# EXAMINATION AND IMAGING TECHNIQUES: WORKS ON PAPER

*Summer Teachers Institute in Technical Art History, 2014*

LINDSEY TYNE

The examination and imaging techniques conservators use to study works on paper can be separated into three general categories: Visible Light, Multispectral Imaging, and Digital Manipulation.

## VISIBLE LIGHT

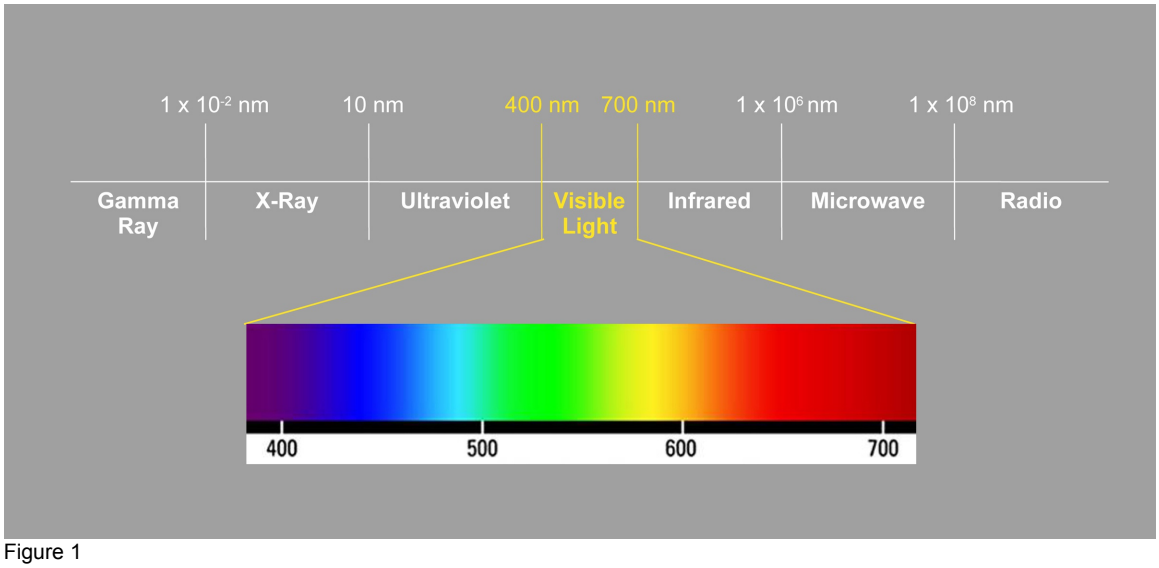


Figure 1

Visible light is a narrow range of wavelengths, approximately 400 to 700 nanometers, on the electromagnetic spectrum that the human eye can perceive (Figure 1). One of the most common ways to examine a work on paper is under “normal” illumination, where the object is illuminated evenly across its surface using visible light. Normal illumination is often used to create images for a publication and to light works on a gallery wall. Looking at works in this lighting setup provides information about the color, style, and scale, but it will not provide all possible information needed to fully understand the work.

Examination of a work on paper using visible light in combination with magnification, raking light and transmitted light can reveal information about the media, the paper support, how the work was made, and its condition.

**VISIBLE LIGHT: Magnification**

Magnification is used to enhance details that are too small for the human eye alone to see. A stereo binocular microscope with flexible fiber-optic lighting in the visible light range (Figure 2), provides magnification and depth perception which are useful in identifying different types of media, paper fibers, printing techniques, the order of application of media, the separation of flaking media, etc.

