

Cross-section Paint Microscopy Report
Interior Paints
Dining Room and Parlor

Eppington
Chesterfield County, VA

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Eppington



Purpose:

The goal of this project is to use cross-section microscopy and pigment analysis techniques to analyze paints from Period I Dining Room and the Period I Drawing Room at ca. 1770-73 Eppington. If coherent paint sequences survive then datable layers will be color-matched for replication using a colorimeter/microscope.

Procedures:

The samples were removed during one site visit on October 19, 200. The painted surfaces in the Dining Room and the Drawing Room were first examined at 30X magnification with a monocular field microscope. Several samples (about 200 microns in size) were removed from each area for cross-section microscopy analysis, pigment identification and color matching. Twenty-one samples were taken from representative areas of the Dining Room and 18 samples were taken from similar areas of the Drawing Room. At the lab these samples were first examined at 45X magnification with a binocular microscope and then the best samples were selected for analysis. This group of samples was cast into polyester resin cubes for permanent mounting. The cubes were ground and polished for cross-section microscopy analysis and photography. The sample preparation methods and analytical procedures are described in the reference section of this report.

The cast samples were analyzed with a Nikon Eclipse 80i epi-fluorescence microscope equipped with an EXFO X-Cite 120 Fluorescence Illumination System fiberoptic halogen light source and a polarizing light base using SPOT Advanced software (v. 4.6) for digital image capture and Adobe Photoshop CS for digital image management. Digital images of the best representative cross-sections are included in this report. Please note that the colors in the digital images are affected by the variability of color printing and do not accurately represent the actual colors.

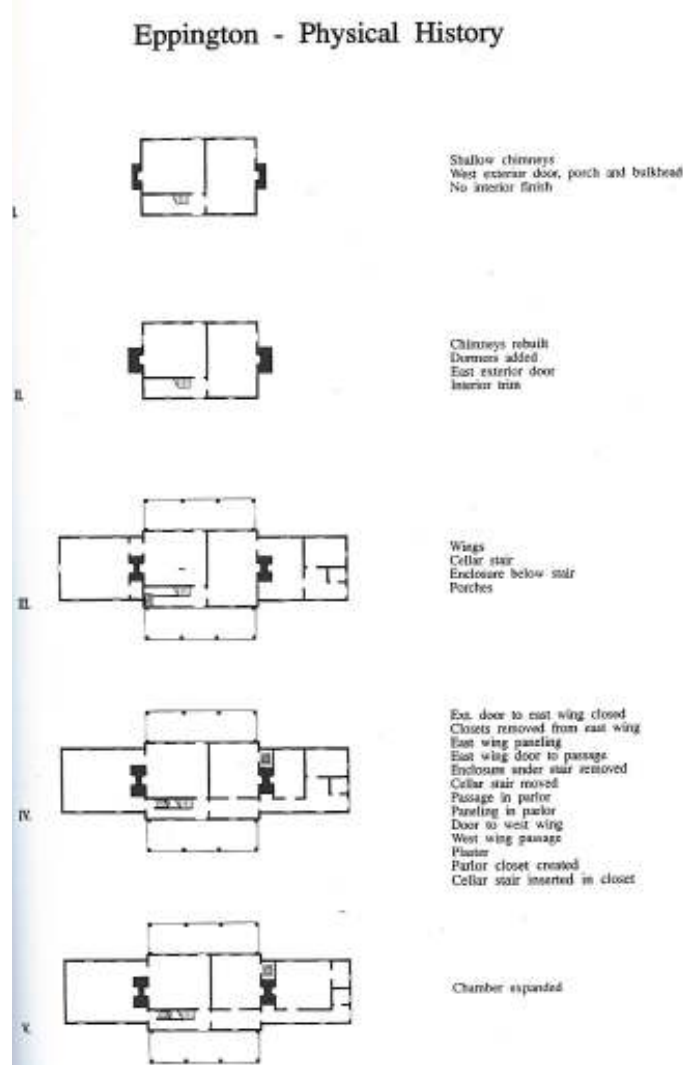
Background:

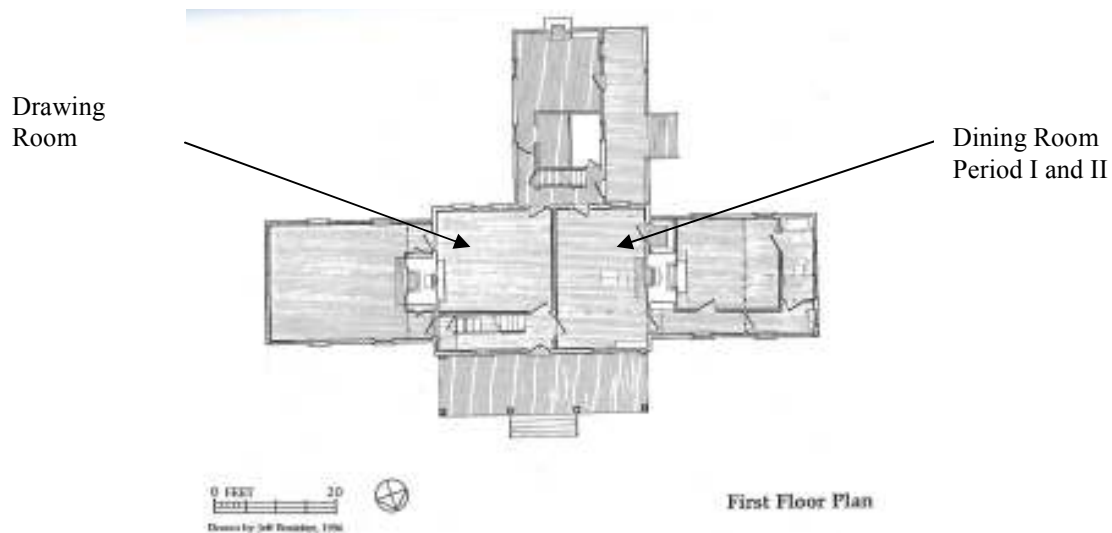
The evolution of Eppington has been thoroughly studied by Colonial Williamsburg Foundation architectural historians Mark R. Wenger, Edward A. Chappell and Willie Graham. The results of this research are compiled in an unpublished report “Eppington: An Architectural Study” dated May 15, 1995. The report has been a valuable resource for dating the paint layers on original architectural features compared to the paints on elements dating to later alterations. Floor plans for the building, as it was expanded during the five building periods identified by Wenger, Chappell and Graham, are very helpful in assessing how the expansions affected the configurations of the Dining Room and the Drawing Room. Because of the additions on three sides of the house, new door openings were created in both of these rooms, and woodwork elements were added and rearranged.

One of the key conclusions of the report was that the house was not finished on the interior in Period I: “Though the drawing room woodwork and related trim on the upper floors is not original to period I, they were clearly the first finishes to be installed at Eppington. There is not evidence of plaster or other finishes behind the drawing room cornice, nor behind the paneled surrounds of the second-floor fireplaces. That portion of the upstairs partition covered by the second-period attic stair has never been lathed and so proves that the space could not have been finished during initial construction. In fact most of the house – if not the entire structure – remained unplastered until Period IV.¹

¹ Wenger, Chappell and Graham. “Eppington: An Architectural History”, unpublished report for the Eppington Foundation, 1995. 14.

The drawings which show the building from Period I to Period V are reproduced as scanned images in this report for reference. The floor plan of the building as it is now is also included in this section as it is a helpful reference for sample locations.





Analysis Results:

This section of the report covers the comparative paint evidence found in the Dining Room and the Drawing Room. The Dining Room paint stratigraphies will be described and illustrated first, followed by the stratigraphies in the Drawing Room. Comparable elements – doors, plaster walls, architraves, windows, paneling – were sampled in each room, and it was expected that might be possible to relate specific layers found in one room with comparable layers found in the other room.

Dining Room.

Period I and II Dining Room

Period III and IV Parlor

The Colonial Williamsburg report “Eppington: An Architectural History” is particularly helpful in understanding the evolution of the Dining Room which was substantially altered in Periods III, IV and V. This room is part of the original construction of the house and was the dining room in Periods I and II (ca. 1770 and ca. 1783) and the parlor in Periods III and IV (ca. 1790 and ca. 1798-1802). The current form of the room, with doors on either side of the fireplace, dates to Period IV, ca. 1815, when the first-floor west chamber was added. But the architectural research for this room suggests that there was an east-west partition in place during Period IV, so the current configuration of the room does not exactly match any of the early identified periods.

Importantly, Wenger, Chappell and Graham’s research suggest the woodwork in this room was not installed until Period II and the room might not have been plastered until Period IV.

Twenty-one samples were removed from this room, and because the paints were never stripped or sanded during the later alterations it is possible to create a table of the paint layers in the room that shows the full stratigraphy of paints on the original elements to identify specific the layers that relate to the additions and alterations. Photomicrographs

of the cross-section samples which best illustrate the complete paint stratigraphy, as well as the later replacements, are included at the end of this section.

West Chimney Wall



Original opening to the exterior on the west wall



South Wall



Original board on plaster wall



Later Bookcase in Northwest Corner



Cornice Above Door on East Wall



Dining Room Woodwork. The most intact woodwork cross-section (sample 13 from the stair hall door architrave) contains approximately 16 generations of paint. The woodwork paint color sequences begin with a verdigris-based green paint on a gray primer which would have produced a glossy green woodwork color. This is a typical period practice – verdigris is a translucent pigment so verdigris-based green glazes and finish coats were almost always applied on top of green, gray or blue base coats to enhance the green color of the finish coat. The subsequent two generations are tannish-yellow, followed by three more verdigris-based green paints. In generation 11 the room was painted medium blue-green, which is similar to the current room color.

Interestingly, comparisons of the paint evidence on the applied board on the south wall (sample 19), with the other original woodwork, confirms that the first generation of bright green verdigris-based paint was also used on this board. This shows that the board is original to the room and may have been used to support a large frame or a mirror. The paint history on one window muntin (sample 18) is missing all the early green paint layers, but it is notoriously difficult to obtain intact samples from window sashes as they are subject to movement, condensation, reglazing and reputtying, all of which compromises the paint evidence.

The stratigraphy on the mantel shelf (sample 1) begins with a much later shellac layer, followed by yellow paint. This sample may be incomplete because it was from a relatively exposed location. It is more likely that the mantel shelf was painted with the same early greens to match the paneling, similar to the treatment of the mantel shelf in the adjacent Drawing Room. The uppermost glossy, clear layer on the surface of most of the samples from the woodwork is a consolidant layer applied by the Chesterfield County maintenance department to help contain the flaking paint and limit the amount of lead paint particles in the air.

Dining Room Woodwork Paint Sequence

<u>Layer</u>		<u>Generation</u>
Clear consolidant		
Blue-green paint	16	
Bright blue-green	15	
Medium yellow paint	14	Paints on bookcase begin here
Medium yellow paint	13	
Medium yellow primer	13	
Thick white paint	12	Paints on window muntins start here
Plant resin varnish	11	
Pinkish-tan paint	11	
Medium blue-green paint	10	
Blue-green paint	9	
Plant resin varnish	8	
Thin yellowish-green paint	7	
Plant resin varnish	6	
Yellowish-green paint	6	
Plant resin varnish	5	
Green finish coat	5	
Off-white base coat	5	
Verdigris-based green finish	4	
Light green verdigris-based primer	4	
Tannish paint	3	Period IV paint layer
Tannish-yellow paint	2	
Verdigris-based green finish**	1	
Gray primer*	1	Begins at Period II

* Original primer on the cornice, fireplace paneling, architraves, board on south wall, likely sash and mantel shelf. Baseboards and doors are dark red-brown.

** Original paint on the cornice, fireplace paneling, architraves, board on south wall, likely sash and mantel shelf.

Sample 13. Dining Room. East wall, left architrave for door to hall, about 5-feet up.
Complete woodwork paint chronology
Visible Light 100X



Original verdigris-based finish coat on gray primer

Dining Room Doors and Baseboards. Samples taken from the doors in the room show that they were originally deep brown, followed by a series of pigmented varnishes, shellac, dark gray and more pigmented varnishes (see sample 7 from the inner surface of the closet door). The doors were repainted less frequently than the rest of the room, but the evidence on all elements may not line up exactly because of the room alterations and because the doors were not generally painted the same color as the woodwork. The doors were eventually painted deep yellow to match the rest of the woodwork in generation 14, followed two coatings of the most recent finely ground, evenly mixed twentieth-century blue-green paints. The graining that can be observed on the closet side surface of the door to the left of the fireplace is quite recent – it is concurrent with the fifteenth generation of paint in the rest of the room.

