Analysis of Historic Paints on Woodwork at Andalusia Mansion - Understanding the Period of Benjamin Latrobe and Thomas Walter

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Analysis of Historic Paints on Woodwork at Andalusia Mansion - Understanding the Period of Benjamin Latrobe and Thomas Walter

Abstract
This study of architectural finishes is intended to substantiate evidence of physical and material changes to the building by way of paint evidence. It augments existing research, including the recently published 2014 Andalusia Big House Historic Structure Report and the 2014 report on the doors styles of the house by students in the Graduate Program in Historic Preservation at the University of Pennsylvania, both of which raised questions concerning the evolution and changes in appearance of the building. With the intention of shedding light on changes to the door arrangement, this study specifically examines and compares finishes in the central core of the house, which represents all three important building campaigns: the original 1797 Craig farm house, the 1808 Federal style addition by Benjamin Latrobe, and the 1835 Greek Revival addition by Thomas Walter. Methods of analysis were limited to microscopic methods, including examination of paint cross-sections under both visible light and ultraviolet light, micro chemical spot testing, and polarized light microscopy. Because of extensive paint removal on the doors within the past 30 years, the author was not able to establish changes the doors. However, traces of historic finishes on the doors, the door surroundings and staircase will benefit future researchers in building upon this initial effort at finishes analysis at Andalusia.

Keywords
Andalusia, Benjamin Latrobe, Thomas Walter, finishes analysis, microscopy

Disciplines
Historic Preservation and Conservation

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ANALYSIS OF HISTORIC PAINTS ON WOODWORK AT ANDALUSIA MANSION
- UNDERSTANDING THE PERIOD OF BENJAMIN LATROBE
AND THOMAS WALTER

Shuang Wu

A THESIS

in

Historic Preservation

Presented to the Faculties of the University of Pennsylvania in
Partial Fulfillment of the Requirements of the Degree of

MASTER OF SCIENCE IN HISTORIC PRESERVATION

2016

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CHAPTER 1

INTRODUCTION TO THE ANDALUSIA BIG HOUSE

This research addresses the interior finishes of the central core of the primary residence, known as the Big House, of Andalusia Estate, a National Historic Landmark\(^1\) located along the banks of the Delaware River in the Bensalem Township, Bucks County Pennsylvania. Significantly modified twice in the first half of the nineteenth century by two of the country’s most important architects, Benjamin Latrobe and Thomas Ustick Walter, it became an icon of the American Greek Revival residential architecture of the early nineteenth century. However, despite the notoriety of its important architects and the elegance of this imposing residence, limited research has been carried out on this important building. To date, there is no record that the architectural finishes in the house have ever been analyzed.

This focused analysis of finishes is intended to contribute to the limited scholarship on the building by documenting physical and material changes to the building by way of paint evidence. It augments existing research, including the recently published *Andalusia Big House Historic Structure Report*\(^2\) and the University of Pennsylvania

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\(^1\) The house was declared a National Historic Landmark in 1966. National Register of Historic Places, Nicolas Biddle Estate, Bensalem, Bucks, Pennsylvania, National Register Information System ID 66000649. [http://focus.nps.gov/AssetDetail/NRIS/66000649](http://focus.nps.gov/AssetDetail/NRIS/66000649).

student course paper\textsuperscript{3}, both of which raised questions concerning the evolution and changes in appearance of the building. In particular it examines and compares finishes during the three important building campaigns: the original 1797 Craig farmhouse, the 1808 Federal style addition by Benjamin Latrobe, and the 1835 Greek Revival addition by Thomas Walter.

The central core of the building was chosen because it represents all three building campaigns. Operating on the premise that changes in the placement of the doors in this often altered original core of the house would be seen in the paint stratigraphies, a plan for comparing finishes also aimed at shedding light on the two important American architects and how they configured the house. Specifically, it considered how Walter re-used doors as part of his new vision of the house.

Figure 1.1 First Floor Plan. The central core of the house showing in gray shade (Source: Historic American Building Survey (HABS)).

Figure 1.2 The central core of the house. (Source: Historic American Building Survey (HABS)).


5 Cortlandt V. Hubbard, "stair hall, looking north - Andalusia, State Road vicinity (Bensalem Township), Andalusia,
The primary Craig Residence was built by John Craig, the owner of the property. It is most likely that John Craig hired a skilled master builder from Philadelphia or Bucks County, which was common during that time. The farm residence was designed according to Federal Style and as early as 1802 was referred to as Craig Hall.6

Craig Hall was composed of 2-1/2 stories of stone masonry construction with two bays

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from riverside to landside (south to north) and four bays on the river façade (east to west). A watercolor rendering in the possession of the Andalusia Foundation offers the most complete depiction Craig Hall at that time.\textsuperscript{7}

1.2 Craig Hall Addition by Benjamin Henry Latrobe - 1807 to 1808

After living in the residence known as Craig Hall for decades, John and his wife Margaret Craig employed the Baltimore based architect Benjamin Latrobe to enlarge the house. Latrobe was trained in England as both an engineer under John Smeaton and an architect under Samuel Pepys Cockerell and immigrated to America after suffering financial and personal disaster in London.\textsuperscript{8} Her mother was an American and her family owned land in Pennsylvania, a factor that influenced Latrobe’s decision to settle down there and begin pursuing his new career. He landed in Norfolk, Virginia in March of 1796 and eagerly waited for a chance to realize his architecture ambitions.\textsuperscript{9} His first project was a residential project for Captain William Pennock in Norfolk, Virginia.\textsuperscript{10} Latrobe spent two years in Virginia, during which time he finished the Richmond Penitentiary. But by March 1798 he pronounced himself “unwilling to remain without

\textsuperscript{7} Ibid.
\textsuperscript{10} Cohen and Brownell, Volume 2, Part 1, 82.
the advantage of having seen what has been done at Philadelphia, and it seems to me to be of importance to the public that I should know it." He spent half a month in Philadelphia for his first visit to this city, and he had the chance to meet the Samuel Fox, the president of Bank of Pennsylvania. Latrobe left Fox with a simple sketch of the new bank design. After four months, he received a letter noticing that his design was accepted. Latrobe then moved to Philadelphia in 1798 and started supervising the project in December. It is widely accepted that Latrobe's design of the First Bank of Pennsylvania (1798-1801) announced the arrival of a new classical vocabulary in American architecture. Latrobe, along with his pupils William Strickland and Robert Mills, and with French immigrants Maximilian Godefroy and Joseph Ramée, was among the first group of architects responsible for establishing the architectural profession in America. The American history of architecture in the nineteenth century would have been very different if Latrobe's English background and romantic leaning toward the ancient Greek style had not pervaded the country, bringing it closer than any other to being the American national style. The significance of his contribution to American architecture in the early nineteenth century is unparalleled.

11 Correspondence of Latrobe, volume 1, 80; in Cohen and Brownell, Volume 2, Part 1, 180.
12 Cohen and Brownell, Volume 2, Part 1, 180.
Latrobe’s final design at Andalusia consists of two nearly-square pavilions placed at the northeast and northwest corners of the original residence and connected by a five-bay open piazza between them. It is speculated by the authors of the Historic Structures Report\textsuperscript{15} that the rooms within the pavilions served as utilitarian spaces, most likely a summer kitchen on the east, and a farm office on the west, while the piazza provided a protected entrance. The exterior location of a “summer kitchen” was common during this period and had the advantages of reducing heat in the residence and risk of fire.\textsuperscript{16}

The riverside façade was not modified this time.

\textsuperscript{15} Daniel T. Campbell, AIA and Kathleen M. Abplanalp, Ph.D. et al., “Andalusia Big House Historic Structure Report” (Commissioned by the Andalusia Foundation, Andalusia, PA. Published in West Chester, PA, 2014), 1.3.7-8.
\textsuperscript{16} Ibid.
1.3 Nicholas and Jane Biddle Residence; addition by Thomas U. Walter

The most visible change to the architectural character of the Andalusia Big House was the result of the additions and redesign by Thomas Ustick Walter between 1833 and 1835. Like Latrobe, Walter was also one of the most important architects in the nineteenth century America. Born in Philadelphia, the son of a bricklayer of German descent, Walter was apprenticed to his father for five years (1819-24) but soon began to pursue his own interest in architecture. His association with renowned Greek Revival architects William Strickland and later John Haviland, who he trained, attests to his influence. His greatest design in Philadelphia was the group of buildings for Girard College (1834-48). This Greek Revival masterpiece earned him national recognition and prominence as one of the most successful architects of his day. Such popularity brought him financial success and many commissions, including the remodeling of Nicholas Biddle’s country house, Andalusia. By 1850 when he won the commission for the dome and extensions to the United States Capitol in Washington, D.C., his national stature as a leading architect was established.

The additions at Andalusia are located at two principal areas: the south façade facing

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18 Ibid.
the Delaware River (Greek Revival Temple form): and the north façade facing State Road. Biddle, the owner, and Walter, the architect, were both devotees of the Neo-Classical style.\(^{19}\) They considered wrapping the entire house with a temple initially. However, Walter eventually decided on a smaller version of the Greek temple. It was actually easier for Walter to completely surround the existing house with a four-sided temple form, but he solved the proportions and scale problem by adding the third floor or attic story to achieve the proportions of a Greek temple.\(^{20}\)

To install these two wings, Walter needed to remove the previous addition designed by Benjamin Latrobe. That portion had consisted of the two one-story pavilions and an intersecting hyphen between them, with an entry piazza. By chance or by choice, Walter’s northern replacement addition can be described as a larger version of the prior design by Latrobe.\(^{21}\)

It is conceivable that Walter and Biddle re-used material from Latrobe’s period or the previous Craig’s period, as described in the Historic Structures Report.\(^{22}\) Also, 


\(^{20}\) Ibid.

\(^{21}\) Ibid.

\(^{22}\) Daniel T. Campbell (AIA, Architect) in discussion with the author, March 2016. Campbell wrote that: “The materials conservator Andrew Fearon and I both believe that the door at the north of the foyer, the surround and the transom (all in Federal Style and detail) were relocated to the north wall (a Thomas U Walter wall) from the 1795 Craig House, or 1808 Latrobe renovation. That is based on stylistic judgment (Federal vs Greek Revival), and a watercolor dated 1818 (copied in the HSR) which shows a door with a semi-circular transom on the north wall of the house, before the Walter additions.”
communication with Daniel Campbell, one of the authors of the Historic Structures Report, substantiates these speculations. Details of the door descriptions could be found in the Historic Structure Report: Interior – First Floor description in Section 1.4A.23

These incomplete architectural findings warrant the examination of architectural finishes. The following sections will describe a first effort at finishes research focused on the central core of the house.

![Figure 1.5 The south façade of Andalusia (the riverside façade), February 2016 (photograph by author).](image)

Figure 1.6 The north façade of Andalusia (the landside façade), February 2016 (photograph by author).
CHAPTER 2
LITERATURE REVIEW

Because of the multi-faceted nature of this research topic, the author has reviewed literature in several unrelated subjects. The resulting literature review addresses each subject individually. They include: 2.1. The domestic architecture of Benjamin Latrobe and Thomas Ustick Walter and their residential design at Andalusia Mansion and elsewhere. 2.2. The architectural history and chronology of change at Andalusia, including original construction, alteration and maintenance of the physical fabric to the Big House, and the Latrobe and Walter building campaigns. 2.3. In the third section, the Latrobe finishes at the First Bank of America, which are regarded as good examples of Neoclassical colors, are reviewed.¹ 2.4. The final section considers relevant examples of architectural finishes studies including fluorescence microscopy and polarized light microscopy and the studies focused on identifying architectural change similar to this research.

2.1 THE ARCHITECTS AND THEIR ARCHITECTURE

2.1.1 Benjamin Henry Latrobe

Various sources that address the history of Latrobe as an architect have been reviewed in this section. Kerry Johnston’s 2007 Master Thesis: Free Neoclassicism and Interior Architectural Surface Finishes: The Investigation, Analysis and Interpretation of William Strickland's St. John's Episcopal Church, Philadelphia\(^2\), offers a useful bibliography of sources concerning Latrobe. Various publications outlined Latrobe’s biography, influences, and impact and call out details and sources particularly relevant to this thesis, such as Fiske Kimball’s *Domestic Architecture of the American Colonies and of the Early Republic*\(^3\); Mark Gelernter’s *History of American Architecture: buildings in their cultural and technological context*\(^4\); Paul F. Norton’s *Latrobe, Jefferson, and the National Capitol*\(^5\), Jeffrey A. Cohen and Charles Brownell’s *The Architectural Drawings Of Benjamin Henry Latrobe*.\(^6\) Those sources give detailed descriptions of Latrobe’s English background, as both an architect and as an engineer, and his great contribution to the establishment of


the architecture profession and Greek Revival movement in America. In Mark Gelernter’s book *History of American Architecture: buildings in their cultural and technological context*, the author noted that Latrobe, as the first generation of immigrated architect, brought the European idea of paying an architect a fee based on a percentage of the entire cost of the building, which was unheard of the United States at that time. In Johnston’s thesis, she especially pointed out that it is widely accepted that Latrobe's design of the first Bank of Pennsylvania (1798-1801) announced the arrival of a new classical vocabulary in American architecture. In the “American Architecture Series Benjamin Latrobe webpage”, the author evaluated Latrobe contribution highly as follows:

> The history of architecture in 19th century America would undoubtedly have been very different if the French architects, such as Stephen Hallet (1755–1825), who worked at the Capitol, had introduced their version of classicism. But it was Latrobe's English background and firm intellectual and romantic leaning toward the ancient Greek style that pervaded the country, coming closer than any other to being the American national style. His contribution to American art should not be underestimated.