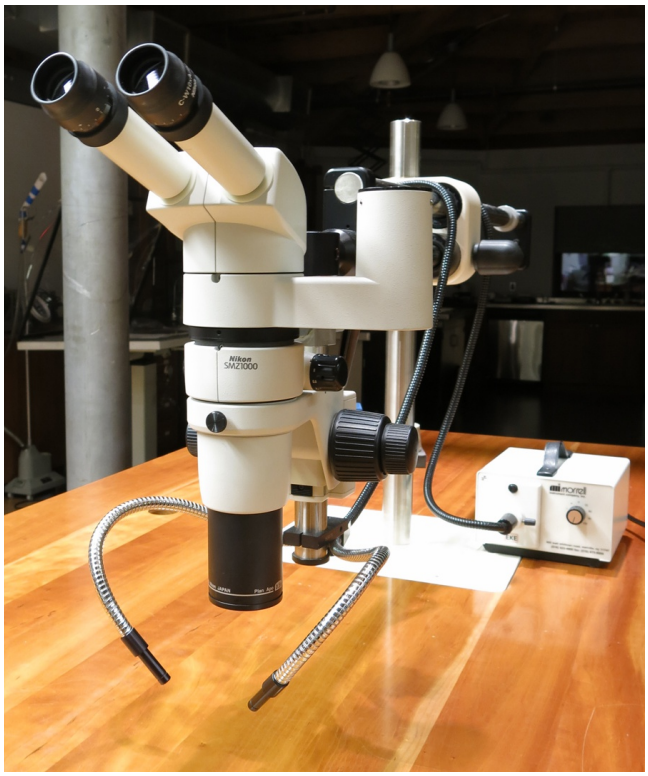


Figure 2

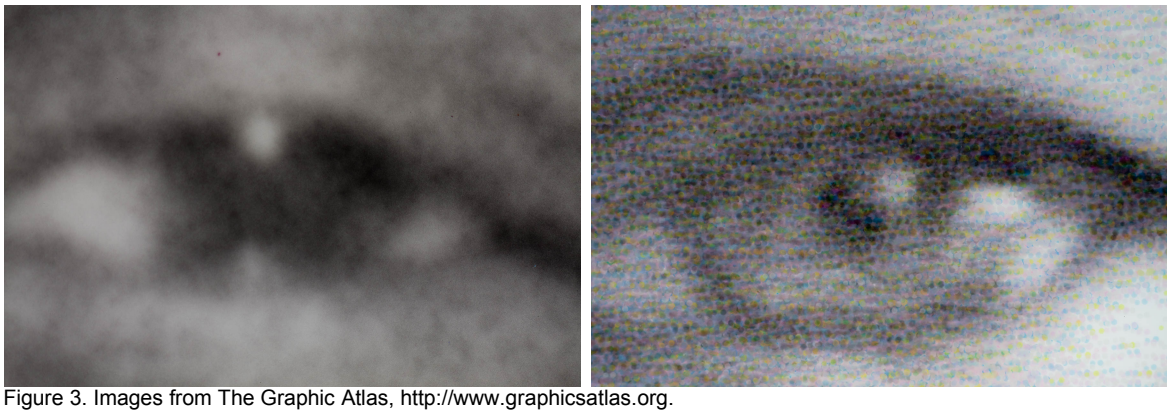

Figure 3. Images from The Graphic Atlas, http://www.graphicsatlas.org.

In Figure 3, magnification of two “black and white photographs” reveals that the image on the left is a silver gelatin photograph (no discernible pattern), while the image on the right is an inkjet print (colored dot pattern).

**VISIBLE LIGHT: Raking Light**

Raking light is used to exaggerate the surface texture of a work on paper, in order to reveal its topography or condition problems. To view a work in raking light, a single light source is fixed in a position parallel to its surface (Figure 4).

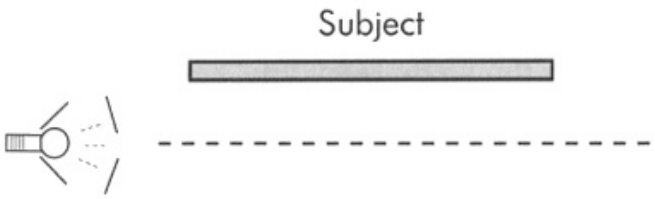


Figure 4. Image altered from *The AIC Guide to Digital Photography and Conservation Documentation.*

