the Hunterian Museum at Glasgow University

analyzed and results detected traces of As. Conservators believe that the presence of As could be due to an arsenic coating applied to the paper as a pest repellant (St. John 2013).

The second scroll from the Hunterian Museum dates to 1661 and consists of prayers, biblical texts and magical formulae which was intended to act as an amulet to protect its owner from all ills and dangers (Weston 2001) (Figure 5, Figure 6).

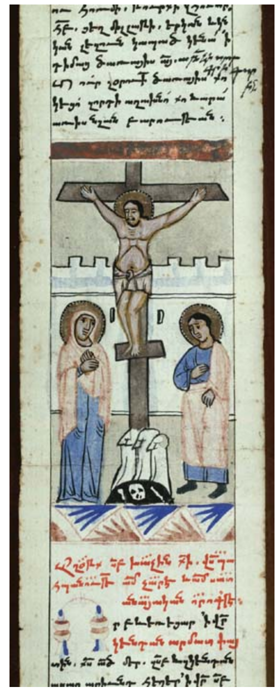

Figure 6. Detailed image of hand written Armenian prayer scroll from the Special Collections at The Hunterian Museum at Glasgow University representing *Crucifixion of Jesus Christ*

Similar to most prayer scrolls (*hmayils*), this manuscript is illuminated with portraits of saints and scenes from the life of Christ. The manuscript is hand-written in black/brown ink and is approximately 492 cm in length x 8 cm in width. The scroll is comprised of twelve pieces of paper joined together to form one long scroll (Weston 2001). Much like many other Armenian prayer scrolls, the dates can be found in the colophon[4] at the end of the scroll. The colophon contains the first words of the Lord's Prayer along with a date which reads "July, Armenian Era 1110", the equivalent of 1661 A.D.

The scroll most comparable to the one being studied is the third and final scroll that is housed in The Library of Congress (Figure 7). The colophon reveals that the printed scroll was manufactured in 1725 in Constantinople.

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[4] Colophon: An inscription recording information relating to the circumstances of the production of a manuscript or printed book. They are generally located at the end of a book and include the date, place, and people involved in the production Brown, M. P. (1994). Understanding Illuminated Manuscripts: A Guide to Technical Terms. Los Angeles, Getty Publications.

Figure 7. Detailed image of printed Armenian prayer scroll from the Near East section of the African and Middle Eastern Division of The Library of Congress.

The scroll contains the same text and miniatures as the one in this study, with the exception of the colophon. The coloring materials used on the Library of Congress scroll are visually similar with the exception of the addition of blue (Figure 8 and Figure 9). The application of the colorants/pigments are also comparable appearing as dilute washes with no shading. The scroll housed in the Library of Congress is approximately 8 meters in length by 10 cm in width and was printed on western paper. The scroll has undergone extensive conservation treatment and was thus safely re-rolled (Figure 10).

Figure 8. (Left) Detailed image of printed Armenian prayer from the Near East section of the African and Middle Eastern Division of The Library of Congress.

Figure 9. (Right) Detailed image of 18th-century printed Armenian Scroll from this study.

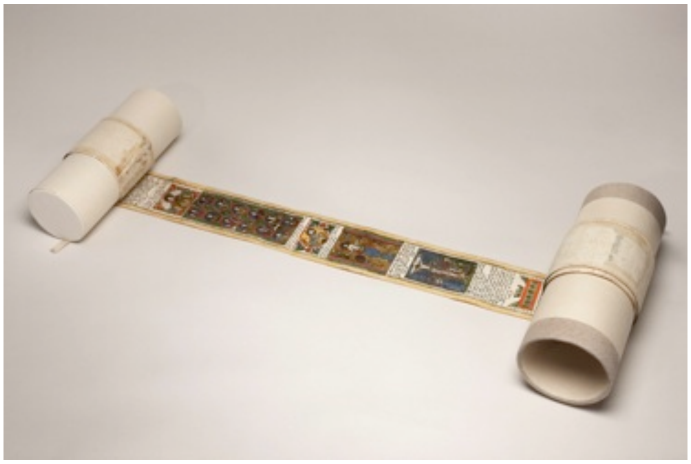

Figure 10. Printed Armenian prayer scroll from the Near East section of the African and Middle Eastern Division of The Library of Congress; After conservation treatment.

Although the prayer scrolls from UCLA, Glasgow University, and The Library of Congress collections share similar characteristics, very little analytical research has been carried out. Therefore, comparative technical analyses of the manuscript under consideration derive mainly from illuminated Medieval and Renaissance manuscripts, while at the same time bearing in mind that several of the materials and techniques probably differ to varying degrees.

Illuminated medieval manuscripts from the J. Paul Getty Collection were studied using a portable XRF spectrometer (pXRF) to identify elements in the paper, ink, and colorants/ pigments. The paper substrate is not a major contributor to the overall elemental distribution identified by the XRF with the exception of Ca and Fe. The presence of Ca can originate from possible chalk fillers, while Fe can be transferred into the paper from screens or other metal-containing devices used in the manufacturing process or introduced as impurities from water (Trentelman, Patterson et al. 2012). In Medieval manuscripts, the most common type of ink encountered is iron gall (Trentelman, Patterson et al. 2012). Iron gall can be identified by the presence of elevated levels of Fe, which can sometimes be accompanied by Zn and Cu. Elemental signatures detected from analyzing pigments can reveal possible pigments used on manuscripts. For example, the pigment vermillion, is ubiquitous in manuscript illuminations and is easily inferred from the detection of a single element, Hg (Trentelman, Patterson et al. 2012).

Although many other pigments such as lead white, red lead, iron earths, orpiment, azurite, and mosaic gold, might not have unique elemental signatures, when pXRF is coupled with other analytical methods these pigments can be inferred (Trentelman, Patterson et al. 2012).

According to Aceto et al. (2014), four pigments were usually employed by illuminators for red and orange painted areas. These include vermillion (HgS), minium or red lead (Pb_3O_4), realgar (As_4S_4), and iron-oxide or hematite (Fe_2O_3) pigment. A technical study on a fifteenth-century Armenian Illuminated Gospel from the Verin Noravank Monastery conducted by scientists and conservators from the Library of Congress was performed to identify the materials of manufacture. For the analysis they used pXRF, Fourier transform infrared (FTIR) spectroscopy and x-ray diffraction (XRD). Results indicated the presence of red lead and vermilion (paint mixture) in the red areas which contradicts more traditional applications consisting of vermilion and madder lake (Orna and Mathews 1981, Brostoff, Khan et al. 2010)

Chapter 3 Cultural Context

3.1. Use in History

For centuries, prayer scrolls and illuminated Gospels have played a crucial role in Armenian history and culture. The portability and compactness of rolled prayer scrolls allowed travelers to stay close to their faith and fulfill their religious duties while being away from home. Often referred to as a *hmayil*, these scrolls were used for the protection of the owner from misfortunes or for prayer intentions for the owner. The term *hmayil* originates from the lexeme *humav,* which translates to blessing in Pahlavi, a Middle Persian language used from the end of Achaemenian dynasty (559–330 B.C.E.) (Ghazaryan 2011). Prayer scrolls (*hmayils*) are believed to represent an early form of prayers or maledictions (Ghazaryan 2011). It is also popular belief that amulets or charms worn on the body bring good luck and offer divine protection against evil, sickness, danger, and enemies.