The pinnacle of Latrobe’s professional career would be his work in the US Capitol. The

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10 Ibid.
US Capitol webpage\(^{11}\) notes that he is honored as the second Architect of the Capitol. The author described that Benjamin Henry Latrobe was hired by President Jefferson in 1803 to fill the position of "Surveyor of Public Buildings," with the principal responsibility of constructing the Capitol's south wing. That both men shared a love of the Greek form of architecture cultivated a desire to work together and they became friends. While both benefited from the ideas of the other, scholars have often noted Latrobe’s influence on Jefferson’s design for the University of Virginia.\(^{12}\) The webpage also asserts that Latrobe’s design for the interior of the US Capitol, which includes the Hall of the House (now National Statuary Hall), the Old Senate Chamber, and the Old Supreme Court Chamber, is among the greatest interiors in the history of neoclassicism in America.\(^{13}\)

The Blue Grass Trust for Historic Preservation Pope Villa website\(^{14}\) notes that over Latrobe’s illustrious career he helped create a distinctly American style of architecture “elegantly austere exteriors which contained interiors rich in variety” and set a standard of professionalism that resonates today. He designed and collaborated on some of the country’s most important structures, including the Bank of Pennsylvania, which was the first major Greek Revival building in the country, as well as the Baltimore Basilica, Christ

\(^{11}\) Several generation of architects have worked in the US capitol, including Benjamin Latrobe, Dr. William Thornton, Thomas Ustick Walter, etc. “Architects of the Capitol,” Architect of the Capitol, https://www.aoc.gov/architect-of-the-capitol.


Apart from institutional buildings, Latrobe continued to design houses after he immigrated to the United States. Only three American Latrobe houses remain standing, and each building represents a different style. The three houses are the Decatur House in Washington, D.C., an urban townhouse, which was registered as a National Historic Landmark in 1960; and the Pope Villa in Lexington, Kentucky, a suburban villa; and Adena, the only surviving Latrobe country house. Because Walter significantly changed Andalusia after Latrobe’s time, Latrobe’s work on the house is not regarded as one of his important residential designs. However, information about the past conservation projects of Pope Villa, the Decatur House and the Adena Mansion found in various sources indicate that these houses have been carefully documented and studied in the past and may have included finishes studies. In Michael W. Fazio and Patrick A. Snadon’s 2006 book Domestic Architecture of Benjamin Henry Latrobe, the authors moved one step further to describe Adena Mansion as particularly similar to the Latrobe’s modifications of the Craig house because it also included a loggia between two

temple-like dependencies. In the same book, the authors describe the interior decoration in Adena as being quite plain, a definite possibility given that Latrobe himself never visited the site and could not supervise the construction. The millwork, including the rail, door and window surrounds, and stair balusters and handrail, as well as the Adam-derived Federal style mantelpieces, may have reflected local taste and craftsmanship more than Latrobe’s influence. During the recent restoration process, the black, green and white circular-repeat wallpaper patterns were exposed under an 1892 doorframe connecting Thomas Worthington’s library/office with the servant’s room to the north, which belonged to be Latrobe’s period.

In Hitch and Lugg’s 2002 article, the authors noted that the Ohio State Archeological and Historical Society took great care during the 1947-1953 restoration. They surveyed existing evidence and conducted limited finishes research following procedures established at Colonial Williamsburg at that time. An 1821 fire insurance survey was the primary source for understanding the house. This survey provided the name and dimensions of rooms and indicated if the room was painted or wall-papered. During the 1940’s-1950’s restoration, the OHS contacted the descendants from the Worthington family and asked if they have seen the wallpaper in the living room. Around year 2001, a

18 Ibid., 302.
19 Ibid., 311-314.
21 Not able to locate the finishes study.
piece of the side wall paper sample and the border fragment were sent to Frank Welsh at Welsh Color and Conservation, Inc. His analysis suggested that the papers were original to the house and dated to the early nineteenth century. The paper, which was analyzed with polarized light microscopy, was composed of flax fibers with a few animal hairs. Both the side wall paper and border were block-printed with distemper paints. Using a soft sponge, Welsh cleaned portions of the paper to remove the surface dirt. He then microscopically analyzed the distemper paints to identify the pigment composition: 22 He found that the sidewall paper was composed of a white ground containing calcite and Prussian blue. The white figures were rendered with whiting (calcium carbonate). Blue-green passages were pigmented with calcite and blue verditer and the black was made with lamp black. The border wallpaper was rendered in a white made of whiting (calcium carbonate) and a moderate reddish brown composed of red iron oxide and burnt umber.

To understand the original design intent of an architect, it is important to know his or her design theory. Latrobe’s design theory was described in Michael W. Fazio and Patrick A. Snadon’s 2006 book: Domestic Architecture of Benjamin Henry Latrobe. 23 In this book, the authors mentioned Latrobe’s special interest in seeing a “rational house” built in

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Philadelphia. Being described by some scholars as a rational classicist, Latrobe was pursuing the pure geometry of a building. The idea of rational architecture was triggered in the European Enlightenment Movement. Latrobe announced that his design included “arrangement, construction and decoration”\(^\text{24}\), suggesting that he would have invested considerable thought in interior finishes.

Latrobe recommended that the American “rational” house should have a service story at grade or a few steps above grade if there were cellars, including an entry hall, and a kitchen and kitchen offices within the structure, all beneath the principal story. Latrobe also believed that good “decoration” had to be rational as good arrangement and good construction, saying “that which is rational is made to supply the decoration required.”\(^\text{25}\)

In the same book, there is also a section called “relationships with artisans and craftsperson”, which describes how Latrobe worked closely with craftsman and artisans, as he worked closely with his pupils and employees. Details about his work with artisans in Andalusia will be discussed below.

Architectural historian Pamela Scott evaluates Latrobe’s work:

No other American architect of Latrobe's generation left such a rich graphic legacy of domestic architecture of the federal period. Latrobe's sophisticated command of small-scale architectural forms and imaginative domestic

\(^{24}\) Ibid., 186.

\(^{25}\) Ibid., 191.
arrangements were unsurpassed in his day, and arguably stand near the acme of American residential design. Latrobe's considerable influence on contemporary builders and architects was particularly strong in Georgetown and Washington, where even details as simple as his sunken circular molding to terminate lintels that extend beyond the window or door openings (bull's-eye lintels) were widely copied.26

2.1.2 Thomas Ustick Walter

Various sources have been reviewed for understanding Thomas Ustick Walter. In Stephen G. Harrison’s 1992 Master Thesis “Documenting a Design: The Thomas Ustick Walter House, 1861-1866, Germantown, Pennsylvania”,27 he based his survey on numerous first hand resources, including original drawings and papers from Walter. These resources were held in private hands until the 1990’s when they were acquired by the Athenaeum of Philadelphia and made accessible to scholars for the first time. Harrison references the work of scholars such as Robert Bruce Ennis, Sandra L. Tatman and Roger W. Moss, which provide valuable background information about Thomas Ustick Walter.28

Like Latrobe, Walter was also a “Capitol Architect”. Again in the US Capitol official

webpage\textsuperscript{29} descriptions of Walter’s work in the Capitol could be found. However, extensive finishes analyses and conservation of the interior painted finishes and mural paintings, which include frescoes and decorative painting by Contantino Brumidi, do not offer insight into the type of finishes that Walter would have selected for Andalusia, where the simplicity of form and tastes of the owners would have been entirely unlike the iconographic goals of the US Capitol.\textsuperscript{30} Harrison provided a bibliography outlining the architect’s significance and outlined Walter’s success in the US Capitol and his importance in the Greek Revival movement following Latrobe.\textsuperscript{31} He also pointed out that the work on the Capitol occupied fifteen years of Walter’s life and become his most significant achievement. He further clarified Walter’s contribution as “revered by his peers and helped found the American Institute of Architects, where he became the first vice president and later president.”\textsuperscript{32} Walter retired in 1865 to the home he had built in Germantown (1861). He finally secured a position with John McArthur, Jr, as second in command for the construction of the Philadelphia City Hall, a position he held until his death in 1887.\textsuperscript{33}

Understanding the two important architects is vital because they frequently cooperated

\textsuperscript{30} Chris Frey and Elizabeth Lizzy, in discussion with author, February 2016.
\textsuperscript{32} Ibid.
\textsuperscript{33} Ibid.
with and learned from each other during this time period, as written in Jeffery A. Cohen’s article: *Building a Discipline: Early Institutional Settings for Architectural Education in Philadelphia, 1804 – 1890*. 34 He noted that among the most prominent figures involved as instructors, lecturers, organizers, or students were Benjamin Latrobe, Owen Biddle, William Strickland, John Haviland, T. U. Walter, G. Parker Cummings, and John McArthur, Jr. and others.35

2.2 ANDALUSIA MANSION – THE PHYSICAL FABRIC

2.2.1 The Historic Structure Report (HSR) of Andalusia Big House36

The most important document reviewed for this paper is the recent 2014 *Historic Structure Report* of Andalusia Big House by a group of professionals including the architect Daniel T. Campbell AIA, architectural conservator Andrew Fearon and historian Kathleen M. Abplanalp, PhD.37 The report detailed the building history, changes in appearance over time, and the results of close investigation into the physical structure. The report revealed that elements of all three building campaigns still remain discernible
on this house, with remnants of two previous Federal-styles building forms wrapped within the envelope of the current residence. The Thomas U. Walter Greek Revival form is the most evident because of the imposing new additions at the north and south facades of the previous house and the replacement of the entire roof structure. The earliest Federal style residence, which was mostly likely to be executed by John Craig is the second-most discernible due to a prominent triple-faceted bay attached to each of its east and west facades. The second Federal-period design by Benjamin Latrobe was almost all removed by Thomas Walter, and therefore is the least evident of the three chronological campaigns.

Given the chromachronological focus of this paper, finding evidence of any of these periods of finishes would be considered the most important achievement of this research. Although the physical evidence of this building is carefully surveyed in the Historic Structure Report, some assumptions were still made. Scientific analytical methods, such as paint analysis, are still needed to prove the findings. A starting point for the study of finishes may be found in a reference to Latrobe as an economic architect who saved several doors from the previous Craig period and relocated them in a few new locations.  

38 Daniel T. Campbell (AIA, Architect) in discussion with the author, March 2016. Campbell wrote that: “The materials conservator Andrew Fearon and I both believe that the door at the north of the foyer, the surround and the transom (all in Federal Style and detail) were relocated to the north wall (a Thomas U Walter wall) from the 1795 Craig House, or 1808 Latrobe renovation. That is based on stylistic judgment (Federal vs Greek Revival), and a watercolor dated
The Historic Structures Report purports that the Craig Residence was most likely designed by John Craig himself, because no evidence was found that he hired a trained architect. He probably executed his design idea through a builder from the Bucks County or Philadelphia County. The first structure was a middle sized farming residence near the Delaware River bank. It dimension was about 35 feet from north to south and 40 feet from east to west. It had two polygonal bays. There have been speculations in the past that the bays were built by Craig or added by Benjamin Latrobe, however, physical evidence has proved that they were built during Craig’s period, as evidenced by discovery that the foundation wall of these bays is contiguous with the gable end walls of the Craig house structure. The first floor seemed to have little room for a kitchen. It is most likely they used the basement room as a kitchen place.

The HSR reports that the house was known as Craig Hall for about two decades until John Craig and his wife Margaret Craig hired the Baltimore-based architect Benjamin Latrobe to enlarge the house due to their expanding family and business. The expansion took the form of a one-story addition approximately 12 feet deep and 45 feet wide

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40 Ibid., 1.3-2.
41 Ibid., 1.3.1-6.
attached to the landside (north) elevation of the residence.\textsuperscript{42}

Authors of the HSR report that the addition was divided into three parts - the two pavilions and a central piazza. In the early drawings the central piazza seemed to be enclosed. The final design was presented it as two almost square pavilions at the northeast and northwest corner of the original residence, and connected with an open plaza, with a few steps.\textsuperscript{43}

They report that a summer kitchen was common during this time because it reduced heat loss and saved energy, while protecting the main residence from fire.\textsuperscript{44} It is logical to conclude that the service rooms in the pavilion served such utilitarian purposes. A summer kitchen probably existed at the east corner and a farm office at the west corner, while the plaza provided a protected entrance.

The HSR also reports on evidence of two chimneys from Latrobe’s addition. One is located between the present Study and Library. The second one is between the Kitchen and Butler’s Pantry. These are in the same location as Latrobe’s west and east pavilion's wall, respectively. Some of the moldings and doors may also date to the Latrobe's

\textsuperscript{42} Ibid., 1.3.6-9.  
\textsuperscript{43} Ibid.  
\textsuperscript{44} Ibid.
The remaining moldings and relocated doors will be discussed below.

The HSR continues to explain that the most evident and visibly defining feature of the Andalusia Big House is the 1833-35 addition by Thomas Walter. This addition was a very challenging design. Because of constraints with the ratio and scale, it was actually easier to wrap the entire house in a Greek temple form. Walter skillfully handled the problem of height by adding a third story behind the Greek temple wall.

In contrast to the open portico design of the south façade of the house, the north addition was enclosed constructions. Walter decision to add two new wings required the removal of Latrobe’s pavilions and the hyphen that connected them. Campbell points out that, whether it was by accident or by choice, Walter’s design was essentially an enlarged version of Latrobe’s design. Although the changes he made were two storeys in height, they involved the same addition of east and west pavilions with gabled roofs and a hyphen with the entrance between them.

The HSR continues to explain that the Big House is a structure that has evolved during the three major building campaigns of 1797, 1808 and 1835. Thomas Walter replaced all the exterior doors with Greek Revival panel patterns except for the Federal style front.
door at the north facade which served as the main entrance during the Latrobe period. It is currently in the middle of the two-story hyphen at the north façade under the porch. This is a six-panel door with semicircular fanlight transom above. Although located in a Walter period wall, the door, its transom and accompanying architrave are designed in the early Federal style indigenous to the original Craig home. The most likely explanation is that this door was the landside entry door into Craig Hall from 1797 until circa 1834 at which time it was removed, salvaged and relocated to its current position during the Walter additions.

Section 1.4 A: Architectural Condition Assessments – Interior, First Floor Room Assessments of the Historic Structure Report and the measured drawings of the house by architect Daniel Campbell, located in Appendix A, provide detailed descriptions of the doors in the central core of the house.

2.2.2 The 2014 Wood Seminar Student Reports

An important report by students Lauren Shaughnessy and Meredith Leep from the

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48 The land side is facing the north while the river side is facing the south.
49 Ibid., 1.3-21.
Graduate Program in Historic Preservation at the University of Pennsylvania considered the woodwork typology at the Big House. Serving as a foundation for this study, this report shed light on the stylistic period to which the doors throughout the house belonged. Although the survey only included the main entrance door (101/1) in the main core of the house, it offered good background knowledge for differentiating between the Federal and Greek Revival period doors, allowing the author to identify the period to which the doors in the central core belonged.

