Pigment Analysis of Ethiopian Manuscripts

OBJECT INFORMATION	EXAMINATION AND ANALYTICAL TECHNIQUES	FOLIO (R= recto, V= verso)	WRITING INKS			ILLUMINATIONS																
			Black	Red	Others	Underdrawing	Blind ruling for illumination	Black	Blue 1	Blue 2	Grey	Red 1	Red 2	Red 3	Flesh	Yellow 1	Yellow 2	Orange	Green 1	Green 2	White 1	White 2	Brown
Walters Art Museum, W.836, codex, early 14th century	Visual examination, XRF, and FORS	1R	Carbon based (not analyzed)	Vermilion/cinnabar	None	Indigo	Yes	Carbon based	Indigo	None	No data	Vermilion/cinnabar	None	None	No data	Orpiment	None	None	Copper based (likely verdigris)	No data	Exposed parchment	None	None
		4R																		Copper green and orpiment			
		6R																Vermilion/cinnabar and orpiment		No data			Vermilion/cinnabar and iron earth
		123V										No data								Copper green and orpiment			None
Walters Art Museum, W.839, double-sided leaf, late 14th century	XRF, Raman, and FORS*	R	None	None	None	Indigo	Yes	Indigo (for black)	Indigo	None	None	Vermilion/cinnabar	None	None	Lead white, vermilion/cinnabar, and orpiment	Orpiment	None	None	Copper based	Copper based and orpiment	Exposed parchment	Lead white	No data
		V														None			None	None		No data	
Walters Art Museum, W.840, single-sided leaf, late 14th–early 15th century	Visual examination	V	None	None	None	Indigo	Yes	Carbon based (?)	Indigo	None	None	Vermilion (?)	None	None	Exposed parchment	Orpiment	None	None	Vergaut (?)	Not reported	Exposed parchment	None	None
Walters Art Museum, W.838, bifolio, 14th–early 15th century	Visual examination	2R	-			None	Yes	Carbon based (?)	Indigo	None	None	Vermilion	None	None	None	Orpiment	None	None	Verdigris	None	Exposed parchment	None	None
J. Paul Getty Museum, Ms. 89, single-sided leaf, late 14th–early 15th century	Raman** (")	V	-			Indigo (?)	Yes (limited)	Not reported	Indigo	None	None	Vermilion	None	None	Not reported	Orpiment	None	None	Not reported	None	Not reported	None	None
Morgan Library and Museum, M.828, codex, 1400–1401	XRF and FORS	10V	Not analyzed	Not analyzed	Not analyzed	Indigo	Yes	Carbon based	Indigo	None	None	Vermilion/cinnabar	None	None	Vermilion/cinnabar, lead white, orpiment, and iron earth	Orpiment	None	Vermilion/cinnabar and orpiment	Vergaut	Verdigris	Exposed parchment	Lead white (flesh tones)	No data
		11R																					Iron earth and lead white