The original paint layer on the earliest doors in the room (sample 7 from the closet side of the door to the south of the fireplace and sample 15 from the east wall door leading to the stair hall) is a coarsely ground deep red-brown paint. The closet door on the west wall was turned around but is in a Period I exterior opening. The evidence in samples 6 and 7 from this door show that the side now facing the room was originally the exterior surface because of the evidence of weathering. The same deep red-brown paint layer was found in sample 5, from the door in the northwest corner of the west wall, which is a Period IV installation, but it may have been moved from another area of the house because it retains the earliest red-brown paint layer, as well as the later pigmented varnishes.

The early baseboard paints can be aligned with the door paints, so the baseboards in the Dining Room were originally deep red brown, followed by several pigmented shellac layers, and then they were painted dark gray, like the doors, in generation 6.

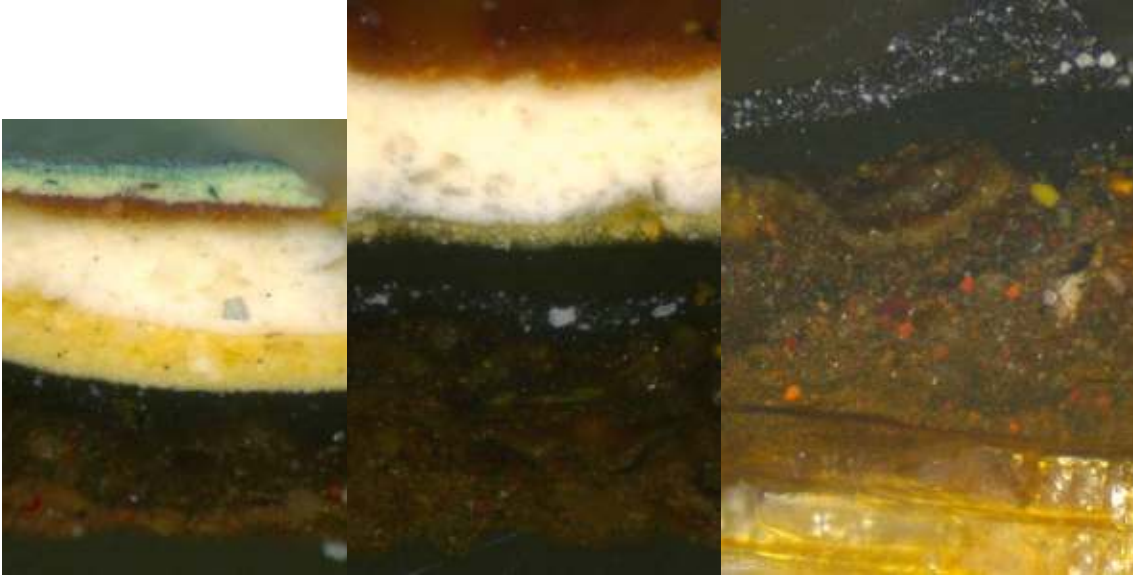
Dining Room Door Paint Comparison

Door in NW corner

West wall closet door

East wall, stair hall door

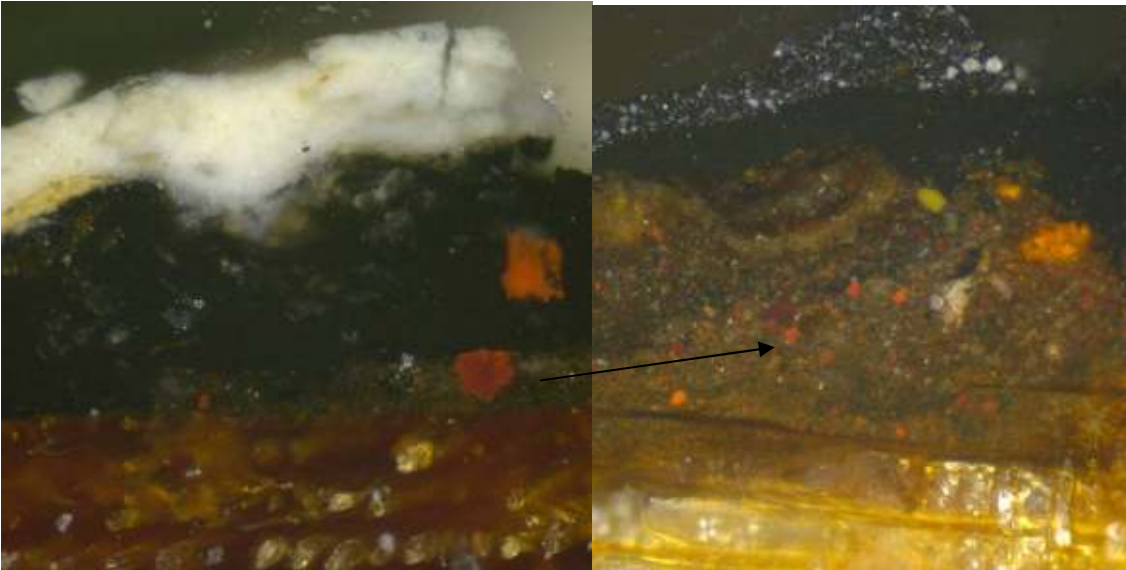
First deep red-brown paint layer found in all three samples



Baseboard sample compared to stair hall door sample

Baseboard

East wall stair hall door



Dining Room Plaster. One important wall plaster cross-section (sample 20) shows that the plaster in the Dining Room was originally coated with an unpigmented limewash on top of a sandy white plaster substrate. This was followed by eight more generations of traditional unpigmented limewash on the walls. The most recent thick white paint on the walls was likely applied to simulate limewash. Wenger, Chappell and Graham suggest the plaster was not completed until Period IV, so perhaps the most appropriate paint scheme for interpretation of this room are the Period IV paint layers which would include white limewashed walls, red-brown doors and baseboards and a verdigris-based bright green paint. This is similar to the original Period II paint scheme, except the room may not have been plastered at that point.

Sample 1. Dining Room. West wall, fireplace wall, leading edge of mantel shelf, about 3-inches from right corner.

Visible Light 200X



Ultraviolet Light 200X



Modern sealant layer

Later shellac layer on shelf

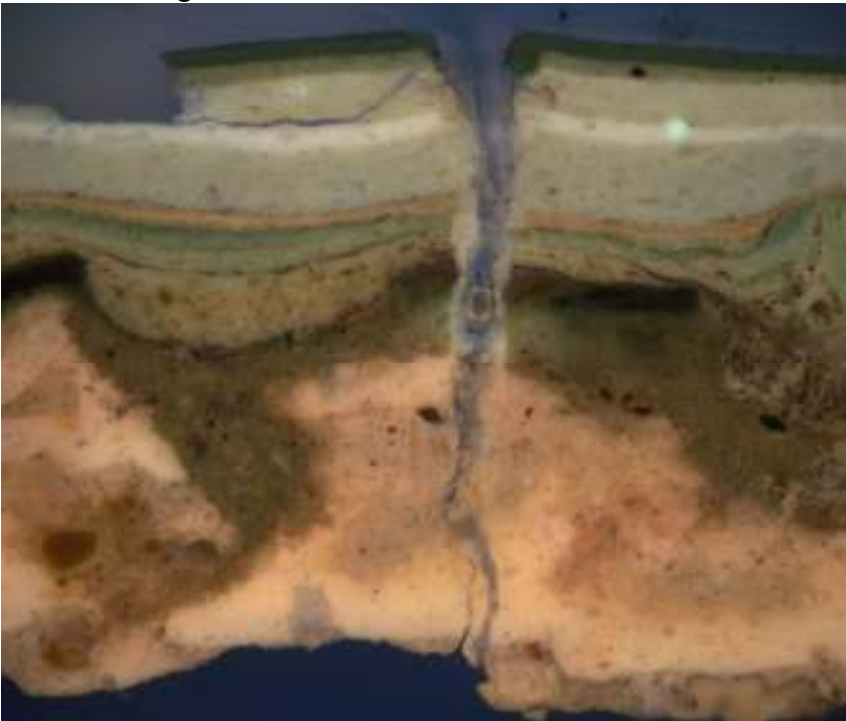
Sample 2. Dining Room. West wall, panel just right of fireplace, at lower edge where quarter-round molding meets chamfered edge of raised panel.

Visible Light 100X



← Early paint layers are disrupted, perhaps due to heat exposure from the fireplace

Ultraviolet Light 100X



Sample 4. Dining Room. West wall, NW corner, outer band of door architrave, left side, about 4-feet up, at cove molding.

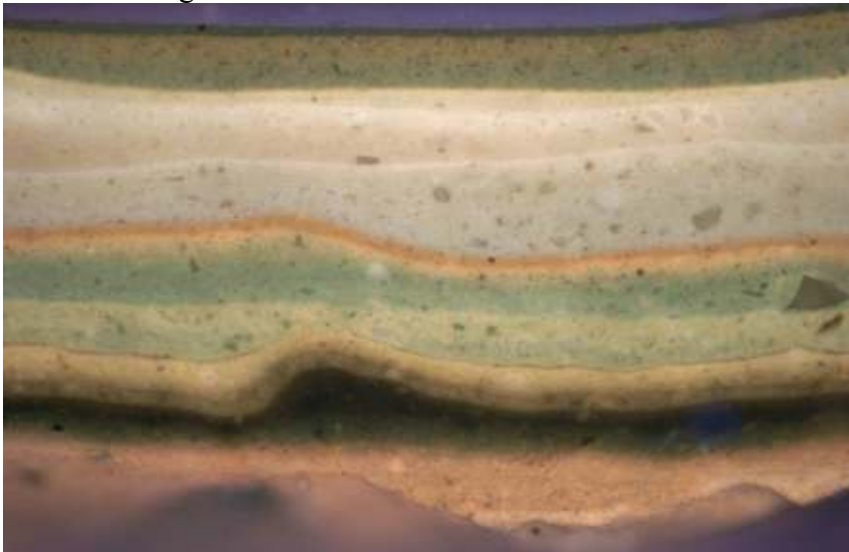
Visible Light 100X



Four more generations of bright green paint begin at generation 4

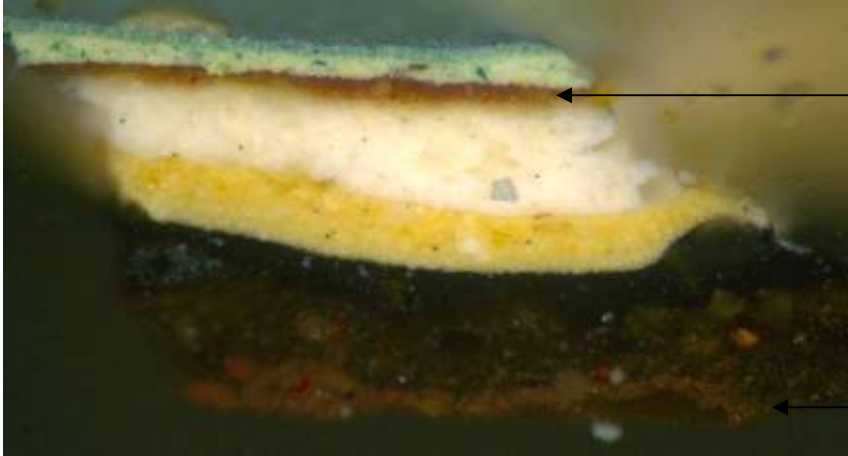
Original gray primer, but the verdigris-based green finish coat is missing in this sample

Ultraviolet Light 100X



Sample 5. Dining Room. West wall, door in NW corner, upper left corner, lower left panel.

Visible Light 100X



Late grain-painting on the door just before the room was painted blue-green

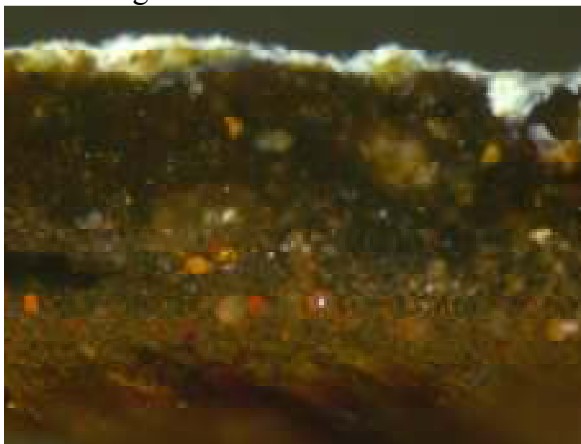
Paint on later door begins with deep red-brown

Ultraviolet Light 100X



Sample 6. West wall, closet door left of fireplace (turned around), room-side surface, lower left corner of middle left panel. (This surface is very weathered, formerly exposed as an exterior door.)

Visible Light 200X



Ultraviolet Light 200X



Sample 7. Dining Room. West wall, door left of fireplace, inner closet surface, lower left corner of middle left panel, currently has a dark graining.