Leep and Shaughnessy’s report provided an analysis of the interior woodwork of the mansion, with a particular focus on the styles and chronology of doors and how their placement may have changed during Andalusia’s various building campaigns. They surveyed, photographed and produced measured drawings of three types of features - doors, fireplace mantels and staircase.

In the survey of the doors, they first referenced Whelan’s book *The Wooden Plane* to understand the craft and language of planning styles. Later, the authors provided text descriptions, measured drawings and photographs of doors: 101/1, 107/1, 108/2, 203/1,

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51 led by instructor Andrew Fearon in HSPV 740 Seminar in Architectural Conservation of Wood.
53 Other 2014 wood seminar reports include: Andalusia: Window typology and assessment, done by Julianne Wiesner-Chianese, Wenwen Xia, Dana Rice. Andalusia Portico Analysis, done by Cesar Bargues Nallester, Jocelyn Chan, Shuyi Yin.
211/1, 212/1. They also recommend further investigation of the Attic Floor doorways for the Servants’ Quarters, as they are only documented with photographs.55

In the final analysis, they concluded that among the many doors surveyed, the majority appeared to match the age of the construction campaign where they were located, be it the Craig campaign of 1797, the Latrobe campaign of 1808, or the Walter campaign of 1833-1835. However, two of the doors surveyed departed from the expected chronology of their surroundings. Located on the first floor, between the Craig and Walter wings, door 107/1 features both Federal and Neoclassical components. The door frame, which transverses the former bearing wall of the Craig house, has Federal-style paneling, while the profile of the door itself dates to the neoclassical period. Likewise, although door 211/1 (painted floor bedroom) was located in the Craig section of the mansion, both frame and door appear to date to sometime between the late nineteenth to early twentieth centuries, suggesting that they were added to the second floor at a later period. Due to the limited scope of research, doors 107/1 and 211/1 were not included in this research, but future investigation may consider additional doors in the building.56

56 Ibid.
2.2.3 The domestic architecture of Benjamin Henry Latrobe

In Michael W. Fazio and Patrick A. Snadon’s 2006 book *Domestic Architecture of Benjamin Henry Latrobe*, which lists almost all of Latrobe’s domestic designs, a few pages are devoted to Andalusia. The authors noted that the drawing of Latrobe’s work no longer exists. They also noted that:

Landside entry into the two small rooms, and circulation proceeded along a short corridor, really an extension of the stair hall. Currently, this corridor ends awkwardly at the longitudinal partition between the two riverfront rooms. Although this partition is wooden, it stands directly above a masonry wall in the cellar and so could easily be original. Only subsurface investigation might prove conclusively whether it dates from the late eighteenth century.

However, Daniel Campbell raised questions about this statement. He believes that the author might be referring to the partition wall between the Dining Room and the Red Parlor. Because of the focus of the book, the authors may have attributed changes in the house to the period of the Benjamin Latrobe north additions, which may or may not be true. This wall in question is parallel to the floor framing above and below, so it is not a bearing wall. Perhaps that is the reason for the authors’ speculation derives from the existence of the brick wall or row of piers in the basement below it, as if it was bearing at one time. However, Campbell emphasized that the presence of the basement wall

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58 Ibid., 318-319.
59 Daniel T. Campbell (AIA, Architect) in discussion with the author by email, January 2016.
60 Ibid.
or piers doesn't mean that this wall was necessarily bearing.  

Fazio and Snadon’s book goes on to describe that when Margaret Craig died in 1814, Nicholas Biddle, by now married to her daughter Jane Margaret Craig, purchased his mother-in-law’s house. When Biddle hired Walter, he was in effect hiring an architect descendent of Latrobe, since Latrobe trained William Strickland, for whom Walter worked. In his 1833 plan, Walter proposed to enlarge and regularize the existing building by making it a giant Doric temple.

Fazio and Snaden’s book holds a relatively negative perspective of the Greek temple form of this residential building. It expressed its attitude as:

Walter’s final scheme further enhanced, at least in scale, the prominence of the landside, it particularly aggrandized the riverfront, so that the building would appear as a dominant “modern” landmark when seen from the Delaware river. This abandoning of Latrobe’s relatively modest, elegant, classical re-composition in favor of Walter’s chaste but overwhelming Grecian remodeling documents the close of Federal period investigations in architectural balance and the arrival of self-confident, eventually self-indulgent American Nationalism celebrated by full-blown Greek Revivalism.  

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61 Ibid.
63 Ibid.
2.3 LATROBE’S PALETTE

2.3.1 Colors of the late eighteenth century

Kerry Johnson’s 2007 Master Thesis addresses American architectural painting trends from the British tradition. She noted that the prevalent trend by the middle of the 1760’s was defined by Robert Adam, who had his unique way of treating wall surfaces. Adam’s use of color to add complexity to form and decoration was distinctive. The Adam Brothers believed the white color was too bright and cold in practice, therefore they argue for a colored background to soften the white and bring out the details of the decorations.64

Johnson contends that at the time of the Federal period in the newly established United States of America, interior decorating trends were significantly behind the times when compared to those in England. Perhaps the most influential factor of paints and colors used in eighteenth century America was economy.65

Architectural finishes were both methods for achieving elegance on a budget and for

65 Ibid.
displaying opulence by way of expert decorative finishes and expensive materials. Because of the rarity and expense of obtaining precious pigments, pigments such as verdigris were only accessible to the very wealthy. High quality faux finishes like graining or marbling were also sometimes symbols of wealth during this time. Johnson describes finishes of this period of time as "clean and airy", achieved through the use of light colors and white woodwork. Free Neoclassical interiors announced a departure from the dark blue, gray and yellows use in colonial period, yet they had been greatly influenced by the Adam's style palette.

Johnson used Latrobe’s Bank of Pennsylvania in Philadelphia as a case study for her thesis. Although the Bank of Pennsylvania was finished in 1801, it was not painted until 1805, to allow sufficient time for the plaster to dry. According to the letter from Latrobe to Samuel Fox, the President of Bank, Latrobe wrote a detailed decoration plan to be carried out by painter John Joseph Holland. Interestingly, Holland employed both Strickland and his father in the rebuilding of the Park Theater in New York in 1807.

Johnston refers to scholars such as Cohen and Brownell and she described how Latrobe’s use of color changed the physical experience of a visitor:

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66 Ibid.
67 Ibid.,104-150.
68 Ibid.,105.
In the rotunda, the main room of the bank, Latrobe suggested that the wall will “have a good effect if painted of a pale, but warm Oker, or straw color,” to extend “over the great Niches, but the band which runs round them should [be] white.” He then emphasized not to use “too dark” a yellow. For the recessed panels in the wall, the flat inset areas were to be a paler version of the same yellow tone of the wall, the margins “Lake” and the panel moldings white. The general “lake” color Latrobe describes is most likely a light pink derived from the use of a red lake pigment. “All of these colors,” he says, “should be kept very tender.” The ground of the frieze was to be “white faintly broke with blue,” meaning it was to be painted in the imitation of a fairly neutral whitish marble with pale blue veins. The moldings above the frieze were to be “pure white” while the Greek fret running across the frieze was to be “a dark rust color, almost Spanish brown.”

Latrobe’s 1805 letter to Fox reveals a lot about the architect’s knowledge of color and the ways in which it could be used to evoke emotion through architecture. The Bank of Pennsylvania color scheme is one Latrobe utilized repeatedly. Also, it shows Latrobe’s intentions, how he thought about color in his architecture, and how these ideas evolved over time.

2.3.2 Colors of the Greek Revival Period

Johnston’s thesis noted that the Greek Revival period carried with it different attitudes about color and architectural finishes, such as the re-emergence of faux finishes. Decorative painting techniques such as marbleizing, bronzing, and graining in the English
architectural history occurred in early nineteenth century England as discussed in the 1828 T.H. Vanherman, in his *Every Man His Own House-Painter and Colourman*.\(^{72}\)

Likewise, bronzing became fashionable, in which capitals, moldings, and other decorative architectural elements were painted to represent patinated bronze, often achieved through the use of dark green paint.

Similarly, graining was introduced back into the English interiors by French workmen in the late eighteenth century, which replaced the explicit use of white woodwork. The use of painted panels became popular in the 1810s and 1820s in England and later helped define 1830s American Greek Revival interior decorating wall treatments. By this time, white woodwork was no longer in style, as Andrew Jackson Downing explains in his *The Architecture of Country Houses*\(^{73}\): “The surface for painted wood is always somewhat rough, and catches dirt readily, and white lead (or other light shades of which it is the base) always oxidizes or changes color, more or less. The grained surface, on the contrary, being made smooth by varnishing, does not readily become soiled, and when it does, a moment’s application of a damp cloth will make it clean and bright.”

\(^{72}\) Bristow, Architectural Colour, 179.

2.4 MICROSCOPICAL EXAMINATION AND ANALYSIS

This research also required that the author review microscopical analysis of architectural finishes and gain proficiency in microscopy and microscopical methods, especially examination of polished cross sections, photomicrography, microchemical spot testing, polarized light microscopy and fluorescence microscopy. Several resources, including written source materials, were used to achieve these goals.

In Marie Carden’s 1991 article “Use of Ultraviolet Light as an Aid to Pigment Identification” in APT Bulletin, the author introduced the method of UV light as a useful tool in architectural finishes analysis, especially for white pigments. She explains that the fluorescence of pigments under ultraviolet light can provide clues for dating the paint layers in architectural finishes. These clues can be valuable in tracing the evolution of an historic structure.

She noted that the use of ultraviolet light has long been included in the standard methodology for performing paint analysis at the Building Conservation Branch (formerly the North Atlantic Historic Preservation Center), North Atlantic Region of the National Park Service, and has been described as part of the Center's standard practices.

and procedures in a 1978 article in the *APT Bulletin* by conservator Carole L. Perrault. 75

She pointed out the initial purpose of this technology was designed for zinc oxide identification. Based on the knowledge that zinc oxide pigments exhibit a bright yellow fluorescence and that they began to be economically competitive with lead paint around 1850, it was possible to place a mid-nineteenth century date on paint layers that fluoresced yellow paint samples.

She later explained that this technology has been largely expanded because in 1986, during the analysis of interior finishes in the Arlington House (the Robert E. Lee Memorial, ca. 1802-50), in Arlington, Virginia, people noticed a lot of unexpected phenomenon in their architectural finishes research. During their observation, they found that the Sodium Sulfate (Na₂S) lead paint text was positive in a continuous of layers, and a lot of them show fluorescence. Apparently, based solely on chemical test or UV light test for zinc oxide would not be enough. This led to the survey of the most commonly used pigments in the nineteenth and early twentieth century, if they demonstrate any fluorescence character. 76

She also pointed out that bulk or powder form as well as the mix (in oil or in other

75 Ibid., 26.
76 Ibid., 26-27.
medium) will influence the color we see during the application of ultraviolet light test of these pigments.77

She then continues to explain the important basic concept of primary fluorescence (or autofluorescence) and secondary fluorescence. A lot of substances have primary fluorescence character; it is called primary fluorescence or autofluorescence. The pigments particles are excited by a wave length of UV light and then show fluorescence phenomenon. When using fluorescent stains, it is called secondary fluorescence. Fluorescence could be observed with naked eye. However, more precise measurement may be accomplished by recording the fluorescence spectrum with a fluorescence spectrometer shortwave and multi-band options.

Because the UV autofluorescence method gave an initial clue of what white pigments in this research might be, it still needs more accurate methods to prove the findings. Therefore, microchemical spot test and the polarized light microscopy methods are reviewed here.

Andrea M. Gilmore’s article “Analyzing Paint Samples”78 emphasizes polarized light

77 Ibid., 27.
microscopy as a method of pigment analysis. She talks about the most widely used white pigments in early times were white lead and that it could be identified by adding a drop of sodium sulfide solution. If it contains white lead, it will become black in contact. However because white lead was so universally used until late 1950, identifying white lead is not so informative. In the early times, it could be non-oil based paints like (whitewash or distemper) or zinc oxide. Zinc oxide was first used in the middle of the nineteenth century in architecture as a white paint, and it could prove a dating point in layering sequence.  

She also cautions that microchemical spot test, because they involve chemical reaction of the sample (pigments) with the chemicals, can be informative, they are only used on a limited basis by architectural conservators because they damage the sample. Therefore, an increasing number of conservators prefer to use Polarized Light Microscopy (PLM) to more precisely identify the pigments. With the polarizing light microscope, pigment particles are often characterized and reasonably well identified by comparing their color, crystal shape, size, refractive index and polarization colors with those of known pigment particles that are mounted and identified on standard reference slides.  

80 Ibid., 181.
Because of the multi-faceted nature of this research and the short timeframe for accomplishing it, only a small number of sources could be referenced. Many additional references may be brought to bear on this subject area in future efforts to expand this inquiry.
CHAPTER 3
METHODOLOGY

This chapter outlines the documentary and laboratory methods employed in conducting this research. Previous research on the physical fabric carried out of the house by way of the Andalusia Historic Structure Report\textsuperscript{1} and the University of Pennsylvania Fall 2014 Wood Conservation Seminar Reports\textsuperscript{2}, have produced a foundation of knowledge about the building and raised questions for this study. The main aim of this research is to employ the study of finishes as a means for dating changes within the building, while answering questions from previous research and contributing to the scholarship of this important but under-researched building.

3.1 Statement on Location Selection (doors and surrounds, the staircase)

The Andalusia Big House is not a small building and the finishes exist on both the exterior and the interior of the building. Due to the limitation of time, the analysis of finishes throughout the house was not possible. Thus, the first step focused on determining where finishes analysis would be most valuable. The criteria for selecting

\textsuperscript{1} Daniel T. Campbell, AIA and Kathleen M. Abplanalp, Ph.D. et al., “Andalusia Big House Historic Structure Report” (Commissioned by the Andalusia Foundation, Andalusia, PA. Published in West Chester, PA, 2014).

locations for analysis required that the surfaces in question retained original finishes and represented more than one building campaign. The Historic Structure Report and the University of Pennsylvania Wood Conservation Seminar Report served as the most important sources of information. Following review of these reports, the authors, Daniel T. Campbell, AIA, the editor of the Historic Structure Report and Andrew Fearon\(^3\), were interviewed. Connie S. Griffith Houchins, the Executive Director of the Andalusia Foundation also fielded questions. Chris Frey and Elizabeth Lissy, finishes conservators in Keystone Preservation, who have analyzed finishes in the US Capitol,\(^4\) offered context for the finishes by Latrobe and Walter at the US Capitol.\(^5\)

Following this preliminary research, it became clear that the central core of the house, which includes the stair hall including the hall to the front and the foyer, is the one space in the Big House where all three construction campaigns are represented. Given that it is believed that the doors were moved during Walter’s interventions,\(^6\) the author hypothesized that evidence of the original and later finishes may allow one to more

\(^3\) Andrew Fearon is the instructor of the University of Pennsylvania Wood Seminar Course and a wood architectural conservator, also involved in the writing of the Historic Structure Report

\(^4\) Both Latrobe and Walter have been involved in the design and construction of US Capitol, thus, in-person contacts with Chris Frey and Elizabeth Lissy were carried out with questions concerning if there was any wood graining or finishes findings of those two architects in the US Capitol building.