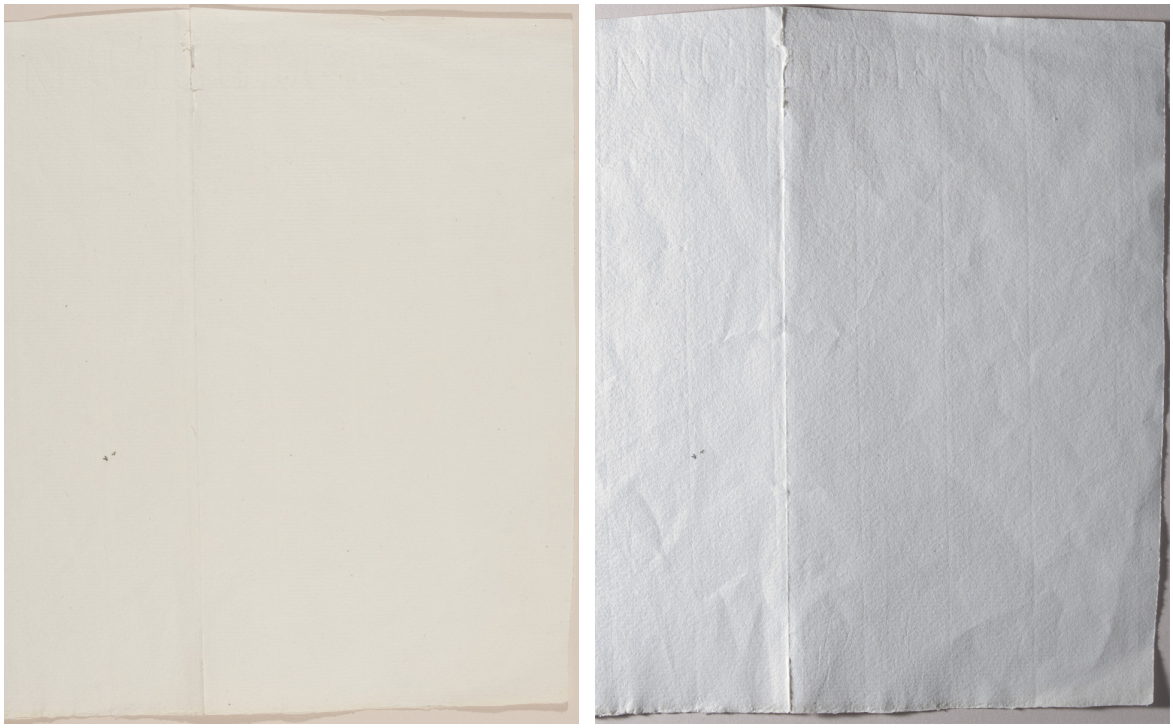

Figure 5

In Figure 5, a single sheet of blank paper is imaged in normal illumination on the left and in raking light on the right. In the left image, the paper appears smooth and flat, while the right image reveals the laid structure of the paper by exaggerating the vertical chain lines and the watermark at the upper edge. Raking light also highlights the central vertical crease running through the sheet, the tears extending along the crease from the edges, and shorter handling creases scattered throughout the sheet.

**VISIBLE LIGHT: Transmitted Light**

Transmitted light is used to examine the internal structure of a sheet of paper, including watermarks, laid and chain lines, wove patterns, and deliberate or accidental alterations. Dense media can prevent or interfere with the transmission of light.

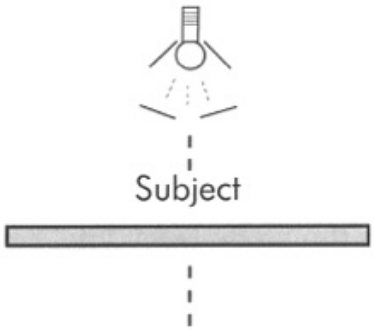


Figure 6. Image altered from *The AIC Guide to Digital Photography and Conservation Documentation*.