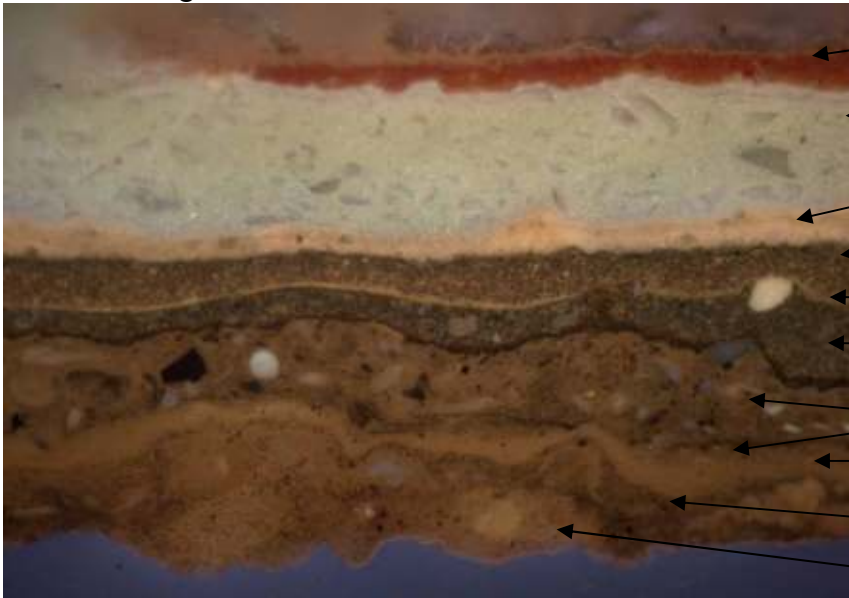
Visible Light 200X



← Most recent grain-painting also found in sample 6

← First layer of dark red-brown door paint

Ultraviolet Light 200X



← 10. Graining glaze with shellac coating

← 10. Graining base coat

← 9. Yellow

← 8. Pigmented varnish

← 7. Shellac

← 6. Dark gray

← 4. & 5. Pigmented shellac

← 3. Shellac

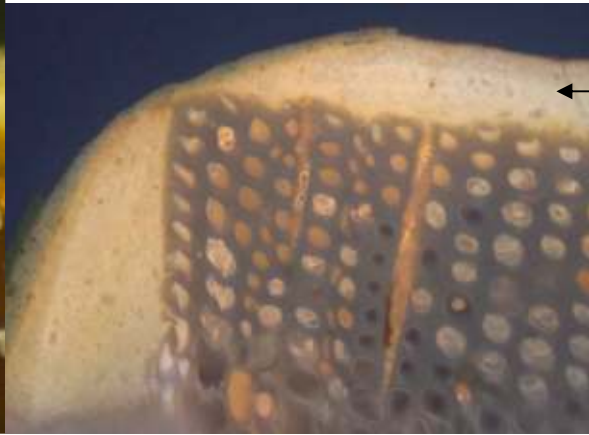
← 2. Pigmented shellac

← 1. Red-brown paint

Sample 10. Dining Room. North wall, NW corner, later bookcase, front edge, top shelf, left side.

Visible Light 200X

Ultraviolet Light 200X

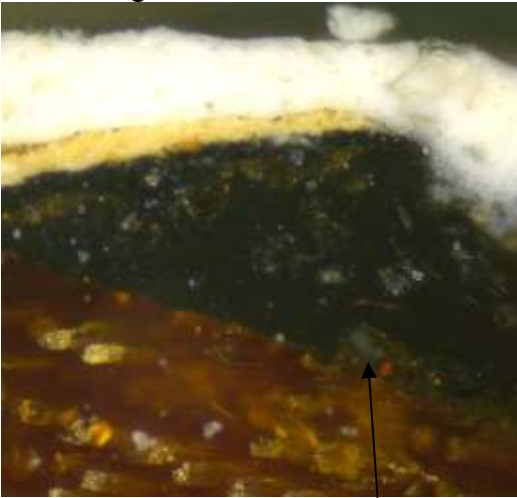


Generation
14

Sample 11. Dining Room. North wall baseboard, 3-feet left of east wall, just below top bead molding.

Visible Light 200X

Ultraviolet Light 200X



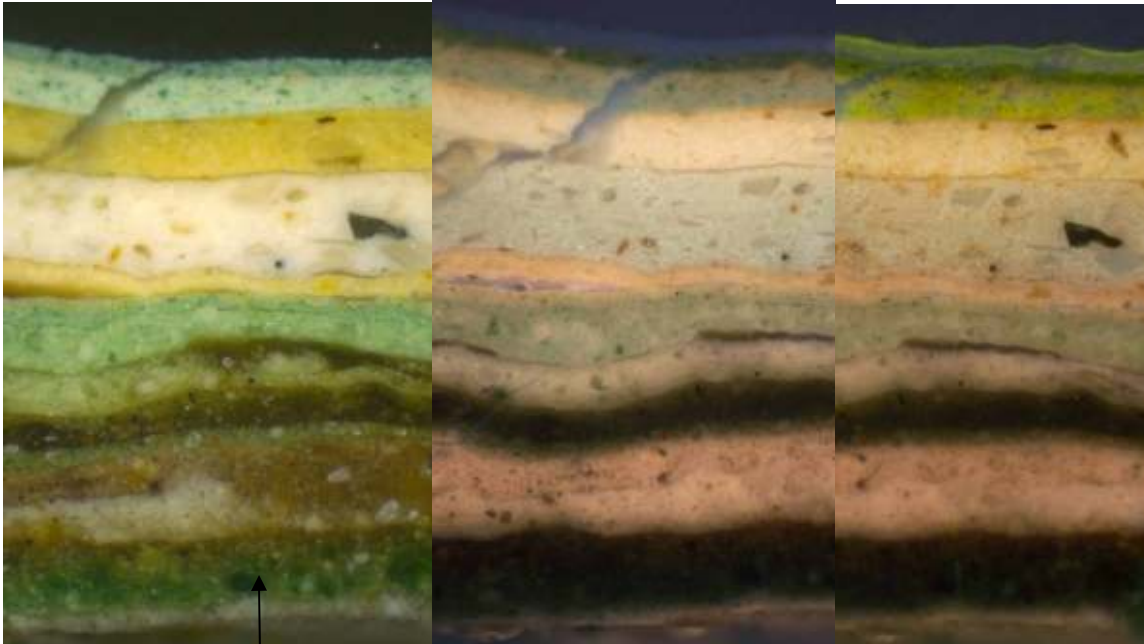
Original deep red paint

Sample 12. Dining Room. North wall window, right architrave, outer molding about 5-feet up from floor.

Visible Light 200X

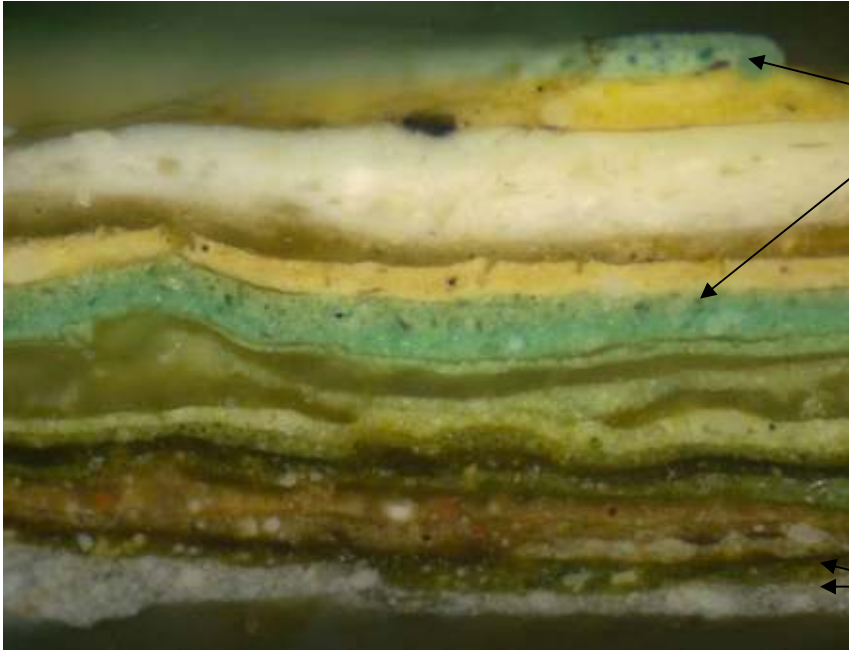
Ultraviolet Light 200X

UV & DCF 200X
For Lipids



Excellent example of intact
original verdigris-based green
paint

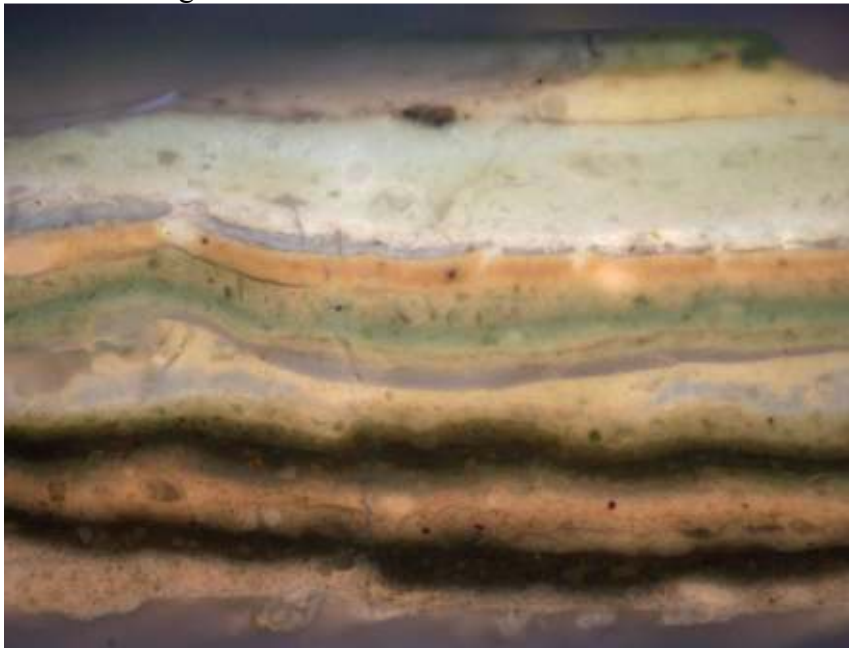
Sample 13. Dining Room. East wall, left architrave for door to hall, about 5-feet up.
Visible Light 100X



The most recent paint color may have been intended to mimic the blue-green paint in generation 11

Original gray primer with bright green finish coating

Ultraviolet Light 200X

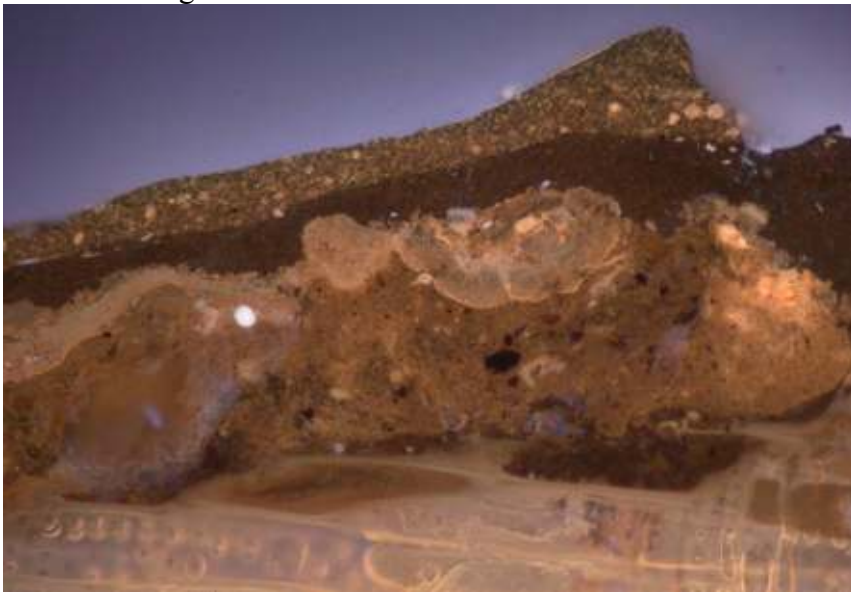


Sample 15. Dining Room. East wall door, upper left corner of middle left panel.
Visible Light 200X



← Earliest red-brown
paint on the original
door to the passage

Ultraviolet Light 200X

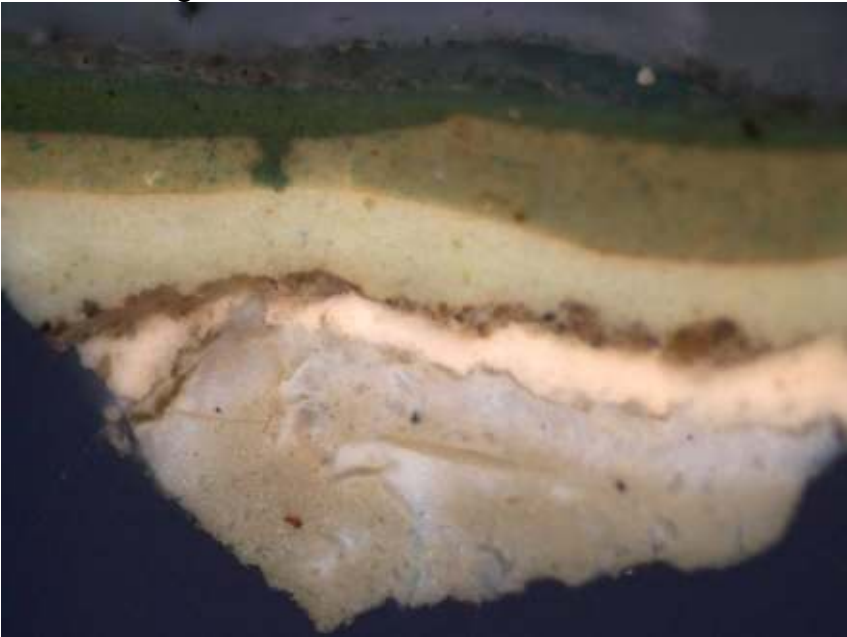


Sample 18. Dining Room. South wall, window muntin, lower right pane, left side.