3.2. Place of Print

By the sixteenth and seventeenth centuries a diverse wide-ranging Armenian diaspora was formed as a result of many different factors (Evans and Merian 1994). This dispersion spanned from Amsterdam, Marseilles, and Venice in the West to Madras and the East Indies in the Orient. Armenian communities were also established in Poland and Russia in the north. Meanwhile, the territory of Armenia was divided between two Islamicate empires, that of the Ottomans, who had their capital in Constantinople, and the Safavid Persians, who had their capital in Isfahan (Evans and Merian 1994). Although Armenian artists were open to appropriating foreign stylistic elements, especially in these capitals, Armenian scribes and illuminators continued to manufacture texts and artworks strongly linked to the earlier tradition.

Armenian printing in Constantinople (Istanbul from 1925) first occurred in 1567, while the Ottoman Empire did not officially permit printing in Turkish until the eighteenth century. Armenian printers from the sixteenth century, like other early printers, looked to medieval manuscripts for inspiration (Evans and Merian 1994). Grigor Marzvanetsi of Baghesh (Bitlis), a scribe and manuscript illuminator, who spent four years mastering the arts of printing and engraving, opened a printing business in Constantinople that would later be passed from one generation to the next until the nineteenth century (Hacikyan, Basmajian et al. 2002). Marzvanesti collaborated with Astvatzatur Kostandnupolsetsi (Priest of Constantinople) who published prayer scrolls in Constantinople.

3.3. Texts and Miniatures

The Armenian alphabet has been the vehicle for expression of all three phases of the historic evolution of the Armenian language: Classical (*Grabar*), Middle, and Modern (Sanjian 1996). The latter is represented by two standard literary forms, East and West Armenian. The text on these scrolls is written in *Grabar*, the written language used from the 5th century until the 19th century.

Three different kinds of scripts can be distinguished in manuscripts. The first script is an uncial script called *erkat'agir* or "iron script" with reference to the earliest inscriptions that were chiseled into stone with an iron tool (Mathews 1994). These letters can be "rounded" with gentle curves or angular. In either style, words run together without spacing. In the tenth century the second script *bolorgir* or "round" permitted greater compression and introduced word breaks. The third script *notragir* was an even more compressed style and was introduced in the seventeenth century (Mathews, Taylor et al. 1994). This printed scroll represents all three scripts.

The initials are in *erkat'agir* and the superscriptions are in *notragir*, while the main text is written in *bolorgir* (Figure 11).

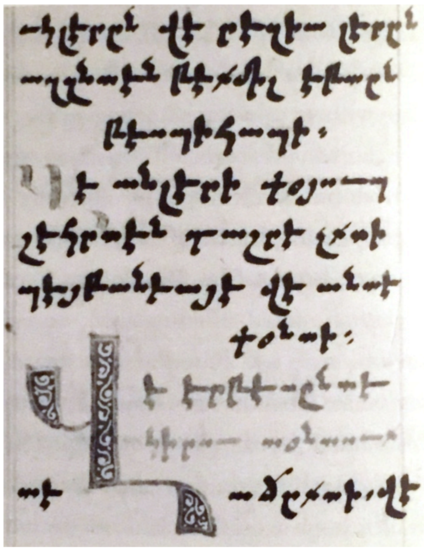

Figure 11. *Nostragir* script detail from John Frederick Lewis Oriental MS 116, fol. 98v, Free Library of Philadelphia. (Mathews 1994)

As stated above, the text in the scrolls typically contained magical formulae and prayers in order to avoid all kinds of dangers and ward off demons (Brown 1994). Each Gospel/prayer begins with a zoomorphic multicolored stylized drop cap (Figure 12). The text on the prayer scrolls is often illustrated with depictions of saints, angels and scenes from the life of Christ, usually associated with healing. Prayer scrolls are often decorated with miniatures that are directly correlated to the written text/prayer above or below. Armenian prayer scrolls commonly share similar text and miniature arrangements. For instance, scenes of healings by Jesus Christ are usually combined with a passage from the prayer of St. Nerses Shnorhali *I Confess with Faith*, and can include parts of the *Book of Lamentation* by St. Grigor Narekatsi. Printed scrolls are also frequently decorated with scenes of the Holy Scripture: Tree of Life, Crucifixion, and the Twelve Apostles. This particular scroll contains twenty-five printed miniatures (Figure 14, Figure 13).

Figure 12. Detailed image of drop cap on 18th-century printed Armenian prayer scroll from this study.

Figure 14. Detailed image in 18th-century Armenian scroll from this study representing *The Tomb of Christ*.

Figure 13. Detailed image in 18th-century Armenian scroll from this study representing *Saint Gregory The Illuminator*

Located on the viewer left bottom corner of the Tree of Life illustration is the monogram of Grigor Marzvanetsi (Figure 15). Marzvanetsi was trained as a copyist and illuminator at the Amrdawlu Monastery near Bitlis and prepared Armenian fonts and plates (Kouymjian 2014). His woodcuts can be found in books published from 1706 to well after 1734, when he died or simply retired. Marzvanetsi developed a very characteristic graphic style, inspired both by the iconography and manner of European engravers (Kouymjian 2014). He often mimicked the work of Christoffel Van Sichem II, whose woodblocks were used in not only the *hmayils*, but in The Voskan Amsterdam Bible of 1666-1668 and the earlier Psalter[5] (Figure 16).

Figure 15. Detailed image of 18th-century printed Armenian prayer scroll from this study representing *Tree of Life* with the monogram of Grigor Marzvanetsi.

Figure 16. Detailed image of *Tree of Life* by Christoffel Van Sichem II .(Merian 2014)

According to Davit Ghazaryan, an assistant curator at the Manuscript Depository from the Mashtots Institute of Ancient Manuscripts in Armenia, it was not uncommon for other publishers to rent the printing plates of miniatures, as it was a frequent practice at that time (Ghazaryan 2011).

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[5] The psalter: The Book of Psalms. Medieval manuscripts of the Psalms were used in liturgical as a private devotional contexts ibid.

3.4. Paper Production

The earliest known Armenian manuscript on paper dates from 981. However, paper did not widely replace vellum until the thirteenth century. While the exact supplier of paper for Armenian manuscripts is unknown, colophons attest to the purchase of paper from established Islamic paper production centers such as Tabriz (Iran) or Damascus (Syria). However, imported European paper was also used and can be indicated by the presence of watermarks. Prior to printing the paper was often further prepared by a process called sizing which prevented the ink from bleeding. Sheets of paper were either dipped in a starch solution or brushed onto the surface of the paper. Prior to cutting and folding, sheets were polished to give the paper a smooth shiny surface (Merian, Mathews et al. 1994). Unfortunately, as is normal in such manuscripts, no information within this scroll or in the colophon specifies a center for paper production.

3.5. Printing Technique

The miniatures and the text on the prayer scroll were visually examined with the use of a small folding glass magnifier up to 10x magnification, and were also viewed under higher magnification using a digital microscope. Visual analysis of the ink patterning on the paper revealed the use of a woodcut printing technique. A woodcut comprises lines drawn on the plank side of the wood with every other part of the wood removed except for the lines of the image (Gascoigne 1986). Ink is then applied to the woodblock using a dabber and could either be stamped by hand onto the paper or the paper could be placed on top of the woodblock (Gascoigne 1986). The woodblock technique was an efficient way to print images and text in a single operation. There are several identifiers that can reveal the use of a woodcut, one is the lines of a stamped image that stand out in relief in the same way as the printers' type. A second is the unexplained gaps or sudden changes in width or direction of lines within an image (Figure 17, Figure 18).

