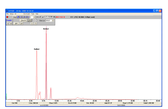
Short wavelengths

Violet Indigo Blue Green Yellow Orange Red

X-rays

200nm

X-ray Fluorescence: What Color Is That?



In this screen capture, a green pigment sample taken from Russell's paint SH exhibits a copper and arsenic peak, helping to confirm its identity as emerald green.

The examination of Russell's studio materials revealed that he used nearly seventy different pigments in his palette. Identifying them required the use of X-ray fluorescence, or XRF.

Even under a microscope, colors like vermilion and red ochre appear virtually identical, but with XRF a pigment's unique properties are brought to light. For example, if XRF detects mercury, vermilion is confirmed because red ochre contains no mercury.

The Bruker XRF, Tracer III-V model, was employed in the Amon Carter's conservation lab to study Russell's pigments.

How it works: Each element on the periodic table—which consists of the 118 known chemical elements organized by their atomic structures—has electronic orbitals, or regions, of characteristic energy. Bombarding a pigment sample with high-energy X-rays causes a displacement of the sample's orbital electrons, which in turn produces a unique spectra as singular as a thumbprint.

Ultraviolet (UV)

300nm

Ultraviolet Radiation: How What Is Lost Is Found

Story Teller (detail) in natural light.

Story Teller (detail) under UV illumination. The now faded smoke wafting around the central figure's head is easily visible with UV but barely perceivable in visible light.

Examining an artwork or pigment using ultraviolet radiation (UV) can reveal faded colors and confirm the identity of certain pigments. Ultraviolet on the electromagnetic spectrum lies just beyond the color violet, which is where it gets its name. But UV illumination can also isolate and define brush strokes within a painting, revealing information about application and how the artist moved his brush as he applied paint.

For example, the watercolor pigment Chinese white (also known as zinc white) fluoresces a bright lime green under UV illumination. Because Russell used Chinese white extensively, it is possible to see many of his brush strokes in detail. Originally, *Story Teller* (ca. 1893–95) showed bands of smoke wafting around the central figure's head. Now faded with time, the smoke is made visible again under UV radiation.

400nm — 700nm

Visible Light

Light: Visible and Invisible

Light is electromagnetic radiation of any wavelength measured in nanometers (nm), whether visible or invisible. Its range is represented by what is called the electromagnetic spectrum, shown in the diagram above. Light that the human eye can see lies in the middle of the spectrum and contains the colors red, orange, yellow, green, blue, indigo, and violet.

While the eye is unable to perceive radiation outside of this visible spectrum, such as infrared, ultraviolet, and X-ray waves, various scientific instruments can exploit these areas of the spectrum to reveal what is hidden. Russell's use of underdrawing, for example, can be seen through the use of infrared photography, which makes it possible to see beneath a painting's surface. His method of paint application can be studied through ultraviolet radiation and low-powered magnification, and his watercolor pigments can be indentified using polarising light microscopy and X-ray fluorescence. These panels show what such tools can reveal and how they work.

Infrared (IR)

800nm

Infrared: Seeing Beneath the Layers

His Wealth in normal light.

His Wealth in infrared. This image was captured using a *Bettenlight* Digital Scan Camera, Model SuperIR, with a Sinaron 180mm f5.6 lens and R72 infrared filter (720nm).

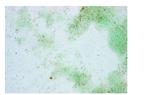
Infrared radiation has a longer wavelength and lower frequency than visible light. A digital camera with an infrared filter made it possible to see beneath the layers of paint to reveal Russell's underdrawings. The resulting images offer profound insight into the artist's first marks on the paper, including how his compositional drawings evolved over the course of his career.

Russell used underdrawing extensively in his early works, and most of it is somewhat awkwardly rendered. In the latter part of his career, however, his underdrawing reveals a much more confident hand, as seen in the painting *His Wealth* (ca. 1910). Here, he uses underdrawing as a visual shorthand rather than a map to be strictly followed. Notice that he painted the figure at the far left without the guidance of any underdrawing.

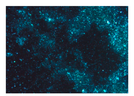
Long wavelengths

Looking at pigment samples using the polarising light microscope.

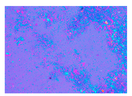
Polarising Light Microscopy: An Up-Close View



Plain polarised light at 40x magnification.



Cross-polarised light at 40x magnification.



Cross-polarised light through a Bertrand Lens at 40x magnification.

Like XRF, polarising light microscopy (PLM) was used in this study to identify pigments. The two methods work in tandem toward the same end. But where XRF uses radiation not visible to the naked eye, PLM uses visible light, but on a microscopic level, and manipulates its speed through the use of polarisers. In addition, XRF is useful solely for inorganic material, while PLM works just as well with organic matter.

As shown above, when the aligned polarised light beam is twisted 90 degrees (hence cross polarisation) to illuminate a sample, it either glows brightly, like the middle image or appears completely black—yet another identifying factor of the specific pigment. The information provided in these three views help characterize the sample as the pigment emerald green.