\(^5\) According to Frey and Lissy, most of the finishes they surveyed were on metal substrates. The US Capitol was largely damaged during the fire in 1814 set by the British troops, and most of the wood elements were replaced by cast iron later. The original finishes are not extant. “The Evolution of the Capitol,” \textit{US Capitol Visitor Center}, \url{https://www.visitthecapitol.gov/about-capitol/evolution-capitol}.

\(^6\) Daniel T. Campbell, AIA and Kathleen M. Abplanalp, Ph.D. et al., “Andalusia Big House Historic Structure Report” (Commissioned by the Andalusia Foundation, Andalusia, PA. Published in West Chester, PA, 2014), Section 1.4A - Interior – First Floor description.
specifically link the doors to particular locations and changes in the building. Based upon the stylistic identification of doors conducted in the Wood Seminar, three pairs in the central core appeared to date from the same period: the Federal front door and the Butler’s Pantry door; the door to the Dining Room and the door to the Red Parlor; the door to the Study and the door to the Kitchen. While considering previous research, this thesis will address the three pairs of the doors in the central core as a method of comparing periods of change at Andalusia.

During the first two site visits and initial analysis of the paints samples, it was found that no evidence of early paints remained on doors. Therefore, the inquiry of the research was adjusted to not only include the doors but the door surrounds and to consider other features retaining evidence of early finishes in the stair hall, such as the handrail. It was speculated that examination of these additional features might in combination shed light on the change in this space.

The questions considered for each pair of doors are outlined below:

**Pair A:** The Front Federal style door and the door to the Butler’s Pantry. Do the Butler’s Pantry door and the Front door appear to be contemporary with each other? How do the finishes on the doors and their surrounds correspond?

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**Pair B:** The door to the Red Parlor and the door to the Dining Room. Do the doors to the Parlor and Dining Room appear to be contemporary with each other?⁸

**Pair C:** The door to the Kitchen and the door to the Library/Study. Given that Campbell mentioned that these doors both have paneled jambs, aligning with their door panels and that they appear to have several more coats of paint, than others nearby,⁹ the question arises as to whether the doors to the Kitchen and the Library/Study once exterior doors and frames, perhaps in the Latrobe pavilions? Are they contemporary with each other? How do the finishes on the doors and their surrounds correspond?

**Group D:** What about the finishes on the staircase? Do they offer any clues of original finishes since it is believed that the staircase location has not changed during the three campaigns?

### 3.2 Documentation and Sampling

Three site visits with thesis advisor Cassie Myers in December 2015, January 2016 and February 2016 allowed for the opportunity to re-sample and expand the scope of work over time. Connie S. Griffith Houchins, the Executive Director at Andalusia, was contacted to provide access into the building and to grant permission to take samples.

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⁸ Door surrounds samples of the pair B doors were not determined to sample during the third site visit because according to the initial analysis of those samples, not much productive information was found.

Wherever possible, samples were taken from the least obvious locations, but not sampled at very low locations due to the greater likelihood of damage and repair in those locations. However, in order to acquire the intact samples that included the wood substrate as well as all paint layers, it was necessary that the samples as large as 0.5cm, larger than those normally collected for paint analysis.10

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10 It is worth mention that paints samples need to be larger on the wood substrate than on other substrates like plaster because it is difficult when sampling on the wood substrate because of the paints easily popping off and some of the wood species are very hard. Also, safety problems such as the hazard of the lead white paints should be taken into consideration.
The first site visit was carried out in December 2015. A visual survey was conducted at this time in order to identify research questions. Equipment brought to the site included:

1. a small Nikon stereoscopic microscope (SMZ-1) and its light source.
2. a sampling kit, which include X-acto knives, scalpels, envelopes, marking tape and a flashlight.  
3. A 10X magnification Opti-visor.
4. Removable Self-Stick Notes (to mark the sampling location), notebooks and pens.
5. a camera. Other resources include a printed copy of the measured drawings by Daniel Campbell, which indicate all the room numbers and door numbers, on which the numbering system for this study was built. Sampling locations were also determined at this time.

Choosing the location of samples is an important first step for a finishes study. Locations, such as the outer edges of surrounding molding of the door panels, were chosen for their likelihood of retaining early finishes. After deciding the sampling location, a label was written with the sample number, was adhered to the sample location, and photographed. Next, samples were taken using X-Acto knife. Samples varied in size but were usually measured about 0.5cm in length. Samples from the location were placed in sample bags. A unique sample number, date and reason for sampling was indicated. For example, AND (101/1.1-1), where “AND” is the project name (Andalusia), 101/1 is the door number, .1 indicates the number order the sample was

11 Some of the locations were very dark.
taken, in this case, is the first sample taken on this door. And -1 is the first cut sample got in the lab (some samples are long enough to have a second cut or a third cut in order to present more features).\textsuperscript{12}

A small Nikon stereomicroscope (SMZ-1) was taken to the site for \textit{in-situ} examination. All samples were examined at the site to determine if they illuminated the finishes history or if additional samples were needed.

Samples were taken on the interior (facing the stair hall) face of the Butler’s Pantry door (Door 101/4), the staircase in the Stair Hall (Room 101), and mantels of fireplaces in the second floor rooms (Room 208 & Room 211)\textsuperscript{13}. After the initial examination with the stereomicroscope on site, a good sample was selected from among other samples to be embedded in the lab. Additional sample material was retained for microchemical spot testing and additional examination.

The second site visit was carried out in January 2016 with the intention of augmenting previous samples from the three pairs of doors mentioned before. The samples collected from the first visit were too small to be well presented, and this time, the samples

\textsuperscript{12} Room numbers were referenced in the HSR which utilized the numbering system established by the Historic American Buildings Survey (HABS) produced in 1974.

\textsuperscript{13} Mantel samples were not used at the end because the target of this study was later decided to focus on the central core on the first floor.
collected were larger. Also, only the interior (facing the stair hall) face samples of the Butler’s Pantry were taken during the first time, thus this time the exterior (facing the pantry) face was added taken for a more complete understanding of the door. It is well mentioned that some samples, due to their brittleness, were held in place with tape in order to get a fully intact sample.

A third site visit on February 2016 was directed at augmenting limited evidence of early paints on the door samples collected during the previous two site visits. After extensive examination of paint samples and surfaces from the door at the site, no conclusive evidence of historic paint linking one door to another was found. While the lead paint
layer directly on the wood substrate may date to the building’s early history, subsequent layers are clearly later. After examining the sequence of paint layers from doors and not finding evidence that would help to understand how and when the doors were relocated, the idea of shedding light on the relocation of doors in the central core of the house by way of paint analysis was abandoned.

Therefore, it was necessary to adjust the scope of research. Although the paint had been removed from the doors at least once, it appeared possible that the door surrounds, such as the frames, retained older finishes layers. During the third site visit samples were collected from door surrounds. As with the doors, the frames were paired as follows: Pair A: door to Butler’s Pantry / Federal front door; and Pair C: door to Study / door to the Kitchen. Pair B: door to Red Parlor/ door to Dining Room was not sampled this time because of the very limited information found on the previous door samples. Samples from the staircase, the area least likely to have been changed, were also taken. It was hoped that these samples would provide a reference to the earliest period of painting and a complete history of painting. These samples included the handrail, stair baluster, chair rail in the stair hall. Additionally, hardware, such as the kitchen door knobs, were removed in order access undisturbed finishes.

A list of samples locations is included in Appendix B: Master Sample List. This
information will be important if additional analysis is conducted in the future. The sample tables outline information about each sample and describe the location of the samples in the building and the substrate on which the finishes were applied. All of the tables are included in Appendix C.

3.3 Sample Preparation

The paint samples were first examined under a Leica stereoscope (MZ16) at a range of 2X to 11X magnification to find the most complete chronology for each sampled area. The most intact samples were embedded in Bioplastic polyester resin\textsuperscript{14} and labeled.\textsuperscript{15} Before the samples were set onto the base layer of resin, a drop of resin was added to prevent the sample from floating to the surface.\textsuperscript{16} Then the cubes were filled to the top with another layer of the resin to secure the sample. If there was a sample that had been taped during the sampling process, the tape was embedded with it. The samples were allowed to cure for a couple of days in the fume hood. Heat and good air ventilation (sometimes cure outside the fume hood) can accelerate and ensure the curing of the sample before cutting and polishing, which need certain hardness.

\textsuperscript{14} Smaller trays are easier to remove the cubes.
\textsuperscript{15} Labels with ball pen are easy to disappear so pencil writing or printed versions are believed to work better.
\textsuperscript{16} The first dew samples were glued with super glue, but the cross-section seemed to be not so sound, so the second process shifted to use a little drop of the resin as the glue.
The sample cubes were then hand-sanded with 100-grit paper secured to blocks, as the cubes naturally formed a meniscus in the tray. The sample cubes were cross sectioned using a Buehler Isomet 1000 Precision Saw to produce cross sections. These cross-sections were hand-polished with various grades of abrasive paper ending with micro-abrasive alumina powders (Buehler Micropolish II, 0.05 micron) with water and then mounted on microscope slides with Melt Mount. The mounted cross sections were used for microscopic analysis. The rest of the sample cubes were stored in labeled plastic sample bags for future reference and research. The mounted cross sections are stored in labeled microscope slide storage boxes lying vertically.

3.4 Techniques for Analysis

3.4.1 Microscopical Examination of Cross Sectional Samples in Visible and Ultra-violet Light

The paint samples collected were mostly white paints. When examined under visible light, they appeared to be all white. Layers were indistinguishable in visible light.

17 Ibid.
18 Polish could be done with water or Stoddard solvent, this time used water because Stoddard solvent is slightly toxic while water is non-toxic.
19 Melt mount is not purposely used as a permanent glue, but it has an advantage that when heated, the sample could be removed and glued again.
20 The box is stored vertically in order to prevent the gravity drop of the samples.
Therefore, the samples were examined with the fluorescence microscope, which, because of the distinctive autofluorescence of the pigments in different paint layers, proved to be more helpful in distinguishing the white layers of paint.

Cross-sectional samples were first examined in reflected visible light with dual gooseneck fiber optics at 20X and 40X using a Nikon Optiphot2-Pol microscope accompanied with the Nikon DS-Fi1 Camera and NIS-elements software. Notes were taken on the appearance of paint layers. Pigment distribution within the layer and the presence of dirt layers were also recorded.

Ultra violet light microscopy can be used to identify architectural paint media. Illumination of different materials with UV light may cause them to autofluoresce with characteristic colors\textsuperscript{21}; making use of these characteristic autofluorescence colors of organic and inorganic materials can help observing and distinguishing different white layers.\textsuperscript{22} For example, plant resins such as amber, copal, and mastic autofluoresce bright white.\textsuperscript{23}

\textsuperscript{22} Many common materials used in architectural finishes either fluoresce or develop fluorescence over the years as the materials age. Wolbers, 167.
The four main groups of traditional binding materials found in architectural paints—proteins, oils, gums, and resins—may show different autofluorescence when viewed with appropriately filtered ultraviolet light. Pigments can also exhibit characteristic auto-fluorescence. For example, zinc white usually fluoresces as bright yellow while lead white appears brown. It helps to distinguish pigment type and at the same time to associate layers from samples to each other. Of particular benefit for this study is the fact that aged oil paints autofluoresce greenish yellow and lead autofluoresces brownish color. These characteristic autofluorescence helped differentiate layers that may have contained aged binding media.

Using fluorescence microscopy, the samples were then examined with Nikon Alphaphot-2-YS2 compound microscope ultraviolet light source and filter blocks. Autofluorescence was noted. Each sample was photographed in both visible light and filtered ultraviolet light, normally in 20X or 40X magnification range, depending on the size of the sample and layers to be examined. The photomicrographs of the samples were then inserted into each sample’s data sheet for reference and comparison. A single

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24 Zinc white usually autofluorescence as bright yellow and lead white as brown.
25 Ibid.
26 For example, shellac will appear orange, glues will appear greenish, other proteins as yellowish, resins as white, gums as bluish white, and aged drying oils as greenish-yellow.
27 A BV-1A Nikon filter block was used, which is for blue-violet fluorescence excitation with an excitation bandwidth of 430-440 nm and a barrier filter of 470 nm. The narrow excitation band is used to minimize specimen autofluorescence. The long-pass emission filter allows detection of a wide range of fluorochrome wavelengths. Nikon Microscopy, “Fluorescence Filter Combinations,” http://www.microscopyu.com/articles/fluorescence/filtercubes/blueviolet/blueviolethome.html.
data sheet includes the sample location, date, type of microscopical examination, light source and other basic information. It also contains initial observations and comments about the sample.

The description of the paint stratigraphies begins with the identification of the substrate, in this case, wood. Then the color descriptions are all referred to visible colors (if not especially noted as UV autofluorescence color). The data sheets were then organized in pairs (pair A, pair B, etc.) for comparison because initial research questions were specifically set up as “pairs”. The data sheets with cross-section photographs for each sample used in the analysis are included in Appendix C.

3.4.2 Pigment Identification - Microchemical Spot Test and Polarized Light Microscopy

Due to time constraints and the limited scope of research, the use of fluorescence microscopy was simply used as a tool for observing autofluorescence of paint layers, as opposed to one used for observing secondary fluorescence resulting from staining with fluorochromes. Among all of the white samples, the earliest white layer appeared to be

28 Staining, FTIR, XRD, and SEM-EDS are not considered in this study but are recommended for a more specific identification of pigment.
lead white, due to its warm yellowish white autofluorescence color. On several samples, the layer on top of it autofluoresced bright white, indicating a different type of pigment.