Figure 17. Detailed image of woodcut by Hans Leonard Beck c. 1515 showing variation in line widths (Gascoigne 1986).

Figure 18. Detailed image of printed miniature on 18th-century Armenian scroll showing variation in line widths.

3.6. Intended Owner

Printed within the text above the miniature of *Jesus and the Twelve Apostles* is:

Բարեխօս եւ օգնական լեր մայր
այ ծառայիս քո ________ամէն:

This space was created for the owner to later fill in his/her name. Written in graphite and faintly visible in regular diffuse light are several markings of a name (Figure 19). With the assistance of an image editing software, Photoshop CC 2014, the image was manipulated to reveal the simple markings of the name ‘Ghougas’ (Luke) (Figure 20).

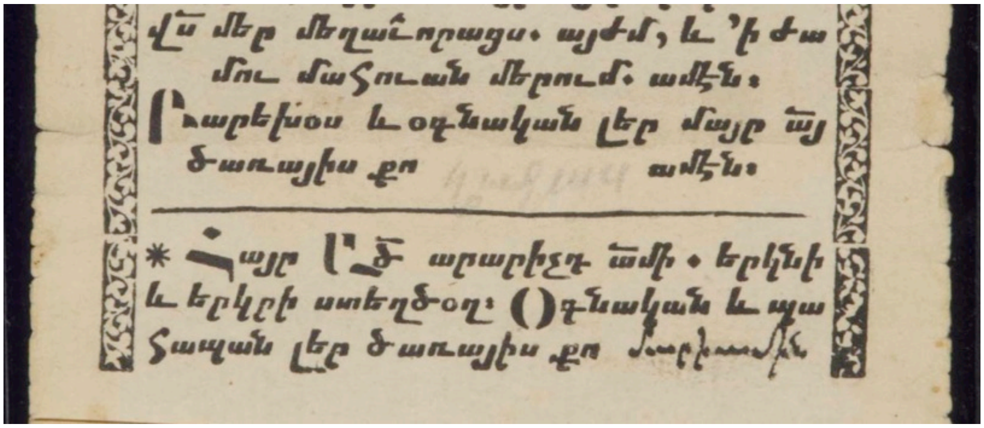

Figure 19. Detailed image of 18th-century printed Armenian prayer scroll from this study in regular diffuse light with owner's name written in graphite.

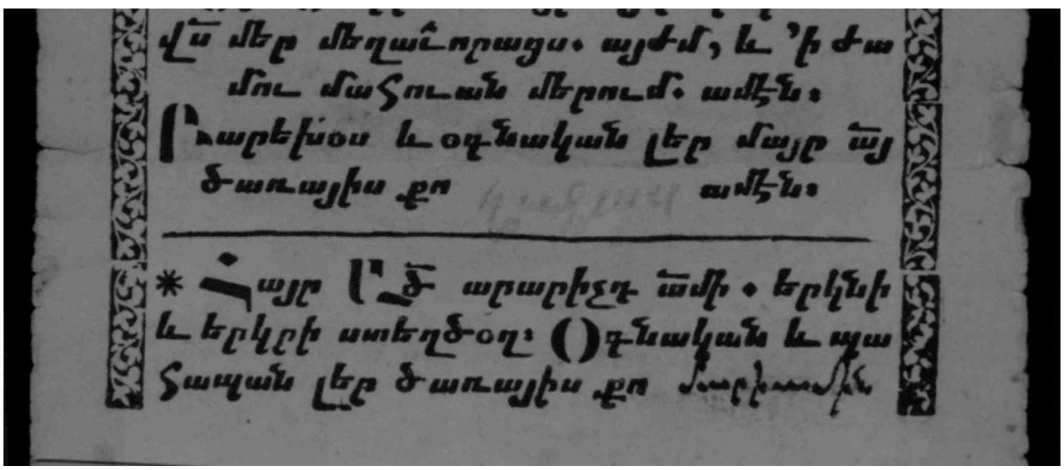

Figure 20. Edited detailed image of 18th-century printed Armenian prayer scroll in this study with owner's name written in graphite.

3.7. Colophon

Although the scroll is in fragmentary condition and has missing segments, the colophon is present. A colophon is a brief statement that can be found at the end of a book or manuscript. It is often divided from the text with the use of a colophon decoration, simple decorative devices including dots, commas, ivy leaves, which serve to highlight the colophon (Brown 1994). A colophon contains information about the written text, such as the place of publication, the publisher and the date of publication. In manuscripts, the scribe would add a colophon, which in a formulaic manner provided a date, place of execution, the patron's name, the ruling authority, the painter, the binder, and naturally the scribe's name with family details. Other details such as the circumstances of copying and political and economic conditions were also included (Bausi, Borbone et al. 2015).

In the case of this printed scroll, the colophon reads "grec‘aw Hemayils i t‘uin Hayoc‘ 1176 Mayisin", translated to "This *hmayil* was written in the year 1176 of the Armenian Era, in May". Armenian manuscripts and scrolls employ the letters of the alphabet in their numerical value up to the seventeenth century as each of the thirty-six letters of the Armenian alphabet has a numerical value (Bausi, Borbone et al. 2015). The date in this printed scroll is written with the Armenian numerals "r ch h z" (Figure 21). The conversion of "r ch h z" translates to 1000, 100, 70, and 6 years. When converted to the Gregorian calendar by adding 551 years, it translates to the year of 1727.

> May God give you as an enjoyment
> This talisman that is written
> May fathers and brothers who buy this
> Enjoy it in peace
> May no evil befall the owner
> May he follow good advice
> May he attain ripe old age
> May he commemorate us with the prayer
> "Lord I have sinned"
> And when hereafter he departs this life
> May he inherit the Kingdom of God
> This Hemayil was written in the year 1176 of the Armenian era in May
> (Cowe 2015)