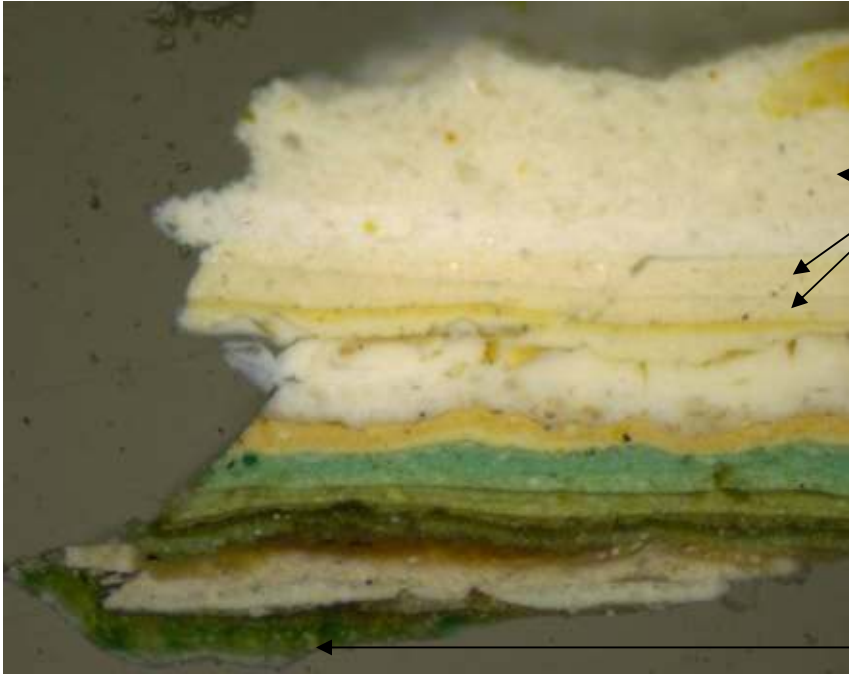


← Early paints missing from the window muntin

Ultraviolet Light 200X



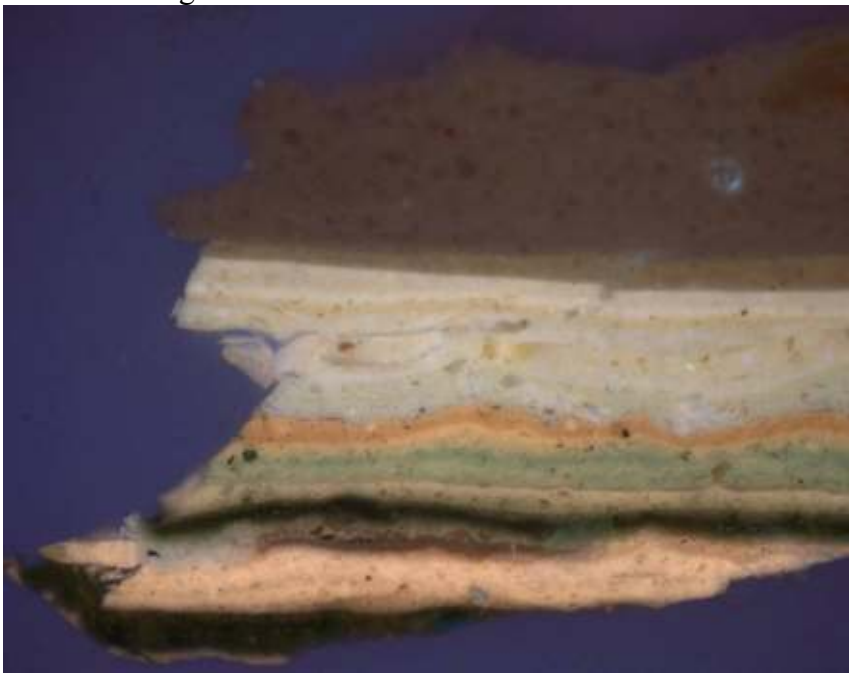
19. Dining Room. South wall, applied board with iron fitting.
Visible Light 100X



Later wall paints
on top of board

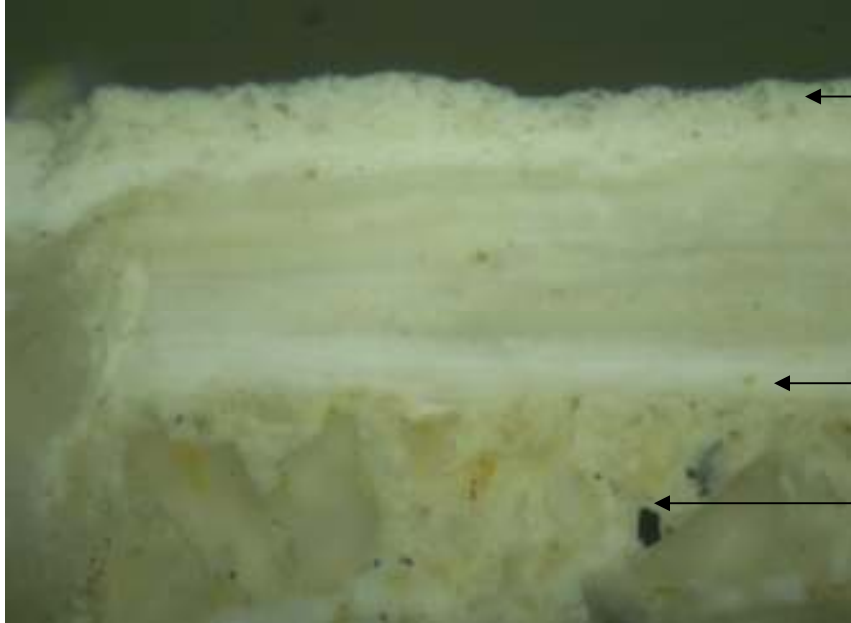
Original bright green
verdigris-based paint on
top of a gray primer

Ultraviolet Light 100X



Sample 20. Dining Room. North wall, east of window, at long crack in plaster about 5-feet up from the floor.

Visible Light 100X



← Most recent white wall paint

← First thin unpigmented limewash layer

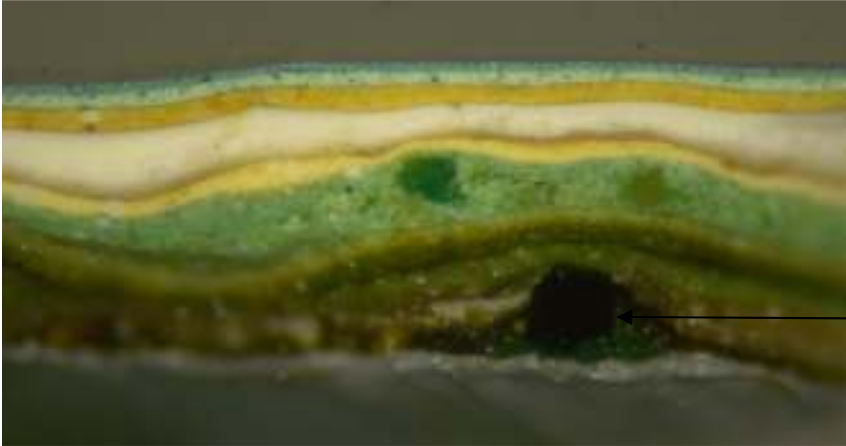
← Sandy white plaster substrate

Ultraviolet Light 100X



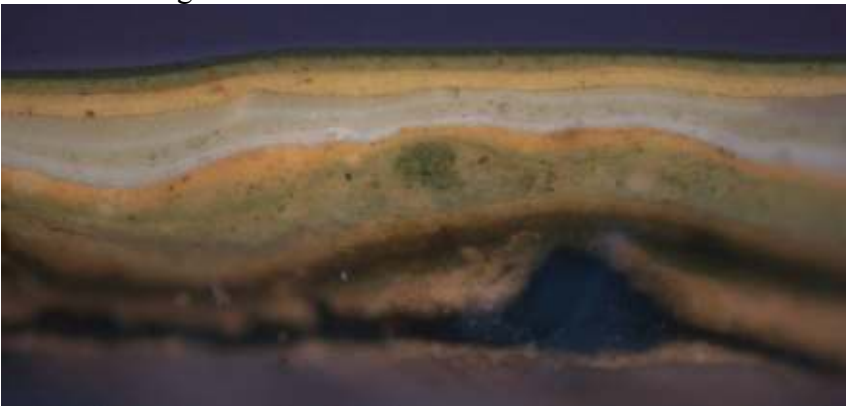
Sample 21. Dining Room. East wall, cornice above door, narrow fillet below uppermost quarter round molding.

Visible Light 100X



Large chunk of
verdigris pigment in
original green paint

Ultraviolet Light 100X



Drawing Room (Parlor).

Like the Dining Room, the paint sequences in the Drawing Room date to Period II, based on the interpretation of the interior woodwork not being completed until Period II. The Colonial Williamsburg Architectural Research Department report calls this room the “Hall” in Periods I and II and the Drawing Room beginning in Period III. In Period III a door was inserted on the east wall, to the right of the fireplace, to lead to a newly constructed east wing room which became a large dining room, according to Wenger, Chappell and Graham. The door opening on the south wall dates to Period I and originally led to a rear porch.

The comparative paint evidence suggests that the Drawing Room was originally painted blue-gray in two separate generations, with initially unplastered walls (followed by whitewashed walls) and deep brown-painted doors. The most complete sequences representing the woodwork paints are in samples 16 (from a chair board) and 18 (from a north wall door architrave). There are approximately twelve generations of woodwork paints in the room and fifteen generations of unpigmented limewashes on the ceiling and walls. The current light blue-green color on the walls did not appear until generation 14, so it is a late twentieth-century application.

Drawing Room Northwest Corner



Northeast Corner



Drawing Room Woodwork. This space retains virtually all its paint evidence, although the paints on the windows are quite disrupted. Interestingly, the woodwork in this room was painted green in generations 4 through 9, but they are different greens than the ones found in the Period I Dining Room. The full paint stratigraphy on the Drawing Room woodwork can be reconstructed from the evidence in the various samples from this room, as shown in the following chart. The paint sequence on the window muntins is incomplete, but it is likely that the sash were painted blue-gray to match the window architraves early on.