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			Black	Red	Others	Underdrawing	Blind ruling for illumination	Black	Blue 1	Blue 2	Grey	Red 1	Red 2	Red 3	Flesh	Yellow 1	Yellow 2	Orange	Green 1	Green 2	White 1	White 2	Brown
Walters Art Museum, 36.9, liturgical fan, late 15th century	Visual examination and FORS	Panel 2	None	Vermilion (?)	None	Indigo	Yes (all panels)	No data	Indigo	None	None	Vermilion/cinnabar	None	None	Vermilion/cinnabar and white (unidentified)	Orpiment	None	None	Vergaut	verdigris	Exposed parchment	No data	None
		Panel 6																					
		Panel 12																					
J. Paul Getty Museum, Ms. 105, codex, 1480–1520	Raman** (")	6R	Not analyzed	Not analyzed	None	Indigo (?)	Yes	Indigo	Indigo	No data	None	No data	None	None	Vermilion and lead white	Orpiment	None	Vermilion	Vergaut	None	Not reported	Lead white and gypsum	None
		7R										Vermilion						Vermilion and orpiment					
		10R																				Lead white	
Church of St. George, Maywäyni Monastery, Maywäyni 041, codex, 18th century	Raman and FTIR** (Tomaszewski et al. 2014)	Inserted 15th-century miniature (blank on verso)	Not analyzed	Not analyzed	None	Indigo (?)	Yes	Carbon based and chalk	Indigo and chalk	None	None	Vermilion/cinnabar	None	None	Earth pigment and vermilion	Organic yellow	None	None	Vergaut	None	Exposed parchment	None	Earth pigment and vermilion
Virginia Museum of Fine Arts, 2012.301, sənsul, 15th century	XRF and FORS	Four panels	None	None	None	Indigo (?)	Unknown	Carbon based	Indigo	None	None	Vermilion/cinnabar	None	None	Not reported	Orpiment	None	Vermilion/cinnabar and orpiment	Verdigris	Vergaut	Exposed parchment	None	Iron earth
Peabody Essex Museum, E67892, sənsul, 15th–early 16th century	XRF and FORS	Five panels	None	None	None	Indigo (?)	Yes	Carbon based	Indigo	None	Indigo and orpiment (little)	Vermilion/cinnabar	None	None	Not reported	Orpiment	None	None	Vergaut	None	Not reported	None	None
J. Paul Getty Museum, Ms. 102, codex, 1504–1505	Raman, in situ XRD** (")	19V	Not reported			Indigo (?)	Yes	Indigo	Indigo	Indigo and lead white	None	Vermilion/cinnabar	None	None	None	Orpiment	None	Vermilion and anhydrite	Vergaut	No reported	Not reported	Anhydrite	Not reported
Walters Art Museum, W.850, codex, early 16th century	Visual examination (all), XRF, and FORS (only on 60V & 61R)	2V	Carbon based	Vermilion/cinnabar	None	Indigo	Yes (limited)	Carbon based	Indigo	Indigo and lead white	None	Vermilion/cinnabar	None	None	Lead white and vermilion/cinnabar	Orpiment	None	Vermilion and orpiment	Vergaut	None	Exposed parchment	Lead white (flesh tone)	None
		61R																					
		60V																					

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			Black	Red	Others	Underdrawing	Blind ruling for illumination	Black	Blue 1	Blue 2	Grey	Red 1	Red 2	Red 3	Flesh	Yellow 1	Yellow 2	Orange	Green 1	Green 2	White 1	White 2	Brown
Walters Art Museum, W.927, double-sided sənsul leaf, 16th century	XRF, Raman, and FORS	R	None	Vermilion (?)	None	Vermilion/cinnabar (?)	Yes (extensive)	Indigo	None	None	Indigo and lead white	Vermilion/cinnabar	None	None	Lead white, vermilion/cinnabar, and iron earth	Orpiment and iron earth	None	None	Vergaut	None	Exposed parchment	None	None
		V													None								
Walters Art Museum, W.928, double-sided sənsul leaf, 16th century	Visual examination	R	None	None	None	Vermilion/cinnabar (?)	Yes (extensive)	-	-			-			-	-		-	-		Exposed parchment	-	-
		V																					
Walters Art Museum, W.929, double-sided, sənsul leaf, 16th century	Visual examination	R	None	None	None	Vermilion/cinnabar (?)	Yes (extensive)	-	-			-			-	-		-	-		Exposed parchment	-	-
		V																					
Bibliothèque nationale de France, MS Eth. Abb. 114, codex, second half of 17th century	Raman** (Wion 1999)	Not reported	Not analyzed	Vermilion/cinnabar	None	Not reported	Not reported	Carbon based	Indigo	None	None	Vermilion/cinnabar	None	None	Vermilion and white pigment (unidentified)	Orpiment	None	None	Organic green	None	Exposed parchment	None	Vermilion and carbon black
Brown University Library, Ms. Ethiopic 14--, codex, ca. 1730	XRF** (+)	10v	Iron-gall ink	Vermilion/cinnabar	None	Not reported	Not reported	-	-			Vermilion/cinnabar	Organic red	-	Vermilion and calcium-based white	Orpiment	Gold	Vermilion and orpiment	Copper based (malachite)	Vergaut	Exposed parchment	Calcium based (gypsum)	-
Walters Art Museum, W.835, codex, late 17th century	FTIR**, XRF, and FORS	60R	Not analyzed	Vermilion/cinnabar	None	Carbon based (?)	None	Carbon based (?)	Smalt	None	Indigo and anhydrite	Insect-origin lake (like kermes or lac)	Vermilion/cinnabar	None	Calcium-based white, vermilion/cinnabar, and orpiment	Orpiment	Orpiment and white (anhydrite)	Vermilion and orpiment	Copper green	None	Exposed parchment	Anhydrite	No data
		116R							None	Indigo and lead white													None
Biblioteca statale del Monumento nazionale di Grottaferrata, Crypt. Aet. 7, codex, 17th century	MSI and FORS** (Master's thesis)	Not reported	Carbon based	Cinnabar	None	Not illuminated		-	-			-			-	-			-		-		-