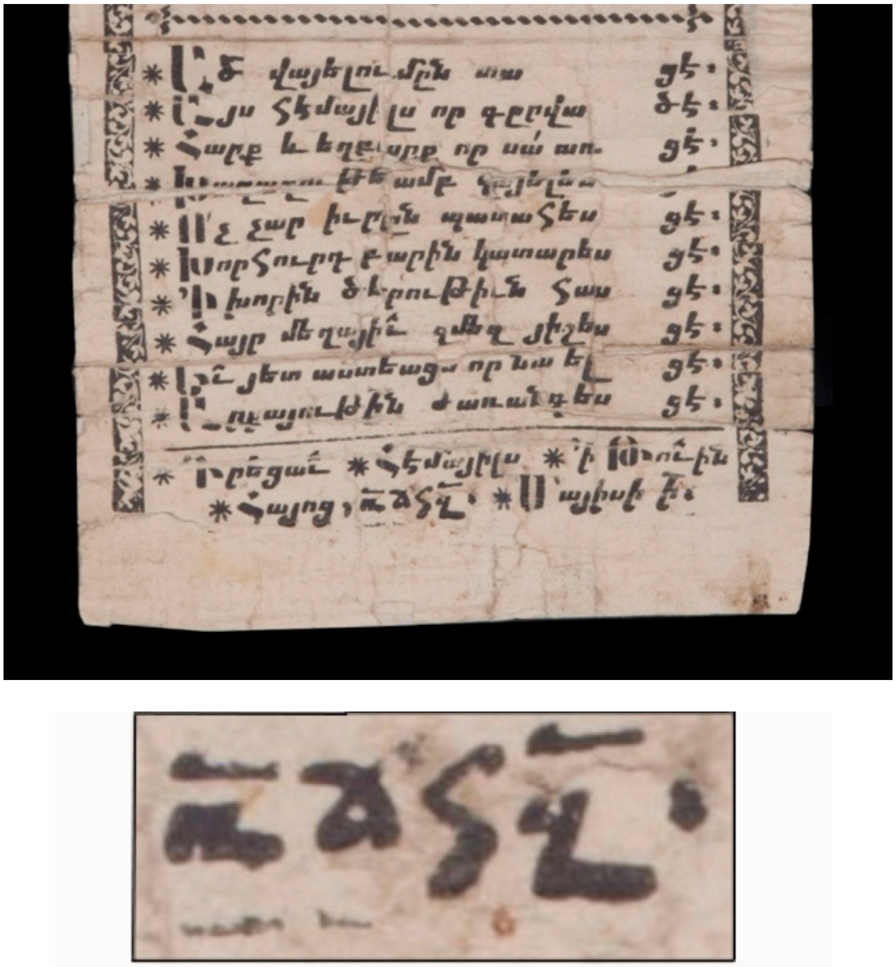

Figure 21. Detailed image of the colophon in 18th-century Armenian prayer scroll showing year of print (1727).

Chapter 4 Scientific Methodology

Given this scroll's cultural significance and delicate nature, sampling for the characterization of the materials was not possible. Non-invasive analytical techniques that did not require sampling were therefore employed. The most widely used techniques today for the characterization of inks and colorants in manuscripts are Raman spectromicroscopy (μRS) (Burgio, Clark et al. 2008) and ultraviolet, visible, near infrared (UV/Vis/NIR) fiber optic reflectance spectroscopy (FORS) (Aceto, Agostino et al. 2014). which can provide molecular and structural information for the identification of both organic and inorganic materials and a portable X-ray fluorescence (pXRF) spectroscopy for elemental characterization (Trentelman, Patterson et al. 2012).

These techniques, supported by analytical photography in reflectance and luminescence from the UV (350 nm) to the NIR (1000 nm), provide the scientific tools for enabling the characterization of the red, green, yellow and brown colorants used for manuscript miniatures (Figure 22).

Figure 22. Spot areas on 18th-century printed Armenian prayer scroll used for non-destructive analysis.

4.1. Non-invasive characterization methods

4.1.1. Analytical photography

Before analysis was carried out, all fragments of the scroll were photographed flat, in 20 cm segments, at a constant focal length using a D90 Nikon DSLR camera. Two tungsten lights were used at 45 degrees angles to generate a continuous distribution of light across the visible spectrum (Pozeilov 2015). TruVue AR Reflection-Free acrylic was placed over the scroll segments to create a flat and glare-free surface. Images were taken with a with 20% image overlap to allow pixel by pixel stitching. Images were digitally stitched together using an image editing software, Photoshop CC 2014, developed and manufactured by Adobe Systems Inc (Figure 23a-b). This software aided in the manipulation, color correction and stitching of scroll fragments, which assisted in the understanding of the original scroll.

The paper scroll was further examined and photographed using ultraviolet (UV) induced visible fluorescence photography (400-700nm). Ultraviolet radiation (300-400 nm) was used to excite fluorescence within the visible range using the Mini Crimescope, an alternate light source that enable narrow band illumination between 300 and 600 nm. A D90 Nikon camera with a PECA 916 filter

Figure 23a-b. Digitally stitched images of 18th-century printed Armenian prayer scroll.

was used to capture only the visible emission of fluorescence from the scroll (Pozeilov 2015).

4.1.2. Photomicrography

The colorants/pigments were examined and imaged using a Keyence VHX-1000 digital microscope, up to 200x magnification.

4.1.3. X-ray Fluorescence (XRF) Spectroscopy

Elemental characterization was performed using a hand-held Tracer III-SD portable XRF spectrometer by Bruker Instruments. The Tracer III-SD uses a rhodium (Rh) x-ray source and palladium slits, meaning Rh and Pd peaks are always present in the spectra and can be ignored from the obtained spectra. The pXRF spectrometer has a spot size of approximately 5 mm diameter, thus rendering analysis of very small areas of interested (< 5mm diameter) challenging. Furthermore, characterization is also limited in the device's inability to detect elements with $Z<12$ (magnesium). Spectra were acquired for three minutes and interpreted using the program S1PXRF (version 3.8.3) from Bruker Instruments. Qualitative data was collected using the following acquisition parameters: 40 kV (kiloVolts), 11 µA (microAmps), no filter, under vacuum; 15 kV, 26 µA, titanium filter (blue), under vacuum. Readings of the pigments (red, green, yellow, brown), ink, and paper were taken.

4.1.4. Ultraviolet, visible near infrared (UV/Vis/NIR) fiber optic reflectance spectroscopy (FORS)

The inks and colorants used in this prayer scroll were analyzed using the FieldSpec3® 3 by Analytical Spectral Devices Inc (ASD), with high spectral resolution (3 nm @ 700 nm and 10 nm @ 1400/2100 nm) and wide spectral range between 350-2500 nm. The high spectral and spatial resolution of the spectrometer was particularly useful for fingerprint identification of different inorganic and organic compounds in the samples due to its high sensitivity to both the electron transitions in the visible part of the spectrum and the overtones from the organic molecules in the near infrared.

Data were collected from four different colors present on the scroll (red, green, yellow and brown).

4.1.5. Raman spectromicroscopy (μRS)

Non-invasive analysis using Raman spectromicroscopy (μRS) was performed on the red, green, yellow and brown colorants/pigments with a Renishaw inVia system, using two lasers of wavelength 785 nm and 633 nm. Parameters such as laser excitation wavelength, laser power, acquisition time, and number of accumulations were adjusted to increase signal to noise ratio.

Chapter 5 Results & Discussion

The prayer scroll arrived at the Getty Villa conservation labs in a cardboard box and in fragmentary condition. The various segments of the scroll were rolled and stored inside the box. Upon examination, it was determined that the 18 scroll fragments included in the box belonged to one prayer scroll.

5.1. Condition of the scroll

The scroll is heavily damaged and in fragile condition owing to years of poor housing, use and previous improper repairs. The paper scroll has small tears along the edges as well as larger tears through the miniatures and text (Figure 24). There are areas of losses in the miniatures and text that impair the scroll's integrity. The mends are clearly visible when the scroll is placed over a light table (Figure 25). On the reverse side of the scroll, previously improper repairs and excess adhesive residues are visible (Figure 26). The mends appear to have been created using segments of a heavier weight, glossy, white paper, which was applied using an adhesive.

Figure 24. Detailed image of the 18th-century printed Armenian prayer scroll showing small tears along the edges and larger tears through the text and miniatures.

Figure 25. Detail of the recto side of the 18th-century printed Armenian prayer scroll in transmitted light highlighting the mends attached at the verso side.

Figure 26. Detail of verso side of the 18th-century printed Armenian prayer scroll showing mend material with adhesive residue.

Segments of the paper are adhered to the original paper mends, which would have initially acted as reinforcement but have embrittled, creating overall stiffness and inflexibility of the scroll. Several mends using the heavier weighted, glossy paper appears to be failing and lifting off the original scroll. Of the 18 segments one has hand written text and miniatures (Figure 27). This segment also includes tears that have been mended out of sequence and orientation. Overall the ink used for printing text and miniatures appears to be stable while some areas with pigments suffer loss. The yellow colored pigments appear to be much lighter and could have faded over time. The red, and brown pigments are in relatively stable condition with the exception of minor losses and abrasions. The green pigment is stable and also suffers minor losses and abrasions however it has also bled through the paper, which would have occurred during manufacturing.