Figure 7

In Figure 7, a single sheet of blank paper is imaged in normal illumination on the left and in transmitted light on the right. In the left image, the paper appears opaque, smooth, and flat, while the right image reveals the thinner areas of the paper making the vertical chain lines, the horizontal laid lines and the watermark at the upper edge visible. Transmitted light also reveals the accumulation of paper pulp along the vertical chain lines as an irregular shadow, indicating that this sheet is handmade.

# MULTISPECTRAL IMAGING

Multispectral Imaging uses wavelengths of electromagnetic radiation outside of the visible light range to examine and record features of a work on paper.

**MULTISPECTRAL IMAGING: Beta Radiography**

Beta radiography is a nondestructive imaging technique that is used to record the internal structure of paper, including chain and laid lines, watermarks, damages, and past structural repairs. A beta particle is an electron emitted from the nucleus of a radioactive atom. The beta particle source for imaging paper is a thin sheet of acrylic (polymethacrylate) containing radioactive carbon-14. The particles from this isotope are low energy and readily absorbed by all materials, including air, making their penetration minimal.

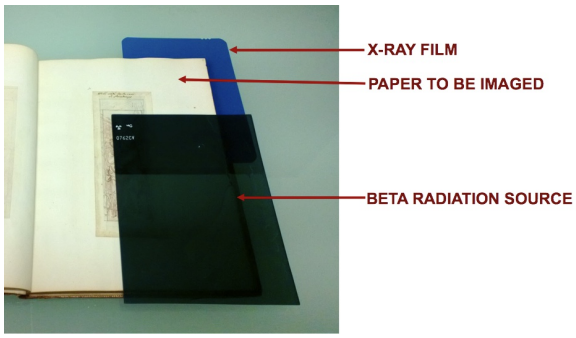


Figure 8

To perform this technique, the beta source is placed in contact with the work on paper and a piece of x-ray film is placed on the opposite side (Figure 8). Exposure times depend on the strength of the beta source and the thickness of the paper; ranging from 0.5 to 20 hours. The result is a 1:1 ratio photographic image of the density of the paper, and in some cases the media. Thin areas of media will not be recorded on the film, however, thick layers or radio-opaque metal-containing media may be recorded as white areas.