Drawing Room Woodwork Paint Sequence

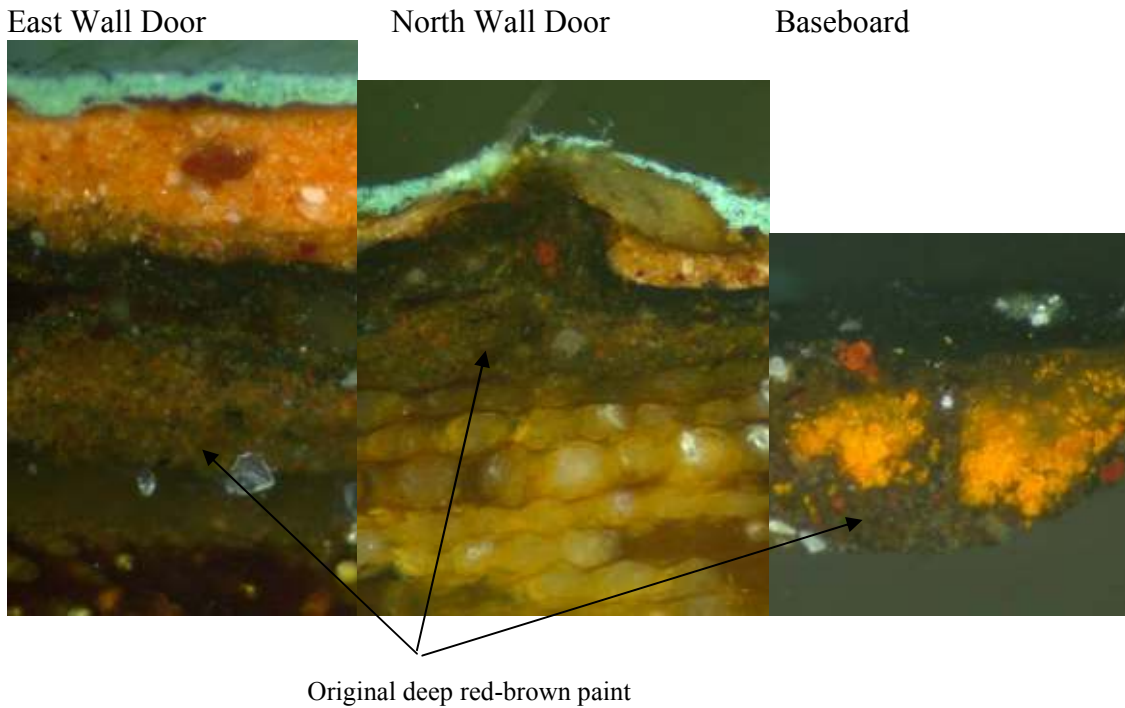
<u>Layer</u>	<u>Generation</u>	
Clear consolidant		
Blue green paint	12	
Bright green paint	11	
Varnish	10	
Verdigris-based green paint	10	
Varnish	9	
Medium yellow paint	9	
Blue-green paint	8	
Off-white translucent primer	7	
Deep yellow paint	6	
Yellowish-green paint	5	
Blue-green paint	4	
Light blue-gray paint	3	Period IV
Blue-gray paint	2	
Light blue-gray primer	2	
Blue-gray paint	1	Begins at Period II. Doors, baseboards are red-brown

Sample 18. Drawing Room. North wall, architrave for door, left side, just below top of wainscoting.

Visible Light 200X

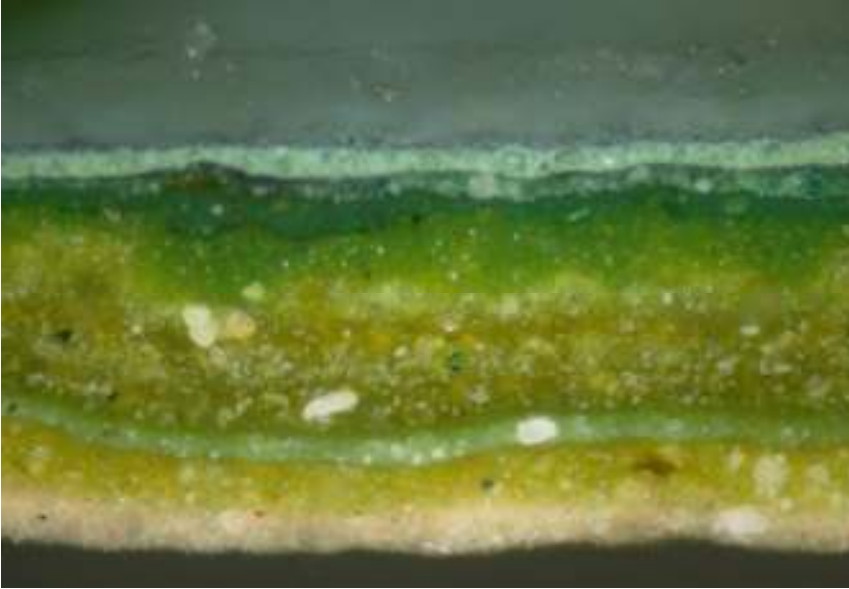


Drawing Room Doors and Baseboards. The comparative evidence suggests that the original paint on the early door and baseboards is the same deep red-brown paint found in the adjacent Dining Room. The baseboard sample is more disrupted than the door samples, but remnants of the first deep red-brown layer are still present. The paint history on the east wall door, which was added in Period III when the east wing was constructed, is essentially the same as the original north wall door paint history, which suggests it is a Period I door that was relocated in Period III. The baseboards start with the same deep red-brown paint as the doors, showing that this element was originally picked out as a different color than the blue-gray paneling.

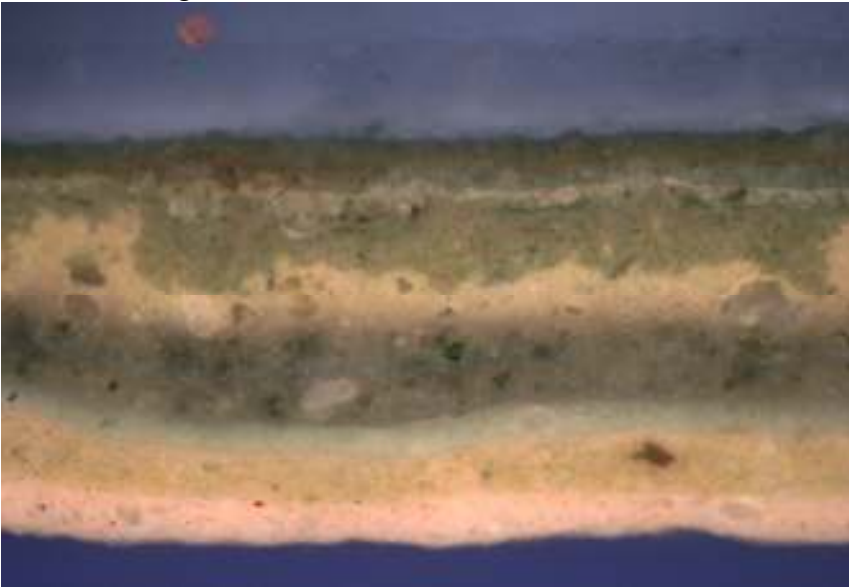


Drawing Room Plaster. Samples taken from different areas of plaster, and from the soffit of the cornice, show that there are up to fifteen generations of unpigmented limewash in some areas, followed by the uppermost opaque blue-green paint now on the walls. The soffit of the cornice (sample 7) was initially coated with at least two of the original blue-gray paints, followed by two generations of limewash, and then a thin deep red layer not found elsewhere in the room. The uppermost four generations of paint – dark gray, light red, off-white, and blue-green) can only be aligned with the woodwork paints in the last blue-green paint layer. This is quite different from the paints on the cornice in the Dining Room which are the same as the paneling paints throughout the paint sequence. Other areas of the cornice should be rechecked before the room is reinterpreted, but the cornice painting does follow the pattern of matching the woodwork paint color for at least the first two paint generations. One sample from the ceiling plaster (sample 8) shows that there are approximately fifteen generations of unpigmented limewash on the ceiling as well as the walls.

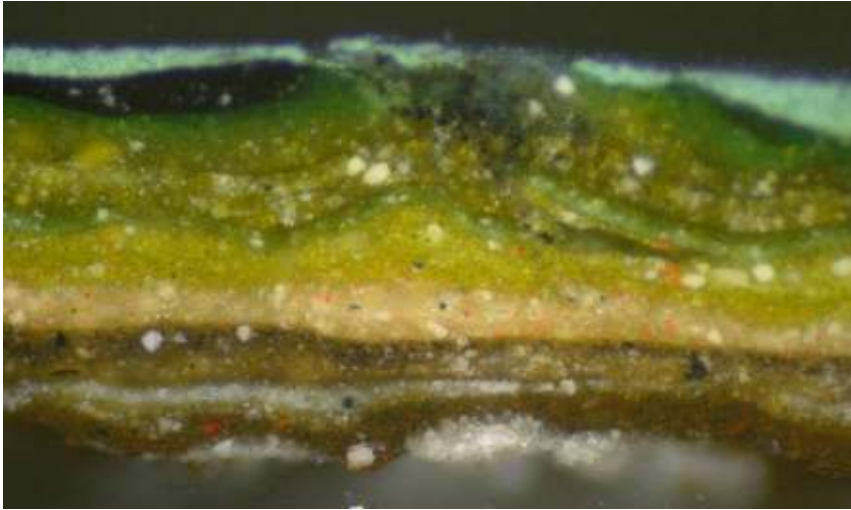
Sample 1. Drawing Room. East wall, frieze of mantel, right side, below shelf.
Visible Light 200X



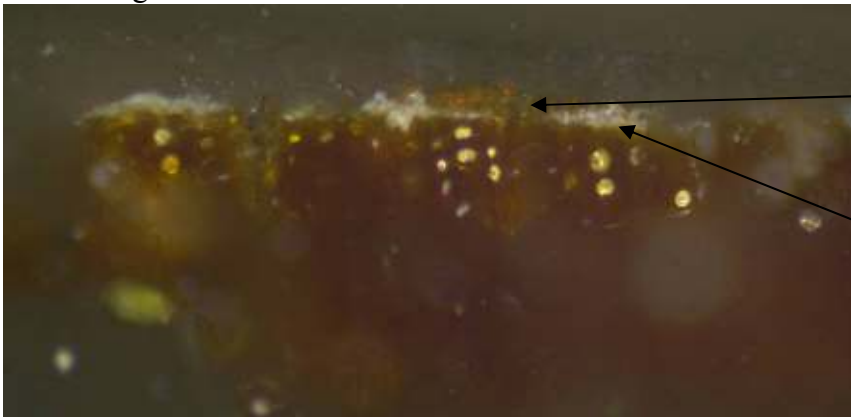
Ultraviolet Light 200X



Sample 2. Drawing Room. East wall, leading edge of mantel shelf, right side.
Visible Light 200X Detached paints



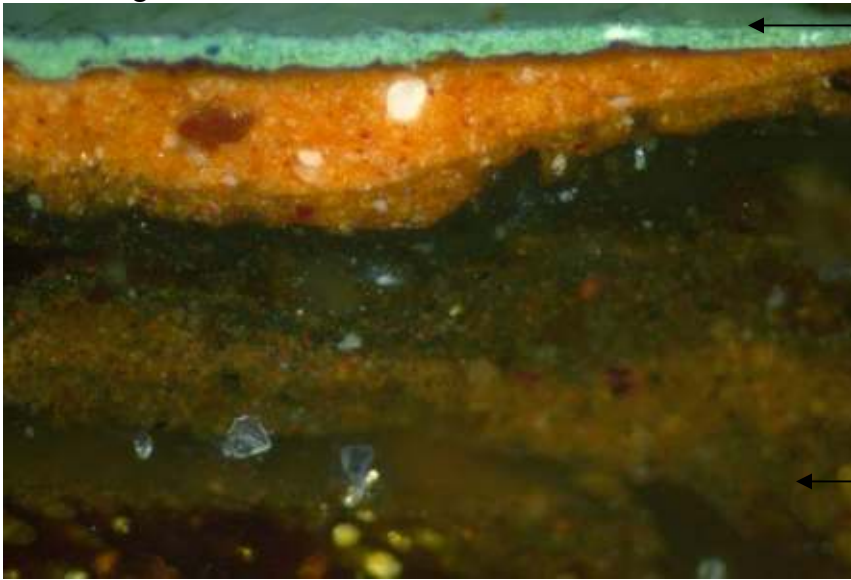
Visible Light 200X Wood substrate



Second red-brown
paint on the mantel
shelf

Remnants of first
blue-gray paint

Sample 4. Drawing Room. East wall door, upper left corner of left panel.
Visible Light 100X



Current blue-green paint

First deep brown paint layer

Ultraviolet Light 100X

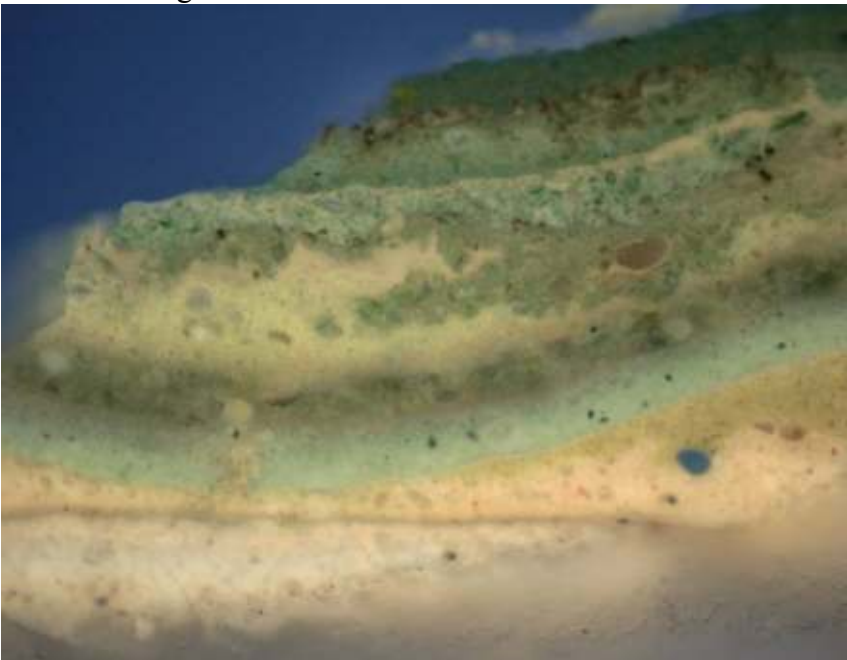


Sample 5. Drawing Room. East wall, left door architrave, about 3-feet up from floor.
Visible Light 200X



First light blue-gray
paint layer

Ultraviolet Light 200X



Sample 6. Drawing Room. North wall, NE corner, plaster above wainscot at join of fireplace wall.