In order to further explore the pigments, microchemical spot tests and particle analysis with polarized light microscopy were carried out.

In this research specifically, particles of the first layer (layer 1 in sample 101_1.10) believed to be lead white (appear to be warm yellowish white in UV) were removed from a loose sample and the pigments were collected on a watch dish for lead spot test. Lead white is basically lead carbonate. A drop of dilute nitric acid was added to the sample and the $\text{H}^+$ reacts with the carbonate and releases air bubbles ($\text{CO}_2$). Then a little amount of potassium iodide crystal was added to the solution, the reaction is: $\text{Pb(NO}_3\text{)}_2 + 2\text{KI} \rightarrow \text{PbI}_2 + 2\text{KNO}_3$. The $\text{PbI}_2$ is bright yellow which indicates that it contains lead. The test for lead proved to be positive.

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29 Because of the filter block this study is using (A BV-1A Nikon filter block was used, which is for blue-violet fluorescence excitation with an excitation bandwidth of 430-440 nm and a barrier filter of 470 nm), lead white autofluoresces warm yellow, instead of the more common russet brown; zinc oxide autofluoresces yellow; and titanium appears bright white.

Figure 3.3 101_1.10 Federal front door, hall-side, frame left bottom. 10X objective. Left: In visible light. Right: in ultra-violet light.

Figure 3.4 The PbI2 is bright yellow which indicates lead contains of the sample (photograph by author).

Then the layer above the lead white layer (the 2nd layer), which autofluoresced bright white under UV light (layer 2 in sample 101_1.10), and thought to be either zinc oxide or
titanium oxide, was analyzed by examining particles with polarized light microscopy. Pigment particles were removed from that layer with a tungsten needle and were evenly dispersed on a glass slide with Meltmount (n: 1.66)\textsuperscript{31}, and covered with a round coverslip. Then with the polarizing microscope, pigment particles are characterized and reasonably well identified by comparing their color, crystal shape, size, refractive index and polarization colors with those of known pigment particles that are mounted and identified on standard reference slides.\textsuperscript{32}

Due to the uncertainty of whether this second layer was either titanium oxide or zinc oxide (titanium oxide and zinc oxide have similar refractive indices and birefringence), another sample (the second layer in Sample 5) was tested again for the presence of zinc. A loose sample with all paint layers attached to the wood substrate was found and placed on a glass watch dish. A drop of sodium hydroxide solution was added to the sample. The solution was in contact with the sample for 15 seconds. Then a few drops of the diphenylthiocarbazone solution were added on the sample. The appearance of a pink-red color along the edge of the spot indicates the presence of zinc.\textsuperscript{33} The test for

\textsuperscript{31} The process of removing these pigments must be done very carefully using the small scalpels and Tungsten needles under a stereoscope with a relatively higher magnification. In this case, the Leica MZ-16 microscope was used.


\textsuperscript{33} “HSPV 555-Introduction to Conservation Science Lab 14 - Identifying Architectural Metals” (Graduate Program of Historic Preservation, University of Pennsylvania, Philadelphia, PA, Spring 2014). This zinc test was modified according to the limited condition of the sample. In the standard test: 1. Degrease a small area of the object with acetone and cotton swabs. Allow to dry for one minute. 2. Using forceps dip a small square of filter paper into the sodium hydroxide soln. and hold the filter paper in contact with the metal surface for 15 seconds. 3. Quickly blot the small square on a larger piece of filter paper making two or three wet spot imprints. 4. Place a few drops of the
zinc proved to be positive in a middle white layer in this test; however, the test was modified due to the limited condition of the sample. Layers with pigments were too hard to remove or separate, so the test was carried out on a bulk sample. Also the quantity of the sodium hydroxide solution and the reaction time were hard to control. For these reasons, more precise analysis with FTIR, XRD, SEM/EDS is still needed for confirmation.

Figure 3.5 Sample 5. Door to kitchen, hall-side, lower part. 10X objective. Left: In visible light. Right: In ultra-violet light.

diphenylthiocarbazone solution on each of these spots. The appearance of a pink-red color along the edge around the spot indicates the presence zinc. 5. Repeat steps 1-4 of this section using the zinc standard. Confirm the presence of zinc in the sample and standard by dissolving the metal scrapings with nitric acid soln., heat, and redissolve with distilled water as in step 3. Add 1-2 drops of sodium hydroxide and allow to dry WITHOUT USING THE HOT PLATE. Add a miniscule amount of sodium bicarbonate, just a few crystals. Set aside and allow to dry. (This should also be followed with a test to detect the presence of cadmium)
Figure 3.6 Zinc test for sample 5. The appearance of a pink-red color along the edge around the spot indicates the presence of zinc (photograph by author). Loose sample in visible light at 5X total magnification.
CHAPTER 4

OBSERVATIONS AND RESULTS

During the expanded investigation of finishes at Andalusia, evidence of original finishes and indication of change were found. Even though the site was visited three times and new samples collected on each trip, the iterative process of sampling and microscopic analysis that is sometimes required to yield results was limited by time constraints. Future research may build upon this preliminary effort.

Examination of samples with both visible light and fluorescence microscopy offered insight into both the original finishes and changes that occurred in the central core of the house. The author’s observations and conclusions are outlined below in four sections corresponding to the original research questions.

The first section addresses the pair of doors (Pair A) believed to date from the Latrobe or Craig period: the Federal front door and Butler’s Pantry door. The second section considers the doors to the Dining Room and the Red Parlor (Pair B). The third section concerns the doors to the Study and the Kitchen (Pair C). An additional group of samples (Group D) from the staircase and chair rail, which were originally intended as reference, offered unexpected information.
4.1 Pair A - Federal front door and Butler’s Pantry door.

The samples from Federal front door and the Butler’s Pantry door, which are believed to date to the Latrobe or Craig period, included both interior and exterior surfaces and interior and exterior doorframes. It was found that samples from the interior surface of the Federal front door (101_1.1-1, 101_1.2, 101_1.3-2) present similar stratigraphies under the UV light. Under the visible light, they all exhibit several layers of white, but under UV light more layers could be seen and described as follows: wood, yellowish white, white, brownish white, gray.

![Image](image.png)

**Figure 4.1 101_1.1-1 Federal front door interior. 10X objective.**

*Left: In visible light. Right: In ultra-violet light.*

1 101_1.1-1 in which 101_1 means this door in measured drawings (in fact it is, but would type easier as 101_1 in computer), .1 means the first sample, -1 means the first cut of this sample.
As shown in the above photomicrographs, in visible light, the layers are difficult to distinguish. In UV, greater distinction is achieved. The first paint layer over the wood substrate autofluoresces warm yellowish white while the layer above it autofluoresces bright white layer. The third layer appears brownish yellow and is followed by a paint layers that appears dark grayish color. The pigment particles are very
clear in the first layers, indicating paint mixed by hand, as opposed to industrially produced modern paints in which pigments are very fine and evenly distributed.

**Figure 4.4** 101_1.12 Federal front door, interior, right frame bottom. 10X objective.
Left: In visible light. Right: In ultra-violet light.

**Figure 4.5** 101_1.10 Federal front door, interior, left frame bottom. 10X objective.
Left: In visible light. Right: In ultra-violet light.

As for the door frame samples, the interior doorframe sample 101_1.12, which was collected at the lower part of the right side of the door frame, shows a similar stratigraphy to that from the door surface, i.e. a sequence of yellow – white - brown yellow – gray. However, other door frame samples exhibit different stratigraphies. For
example, the sample from the interior door frame (sample 101_1.10), which was collected at the lower part of the left side of the door frame, reveals many more layers than other samples from the door surface. In the visible light, multiple white layers and dirt layers between two of the layers could be observed. Under the UV light, the first layer above the wood substrate autofluoresces yellow, followed by a bright white layer, and then several other layers. The autofluorescent yellow – white - brown yellow – gray layer sequence (layer 1,2,3,4), as described before in the door surface sample, appears at the top outer layer of this sample (layer 8,9,10,11), indicating there were several painting campaigns between the first layer and these four layers. In this case, it appears that the paint had been stripped from the door surface several times before the next painting campaign. However, the doorframe appears to have not been stripped of paint and is believed to have retained a full paint layer stratigraphy.

**Figure 4.6 101_4.1 Pantry door exterior (facing the pantry). 10X objective. Left: In visible light. Right: In ultra-violet light.**
The exterior surface of the Butler’s Pantry door (another door in Pair A) faces the pantry while the interior side faces the stair hall. The exterior surface sample 101_4.1 and 101_4.2 show similar paint stratigraphy. These two samples were collected from the pantry door exterior surface. The substrates were both missing. They both contain multiple layers of paints. Under the visible light, one sees a light brown layer, followed by a white layer, and then translucent tan layer in both samples. Layer 8,9,10 in sample 101_4.1 are in correspondence to layer 1,2,3 in 101_4.2, meaning that sample 101_4.1 shows a more comprehensive paint stratigraphy with more old layers. Beneath the brown layer in sample 101_4.1, there are several layers of warm white color paint layers which are likely to be lead white paints. The translucent green layer autofluoresces bright white in UV light which indicating that it is an oil resinous clear coating.
Samples from the interior side of the pantry door (101_4.6 and 101_4.7) have fewer layers than the samples from the exterior side, which is reasonable since the exterior surface of a door must be painted more frequently for protective purpose. Interestingly, a sample from the trim around the door panel (sample 101_4.6) shows a type of wood species with a darker color than the wood elsewhere, suggesting that this panel (bottom left) was replaced or restored in the past. The light wood of sample 101_4.7 collected
from the surface of the door matches that of the other doors.

**Figure 4.10** 101_4.13 Pantry Door, hall-side, frame top. 10X objective.  
*Left: In visible light. Right: In ultra-violet light.*

**Figure 4.11** 101_1.10 Federal front door, interior, left frame bottom. 10X objective.  
*Left: In visible light. Right: In ultra-violet light.*

However, the interior frame samples 101_4.13, collected from the top of the interior doorframe, include more layers than the door surface samples. Specifically speaking, the first paint layer on sample 101_4.13 is a yellowish white layer (autofluoresces yellowish white) which soaked deeply into the wood cells, followed by a bright white layer (autofluoresces bluish white), then several other white layers, and finally with a grayish
layer, which shows a similar stratigraphy as the sample 101_1.10 from the Federal front door interior frame. The outer layer four layers in the interior frame of the pantry door sample (101_4.13) correspondence to the layer 8,9,10,11 in the interior frame of the Federal front door sample (101_1.10), which indicates that they are likely to be contemporary with each other.

4.2 Pair B: Door to the Kitchen and Door to the Study

The two door samples show evidence of being contemporary with each other. The sample from the hall side frame of the Kitchen door (sample 5), the sample from the hall side surface of the Study door (sample 102_1.1), and the sample from the hall side door frame of the Study door all show a very distinguishable clear coating layer with large aggregates. This layer appears as the fifth layer in sample 5, and the second layer in sample 102_1.1-1 and the sixth layer in sample 2. In all samples, this layer appears to be gray in UV light. Although it is unknown, it is likely to be wax. Additional analysis of this layer is needed.

2 Samples from these two doors' surface were only collected on the stair hall facing side.
**Figure 4.12** Sample 5, Kitchen door, hall-side, lower part. 10X objective.
Left: In visible light. Right: In ultra-violet light.

**Figure 4.13** 102_1.1-1 Study/Library door, hall-side. 10X objective.
Left: In visible light. Right: In ultra-violet light.

**Figure 4.14** Sample 2, Study/Library door, hall-side, door frame. 10X objective.
Left: In visible light. Right: In ultra-violet light.
Samples 102_1.1-1, 102_1.1-2 and 102_1.2 from the Study door surface show similar stratigraphies. The fewer paint layers remaining on these surfaces indicate that the door surface has been stripped of earlier paint and the paints on it appear to be modern.

*Pair C: Door to the Red Parlor 105 and the Door to the Dining Room 108*

For the doors to the Red Parlor and the Dining Room, only the doors and not the door surrounds were examined. Based on the examination of samples from the doors, these two doors appear to be contemporary with each other, and possibly contemporary with the previous Pair B doors. The same evidence is the clear coating layer with large aggregates. In samples 105_1.1 and 105_1.2, which are collected from the hall side surface of the Red Parlor door, and the sample 108_1.2, which is collected from the hall side surface from the dining room door, the clear coating layer in these three samples all appear as the second layer in the samples, where the first layer is a warm yellowish white above the wood substrate. The yellow - bright white - brown yellow – gray sequence of layers of modern paints as seen in ultra violet illumination are identical in these three samples as well as all of the door samples, including Pair B doors: the door to the Study and the door to the Kitchen.
Group D: Staircase and Chair Rail

This group includes samples collected in the staircase and chair rail in the stair hall to be used as a reference for the examination of the doors. Sample 101.4 from the attached handrail and sample 101.5 from the free-standing handrail. Both surfaces appear to be wood. Based on microscopical examination, it appears that one surface was grained to match the other. That is, the attached handrail was probably added later than the free-standing handrail. As the graining wore off from use, it was re-grained three separate times. That said, the free-standing handrail could be a replacement but it would certainly have originally been a clear coated wood.³

Figure 4.15. 101.4 Grained staircase handrail. 10X objective.

Left: In visible light. Right: In ultra-violet light.

Secondly, from sample 9-2 it was found that the stair baluster was stained dark brown

³ Traditional building practices over hundreds of years favored unpainted handrails coated with oil resin or other types of clear finishes, Franco Bulian and Jon A. Graystone. Wood Coatings: Theory and Practice (Amsterdam: Elsevier, 2009), 56.
and clear coated with a transparent coating. In visible light, the traces of the dark stain embedded in the wood are apparent at high magnification, over which traces of clear coating exist. These surfaces were later painted white.