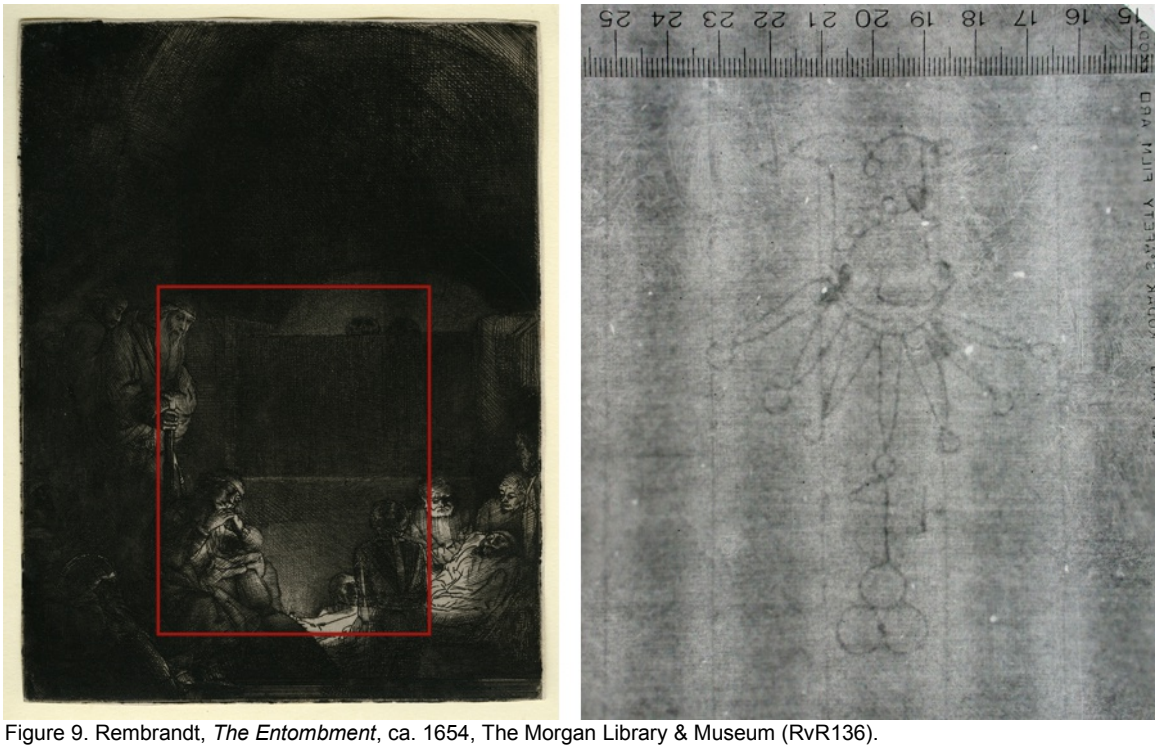

Figure 9. Rembrandt, *The Entombment*, ca. 1654, The Morgan Library & Museum (RvR136).

In situations when a sheet of paper is heavily covered in media, like the Rembrandt print on the left of Figure 9, transmitted light cannot penetrate the work to reveal its internal structure. When this occurs, beta radiography can be used to record what is invisible to the human eye. On the right, is a beta radiograph of this print revealing the laid and chain lines of the paper and its foolscap watermark typical of 17th century Dutch paper.

**MULTISPECTRAL IMAGING: Ultraviolet Induced Fluorescence**

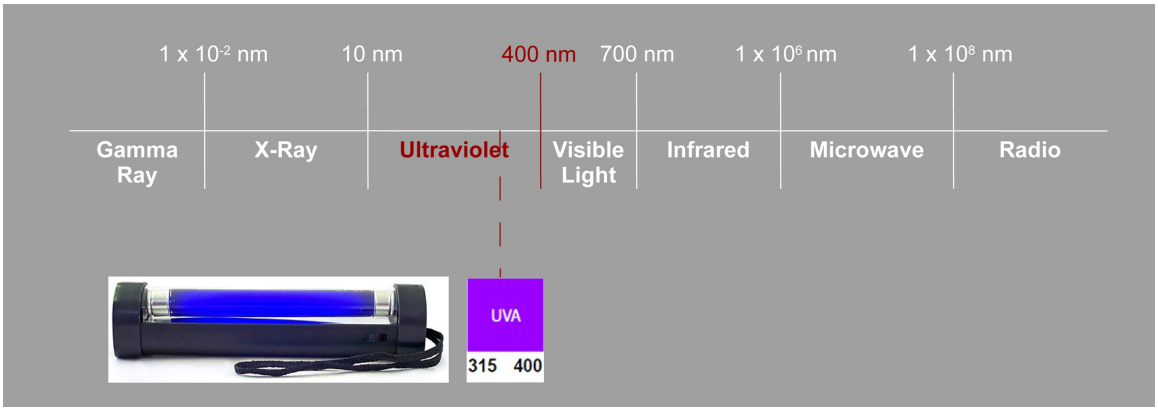


Figure 10

Ultraviolet radiation (UV) is the portion of the electromagnetic spectrum with wavelengths ranging from approximately 10 to 400 nm. UV is not visible to humans directly, but may initiate visible reactions in some compounds. The following subdivisions of UV radiation are used in the examination of works on paper:

- *UV-A*, long wave UV, from 315 to 400 nm, is produced by “black” light bulbs and the sun.
- *UV-C*, short wave UV, from 100 to 280 nm, is produced by germicidal lamps. UV-C wavelengths produced by the sun are absorbed by the Earth's atmosphere.

For examination of works on paper, ultraviolet radiation is used to detect differences in reflectance and fluorescence. Organic substances, including adhesives, foxing, some varnishes and papers containing optical brightening agents are known to fluoresce, as do certain colorants, such as gamboge, carmine, zinc white and Day-Glo paints.