Figure 27. Detailed image of 18th-century printed Armenian prayer scroll from this study showing hand written text and miniature.

5.2. Materials and construction technique

_Following analytical imaging, multiple areas of interest on the scroll including the paper, printing ink, and colorants/pigments were analyzed using portable X-ray fluorescence spectroscopy (pXRF) in an attempt to identify the major, minor and trace elements (Figure 28). UV/Vis/NIR FORS complemented the pXRF analysis providing molecular characterization and assisted in the identification of the organic materials. Colored areas were also analyzed using Raman spectromicroscopy (µRS) confirming results from previous analyses.

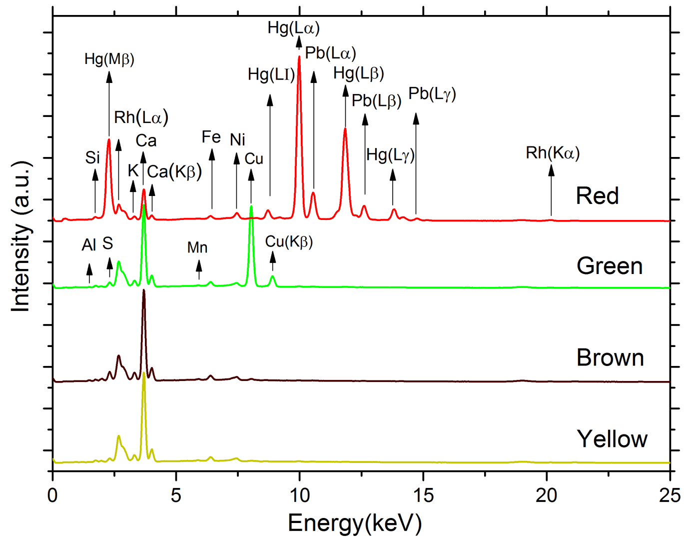

Figure 28. XRF Analysis of four colorants/pigments on 18th-century printed Armeninian prayer scroll

Hue	pXRF (elements identified)	UV/Vis/NIR (absorptions nm)	µRS (Raman shift cm^{-1})	Identification
Black (Text)	na	na	na	Carbon black
Green	Cu	690 nm	na	Copper resinate
Red	Hg, S, Pb	600 nm	250 cm^{-1}, 280 cm^{-1}, 340 cm^{-1}	Cinnabar, Lead-containing compound
Yellow	na	na	na	Organic or inorganic below detection limit.
Brown	na	na	na	Organic or inorganic below detection limit.

Table 2 Palette of eighteenth century printed Armenian prayer scroll, na: not available

The results from all analyses are summarized in Table 2. These suggested a particular processing of the paper and the use of different colored inks – both inorganic and organic – for the miniatures.

5.3. Paper characterization

Until the 1750's all paper was made on a mesh consisting of strong wires about an inch apart, with finer wires laid close together across them (Gascoigne 1986). Laid lines are reproductions of the wires in the sieve that stop the paper pulp and allow water through. They appear in a straight line pattern and cover the complete piece of paper with an average density between 5-15 lines per centimeter (Van Staalduinen, Van der Lubbe et al. 2006). A pattern of 7 lines per centimeter was identified when the scroll was placed on a light table, further confirming the date of print as well as the manufacturing process (Figure 29).

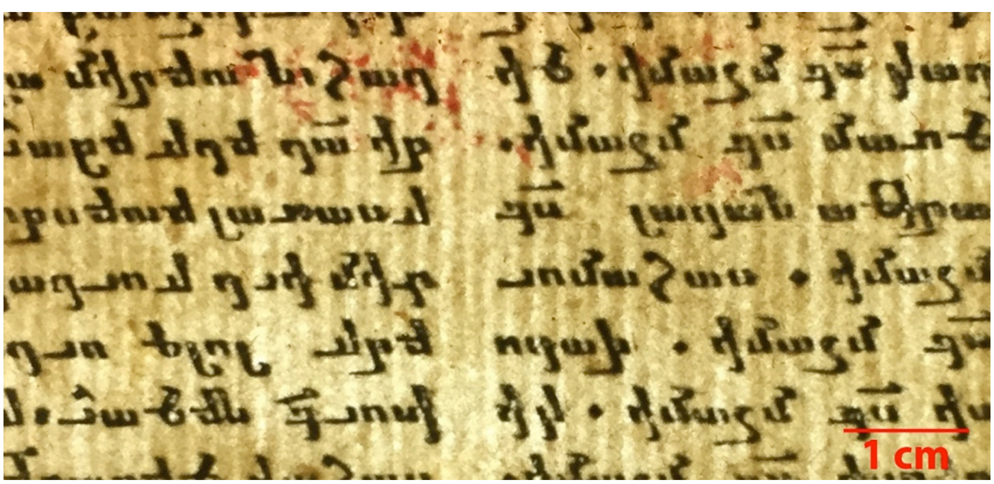

Figure 29. Detail image of 18th-century printed Armenian prayer scroll from this study over a light table showing laid lines of the paper.

pXRF spectroscopy of the paper revealed a strong photon emission characteristic of calcium (Ca) and minor emissions of peaks of potassium (K), iron (Fe), nickel (Ni), aluminum (Al), silica (Si), titanium (Ti), manganese (Mn), copper (Cu), and zinc (Zn) (Figure 30). The major elements identified in the paper were Ca, K, Si, Fe, and Ni. It is difficult to conclude a possible origin of major elements identified in the paper, possibly due to the sizing material that would have been used during the time of production.

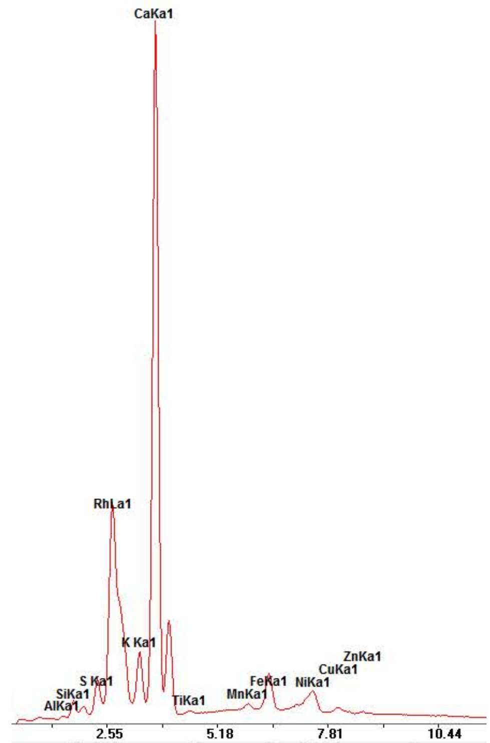

Figure 30. XRF spectrum of plain paper of 18th-century printed Armenian prayer scroll (40kv_11ma_nofilter_vacuum_3mins).

The paper was further examined using μRS which identified Raman shift at 1090 cm^{-1} indicative of calcium carbonate (Figure 31).