**Figure 4.16** Sample 9-2, Stair baluster. 10X objective.  
*Left: In visible light. Right: In ultra-violet light.*

Sample 1 from the chair rail between the Butler’s Pantry and the Dining Room appears to have also been clear coated at the sixth or seventh layer. However, this sample is not well presented and needs to be sampled and examined again. The sample from the stair stringer (sample 8) and the one from the engaged newel post (sample 101.3) both show the large aggregated translucent coating layer as the second layer in the sample. The first layer is a warm yellowish white color, identical to samples from the hall side of the Red Parlor door (105_1.1 and 105_1.2), the hall side of the Dining Room door (sample 108_1.2) and the hall side surface of the Study door (sample 102_1.1).
After the microscopic observation under visible light and UV light, samples were chosen for micro-chemical spot tests and white pigment identification with polarized light microscopy. The purpose of pigment analysis was to utilize knowledge of the history of white pigments to explore the age of the paint layer. Because it is known that the oil based lead white paint is the oldest and most popular paint since antiquity, and one that...
continued to be used well into the mid-twentieth century,\textsuperscript{4} it was important to confirm the presence of lead in those layers appearing to be lead paints with the fluorescence microscope. The arrival of zinc white in the middle of the nineteenth century (ca.1850) and titanium oxide in the early twentieth century (C.1920)\textsuperscript{5} offered important indicators of date.

The test for lead involves extracting lead acetate from lead carbonate with nitric acid; and then precipitating lead acetate with potassium iodide. In the presence of potassium iodide, lead acetate will turn into bright yellow lead iodide. A drop of dilute nitric acid was added to the sample and then it released air bubbles (gas). Then a little amount of potassium iodide crystal was added to the solution. The crystals turned bright yellow (banana yellow), which indicates the presence of lead. After analyzing the lead paint, the layer above it was analyzed. Particles from the paint layer were removed from the sample and dispersed on a glass slide and covered with round cover slip. The pigment particles were characterized by comparing their color, crystal shape, size, refractive index and polarization colors with those of known pigment particles that were mounted and identified on standard reference slides. Titanium oxide pigment particles are finely divided and birefringent.\textsuperscript{6} Because the refractive index and birefringence of titanium


\textsuperscript{6} “Introduction to Optical Birefringence,” \textit{Nikon Microscopy U},
and zinc white are similar, it was difficult to distinguish between these pigments with polarized light microscopy. However, the frequent appearance of this layer as a second layer, such as seen in the sample from the Federal front door interior frame (sample 101_1.10, which is believed to represent a full stratigraphy of all campaigns), suggests that this layer is pigmented with zinc white, as opposed to the later titanium white.

Due to the uncertainty of this layer, another sample (sample 5, from the door to Kitchen, interior frame bottom) was chosen to test again for the presence of zinc. A loose sample with all paint layers attached to the wood substrate was found and placed on a glass watch dish. A drop of sodium hydroxide solution was added to the sample. The solution was in contact with the sample for 15 seconds. Then a few drops of the diphenylthiocarbazone solution were added on to the sample. The appearance of a pink-red color along the edge of the spot indicates the presence of zinc. The test for zinc proved to be positive in a middle white layer in this sample. Because of the limitations of the paint sample (it is very hard to remove or separate a certain paint layer), this test was carried out on a bulk sample. However, even if the test only shows that the pink-red indicator appears in a “middle layer” of the sample (perhaps the 5th or the 6th layer, not necessarily the 2nd layer), it suggests that the layers before the pink-red

http://www.microscopyu.com/articles/polarized/birefringenceintro.html

7 “HSPV 555- Introduction to Conservation Science Lab 14- Identifying Architectural Metals” (Graduate Program of Historic Preservation, University of Pennsylvania, Philadelphia, PA, Spring 2014). This test was modified according to the standard test, details of the standard test is discussed in Chapter 3 Methodology, 58.
layer could not be titanium oxide, because titanium oxide appeared after zinc oxide. Therefore, the second layer could very likely to be zinc oxide. This again suggests that the sample may have retained a full stratigraphy of all campaigns. The test also demonstrated that the sodium hydroxide solution dissolved most of the paint layers without affecting the transparent coating layer, suggesting that the transparent coating may actually be composed of a synthetic polymer.

This test for zinc was modified for this experiment and detail of the standard zinc test was discussed in the methodology. The quantity of the sodium hydroxide solution and the reaction time were hard to control. Therefore, more precise investigation with FTIR, XRD, SEM/EDS is still needed.

8 See Chapter 3 Methodology, page 57-58 in this paper.
Despite Andalusia’s architectural significance as the work of two of the most important architects in nineteenth century America and an icon of the Greek Revival form applied to a residential building, there is still much to be learned about it. The exact nature of changes made by Latrobe and by Walter, as outlined by the authors of the HSR, may be better understood by way of paint analysis.

This research set out to specifically address the perplexing questions of changes in doors in the central core of the building, where all three periods of building are represented. In particular, the author speculated that analysis of finishes in the central core of the house may prove that Walter retained the Federal style doors from Latrobe or Craig’s period in his Greek Revival design. As architect Daniel Campbell pointed out, it would be illogical for Walter to design a Federal style door in a Greek Revival house. By way of paint analysis, the author found evidence to prove that the doors are contemporary with one another and that some of the surfaces retain the full stratigraphy of all painting campaigns and are believed to date to the Latrobe period, if not earlier. The existence of these pre-Walter features contributes to chronicling change over the lifetime of the

1 Daniel Campbell, in discussion with author, March 2016.
house and augmenting findings in the HSR.

Most of the door surfaces appear to have been stripped of paint during the history of
the house, as evidenced by the few layers remaining on samples examined under the
microscope. However, the doorframes do retain as many as over ten layers of paint.
Based on comparative analysis, they are believed to represent the paint history of the
house from the Latrobe design, if not before.

With visible light microscopy, all samples collected from door surfaces as well as door
surrounds showed multiple layers of white paint. Fluorescence microscopy was very
helpful in differentiating these white layers, such as the lead white paint, which
autofluoresced warm yellow\(^2\) and a later paint layer, believed to be zinc oxide or
titanium oxide, which autofluoresced bright white.\(^3\) The positive identification of the
first lead white layer with microchemical lead spot testing and preliminary identification
of the second layer zinc oxide with polarized light microscopy and microchemical spot
testing for zinc\(^5\) clarified the identity of these paints. Because the refractive index and
birefringence of titanium and zinc white are similar, more precise identification of the

\(^2\) This autofluorescent color of lead white was determined by way of comparison with standards lead white samples.
\(^3\) Because of the filter block this study is using (A BV-1A Nikon filter block was used, which is for blue-violet
fluorescence excitation with an excitation bandwidth of 430-440 nm and a barrier filter of 470 nm), lead white
autofluoresces warm yellow, instead of the more common russet brown; zinc oxide autofluoresces yellow; and
titanium appears bright white.
\(^4\) the autofluorescent color of zinc white was determined by comparison with zinc white control samples.
\(^5\) The zinc spot test was positive in a middle layer (not certainly the second layer) of the sample, details of this test is
described before in chapter 4 observations.
pigments should be sought in the future to determine if the second layer is zinc oxide or
titanium oxide with FTIR, XRD, or SEM-EDS.

In comparison with the doors, the door surrounds were found to have retained more
finishes layers. When comparing all the samples from the doorframes, a common
phenomenon was found: first a warm yellowish white layer of unknown composition
directly on the substrate appears to be lead white, and then a brighter white layer
appears to be either zinc oxide or titanium white. These layers are followed by several
other white layers. Interestingly, the final four layers consistently autofluoresce in a
sequence that precisely corresponds to the first four layers of the door samples, namely
yellow – white - brown yellow – gray. If it is true that the paint layers on the
doorframes chronicle all painting campaigns, including those that were scraped away on
the doors between the first lead white layer and later four modern layers, then the
second paint layer on the doorframes - which tests indicate is not lead⁶ - should be zinc
oxide, given that zinc oxide as a pigment used in house paints was available in the
middle of the nineteenth century, while the other possibility for a white pigment –
titanium- was not widely available in house paints until almost a hundred years later.⁷

Another interesting finding is that a layer of translucent coating with large aggregate was

⁶ The lead test was negative.
⁷ Analysis of zinc with FTIR or other precise analytical method is needed for confirmation.
found in almost every door and doorframe sample and in most samples in the Group D Stair Hall. Although the composition of the layer is not known, it may be a layer of wax or a modern synthetic coating. 89 This layer always appears on the interior of a door, either the door surface or frame, and often times appears as the second layer in the sample. Acting as a point of reference, the presence of this unique layer suggests that all six doors are possibly contemporary with each other. However, because samples from the doorframes of the Red Parlor and Dining Room were not collected at this time, further investigation is needed to substantiate this claim.

Given that lead paint could have been applied to the woodwork at anytime in the nineteenth century or later, it is difficult to make sure that the early white paint layer, which has been identified as lead white, represents the original construction, or any particular period. Rather, it is the presence of the paint layer within the stratigraphy of layers that suggests this first lead paint layer may date to the nineteenth century and possibly to the original Craig period. Judging from the penetration of paint into the wood cells and the autofluorescence of the paint consistent with lead, all six doors in the three pairs appear to retain the original paint composed of lead white in oil. 10

8 This layer autofluoresces gray in UV light.
9 This layer is not any dissolvable to sodium hydroxide solution in the zinc test, details of the test is described before in chapter 4 observations.
10 Additional analysis is needed for substantiation.
With some degree of certainty, it can be said the doors were originally painted white. There is no evidence of staining or clear coating, which would have been visible in the wood cells. Judging from the few layers of modern paint overlying the original lead paint, the doors were stripped of most of the historic paint layers relatively recently and were repainted with modern white paint.

The presence on the panel trim of the interior surface on the Butler’s Pantry door of a darker and harder wood than that found elsewhere documents a repair in that location.

Microscopical examination of aspects of the stair proved to be more illuminating. These surfaces do not appear to have been stripped, thus providing valuable information. One interesting discovery was that the attached handrail of the staircase on the left side of the stair was grained several times. Judging from the number of layers of paint and relationship to other features of the stair, it is plausible that these finishes are original to the Craig or Latrobe period. The lack of evidence of graining on samples collected on the free-standing handrail raises the question of why the two handrails were treated differently. One explanation is that the free-standing handrail was probably clear coated and that the attached handrail was grained to match it. As the graining would have worn off with use, it would have required new graining, which accounts for the multiple campaigns of graining. It is also possible that the existing free standing handrail was
replaced at some point and matched to the graining as it appeared at that time.

The Group D samples from the stair baluster, engaged newel post and the chair rail between the Butler’s Pantry and the Dining Room all show the translucent coating with large aggregates and those samples seem to retain the full stratigraphy of all painting campaigns. Judging from the style and paint evidence, these features and surfaces appear to be original to the Craig period.

![Figure 5.1 Sample (sample 9-2) from the stair balusters indicate that the wood was originally stained dark brown and clear coated. 10X objective. Left: In visible light. Right: In ultra-violet light.](image)

Sample (sample 9-2) from the stair balusters indicate that the wood was originally stained dark brown and clear coated. If the doors and stair originally had the same sort of finish, that is, stained and clear coated wood, this lack of evidence of staining, varnishing, or any other clear coating found on the doors, as supported by historic documentation in previous studies, raises the possibility that the stained balusters were
original to the Craig period and the doors were added during the Latrobe period. It could be speculated that the original free-standing handrail might have also been stained, like the baluster. It is also possible that the balusters and free standing handrail were all stained dark brown. It would be interesting to expose passages of the baluster and the grained handrail and to compare the appearance of the first graining layer with the baluster and existing free standing hand rail to see if they match.

Figure 5.2 Attached handrail (photograph by author).
Figure 5.3 Free standing handrail (photograph by author).

Figure 5.4. 101.4 Grained staircase handrail. 10X objective.
Left: In visible light. Right: In ultra-violet light.

It is important to keep in mind the limitations of paint sampling as well as interpretation...
during any finishes investigation. In the case of Andalusia, on site exposures of historic finishes would better explain the paint history, but due to the fact that the house is in good condition and opened to the public, passages in which original paints were exposed would need to be considered in advance and approved by the curator. Additional removal of hardware and other obscuring attachments may be helpful in finding more evidence in the future.

Given the building’s importance and complexity, additional research should be carried out by a professional paint analyst. Additional cross sectional microscopic analysis, pigment analysis, and instrumental analysis of specific materials may build upon information found here to clarify the history of the house. Of particular importance is the confirmation that the later white paint is zinc oxide; and determination of the composition of the translucent coating layer. More attention in the future should also be paid to doorway samples by expanding the selection to include the doors to the Red Parlor and Dining Room. A review of housekeeping and repair records during the long Biddle tenure is also needed. 11

This opportunity to study the finishes in this important building enabled the author to develop a hands-on understanding of some of the aspects of finishes analysis as an

11 These sources, as described by Connie Griffith Houchins, the executive director of the Andalusia Foundation, are possibly in the archive of the foundation, but none of them have been categorized and recorded by people.
architect and as a student of architectural conservation. Acquiring skills such as sample preparation, visible light microscopy, polarized light microscopy, and fluorescence microscopy, formed an essential foundation for the research that followed. Training and experience proved to be important precursors to reading and interpreting cross-sectional paint samples and photomicrographs, especially ones with only layers of white paints. The author came to understand the importance of finding a datum point from which to compare samples. Sometimes this point of reference was a certain color layer, however in this case, it was a translucent coating layer.

Further, the author found that knowledge of the history and evolution of the physical fabric was vital. Close cooperation and inquiry with the architects and engineers, and if possible, previous architectural finishes analysts and conservators may reveal important information gained in the past that inform the direction and focus for the future. Therefore, it is very important that the review of literature is thorough and is conducted in advance of any additional work.