Figure 11. Details of Charles Seliger, *Study for Eagle*, 1966, The Morgan Library & Museum (2009.433).

In Figure 11, a portion of the same drawing is seen in normal illumination on the left and in UV-A illumination on the right. On the left, there is a very faint, hard to read inscription as indicated by the red arrow. When viewed under UV-A illumination, the inscription is revealed to be a signature, “Seliger '66”. UV-A illumination also reveals deterioration of the paper support as a rectangular pale yellow fluorescence and an adhesive in the margins of the drawing as a dark blue-purple fluorescence.

## MULTISPECTRAL IMAGING: Infrared Reflectography (IRR)

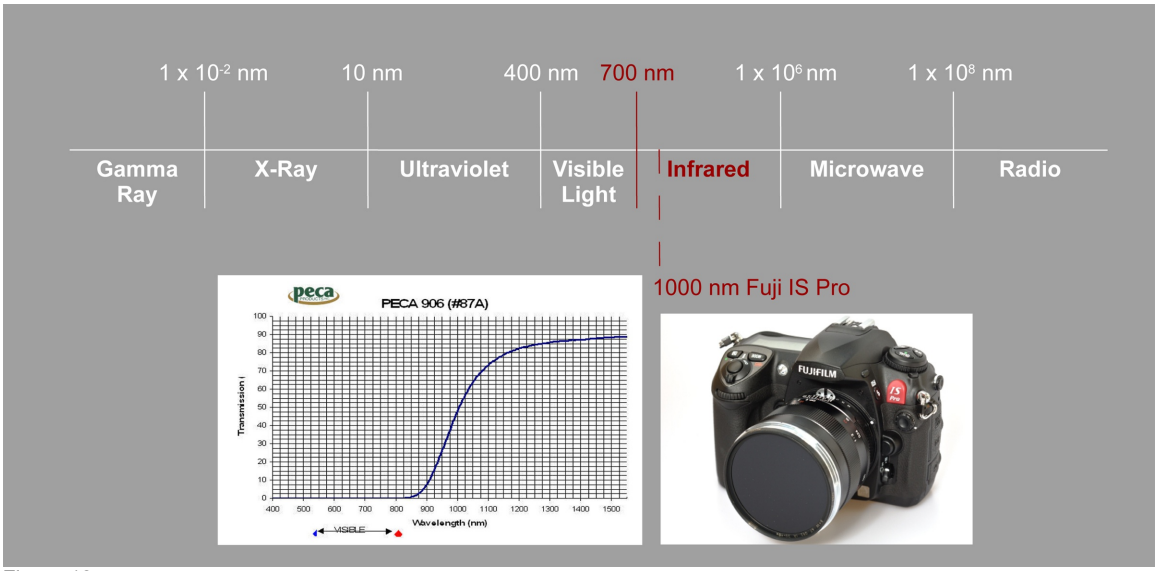


Figure 12

Infrared radiation (IR) is the portion of the electromagnetic spectrum with wavelengths ranging from approximately 700 to 1 x $10^6$ nm, and is not visible to the human eye. When a work on paper is illuminated with an IR-containing light source, its media will either be transparent to, absorb, or reflect IR radiation in varying degrees depending on chemical composition.

IRR is a nondestructive imaging method often used to reveal a carbon-based underdrawing beneath other media layers, or to help distinguish between different pigments and colorants. IRR uses an IR Vidicon camera or a solid-state CCD (charged-coupled device) camera to image the spectral pattern of the infrared light reflected from the surface of the work. Typically, IR imaging uses wavelengths from 800 to 1700 nm, depending on the available equipment and the goal of the imaging.

Figure 13. Details of Virgil Solis, *A Horseman Attacking a Fallen Warrior*, 16th century, The Morgan Library & Museum (1974.10).