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			Black	Red	Others	Underdrawing	Blind ruling for illumination	Black	Blue 1	Blue 2	Grey	Red 1	Red 2	Red 3	Flesh	Yellow 1	Yellow 2	Orange	Green 1	Green 2	White 1	White 2	Brown
Walters Art Museum, 36.10, sənsul, late 17th century	Visual examination, XRF, and FORS	2V	Not analyzed	Vermilion/cinnabar	None	None	None	None	Indigo	None	Carbon-based black and anhydrite	Vermilion	None	None	Vermilion/cinnabar, anhydrite, and orpiment	Orpiment	None	None	Vergaut	None	Exposed parchment	Anhydrite	None
		3R									None												
		3V									Carbon-based black and anhydrite												
Melikian Collection, Melikian 389, codex, 1770s	Visual examination, XRF, and FORS	3R	Carbon based	Vermilion/cinnabar	*Vergaut* (indigo and orpiment)	Carbon-based black (?)	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
		6R							Indigo			Vermilion/cinnabar	Insect-origin dye (like kermes or Indian lac)	Insect-origin dye (like kermes or Indian lac)	No data	Orpiment		Vermilion and orpiment	Verdigris	Vergaut	Calcium based		Vermilion/cinnabar and iron earth
		8R							None						Insect-origin dye (like kermes or Indian lac)								
		17R							None						No data	None		None	None	None	None		None
University of Warsaw Library, Ms 1, Nr akc. 3510, codex, 18th–19th century	Visual examination, IR spectroscopy, Raman, SEM-EDS** (Liszewska and Tomaszewski 2016)	Not reported	Carbon based	Vermilion/cinnabar	None	Not reported		-	-			Organic red and earth pigment	None	None	-	-		-	-	-	-		-
University of Warsaw Library, Sygn. 3649, scroll, 19th century	Visual examination, IR spectroscopy, Raman, SEM-EDS** (Liszewska and Tomaszewski 2016)	R	Carbon based	Vermilion/cinnabar	None			-	-			Vermilion/cinnabar	None	None	-	-		-	-	-	-		-
Walters Art Museum, W.845, scroll, 19th century	Visual examination, XRF, and FORS	R	Carbon based	Vermilion/cinnabar	Organic and lead white	None	None	-	None			Vermilion/cinnabar	Iron earth and orpiment	None	None	Organic (flavonoid type)	None	None	None	None	Exposed parchment	None	None
Walters Art Museum, W.947, scroll, 19th or 20th century	Visual examination, XRF, and FORS	R	Carbon based and iron-gall ink	Vermilion/cinnabar	None	None	None	Carbon based	Indigo	None	None	Vermilion/cinnabar	None	None	None	Organic (flavonoid type) and iron earth	None	None	None	None	Exposed parchment	None	None