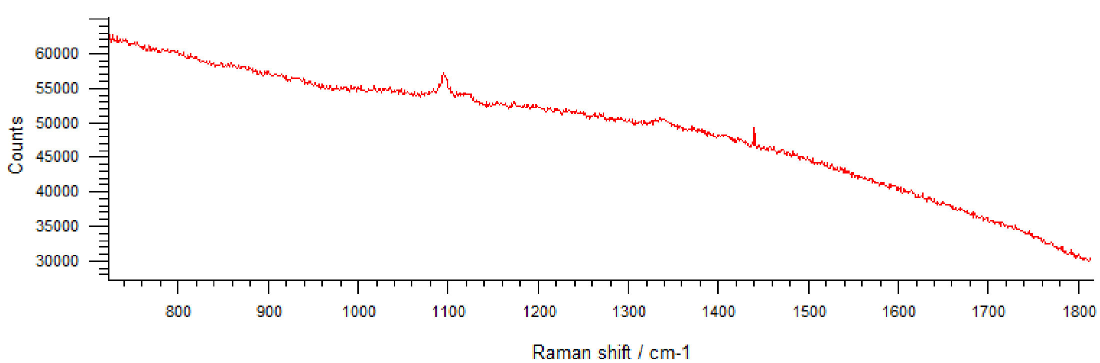

Figure 31. Raman spectrum of plain paper of 18th-century printed Armenian prayer scroll.

5.4. Printing ink characterization

pXRF analysis on the ink revealed the same spectrum as that obtained for the paper. A prominent peak of iron would suggest the use of iron gall ink (Merian, Mathews et al. 1994), however since Fe was only found as minor element and in similar intensity as that in the paper, it is suggested that the ink used in this scroll is carbon based.

The ink used in most Armenian manuscripts was a deep black ink and was most likely a carbon-based ink made of soot. This type of ink will not damage the paper since it does not penetrate the paper. Another type of ink was iron gall made by a tannin containing product and a metallic salt (Merian, Mathews et al. 1994). This was developed and used later than carbon-based inks. As iron gall inks are often acidic they can cause staining and accelerate the degradation of the paper.

5.5. Colorants/pigments characterization

5.5.1. Green

The green colorant applied throughout the scroll was documented using the digital microscope (Figure 32). pXRF analysis of the green areas revealed photon emission energies characteristic for copper (Cu), contributing to its green color. Elements such as calcium (Ca),

Figure 32. Green colorant applied on miniatures of 18th-century printed Armenian prayer scroll.

titanium (Ti), manganese (Mn), silica (Si), and aluminum (Al) were also detected (Appendix 2). However, these are also present in the unpigmented areas of paper and can be attributed to the paper substrate.

UV/Vis/NIR FORS of the green areas showed a reflection maximum in the blue-green region and a broad absorption maximum at ~690 nm (Figure 33) suggesting the presence of copper resinate (Aceto, Agostino et al. 2014).

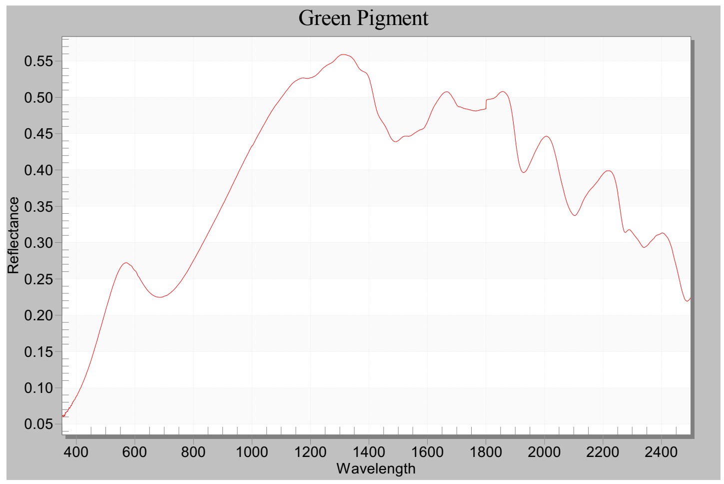

Figure 33. UV-Vis-NIR spectrum of the green colorant applied to miniatures of 18th-century printed Armenian prayer scroll.

There are three general types of green pigments: natural mineral, synthetic inorganic and organic (mainly of plant origin). Most green colorants have come from Europe and span across five continents (Zagorski 2007). There are four unique and significant green colorants that come from Asia: Chinese green (green mud dyestuff from the bark of buckthorn trees: *Rhamnus utilis* and *Rhamnus chlorophorus*), copper resinate, green earth (iron silicate) and malachite (copper carbonate) (Zagorski 2007). The range of green colorants use in manuscript painting were mostly limited to the pigments such malachite, green earth, verdigris (copper acetate), to which two dyes, sap green from ripe berries of the *Rhamnus* species and iris green from *Iris germanica*, can be added to make copper resinate (Aceto, Agostino et al. 2014). Copper resinate, as a pigment was introduced in Dutch painting in the 15th century and in Italian easel painting in the 16th century (Conti, Striova et al. 2014). This green glaze is made up of copper salts of resin acids. It was found used as both a lacquer and as a green pigment mixed with oil, and egg binders. The earliest known recipe of copper resinate dates back to the seventeenth century. For the production of copper resinate, verdigris was dissolved in Venice turpentine on hot ashes to form a very viscous and green mass; it was then left to dry for several months (Conti, Striova et al. 2014). According to Conti, Striova et al. (2014), nowadays, copper resinate can be synthesized in several ways. The most common are: a) by the reaction of a copper salt solution with an aqueous solution of sodium resinate or b) by melting natural resin, such as Venice turpentine (mainly abietic acid), with reactive copper compounds. The resulting product is thus a mixture of copper carboxylate complexes of resin acids. The product can then be used as a liquid or as a dried powder, commonly bound with a drying oil. Depending on how it is synthesized the color range can vary from greenish to greenish-blue or bluish. Organic yellows such as saffron and gamboge are also known to have been mixed together in order to alter the hue. Pigments were commonly used in a wide range of mixtures to obtain a wide spectrum of hues and shades.

5.5.2. Red

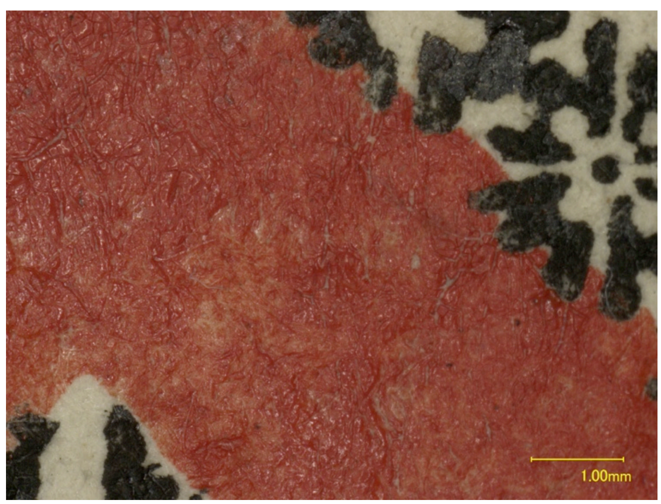

Figure 34. Red colorant applied on miniatures of 18th-century printed Armenian prayer scroll.

The red pigment applied throughout the scroll was documented using the digital microscope (Figure 34). pXRF analysis on the red pigment revealed photon emissions characteristic of mercury (Hg), sulfur (S), and lead (Pb). Additional elements such as calcium (Ca), titanium (Ti), manganese (Mn), silica (Si), and aluminum (Al) were also detected which were attributed to the paper substrate (Figure 30). The presence of Hg, S, and Pb in the red pigment suggests the presence of vermilion (HgS) and a lead-based compound, most likely red lead (Pb_3O_4). The red area was further examined using μRS, which corroborated the use of vermilion with Raman shifts at 250, 280, 340 cm^{-1} (Figure 35). The characteristic Raman shifts for natural cinnabar (similar in chemistry to vermilion) are 252, 282, 343 cm^{-1}, and for red lead 122, 149, 223, 313, 340, 390, 480, and 548 cm^{-1} (Bell, Clark et al. August 2010).