In Figure 13, a portion of the same drawing is seen in normal illumination on the left and as an IRR image on the right. The IRR image was taken using a Fuji IS Pro Camera with a PECA filter #87A (Figure 12), which allows transmission of IR to the sensor of the camera and cuts out visible light. In the IRR image, the lower right feather of the figure's helmet disappears, indicating that there are two chemically different inks used in this drawing.

# DIGITAL MANIPULATION

Digital Manipulation can increase the amount of information derived from examining a work on paper.

**DIGITAL MANIPULATION: False Color Infrared Reflectography (FCIR)**
FCIR images are created by digitally combining an IRR image with a visible light image, so that the red channel of the FCIR image carries the IR information. This produces characteristic colors in the FCIR image that aid in the differentiation of pigments and colorants.

Figure 14. Details of Virgil Solis, *A Horseman Attacking a Fallen Warrior*, 16th century, The Morgan Library & Museum (1974.10).

In Figure 14, a portion of the same drawing is seen in normal illumination on the left and as a digitally manipulated FCIR image on the right. In the FCIR image, the lower right feather of the figure's helmet appears red while the majority of the ink lines appear black. This indicates that the ink appearing as black in the FCIR image is a carbon-based ink, while the ink appearing as red is an iron-based ink.

**DIGITAL MANIPULATION: Reflectance Transformation Imaging (RTI)**
RTI is a photographic method developed by Cultural Heritage Imaging and a team of international collaborators, in which multiple digital images of a work are captured using a stationary camera and light projected from a number of different angles. These images are then synthesized into a single digital file to create a highly detailed virtual topographic map of the work's surface that can reveal impasto, brushstrokes, dents, tool marks, scratches and other traces of the artist's hand, as well as, the physical characteristics of paper, including surface texture and watermarks.

Figure 15. Details of Abraham Bloemaert, *Danaë Receiving the Golden Rain*, ca. 1610, Private Collection.

In Figure 15, a portion of the same drawing is seen in normal illumination on the left and as a RTI image on the right. In the RTI image, the paper texture and extensive incising of the drawing is revealed. Please see http://themorgan.org/blog/drawing-print-abraham-bloemaerts-danaë-receiving-golden-rain for a case study of this drawing.

# FURTHER READING


***Imaging Techniques:***

Frey, Franziska S, and Jeffrey Warda. *The AIC Guide to Digital Photography and Conservation Documentation*. 2nd ed. Washington, D.C: American Institute for Conservation of Historic and Artistic Works, 2011.

***Beta Radiography:***

Kushell, Dan, "Radiographic Methods Used in the Recording of Structure and Watermarks in Historic Papers." *Fresh Woods and Pastures: Seventeenth-Century Dutch Landscape Drawings from the Peck Collection*. Franklin Robinson and Sheldon Peck. Chapel Hill, NC: Ackland Art Museum, University of North Carolina at Chapel Hill, 1999, 117-123.

***Ultraviolet Induced Fluorescence:***

Eastaugh, Nicholas, "Fluorescence at Work." *The Picture Restorer* (2003): 11-12.

***Multispectral Imaging Case Studies:***

- Revealing Picasso Conservation Project, Art Institute of Chicago
  http://www.artic.edu/collections/conservation/revealing-picasso-conservation-project
- The History Detectives: Season 8, *George Washington Miniature*
  http://www.pbs.org/opb/historydetectives/investigation/george-washington-miniature/
- The History Detectives: Season 9, *Teddy Roosevelt's War Club*
  http://www.pbs.org/opb/historydetectives/video/2030319924
- The History Detectives: Season 10, *Vietnam War Diary*
  http://www.pbs.org/opb/historydetectives/investigation/vietnam-war-diary/

***RTI Case Studies:***

Cultural Heritage Imaging, www.culturalheritageimaging.org

Tyne, Lindsey. *From Drawing to Print: Abraham Bloemaert's Danaë Receiving the Golden Rain*, 2012. http://themorgan.org/blog/drawing-print-abraham-bloemaerts-danaë-receiving-golden-rain