Visible Light 100X



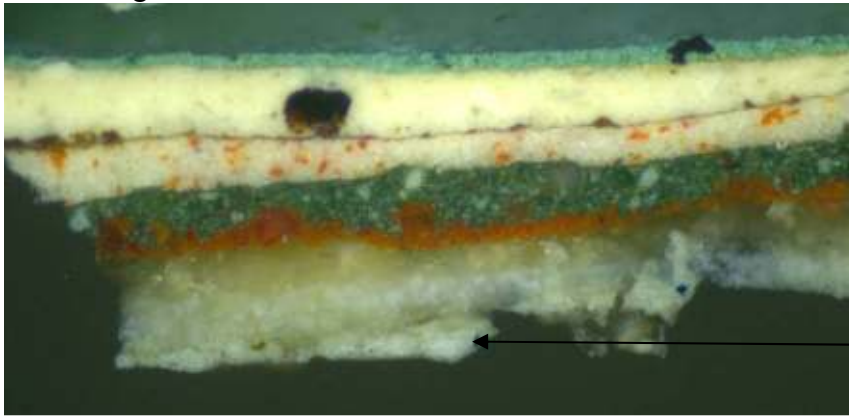
Ultraviolet Light 100X



← Approximately 10 generations of unpigmented limewashes

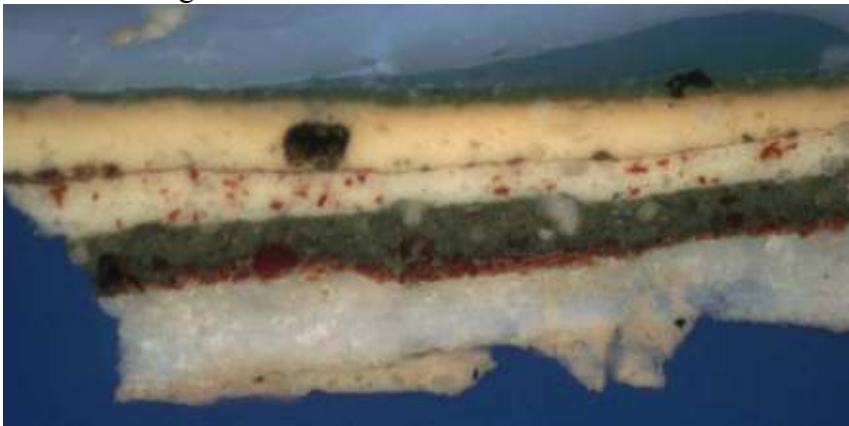
Sample 7. Drawing Room. East wall, soffit of cornice in SE corner.

Visible Light 200X

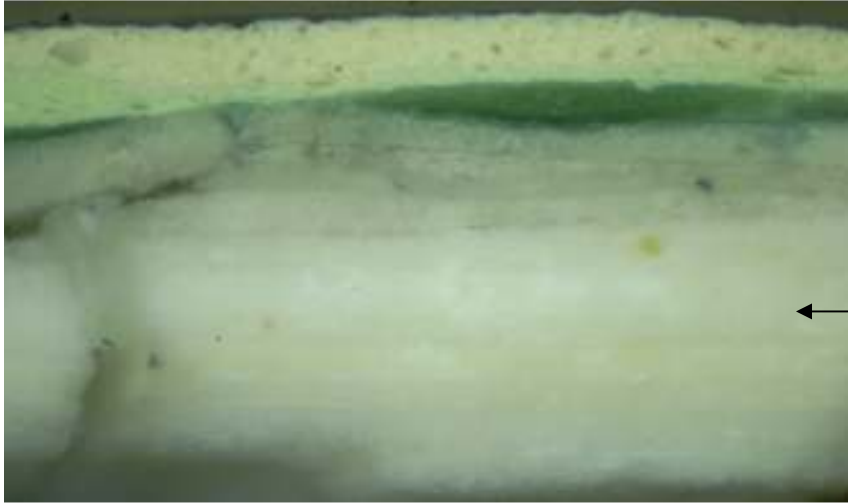


← Remnant of first blue-gray paint

Ultraviolet Light 200X

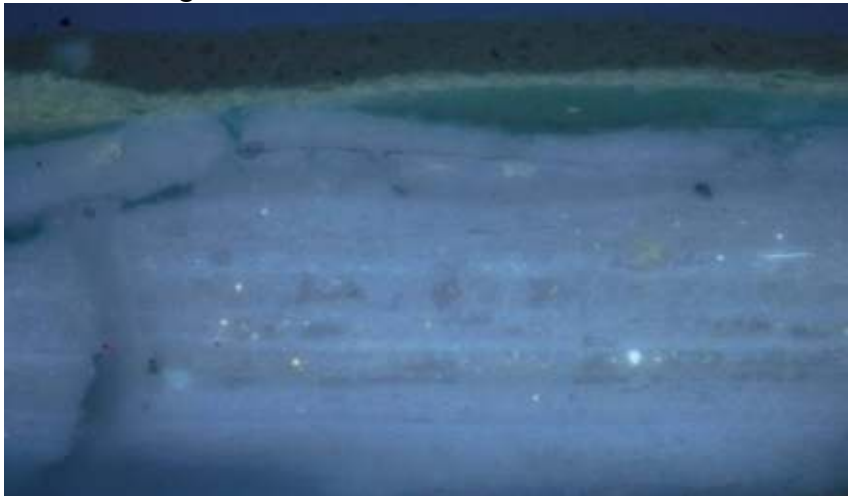


Sample 8. Drawing Room. SE corner, ceiling plaster, multiple limewashes.
Visible Light 100X

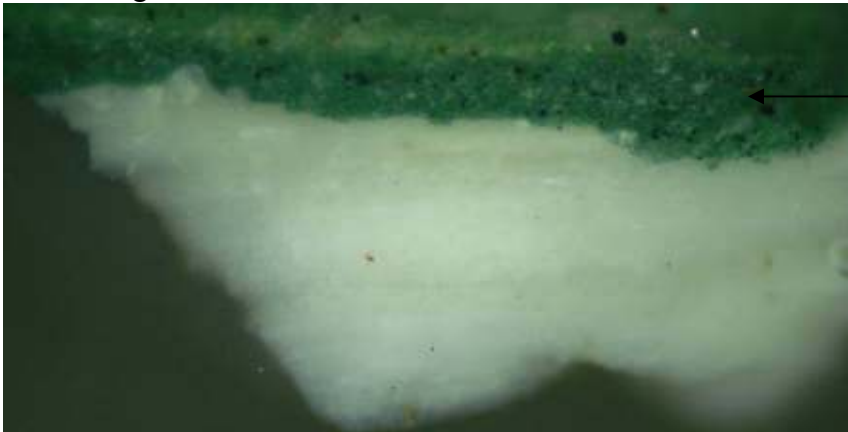


Long sequence of unpigmented limewashes

Ultraviolet Light 100X



Sample 9. Drawing Room. SE corner, plaster wall at crack, directly above chair board.
Visible Light 100X



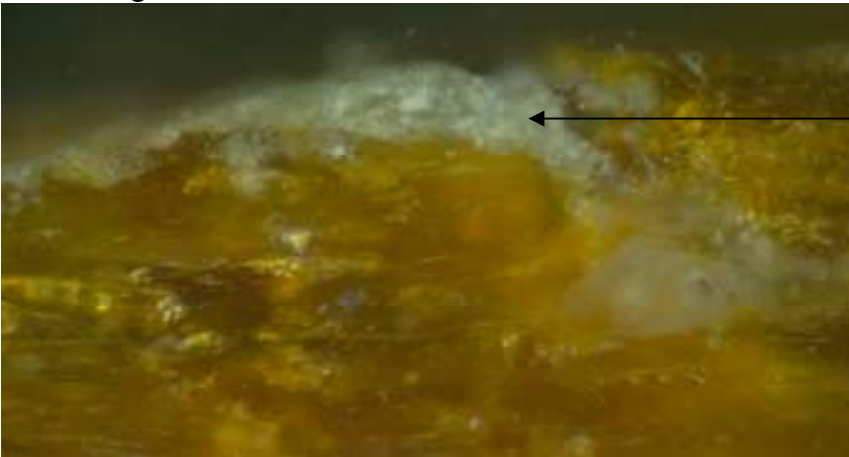
Current blue-green wall paint above at least 13 generations of unpigmented limewash

Sample 10. Drawing Room. South wall, east window, west architrave, about 1-foot above sill.

Visible Light 200X Detached paint flake



Visible Light 200X Wood substrate



Original blue-gray
paint on the wood
substrate

Sample 11. Drawing Room. South wall, east window, sash.
Visible Light 200X



← Only later paints on the sash

Ultraviolet Light 200X



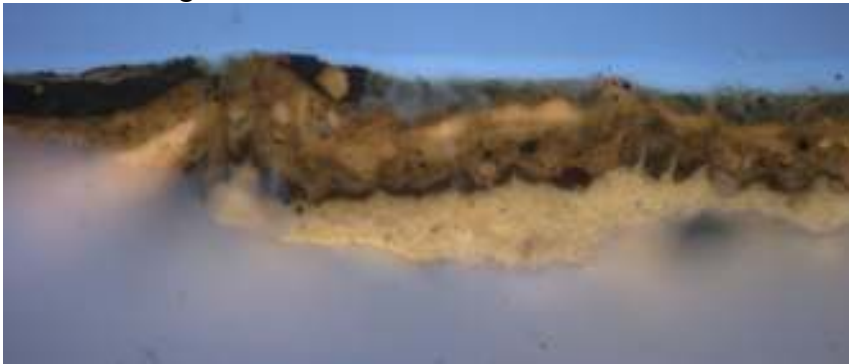
Sample 12. Drawing Room. South wall, top of molding of wainscoting, between two windows, about 6-inches left of west window.

Visible Light 200X



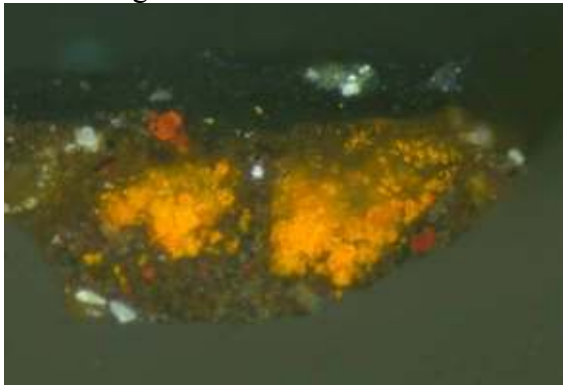
← Remnant of first blue-gray paint

Ultraviolet Light 200X



Sample 13. Drawing Room. East wall, baseboard, right of fireplace.