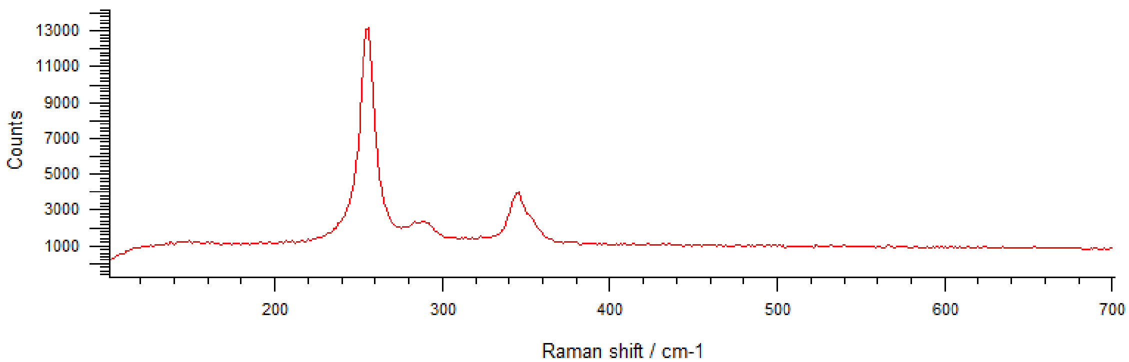

Figure 35. Raman spectrum of red colorant on 18th-century printed Armenian prayer scroll.

The scroll was analyzed using UV/Vis/NIR spectroscopy and red areas showed a characteristic band gap of sulfur (S) and cinnabar/vermilion (HgS) at ~600 nm. Figure 36 shows the reflectance spectra of both the red colorant found on the scroll (Blue spectrum) against the cinnabar reference spectrum (Red spectrum).

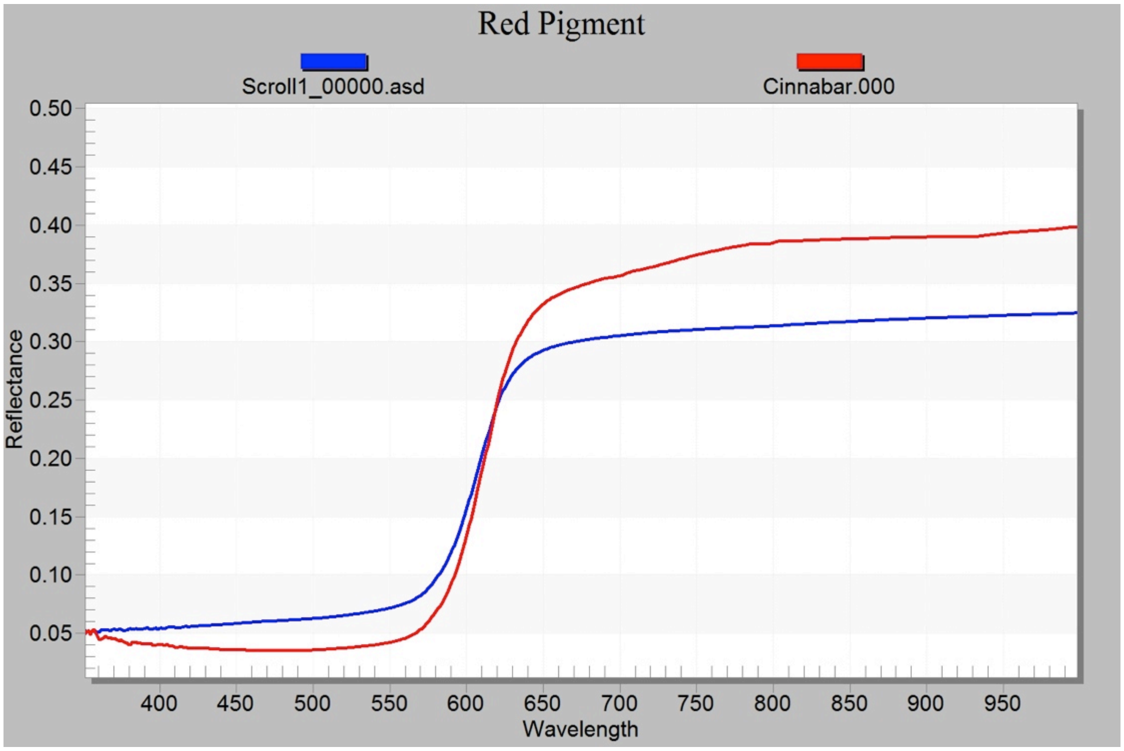

Figure 36. UV-Vis-NIR of red colorant on 18th-centruy printed Armenian prayer scroll in blue with reference spectrum of cinnabar in red.

Scientific analysis carried out on Armenian manuscripts dating from ca. 908 – 1608 have consistently shown the use of vermillion as the red colorant (See Table 1).

5.5.3. Yellow

The yellow colorant used throughout the scroll was difficult to identify due to its dilute and faint application (Figure 37). pXRF analysis was unable to identify any elements other than those already found in the paper substrate. Similarly, UV/Vis/NIR and μRS did not reveal any additional fingerprint markers that could lead to the identification of the

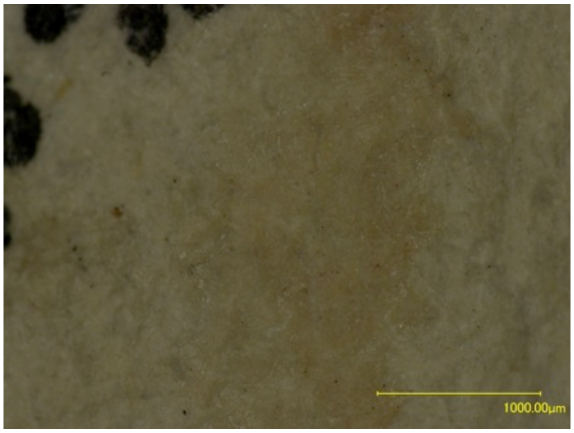

Figure 37. Yellow colorant applied on miniatures of 18th-century printed Armenian prayer scroll.

yellow colorant/pigment.

There are six unique and widely used yellow colorants from Asia: gamboge, Indian yellow, orpiment, saffron, weld and yellow ochre (Zagorski 2007). Commonly used inorganic yellow pigments include orpiment and yellow ochre. Orpiment also came from the Republic of Georgia, Iran, China (probably since antiquity), Japan, and Myanmar (Burma) (Fitzhugh, Riederer et al. 1997). Gamboge, is a resin from the *Garnica hanburyi* tree that is native to Southeast Asia and is used as a paint pigment. Gamboge has been identified in works from the Far East dating back to the eighth century (Zagorski 2007). One of the main drawbacks to using this material is that as a paint pigment it fades in bright light (Ball 2002). Saffron has been grown in India, since at least 500 BCE, and in Iran since antiquity for use as a culinary spice and as a yellow dyestuff and pigment (Ball 2002).