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			Black	Red	Others	Underdrawing	Blind ruling for illumination	Black	Blue 1	Blue 2	Grey	Red 1	Red 2	Red 3	Flesh	Yellow 1	Yellow 2	Orange	Green 1	Green 2	White 1	White 2	Brown
Walters Art Museum, W.954, scroll, 19th or 20th century	Visual examination, XRF, and FORS	R	Carbon based	Iron earth	None	None	None	No data	Indigo and verdigris	None	None	Iron oxide red	None	None	None	Organic (flavonoid type)	None	None	None	None	Exposed parchment	None	None
Musée du quai Branly, 73.1995.2.06, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Not reported			None	Organic yellow	None	None	Green earth	Not reported	Not reported		Hematite
Musée du quai Branly, 73.1995.2.62, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Smalt	None		Not reported			None	Organic yellow	None	Chrome orange	Not reported		Not reported		Organic
Musée du quai Branly, 73.1995.2.18, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Indigo	None		Vermilion	None		None	Not reported		None	Not reported		Not reported		None
Musée du quai Branly, 73.1995.2.21, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Vermilion	None		None	Organic yellow	None	None	Organic	Not reported	Not reported		None
Musée du quai Branly, 73.1995.2.22, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Indigo	None		Vermilion	None		None	Not reported		None	Not reported		Not reported		None
Musée du quai Branly, 73.1995.2.44, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Vermilion	None		None	Organic yellow	None	None	Copper green, green earth	Not reported	Not reported		None
Musée du quai Branly, 72.1995.2.66, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Vermilion	None		None	Organic yellow	None	None	Orpiment + organic (indigo)	Not reported	Not reported		None
Musée du quai Branly, 73.1995.2.25, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Vermilion and red lead	None		None	Orpiment	None	None	Green earth	Not reported	Not reported		None
Musée du quai Branly, 73.1995.2.64, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Indigo	None		Vermilion and red lead	None		None	Chrome yellow	None	None	Not reported		Not reported		None
Musée du quai Branly, 73.1995.2.34, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Hematite (iron oxide)	None		None	Organic yellow	None	None	Organic	Not reported	Not reported		None
Musée du quai Branly, 73.1995.2.17, scroll, 19th century	XRF and XRD** (Richardin et al. 2006)	R	Not reported			Not reported		Not reported	Not reported			Not reported			None	Organic yellow	None	None	Orpiment + organic blue (indigo)	Not reported	Not reported		None

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			Black	Red	Others	Underdrawing	Blind ruling for illumination	Black	Blue 1	Blue 2	Grey	Red 1	Red 2	Red 3	Flesh	Yellow 1	Yellow 2	Orange	Green 1	Green 2	White 1	White 2	Brown
Archivio storico dell'Emilia Romagna, no. 642, scroll, 19th–20th century	IRR, FTIR, and IBA** (Vadrucci et al. 2023)	R	Carbon based and iron-gall ink	None	None	Not reported		Carbon based and iron-gall ink	Not reported			Earth pigment and organic	None		None	Not reported		None	Not reported		Exposed parchment		None
Archivio storico dell'Emilia Romagna, no. 643, scroll, 19th–20th century	IRR, FTIR, and IBA** (Vadrucci et al. 2023)	R	Carbon based and iron-gall ink	None	None	Not reported		Carbon based and iron-gall ink	Not reported			Cinnabar and earth pigment	None		None	Not reported		None	Not reported		Exposed parchment		None
Archivio storico dell'Emilia Romagna, no. 644, scroll, 19th–20th century	IRR, FTIR, and IBA** (Vadrucci et al. 2023)	R	Carbon based and iron-gall ink	None	None	Not reported		Carbon based and iron-gall ink	Not reported			Cinnabar and earth pigment	None		None	Not reported		None	Not reported		Exposed parchment		None
Archivio storico dell'Emilia Romagna, without number, scroll, 19th–20th century	IRR, FTIR, and IBA** (Vadrucci et al. 2023)	R	Carbon based and iron-gall ink	None	None	Not reported		Carbon based and iron-gall ink	Not reported			Cinnabar and earth pigment	None		None	Yellow ochre	None	None	Not reported		Exposed parchment		None

*Analysis performed by former Walters Conservation Scientist Dr. Glenn Gates. **Analytical information collected from internal reports and publications. (") Karen Trentelman, Internal Analytical Reports on Ethiopian Gospel, 1480–1520 (Ms. 105) analyzed March 2010, and Ethiopian Gospel, 1504–1505 (Ms. 102), Technical Studies Research Laboratory, Getty Conservation Institute. Catherine Patterson, Internal Analytical Report on Ethiopian Gospel leaf, late 14th–early 15th century (Ms. 89) analyzed September 2015, Technical Studies Research Laboratory, Getty Conservation Institute. (+) Michele Derrick, Analytical Report, Ethiopian Illuminated Manuscript "Miracles of the Virgin Mary" (Ms. Ethiopic 14--) from the Brown University Library (NEDCC Job #13.215P), Scientific Research Laboratory, Museum of Fine Arts, Boston [4/10/2014].