Visible Light 200X

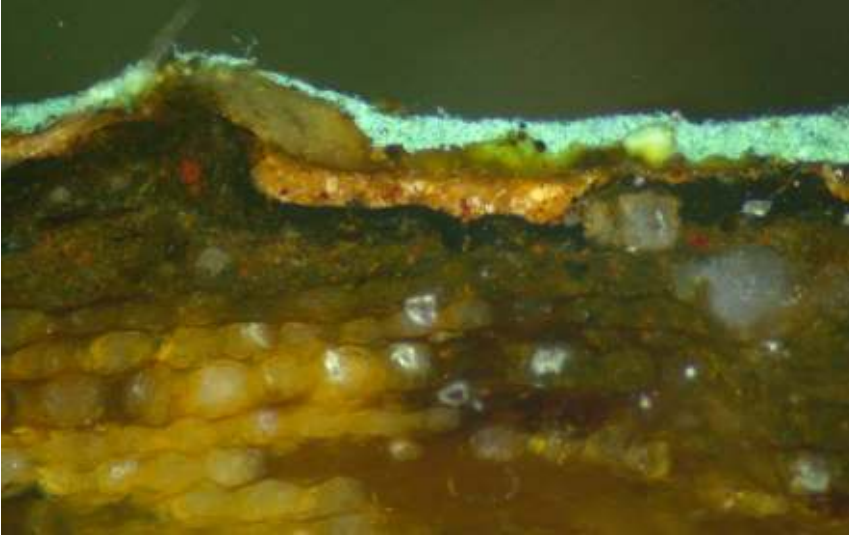


Ultraviolet Light 200X



Sample 14. Drawing Room. North wall, door in NW corner, upper left corner of upper left panel, room-side surface.

Visible Light 200X



Ultraviolet Light 200X



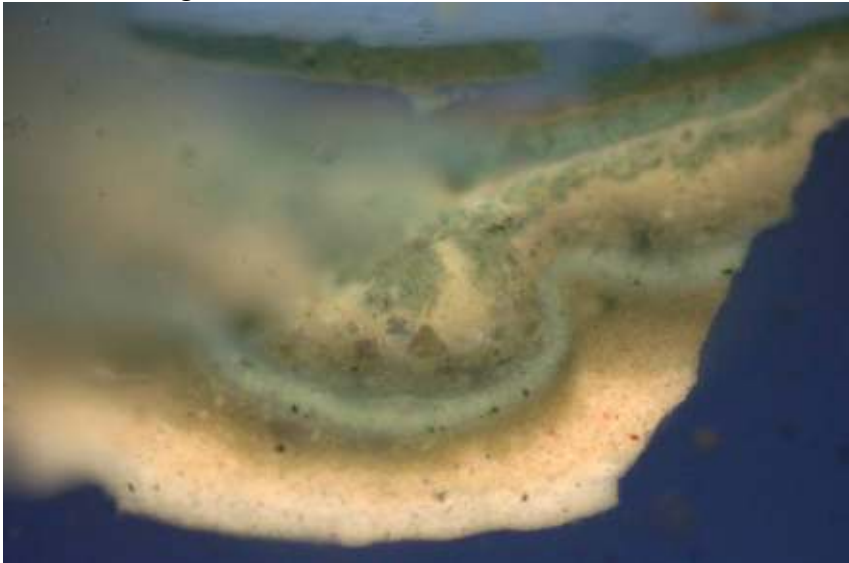
Sample 15. Drawing Room. South wall, door architrave, left side, about 3-feet up from floor.

Visible Light 200X



Original blue-gray paint

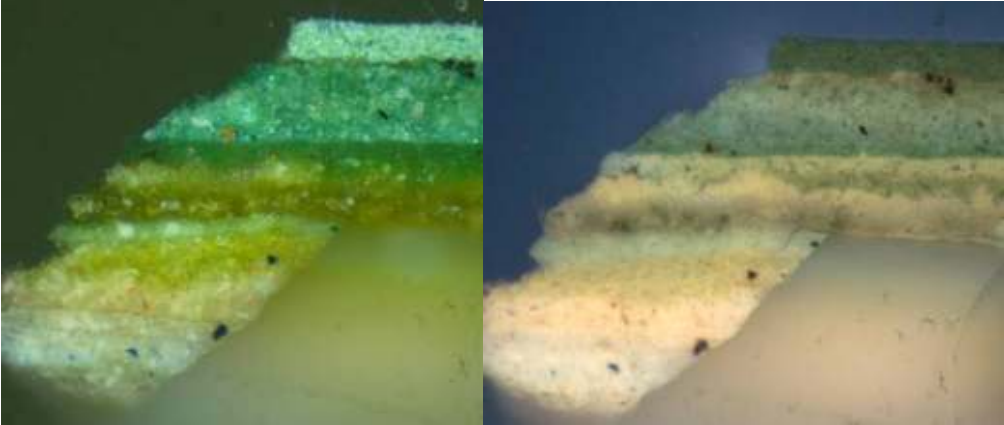
Ultraviolet Light 200X



Sample 16. Drawing Room. North wall, fillet molding below surbase, about 3-feet right of door in NW corner.

Visible Light 200X

Ultraviolet Light 200X



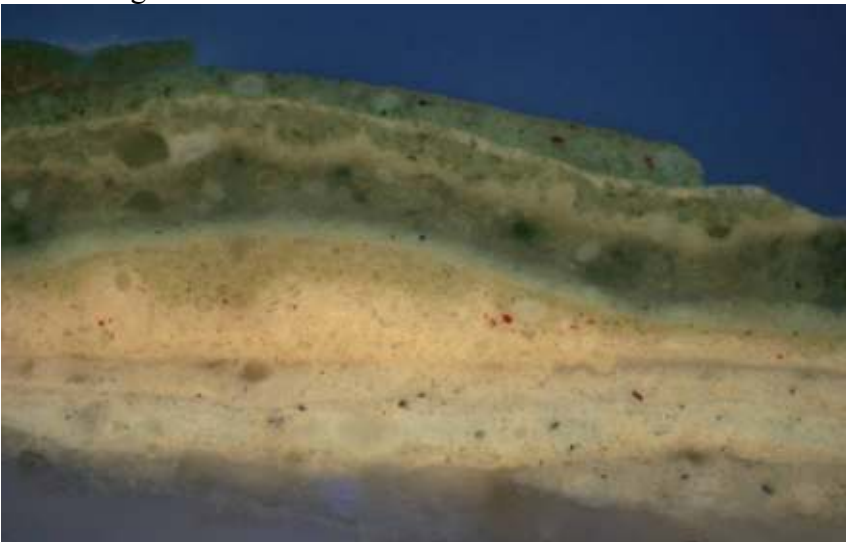
Sample 18. Drawing Room. North wall, architrave for door, left side, just below top of wainscoting.

Visible Light 200X



First blue-gray paint

Visible Light 200X



Conclusion:

Cross-section microscopy analysis of the paints in two of the earliest rooms at Eppington reveals that there is a remarkable amount of intact paint evidence remaining on almost all the elements of both rooms. This is precious material because very few houses survive with this level of physical information about the paints, limewashes and varnishes applied throughout the history of the property. It is likely that the rooms were repainted with each alteration, so if the paint sequences start at Period II, when Wenger, Chappell and Graham propose that the woodwork is installed, then the first generation of woodwork paint in the cross-sections relates to Period II, the second generation of paint relates to Period III, and so on. But if the plaster was not installed until Period IV, and the configuration of the rooms now are closest to the Period IV forms, then the most appropriate interpretation point for the paint sequences would be Period IV.

Binding media analysis with fluorochrome stains suggests that all the early paints are oil-bound and the limewashes are simply slaked lime and water, with no organic additives. Many of the early woodwork paints have plant resin varnish coatings (based on combinations of natural resins such as dammar, mastic, amber and copal). These plant resin-based varnishes were identified based on their characteristic bright white autofluorescence in reflected ultraviolet light. A number of shellac coatings, both with and without pigments, were found on the doors and baseboards. Shellac is made from the processed resinous exudate of the lac beetle (shellac was imported mostly from India) and it was identified in the cross-sections based on its typical orange autofluorescence color.

Pigments in selected layers were isolated and cast onto microscope slides for polarized light microscopy analysis. The bright green copper-based pigment verdigris, $\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2\text{Cu}(\text{OH})_2$, was also identified in the cross-sections based on the presence of large, chunky, bright green, translucent particles and the lack of autofluorescence in those oil-bound layers. Verdigris was the most brilliant green pigment available in the eighteenth and early nineteenth century, but it is chemically unstable and will discolor to brown or black when exposed to weathering and light. The pigments in the first blue-gray layer in the Drawing Room were identified as white lead, Prussian blue, and a few isolated charcoal black and yellow ochre particles. The first red-brown paint on the doors and baseboards is primarily red ochre, with some burnt sienna and lampblack.

However, before the rooms are repainted to any specific period it is important to settle on a philosophy for the interpretation of the interior. This point was concisely made in the Colonial Williamsburg Foundation report and it is worth repeating here: “In any “restoration” it is wise to develop up front a philosophical plan for how it will be treated, usually by determining a period to which the house will be restored. This need is especially great at Eppington, given the complex nature of the building and the degree to which original fabric could be potentially lost.”² In a similar vein, it is also important to establish a philosophy for conservation and stabilization of the surviving paints. Typical painting practices would dictate removal of the flaking paints prior to repainting, and

² Ibid., 59.

most commercial painters would propose to strip away all the paints before repainting. However, that approach is not appropriate at Eppington. One of the unique and important characteristics of Eppington is its accretions of architectural changes and paint layers applied over time. Removal of any of the historic paints would compromise the ability to conduct further research in the future and would result in the loss of historic material. There are developments in the conservation of architectural paints involving the use of stable, conservation-grade polymer resins which can either be applied as consolidants (wicking under the lifting paints) or as barrier coats. Further research would be required before determining the best approach for saving and protecting the interior paints at Eppington, and this is an area that must be addressed at the same time as a plan for repainting and/or reinterpreting the rooms is devised.

The table below shows the comparative paint sequences in the two rooms, indicating the Period IV finishes for the Dining Room would be tan woodwork, glossy, deep red-brown doors and baseboards, and white limewashed walls. The Period IV finishes for the Drawing Room would be blue-green woodwork, deep red-brown doors and baseboards, and white limewashed walls. The matches for the Period II and IV colors are at the end of this report.

Room/Element	Period II	Period III	Period IV	Period V	Period VI
<i>Dining Room</i>					
Walls	No plaster	No plaster	Limewash	Limewash	Limewash
Paneling	Glossy green	Tannish-yellow	Tan	Glossy green	Bright green
Mantel shelf	Glossy green	Tannish-yellow	Tan	Glossy green	Bright green
Doors	Deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown
Baseboards	Deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown
Cornice	Glossy green	Tannish-yellow	Tan	Glossy green	Bright green
<i>Drawing Room</i>					
Walls	No plaster	No plaster	Limewash	Limewash	Limewash
Paneling	Blue-gray	Blue-gray	Blue-gray	Blue-green	Yellowish-green
Mantel shelf	Blue-gray	Deep red-brown	Blue-gray	Deep brown	Deep brown
Doors	Deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown
Baseboards	Deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown	Glossy deep red-brown
Cornice	Blue-gray	Blue-gray		Limewash	Limewash

Further Research:

- Paint investigation of other rooms would contribute to a more complete understanding of the comparative paint stratigraphies as they relate to the paints in the Dining Room and Drawing Room.
- Research into appropriate methods for stabilizing, consolidating and protecting the historic paints in the house is critical before undertaking any repainting efforts.
- Research into the use of bright green verdigris-based paints in other late eighteenth and early nineteenth-century houses in Virginia and Maryland to determine how this brilliant color was perceived in the period.

COLOR MEASUREMENT PROCEDURES

Uncast portions of the paints from the most intact areas of the Dining Room and Drawing Room woodwork were matched by eye at 30X magnification using a Munsell swatch book for reference and where possible, the layers were also measured with a Minolta Chroma Meter CR-241, a tristimulus color analyzer/microscope with color measurement area of 0.3mm. This instrument has an internal, 360-degree pulsed xenon arc lamp and provides an accurate color measurement in a choice of five different three-coordinate color systems.

The measurements were first generated in the Munsell color system (a color standard used in the architectural preservation field), and after the measurements were taken the closest Munsell color swatches from a standard Munsell Book of Color (gloss paint standards) were compared under 30X magnification to the actual samples. The measurements were also generated in the CIE L*a*b* color space system, which is currently one of the most widely accepted industry color space measuring systems.

Several of the early layers turned out to be too degraded or uneven to allow accurate color measurements so these layers were only matched by eye at 30X under a color-controlled light source. Appropriate period colors were chosen for these elements from the Benjamin Moore Color Preview collection.

Dining Room – Samples 4, 19, 21
First Generation (Period II) Gray Base Coat for Original Green Paint

Color Measurements – February 2, 2007

Color System*		Coordinates	
Munsell	Hue	Value	Chroma
	1.2G	4.6	0.4
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L57.69	a-4.11	b+2.42

Benjamin Moore #HC-163 “Duxbury Gray”

Color System*		Coordinates	
Munsell	Hue	Value	Chroma
	1.2G	5.3	0.7
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L53.71	a-3.88	b+2.56

The color difference between the original gray base coat paint and the Benjamin Moore commercial match is $\Delta E = 3.9$ which means it is an acceptable numeric match. It is a very good visual match under 30X magnification with a color-controlled light source. The primary difference is in the “L” value, showing the commercial match is just slightly darker than the actual sample, while the other coordinates match very closely. The appearance of this layer and binding media reactions suggest it was only moderately glossy.