Finally, oftentimes it is not possible to get all the information needed in one sampling campaign. In this case, the door samples seem to carry too little information for comparison, thus another site sampling of the door surrounds was needed, which resulted in an expanded scope of research. This expansion in scope proved to be useful
in this study. This experience underlined the fact that finishes analysis cannot result from a single visit and round of sample-taking. It also clarified the importance of review of previous research. Finally, the research effort made clear that finishes analysis is not only about reproducing a color in a room, but may serve as a valuable adjunct to other methods in determining the architectural archaeology of a building.
BIBLIOGRAPHY

Thesis, Surveys and Reports


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APPENDIX A
MEASURED DRAWINGS FROM
DANIEL T. CAMPBELL, AIA
APPENDIX B

MASTER SAMPLE LIST
### Table B.1: Master Sample List

<table>
<thead>
<tr>
<th>Pair A</th>
<th>Door ID</th>
<th>Sample ID</th>
<th>Location in Room</th>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Front Door (101_1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.1-1 (Int)</td>
<td>Federal Door hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.1-2 (Int)</td>
<td>Federal Door hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.1-3 (Int)</td>
<td>Federal Door hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.1-4 (Int)</td>
<td>Federal Door hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.2 (Int)</td>
<td>Federal Door hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.3-2 (Int)</td>
<td>Federal Door hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.4-1 (Ext)</td>
<td>Federal Door exterior</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.4-2 (Ext)</td>
<td>Federal Door exterior</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.5 (Ext)</td>
<td>Federal Door exterior</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.10 (frame)</td>
<td>Interior left bottom frame</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.11 (frame)</td>
<td>Interior right bottom frame</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.12 (frame)</td>
<td>Interior right bottom frame</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.13 (frame)</td>
<td>Interior right bottom frame</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.14 (frame)</td>
<td>Interior frame top</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_1.15 (frame)</td>
<td>Exterior left bottom frame (behind the fence)</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td>Door to the Butler’s Pantry (101_4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_4.1 (Int)</td>
<td>Door to Butler’s Pantry, pantry-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_4.2 (Int)</td>
<td>Door to Butler’s Pantry, pantry-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_4.6 (Ext)</td>
<td>Door to Butler’s Pantry, hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_4.7 (Ext)</td>
<td>Door to Butler’s Pantry, hall-side</td>
<td>wood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>101_4.13 (frame,Int)</td>
<td>Door to Butler’s Pantry, hall-side frame tope</td>
<td>wood</td>
<td></td>
</tr>
</tbody>
</table>
### Table B.1: Master Sample List

<table>
<thead>
<tr>
<th>Pair</th>
<th>Door ID</th>
<th>Sample ID</th>
<th>Location in Room</th>
<th>Substrate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pair B</strong></td>
<td>Door to the kitchen (101_3)</td>
<td>101_3.1 (hall-side)</td>
<td>Door to kitchen, hall-side</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101_3.2(a)(b)</td>
<td>Door to kitchen, hall-side</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 (frame)</td>
<td>Door to kitchen, hall-side, lower</td>
<td>wood</td>
</tr>
<tr>
<td><strong>Pair C</strong></td>
<td>Door to the Study (102_1)</td>
<td>102_1.1 (hall-side)</td>
<td>Door to the study, hall-side</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>102_1.2 (hall-side)</td>
<td>Door to the study, hall-side</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 (frame)</td>
<td>Door surround to the study, hall-side</td>
<td>wood</td>
</tr>
<tr>
<td><strong>Group D</strong></td>
<td>Stair Hall</td>
<td>1</td>
<td>Chair rail, stair hall. Butler’s Pantry and Dining Room</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>Stair Stringer, outer side of staircase</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9-1-a</td>
<td>Stair baluster</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9-2</td>
<td>Stair baluster</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101.1</td>
<td>Staircase bottom</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101.2</td>
<td>Staircase baseboard</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101.3</td>
<td>Staircase pilaster bottom</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101.4</td>
<td>Staircase handrail</td>
<td>wood</td>
</tr>
<tr>
<td></td>
<td></td>
<td>101.5</td>
<td>Staircase handrail</td>
<td>wood</td>
</tr>
</tbody>
</table>
APPENDIX C

INDIVIDUAL SAMPLE SHEETS

PAINT LAYER STRATIGRAPHY

Note: The reporting of cross section analysis in this research consists of student-level interpretation.
### PAINT LAYER STRATIGRAPHY ANALYSIS

**Pair A**

<table>
<thead>
<tr>
<th>Sample ID: 101_1.1-1</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, hall-side</td>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

**Visible Light**

**Ultraviolet Light**

---

**Analysis Result / Comments:**

It was found that samples from the interior surface of the Federal front door (101_1.1-1, 101_1.2, 101_1.3-2) present similar stratigraphies under the UV light. Under the visible light, they all exhibit several layers of white, but under UV light more layers could be seen and described as follows: wood, yellowish white(1), white(2), brownish white(3), gray(4).

**Sample Location:**
**PAINT LAYER STRATIGRAPHY ANALYSIS**

**Pair A**

<table>
<thead>
<tr>
<th>Sample ID: 101_1.1-2</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, hall-side</td>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td>Date Sampled: 12/16/15</td>
</tr>
<tr>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
<td></td>
</tr>
</tbody>
</table>

**Sample Location:**

- Federal front door, hall-side

**Analysis Result / Comments:**

The last layer is the autofluorescences gray layer, as in all other samples. A clear coating layer (the second layer) was found in the sample.
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair A

Sample ID: 101_1.1-3 | Room: 101 Stair Hall | Analyzed by: Shuang Wu
Sample Location: Federal front door, hall-side
Substrate: Wood | Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2 | Approximate Magnification: 100x
Date Sampled: 12/16/15 | Date Analyzed: 2/13/16 | Camera: Nikon DS-Fi1

Visible Light | Ultraviolet Light

Analysis Result / Comments:
It was found that samples from the interior surface of the Federal front door (101_1.1-1, 101_1.2, 101_1.3-2) present similar stratigraphies under the UV light. Under the visible light, they all exhibit several layers of white, but under UV light more layers could be seen and described as follows: wood, yellowish white(1), white(2), brownish white(3), gray(4). Some oil based lead white paints has been soaked into the wood cells which autofluoresces warm yellowish white.

Sample Location:
Sample ID: 101_1.1-4  Room: 101 Stair Hall  Analyzed by: Shuang Wu
Sample Location: Federal front door, hall-side
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Analysis Result / Comments:
Similar to the previous samples found on the same surface of this door, under UV light layers could be seen and described as follows: wood, yellowish white (1), white (2), brownish white (3), gray (4). Some oil based lead white paints has been soaked into the wood cells which autofluoresces warm yellowish white.

Sample Location:
### Paint Layer Stratigraphy Analysis

**Pair A**

<table>
<thead>
<tr>
<th>Sample ID: 101_1.2</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, hall-side</td>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

**Analysis Result / Comments:**

Similiar to the previous samples found on the same surface of this door, under UV light layers could be seen and described as follows: wood, yellowish white(1), white(2), brownish white(3), gray(4). Some oil based lead white paints has been soaked into the wood cells which autofluoresces warm yellowish white.

**Sample Location:**

![Visible Light](image1.jpg) ![Ultraviolet Light](image2.jpg)
Analysis Result / Comments:
Similar to the previous samples found on the same surface of this door, under UV light layers could
be seen and described as follows: wood, yellowish white(1), white(2), brownish white(3), gray(4). Some oil based lead white paints has been soaked into the wood cells which autofluoresces warm yellowish white. Pigments particles could be seen in layers.
**PAINT LAYER STRATIGRAPHY ANALYSIS**

**Pair A**

<table>
<thead>
<tr>
<th>Sample ID: 101_1.4-1</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, exterior</td>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

**Analysis Result / Comments:**
This sample from the exterior of the Federal door shows some original lead white oil based finish in warm yellow color (1) soaked into the wood, and the final outside layer is the autofluorescent gray layer(2), as found in all other samples.

**Sample Location:**

![Sample Location Image]
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair A

<table>
<thead>
<tr>
<th>Sample ID: 101_1.4-2</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, exterior</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

Analysis Result / Comments:
This sample from the exterior of the Federal door shows some original warm yellow finish (lead white oil based)(1) soaked into the wood, and the final outside layer is the autofluorescent gray layer (2), as found in all other samples.

Sample Location:
Analysis Result / Comments:
This sample from the exterior of the Federal door shows some original warm yellow (lead white oil based) finish(1) soaked deeply into the wood, and the final outside layer is the autofluorescent gray layer(2), as found in all other samples.
Analysis Result / Comments:
Sample 101_1.10, which was collected at the lower part of the left side of the door frame, reveals many more layers than other samples from the door surface. In the visible light, multiple white layers and dirt layers between two of the layers could be observed. Under the UV light, the first layer above the wood substrate autofluoresces yellow(1), followed by a bright white layer(2), and then several other layers. The autofluorescent yellow – white - brown yellow – gray layer sequence, as described before in the door surface sample, appears at the top outer layer of this sample (layer 8,9,10,11), indicating there were several painting campaigns between the first layer and these four layers. In this case, it appears that the paint had been stripped from the door surface several times before the next painting campaign. However, the doorframe appears to have not been stripped of paint and is believed to have retained a full paint layer stratigraphy.
### PAINT LAYER STRATIGRAPHY ANALYSIS

**Pair A**

<table>
<thead>
<tr>
<th>Sample ID: 101_1.11</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, interior frame, right bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

**Analysis Result / Comments:**

Compare to the previous sample 101_1.10, this one has fewer paint layers. The possible original lead oil based paint layer(1) is present.

**Sample Location:**

![Sample Location Image]
Sample ID: 101_1.12
Room: 101 Stair Hall
Sample Location: Federal front door, interior frame
Substrate: Wood
Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2
Approximate Magnification: 100x
Date Sampled: 12/16/15
Date Analyzed: 2/13/16
Camera: Nikon DS-Fi1

Analysis Result / Comments:
Compare to the previous sample, 101_1.11, this one has more finish layers. The autofluorescence stratigraphy descibed several times before: under the UV light, wood, yellowish white(1), white(2), brownish white(3), gray(4) is present. Some oil based lead white paints has been soaked into the wood cells which autofluoresces warm yellowish white. The three samples from the Federal door interior frame all show different stratigraphies.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair A

Sample ID: 101_1.13  Room: 101 Stair Hall  Analyzed by: Shuang Wu
Sample Location: Federal front door, interior frame
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Analysis Result / Comments:
Compare to the previous samples, this one has a obvious clear coating layer with large aggregates which is also seen other door frame samples in the stair hall (sample 8, stair stringer, outside of the staircase and sample 101.3, engaged newel, all show this large aggregated translucent coating layer as the second layer in the sample.). Before this layer, there are many old lead oil based paint layers. The first layer is a warm yellowish white color, identical to samples 105_1.1 and 105_1.2, from the hall side of the Red Parlor door; 108_1.2, and the hall side surface from the Dining Room door; and sample 102_1.1 from the hall side surface of the Study door.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS

Pair A

<table>
<thead>
<tr>
<th>Sample ID: 101_1.14</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Federal front door, interior frame top</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

Analysis Result / Comments:
This sample doesn't show as much information as the previous ones from the Federal door interior frame bottom.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair A

Sample ID: 101_1.15  Room: 101 Stair Hall  Analyzed by: Shuang Wu
Sample Location: Federal front door, exterior frame (behind the fence)
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Visible Light  Ultraviolet Light

Analysis Result / Comments:
This sample shows some strong autofluorescence oil based paints soaked into the wood.

Sample Location:
Analysis Result / Comments:
The exterior surface sample 101_4.1 and 101_4.2 show similar paint stratigraphy. These two samples were collected from the pantry door exterior surface. The substrates were both missing. They both contain multiple layers of paints. Under the visible light, it is distinguishable to see a light brown layer (8), followed by some white layers (9), and then translucent green layer (10) in both samples. Layer (8),(9),(10) in sample 101_4.1 are in correspondence to layer (1),(2),(3) in 101_4.2, meaning that sample 101_4.1 shows a more comprehensive paint stratigraphy with more old layers. Beneath the brown layer in sample 101_4.1, there are several layers of warm white color paint layers which are likely to be oil based lead white paints. The translucent green layer autofluoresces bright white in UV light which indicating that it is an oil resinous coating.
Analysis Result / Comments:
The exterior surface sample 101_4.1 and 101_4.2 show similar paint stratigraphy. These two samples were collected from the pantry door exterior surface. The substrates were both missing. They both contain multiple layers of paints. Under the visible light, it is distinguishable to see a light brown layer (8), followed by some white layers (9), and then translucent green layer (10) in both samples. Layer (8),(9),(10) in sample 101_4.1 are in correspondence to layer (1),(2),(3) in 101_4.2, meaning that sample 101_4.1 shows a more comprehensive paint stratigraphy with more old layers. Beneath the brown layer in sample 101_4.1, there are several layers of warm white color paint layers which are likely to be oil based lead white paints. The translucent green layer autofluoresces bright white in UV light which indicating that it is an oil resinous coating.

Sample Location:
**PAINT LAYER STRATIGRAPHY ANALYSIS**

**Pair A**

<table>
<thead>
<tr>
<th>Sample ID: 101_4.6</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location:</td>
<td>Door to Butler’s Pantry, hall-side</td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 40x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

**Visible Light**

**Ultraviolet Light**

**Analysis Result / Comments:**

Samples from the interior side of the pantry door (101_4.6 and 101_4.7) have fewer layers than the samples from the exterior side, which is reasonable since the exterior surface of a door must be painted more frequently for protective purpose. Interestingly, a sample from the trim around the door panel (sample 101_4.6) shows a type of wood species with a darker color than the wood elsewhere, suggesting that this panel (bottom left) was replaced or restored in the past. The light wood of sample 101_4.7 collecting from the surface of the door matches that of the other doors.

**Sample Location:**
PAINT LAYER STRATIGRAPHY ANALYSIS

Pair A

<table>
<thead>
<tr>
<th>Sample ID: 101_4.7</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door to Butler’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pantry, hall-side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reflected Quartz</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Halogen, Ultraviolet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nikon Alphaphot-YS2</td>
<td>Approximate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magnification:</td>
<td></td>
</tr>
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<td></td>
<td>100x</td>
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<tr>
<td>Date Sampled:</td>
<td>Date Analyzed:</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
<tr>
<td>12/16/15</td>
<td>2/13/16</td>
<td></td>
</tr>
</tbody>
</table>

Visible Light

Ultraviolet Light

Analysis Result / Comments:
Samples from the interior side of the pantry door (101_4.6 and 101_4.7) have fewer layers than the samples from the exterior side, which is reasonable since the exterior surface of a door must be painted more frequently for protective purpose. Interestingly, a sample from the trim around the door panel (sample 101_4.6) shows a type of wood species with a darker color than the wood elsewhere, suggesting that this panel (bottom left) was replaced or restored in the past. The light wood of sample 101_4.7 collecting from the surface of the door matches that of the other doors.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair A

Sample ID: 101_4.13   Room: 101 Stair Hall   Analyzed by: Shuang Wu
Sample Location: Door to Butler’s Pantry, hall-side, frame top
Substrate: Wood   Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2   Approximate Magnification: 100x
Date Sampled: 12/16/15   Date Analyzed: 2/13/16   Camera: Nikon DS-Fi1

Visible Light   Ultraviolet Light

Analysis Result / Comments:
However, the interior frame sample 101_4.13, collecting from the top of the interior door frame, contains more layers than the door surface samples. Specifically speaking, the first paint layer on sample 101_4.13 is a yellowish white layer (autofluorescences yellowish white) which soaked deeply into the wood cells, followed by a bright white layer (autofluorescences bluish white), then several other white layers, and finally end up with a grayish layer, which shows a similar stratigraphy as the sample 101_1.10 from the Federal front door interior frame. A clear coating layer is also present.