5.5.4. Brown

The analysis was unable to reveal any characteristic signatures for the brown color (Figure 38). pXRF only detected the elements consistently identified in the paper substrate. No additional fingerprint markers leading to the identification of the brown colorant/pigment were identified with UV/Vis/NIR and μRS.

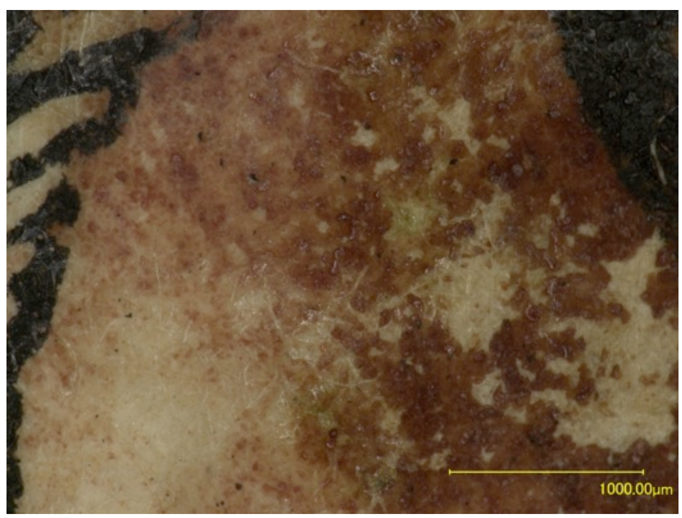

Figure 38. Brown colorant applied on miniatures of 18^{th}-century printed Armenian prayer scroll.

Inorganic brown pigments, much like yellow, consist of a limited set of sources from the local region. Brown pigment can be derived from animal, mineral, and plant sources. There are five brown colorants from Asia: asphaltum, bister, brown ochre, sepia and umber (Zagorski 2007). Bister is a dark grayish brown pigment made from the soot of burnt beech or birch trees. Bister was used in manuscript illumination since at least the fourteenth century (Ball 2002).

Chapter 6 Risk assessment and preventive conservation

To ensure the long-term preservation of the 18th-century printed Armenian prayer scroll, appropriate housing was designed and constructed using archival quality conservation materials as a preventive conservation measure. Given to the fragile nature of the scroll, the scroll could no longer be safely re-rolled and therefore each fragment was stored flat.

Paper Conservators from both The Library of Congress (Yasmeen R. Khan and Tamara Ohanyan) as well as conservators from the Los Angeles County Museum of Art suggested that since extensive conservation treatment was needed, it should be (for the time being) stored flat. Janice Schopfer, Head of Paper Conservation at the Los Angeles County Museum of Art, was consulted for housing strategies and storage design. Different methods for storage, as well as the materials used for housing paper of this nature, were discussed and considered.

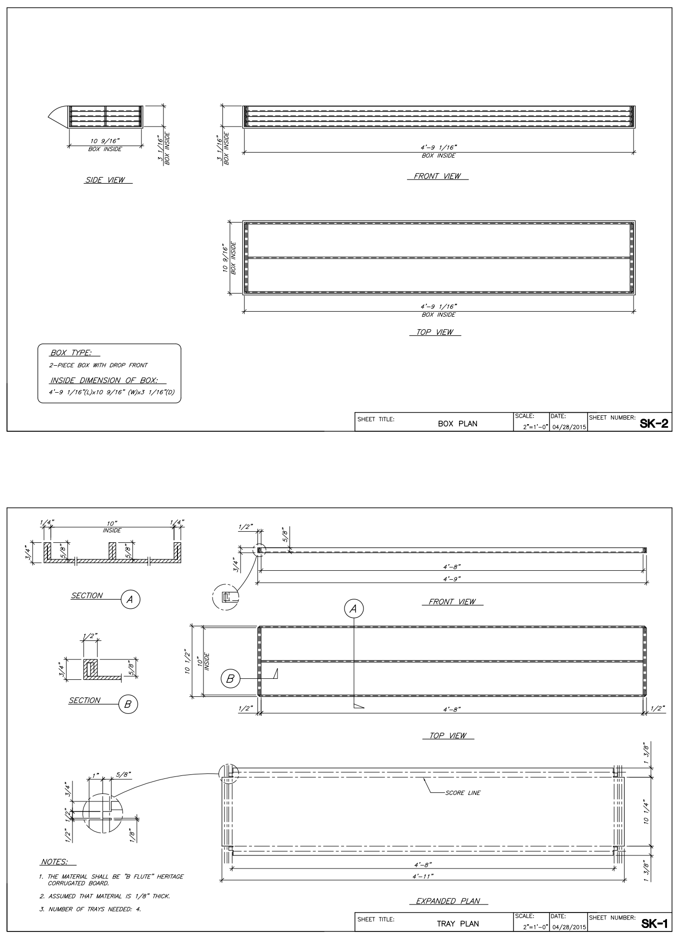

Figure 39. Computer aided design (CAD) drawing of 18th-century printed Armenian prayer scroll trays and storage box.

An archival storage box was designed using a computer-aided drafting software program for creating 2D and 3D designs (CAD) (Figure 39). The box was custom cut by Talas, a bookbinding, archival and conservation supplier in Brooklyn, New York and assembled at the UCLA/Getty CAEM IDP training laboratory at the Getty Villa. The storage design consisted of a drop down box with a separate lid (Figure 40). The box, lid, trays, and palettes were all constructed out of acid-free, archival, multi-use Heritage Corrugated board (B-Flute). The box measured 5 feet in length, 4 inches in height, and 11 inches in width and consisted of four trays, each measuring ¾ inch in height, stacked on top of one another. Stored inside of each tray are two removable palettes with a central divider between the two palettes for easy lifting and safe handling without directly moving the artifact (Figure 41, Figure 42). Scroll fragments were safely secured in envelopes constructed out of archival pure polyester film (Mylar) (Figure 43), which were then adhered with photograph mounting corners (Mylar with an acid-free adhesive) onto removable palettes. The polyester film protects scroll fragments from dust and debris as well as prevents movement while stored in the box. Storage box should be kept flat in a cool relatively dry (about 35% relative humidity), clean and stable environment, away from direct intense light, radiators and vents (Library of Congress 2015).

Figure 40. Storage box created for the 18th-century printed Armenian prayer scroll.

Figure 41. Storage box created for the 18th-century printed Armenian prayer scroll showing the multilayer construction.

Figure 42. Detail of two of the storage box removable palettes with fragments of the18th-century printed Armenian prayer scroll.

Figure 43. Detail of removable palette created for 18th-century printed Armenian prayer scroll showing Mylar envelopes.

Chapter 7 Conclusion and Future Research

The analysis of the 18th-century printed Armenian prayer scroll with the use of non-invasive techniques has provided strong evidence for the use of inorganic pigments such as vermilion and a lead-containing material (most likely red lead); an inorganic/organic green compound identified as copper resinate and carbon black of organic origin. Combined non-invasive and non-destructive techniques including pXRF, UV/Vis/NIR spectroscopy and μRS collectively contributed to the characterization and identification of pigments and potential surface treatment of the paper used as substrate for the prayer scroll. The yellow and brown colors were unable to be identified with the techniques used. However, this could be due to low concentrations below the instruments' detection limits. Further research would be required using micro-analytical techniques of high specificity and sensitivity for the characterization of these colorants/pigments.

Lastly, the newly designed and developed housing made as a preventive measure for the scroll was not only able to keep multiple fragments of the manuscript flat and in order, but also created a safe environment for the prayer scroll as well as an easy way for the owner to access and continue to enjoy/use it.

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