Dining Room – Samples 4, 19, 21
First Generation (Period II) Original Glossy Green Paint

Color Measurements – February 2, 2007

Benjamin Moore #2036-20 “Irish Moss”

<u>Color System*</u>		<u>Coordinates</u>	
Munsell	Hue	Value	Chroma
	2.8G	4.7	6.5
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L47.70	a-35.06	b+16.31

This layer was matched by eye under a color-controlled light source at 30X magnification. The appearance of this layer and binding media reactions suggest it was glossy. The overall appearance of this paint layer is similar to the replicated verdigris-copal resin varnish glaze over a green base coat in the Small Dining Room at Mount Vernon (see below) which was replicated 2001 based on paint analysis conducted by the author.



Dining Room -- Samples 19, 21
Third Generation (Period IV) Tan Woodwork Paint

Color Measurements – February 2, 2007

Benjamin Moore #AC-5 “Springfield Tan”

<u>Color System*</u>	<u>Coordinates</u>		
Munsell	Hue	Value	Chroma
	9.9YR	6.8	3.1
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L69.18	a+3.68	b+19.89

This layer was matched by eye under a color-controlled light source at 30X magnification. The appearance of this layer and binding media reactions suggest it was originally moderately glossy.

Dining Room and Drawing Room -- Samples 5, 7, 15
First Generation (Period II) Red-brown Door and Baseboard Paint

Color Measurements – February 2, 2007

Benjamin Moore #HC-71 “Hasbrouck Brown”

<u>Color System*</u>	<u>Coordinates</u>		
Munsell	Hue	Value	Chroma
	2.6YR	3.3	2.2
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L34.27	a+8.35	b+9.56

This layer was matched by eye under a color-controlled light source at 30X magnification. The appearance of this layer and binding media reactions suggest it was originally moderately glossy.

Dining Room and Drawing Room -- Samples 5, 7, 15
Third Generation (Period IV) Red-brown Door and Baseboard Paint

Color Measurements – February 2, 2007

Benjamin Moore “Tudor Brown”

<u>Color System*</u>	<u>Coordinates</u>		
Munsell	Hue	Value	Chroma
	3.6YR	2.7	1.5
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L27.77	a+5.77	b+7.19

This layer was matched by eye under a color-controlled light source at 30X magnification. The appearance of this layer and binding media reactions suggest it was originally moderately glossy.

Drawing Room -- Samples 5, 15, 16
First Generation (Period II) Blue-Gray Woodwork Paint

Color Measurements – February 2, 2007

Color System*		Coordinates	
Munsell	Hue	Value	Chroma
	2.1GY	5.0	1.4
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L50.80	a-1.89	b-3.60

Benjamin Moore #HC-161”Templeton Gray”

Color System*		Coordinates	
Munsell	Hue	Value	Chroma
	3.0B	5.1	1.2
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L52.45	a-4.41	b-3.53

The color difference between the original gray base coat paint and the Benjamin Moore commercial match is $\Delta E = 3.0$ which means it is an acceptable numeric match. It is a very good visual match under 30X magnification with a color-controlled light source. The primary difference is in the “a” value, showing the commercial match is just slightly more greenish than the actual sample, while the other coordinates match closely. The appearance of this layer and binding media reactions suggest it was moderately glossy.

Drawing Room -- Samples 5, 15, 16
Third Generation (Period IV) Blue-Gray Woodwork Paint

Color Measurements – February 2, 2007

Benjamin Moore #HC-162 “Brewster Gray”

<u>Color System*</u>	<u>Coordinates</u>		
Munsell	Hue	Value	Chroma
	1.5B	5.8	0.8
CIE L*a*b*	Black to White	Green to Red	Blue to Yellow
	L59.04	a-3.49	b-2.14

This layer was matched by eye under a color-controlled light source at 30X magnification. The appearance of this layer and binding media reactions suggest it was originally moderately glossy.

* COLOR SYSTEMS – Derived from the Minolta CR-241 Instruction Manual and Minolta Precise Color Communication

Chroma Meter CR-241 offers five different color systems for measuring absolute chromaticity: CIE Yxy (1931), L*a*b* (1976), and L*C*H* (1976) colorimetric densities DxDyDz; Munsell notation and four systems for measuring color differences.

For two colors to match, three quantities defining color must be identical. These three quantities are called tristimulus values X, Y, and Z as determined by CIE (Commission Internationale de l'Eclairage) in 1931.

Color as perceived has three dimensions: hue, chroma and lightness. Chromaticity includes hue and chroma (saturation), specified by two chromaticity coordinates. Since these two coordinates cannot describe a color completely, a lightness factor must also be included to identify a specimen color precisely.

Munsell Color System: The Munsell color system consists of a series of color charts which are intended to be used for visual comparison with the specimen. Colors are defined in terms of the Munsell Hues (H; indicates hue), Munsell Value (V; indicates lightness), and Munsell Chroma (C; indicates saturation) and written as H V/C.

CIE Yxy (CIE 1931): In the Yxy (CIE 1931) color system, Y is a lightness factor expressed as a percentage based on a perfect reflectance of 100%, x and y are the chromaticity coordinates of the CIE x, y Chromaticity Diagram.

CIE L*a*b*: Equal distances in the CIE x,y Chromaticity Diagram do not represent equal differences in color as perceived. The CIE L*a*b* color system, however, more closely represents human sensitivity to color...Equal distances in this system approximately equal perceived color differences. L* is the lightness variable; a* and b* are the chromaticity coordinates

ΔE : ΔE (Delta E) is the industry measure used to determine how closely two colors match in the CIE L*a*b*. The symbol Δ means “the change in”. It is based on calculating the sum of the differences between each measure. The calculation is: $\Delta E = (L^*)^2 + (a^*)^2 + (b^*)^2$, or, the color difference equals the square root of the squared sums of the differences between each of the three L* a* b* tristimulus values. Industry color standards indicate a ΔE of 1 is barely perceptible to the human eye, and a ΔE of 6 to 7 is acceptable for color matches in the printing industry.

REFERENCES

Cross-section Preparation Procedures:

The samples were cast in mini-cubes of polyester resin (Excel Technologies, Inc., Enfield, CT). The resin was allowed to cure for 24 hours at room temperature and under ambient light. The cubes were then ground to expose the cross-sections, and dry polished with 400 and 600 grit wet-dry papers and Micro-Mesh polishing cloths, with grits from 1500 to 12,000.

The cast samples were analyzed and photographed using a Nikon Eclipse 80i epi-fluorescence microscope equipped with an EXFO X-Cite 120 Fluorescence Illumination System fiberoptic halogen light source and a polarizing light base using SPOT Advanced software (v. 4.6) for digital image capture and Adobe Photoshop CS for digital image management. The samples were photographed in reflected visible and ultraviolet light using a UV-2A filter with 330-380 nm excitation, 400 nm dichroic mirror and a 420 nm barrier filter. Photographs were taken at 100X, 200X and 400X magnifications.

The following fluorescent and visible light stains were used for examination of the samples:

Fluorescein isothiocyanate (FITC) 0.2% in anhydrous acetone to identify the presence of proteins. Positive reaction color is yellowish-green.

Triphenyl tetrazolium chloride (TTC) 4.0% in ethanol to identify the presence of carbohydrates (starches, gums, sugars). Positive reaction color is dark red or brown.

2, 7 Dichlorofluorescein (DCF) 0.2% in ethanol to identify the presence of saturated and unsaturated lipids (oils). Positive reaction for saturated lipids is pink and unsaturated lipids is yellow.

Rhodamine B (RHOB) 0.06% in ethanol to identify the presence of oils. Positive reaction color is bright orange.

N-(6-methoxy-8-quinolyl)-p-toluenesulfonamide (TSQ) 0.2% in ethanol to mark the presence of Zn in the cast cross-section. Positive reaction color is bright blue-white.

Pigment Preparation Procedures:

Pigments from individual paint layers were scraped with a clean scalpel onto microscope slides. The pigments were crushed and dispersed with a scalpel and permanently mounted under cover slips with Cargille MeltMount with a refractive index of 1.66. The pigments were examined under plane polarized light and crossed polars (darkfield) at

400X magnification and 1000X magnification (with a 100X oil immersion objective). Unknown pigments were also compared to a standard set of reference pigments.

Information Provided by Ultraviolet Light Microscopy:

When viewed under visible light, cross-sections which contain ground, paint and varnish may often be difficult to interpret, particularly because clear finish layers look uniformly brown or tan. It may be impossible using only visible light to distinguish between multiple varnish layers. Illumination with ultraviolet light provides considerably more information about the layers present in a sample because different organic, and some inorganic, materials autofluoresce (or glow) with characteristic colors.

There are certain fluorescence colors which indicate the presence of specific types of materials. For example: shellac fluoresces orange (or yellow-orange) when exposed to ultraviolet light, while plant resin varnishes (typically amber, copal, sandarac and mastic) fluoresce bright white. Wax does not usually fluoresce; in fact, in the ultraviolet it tends to appear almost the same color as the polyester casting resin. In visible light wax appears as a somewhat translucent white layer. Paints and glaze layers which contain resins as part of the binding medium will also fluoresce under ultraviolet light at high magnifications. Other materials such as lead white, titanium white and hide glue also have a whitish autofluorescence.

There are other indicators which show that a surface has aged, such as cracks which extend through finish layers, accumulations of dirt between layers, and sometimes a diminished fluorescence intensity, especially along the top edge of a surface which has been exposed to light and air for a long period of time.

Sample Locations

Eppington

Chesterfield County, Virginia

Dining Room.

Period I and II Dining Room

Period III and IV Parlor

1. West wall, fireplace wall, leading edge of mantel shelf, about 3-inches from right corner.
2. West wall, panel just right of fireplace, at lower edge where quarter-round molding meets chamfered edge of raised panel.
3. West wall, right of fireplace, north side of paneling, in center of grain-direction crack at existing loss.
4. West wall, NW corner, outer band of door architrave, left side, about 4-feet up, at cove molding.
5. West wall, door in NW corner, upper left corner, lower left panel.
6. West wall, closet door left of fireplace (turned around, room-side surface, lower left corner of middle left panel. (This surface is very weathered, formerly exposed as an exterior door.)
7. West wall, door left of fireplace, inner closet surface, lower left corner of middle left panel, currently has a dark graining.
8. West wall, NW corner, surbase of chair board, at fillet molding below half-round molding.
9. West wall, NW corner, backing board of chair board, lower edge.
10. North wall, NW corner, later bookcase, front edge, top shelf, left side.
11. North wall baseboard, 3-feet left of east wall, just below top bead molding.
12. North wall window, right architrave, outer molding about 5-feet up from floor.
13. East wall, left architrave for door to hall, about 5-feet up.
14. North wall, lower sash, left edge, adjacent to scraped paint.
15. East wall door, upper left corner of middle left panel.
16. South wall, slightly later door, right side of right long door panel (room-side).

17. South wall window, left architrave as small molding right of backband, about 2-inches up from sill.
18. South wall, window muntin, lower right pane, left side.
19. South wall, applied board with iron fitting (to support a mirror?).
20. North wall, east of window, at long crack in plaster about 5-feet up.
21. East wall, cornice above door, narrow fillet below uppermost quarter round molding.

Drawing Room.

1. East wall, frieze of mantel, right side, below shelf.
2. East wall, leading edge of mantel shelf, right side.
3. East wall, small panel above mantel, upper left corner where panel has slightly shrunk.
4. East wall door, upper left corner of left panel.
5. East wall, left door architrave, about 3-feet up from floor.
6. North wall, NE corner, plaster above wainscot at join of fireplace wall.
7. East wall, soffit of cornice in SE corner.
8. SE corner, ceiling plaster, multiple limewashes.
9. SE corner, plaster wall at crack, directly above chair board.
10. South wall, east window, west architrave, about 1-foot above sill.
11. South wall, east window, sash.
12. South wall, top of molding of wainscoting, between two windows, about 6-inches left of west window.
13. East wall, baseboard, right of fireplace.
14. North wall, door in NW corner, upper left corner of upper left panel, room-side surface.
15. South wall, door architrave, left side, about 3-feet up from floor.
16. North wall, fillet molding below surbase about 3-feet right of door in NW corner.

17. South wall, later door, left side upper panel, about 4-feet up from floor.

18. North wall, architrave for door, left side, just below top of wainscoting.