Sample Location:
**PAINT LAYER STRATIGRAPHY ANALYSIS**  
Pair B

<table>
<thead>
<tr>
<th>Sample ID: 101_3.1</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Door to kitchen, hall-side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

**Visible Light**  
**Ultraviolet Light**

Analysis Result / Comments:  
This sample doesn’t have many layers. The first layer is the autofluorescent gray(1) layer, which is different from most of the other samples (others show warm yellowish white layer as the first layer)
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair B

<table>
<thead>
<tr>
<th>Sample ID: 101_3.2(a)(b)</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Door to kitchen, hall-side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

Visible Light  Ultraviolet Light

Sample Location:

Analysis Result / Comments:
Sample(a) and (b) are from different parts of the same sample. Sample(b) shows a dark stain(1) layer and a translucent layer(2) which the composition is unknown.

Sample Location:
Analysis Result / Comments:
Sample 5 (collected from the hall side frame of the kitchen door) and sample 102_1.1 (collected from the hall side surface of the study door) and 2 (collected from the hall side door frame of the study door), all three samples show a very distinguishable clear coating layer with large aggregates. This layer is appearing at the (5) layer in sample 5 and the 2nd layer in sample 102_1.1-1 and the 6th layer in sample 2. In all samples, this layer autofluoresces gray in UV light. Although it is unknown, it is speculated to be wax. Analysis of this layer is needed.

Sample Location:
Analysis Result / Comments:
Sample 102_1.1-1 (collected from the hall side surface of the study door), sample 5 (collected from the hall side frame of the kitchen door) and 2 (collected from the hall side door frame of the study door), all three samples show a very distinguishable clear coating layer with large aggregates. This layer is appearing at the (5) layer in sample 5 and the 2nd layer in sample 102_1.1-1 and the 6th layer in sample 2. In all samples, this layer autofluoresces gray in UV light. Although it is unknown, it is speculated to be wax. Analysis of this layer is needed.
PAINT LAYER STRATIGRAPHY ANALYSIS

Pair B

Sample ID: 102_1.2  |  Room: 102 Library/Study  |  Analyzed by: Shuang Wu
Sample Location: Door to the study, hall-side
Substrate: Wood  |  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  |  Approximate Magnification: 100x
Date Sampled: 12/16/15  |  Date Analyzed: 2/13/16  |  Camera: Nikon DS-Fi1

Analysis Result / Comments:
This sample shows two lines of strong autofluorescent layers which are likely to be oil resinous layers. This one doesn't have the clear coating layer as the previous one.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair B

Sample ID: 2  Room: 102 Library/Study  Analyzed by: Shuang Wu
Sample Location: Door to the study frame, hall-side
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Visible Light

Ultraviolet Light

Analysis Result / Comments:
Sample 2 (collected from the hall side door frame of the study door), sample 102_1.1 (collected from the hall side surface of the study door) and sample 5 (collected from the hall side frame of the kitchen door), all three samples show a very distinguishable clear coating layer with large aggregates. This layer is appearing at the fifth layer in sample 5 and the 2nd layer in sample 102_1.1-1 and the 6th layer in sample 2. In all samples, this layer autofluoresces gray in UV light. Although it is unknown, it is likely to be wax. Analysis of this layer is needed. The presence of this layer suggests the door to Kitchen and the door to Study are possibly contemporary with each other and the door frames seem to have retained a full stratigraphy.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS

Pair C

Sample ID: 105_1.1  Room: 105 Red Parlor  Analyzed by: Shuang Wu
Sample Location: Door to the Red Parlor, hall-side
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Visible Light  Ultraviolet Light

Analysis Result / Comments:
Sample 105_1.1 also has the clear coating layer, this layer (the 2nd layer) autofluoresces gray in UV light. Paints have been deeply soaked into the wood cells. The presence of the two strong autofluorescent white lines is similar to sample 102_1.2.

Sample Location:
Sample ID: 105_1.2 | Room: 105 Red Parlor | Analyzed by: Shuang Wu
Sample Location: Door to the Red Parlor, hall-side | Substrate: Wood | Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2 | Approximate Magnification: 100x
Date Sampled: 12/16/15 | Date Analyzed: 2/13/16 | Camera: Nikon DS-Fi1

<table>
<thead>
<tr>
<th>Visible Light</th>
<th>Ultraviolet Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Visible Light Image]</td>
<td>![Ultraviolet Light Image]</td>
</tr>
</tbody>
</table>

Analysis Result / Comments:
Sample 105_1.2 also has the clear coating layer, this layer (the 2nd layer) autofluoresces gray in UV light. Paints have been deeply soaked into the wood cells.

Sample Location:
### PAINT LAYER STRATIGRAPHY ANALYSIS

**Pair C**

<table>
<thead>
<tr>
<th>Sample ID: 105_1.3</th>
<th>Room: 105 Red Parlor</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Door to the Red Parlor, hall-side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

#### Visible Light

#### Ultraviolet Light

---

**Analysis Result / Comments:**

This sample doesn't have the clear coating layer, but similarly, it has the autofluoresce gray color at the very outside, the first layer of paint has been deeply soaked into the wood which suggests it is an old paint layer. It also has the two strong lines of autofluorescent white layers, which is similar to samples 102_1.2 (door to Study, hall-side) and 105_1.1 (door to Red Parlor, hall-side).
PAINT LAYER STRATIGRAPHY ANALYSIS

Pair C

Sample ID: 108_1.1  Room: 108 Dining Room  Analyzed by: Shuang Wu
Sample Location: Door to the Dining Room, hall-side
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Sample Location:

Analysis Result / Comments:
This sample is from the corner trim of the door, which has a lot of lime putty (repair work), not well representative of the feature.
PAINT LAYER STRATIGRAPHY ANALYSIS

Pair C

Sample ID: 108_1.2 | Room: 108 Dining Room | Analyzed by: Shuang Wu
Sample Location: Door to the Dining Room, hall-side
Substrate: Wood | Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2 | Approximate Magnification: 100x
Date Sampled: 12/16/15 | Date Analyzed: 2/13/16 | Camera: Nikon DS-Fi1

Analysis Result / Comments:
This sample doesn't have the clear coating layer, but similarly, it has the autofluoresce gray color at the very outside, the first layer of paint has been deeply soaked into the wood which suggests it is an old paint layer. It also has the two strong lines of autofluoresce white layers, which is similar to samples 102_1.2 and 105_1.1. It also has the clear coating layer as the 2nd layer.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Pair C

Sample ID: 108_1.3 | Room: 108 Dining Room | Analyzed by: Shuang Wu
Sample Location: Door to the Dining Room, hall-side
Substrate: Wood | Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2 | Approximate Magnification: 100x
Date Sampled: 12/16/15 | Date Analyzed: 2/13/16 | Camera: Nikon DS-Fi1

Visible Light

Ultraviolet Light

Analysis Result / Comments:
This sample doesn't show a lot of information, is not well representative of the feature.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Group D

Sample ID: 101.1  Room: 101 Stair Hall  Analyzed by: Shuang Wu
Sample Location: Staircase bottom
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Visible Light  Ultraviolet Light

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Color</th>
<th>Scheme</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>White</td>
<td>6</td>
<td>Yellowish White</td>
</tr>
<tr>
<td>2</td>
<td>White</td>
<td>7</td>
<td>White</td>
</tr>
<tr>
<td>3</td>
<td>Grey White</td>
<td>8</td>
<td>White</td>
</tr>
<tr>
<td>4</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Grey White</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis Result / Comments:
This sample contains 8 layers of white. Compare to the 101.2 sample which was also collected from stairs, it has more layers and might have been painted more times than the 101.2 sample. The very thin layer attached to the wood, which is yellowish white under visible light, might be the original layer of paints (lead white in oil).

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Group D

Sample ID: 101.2          Room: 101 Stair Hall          Analyzed by: Shuang Wu
Sample Location: Staircase baseboard
Substrate: Wood          Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2          Approximate Magnification: 100x
Date Sampled: 12/16/15          Date Analyzed: 2/13/16          Camera: Nikon DS-Fi1

Visible Light          Ultraviolet Light

Scheme: Color:
1    Yellowish White
2    Yellowish White
3    White

Analysis Result / Comments:
This sample contains 3 layers of white. It is collected from the baseboard of the staircase. Compare to the 101.1 sample which was also collected from stairs, it has fewer layers. It may because the 101.2 sample is not a well represented sample, or the baseboard paint has been cleaned off and repair often.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Group D

<table>
<thead>
<tr>
<th>Sample ID: 101.3</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: engaged newel bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 100x</td>
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</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

Visible Light

Ultraviolet Light

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Color</th>
<th>Scheme</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yellowish White</td>
<td>6</td>
<td>Yellowish White</td>
</tr>
<tr>
<td>2</td>
<td>Yellowish White</td>
<td>7</td>
<td>White</td>
</tr>
<tr>
<td>3</td>
<td>Grey White</td>
<td>8</td>
<td>Yellowish White</td>
</tr>
<tr>
<td>4</td>
<td>White</td>
<td>9</td>
<td>White</td>
</tr>
<tr>
<td>5</td>
<td>White</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis Result / Comments:
This sample collected from the bottom of the pilaster of the staircase which contains 9 layers of the white paints. The 9th layer is the dark grey green layer in UV light which is the last modern layer.

Sample Location:
Sample ID: 101.4  Room: 101 Stair Hall  Analyzed by: Shuang Wu

Sample Location: Staircase handrail (left, attached to wall)
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Visible Light

Ultraviolet Light

Analysis Result / Comments:
This sample collected from the handrail of the staircase has several layers of wood graining under the microscope. Under the microscope, it contains 10 layers of finishes and likely to have the first layer of original finishes which is yellowish white. Sample 101.4 from the attached handrail and Sample 101.5 is from the free standing handrail - both surfaces appear to be wood. Based on microscopical examination, it appears that one surface was grained to match the other. That is, the attached handrail was probably added later than the free-standing handrail. As the graining wore off from use, it was re-grained three separate times. That said, the free-standing handrail could be a replacement but it would certainly have been a clear coated wood.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Group D

Sample ID: 101.5  Room: 101 Stair Hall  Analyzed by: Shuang Wu
Sample Location: Staircase handrail (right, free stand)
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Visible Light  Ultraviolet Light

Scheme:  Color:
1  Brown
2  Brown

Analysis Result / Comments:
There are two layers in this sample, both appear to be brown in the visible light and white in the UV light. Compare to the sample 101.4, which is also collected from the handrail (left, attached to the wall), this one doesn't have graining.

Sample Location:
Sample ID: 1 | Room: 101 Stair Hall | Analyzed by: Shuang Wu
Sample Location: Chair rail, stair hall, between Butler’s Pantry and Dining Room
Substrate: Wood | Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2 | Approximate Magnification: 100x
Date Sampled: 12/16/15 | Date Analyzed: 2/13/16 | Camera: Nikon DS-Fi1

Visible Light

Ultraviolet Light

Analysis Result / Comments:
This sample seems to have old finish layers which appears to be warm yellowish white under visible light, probably lead white paints in oil(1). There is a thin black layer(2) and a thin brown layer(3) which the composition is unknown, it is likely to be dust. The substrate is missing in this sample.

Sample Location:
Sample ID: 8  Room: 101 Stair Hall  Analyzed by: Shuang Wu
Sample Location: Stair Stringer, outer side of staircase
Substrate: Wood  Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2  Approximate Magnification: 100x
Date Sampled: 12/16/15  Date Analyzed: 2/13/16  Camera: Nikon DS-Fi1

Analysis Result / Comments:
Sample 8 (stair stringer, outside of the staircase) and sample 101.3 (engaged newel post) all show the large aggregated translucent coating layer (2) as the second layer in the sample. The first layer is a warm yellowish white color (1), identical to samples (105_1.1 and 105_1.2, from the hall side of the Red Parlor door; 108_1.2, and the hall side surface from the Dining Room door; and sample 102_1.1 from the hall side surface of the Study door). It is soaked into the wood and likely to be the original finish layer.

Sample Location:
Sample ID: 9-1(a) | Room: 101 Stair Hall | Analyzed by: Shuang Wu
Sample Location: Stair baluster
Substrate: Wood | Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A
Microscope: Nikon Alphaphot-YS2 | Approximate Magnification: 100x
Date Sampled: 12/16/15 | Date Analyzed: 2/13/16 | Camera: Nikon DS-Fi1

Analysis Result / Comments:
Sample 9 has a thick clear coating layer above the wood substrate with large aggregates (1). It autofluoresces gray under UV light. The composition is unknown, probably a wax, further analysis of this layer is needed.

Sample Location:
PAINT LAYER STRATIGRAPHY ANALYSIS
Group D

<table>
<thead>
<tr>
<th>Sample ID: 9-2</th>
<th>Room: 101 Stair Hall</th>
<th>Analyzed by: Shuang Wu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Location: Stair baluster</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substrate: Wood</td>
<td>Illumination: Reflected Quartz Halogen, Ultraviolet BV 1A</td>
<td></td>
</tr>
<tr>
<td>Microscope: Nikon Alphaphot-YS2</td>
<td>Approximate Magnification: 40x and 100x</td>
<td></td>
</tr>
<tr>
<td>Date Sampled: 12/16/15</td>
<td>Date Analyzed: 2/13/16</td>
<td>Camera: Nikon DS-Fi1</td>
</tr>
</tbody>
</table>

Visible Light  Ultraviolet Light

![Image of stair baluster under visible light and ultraviolet light at 40x and 100x magnification]

Analysis Result / Comments:
sample 9-2 it was found that the stair baluster was stained dark brown and clear coated with a transparent coating. In visible light, the traces of the dark stain embedded in the wood are apparent at high magnification, over which traces of clear coating exist. These surfaces were later painted white.
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