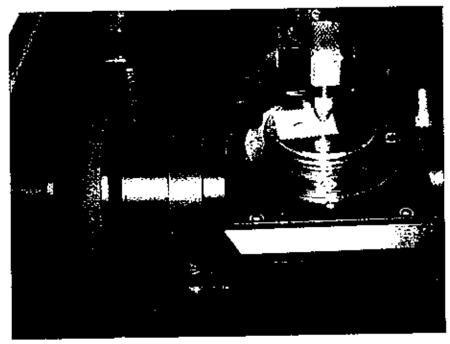
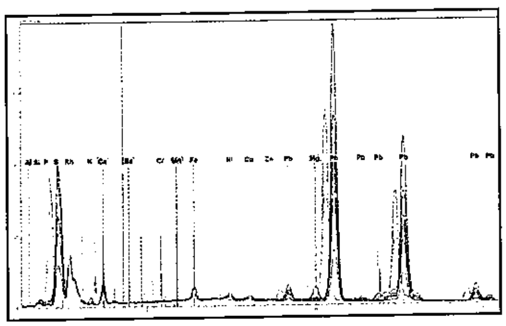
SPECIAL TECHNOLOGY ISSUE

The Chronicle

of the U.S. Classic Postal Issues





In our 1847 section, Wade E. Saadi uses X-Ray fluorescence analysis to show that the pigment in the 5¢ 1847 stamps, despite the wide variety of shades and printings, was always based on lead, rather than iron oxide.

In our 1861 section, Harry G. Brittain uses infrared absorption spectroscopy (among other techniques) to analyze the chemical composition of the ink and paper of the 1¢ 1861 stamps.

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PUTTING THE INK TO THE PAPER

WADE E. SAADI

Collectors have long been intrigued by the panoply of shades found on the 5¢ 1847 stamp. In the February *Chronicle*, I discussed the five different printings of this stamp, with a focus on the printing impressions. In this article, I will address the various shades and the likely pigments that were used to print them. The colors range from the lightest, red orange and brown orange on one end, to the darkest, black brown and fuscous black on the other. I have recorded a total of 27 major shade classifications, and almost 100 more minor varieties. Even the pedestrian red brown shade has over a dozen and a half variants.

Major shades and their varieties are presented herewith, all grouped by printing.[1] Note that many of these shades occur on stamps from more than one printing. Major shades are shown in **boldface**, followed by their subordinate varieties. A single asterisk (*) indicates a shade that is difficult to find; a double asterisk (**) indicates a shade that is very difficult to find. The numbers (#1-#15) are keyed to the accompanying illustrations, which are discussed further below.

First Printing (delivered to post offices 1 July 1847–13 March 13 1848)

Orange Browns: Orange Brown (#10),* Dark Orange Brown,* Very Bright Orange Brown,** Bright Orange Brown,** Deep Orange Brown,** Very Deep Orange Brown

Red Browns: Red Brown, Deep Red Brown, Reddish Brown, Bright Red Brown, Dark Red Brown (#8)

Browns: Brown, Russet Brown, Deep Brown, Dark Pecan Brown

Dark Browns: Dark Brown, Chestnut Brown,* Deep Chestnut Brown,* Dark Chestnut Brown,* Bister,* Seal Brown,** Walnut Brown**

Gray Browns: Grayish Brown,* Dark Grayish Brown,* Grayish Brown (red tint)**

Black Browns: Chocolate Brown,* Deep Chocolate Brown,* Dark Chocolate Brown,** Blackish Brown (#1),** Deep Blackish Brown,** Fuscous Brown (#2),** Fuscous Black (#3),** Deep Olive Brown**

Second Printing (delivered 13 March 1848–19 March 1849)

Browns: Brown, Pale Brown, Deep Brown

Dark Browns: Dark Brown, Sepia (#7)*

Gray Browns: Gray Brown (#5),* Deep Grayish Brown,* Gray Brown (red tint)**

Orange Browns: Orange Brown (#11),* Dark Orange Brown**

Red Browns: Red Brown (#6, #9), Dark Red Brown (#4),* Deep Red Brown*

Third Printing (delivered 19 March 1849–14 February 1850)

Red Browns: Red Brown, Light Red Brown, Reddish Brown, Pale Red Brown, Dark Reddish Brown, Bright Reddish Brown*

Dark Brown: Dark Brown, Very Dark Brown

Browns: Brown, Pale Brown, Bright Brown

Gray Brown: Gray Brown,* Gray Brown (red tint),** Purple Brown**

Orange Brown: Orange Brown,* Dull Orange Brown*

Dirty Plate Impressions: Red Brown,* Dark Red Brown*

Worn Plate Impressions: Pale Red Brown

Fourth Printing (delivered 14 February 1850–7 December 1850)

Red Browns: Red Brown, Reddish Brown, Dark Reddish Brown, Pale Red Brown, Cinnamon Brown**

Gray Browns: Dull Gray Brown,* Gray Brown (dark red tint)**

Browns: Very Pale Brown, Pale Brown, Light Brown, Yellowish Brown**

Dark Browns: Dark Brown, Van Dyke Brown,* Olive Brown*

Brown Oranges: Brown Orange,* Stressed Brown Orange,* Dark Brown Orange**

Orange Browns: Orange Brown,* Oxidized Orange Brown,* Bright Orange Brown,* Deep Orange Brown,** Dark Orange Brown**

Fifth Printing (delivered 7 December 1850—30 June 1851)

Oranges: Orange,** Bright Orange,** Deep Orange,** Red Orange (#14, #15),** Dark Red Orange**

Orange Browns: Orange Brown (#12),* Pale Orange Brown,* Bright Orange Brown,** Deep Orange Brown

Brown Oranges: Brown Orange (#13),* Oxidized Brown Orange,* Bright Brown Orange,** Deep Brown Orange,** Dark Brown Orange**

The multiplicity of 5¢ 1847 shades probably resulted from inconsistent mixing of the pigments. As frequently as daily, the pressman would prepare the ink by mixing the various pigments with spirits and oils. This was an art, not a science. If any of many factors varied, the result could be variation in color: 1. The supplier of pigments had to maintain consistency in the ingredients supplied; 2. The ingredients had to be mixed thoroughly by the pressman before adding to the ink blend; 3. The measurement of each pigment had to be exact; 4. Before each press run, the ink had to be thoroughly remixed; 5. The amount of moisture in the paper had to be constant (these were "wet" printings where the paper was pre-moistened to allow the ink to transfer and adhere to the paper); and 6. The amount of ink applied to the plate had to be consistent, as did the wiping of the ink across the plate surface. All this was made even more complicated because depth of the engraved lines in the plate varied during its use. The deeper the engraved line, the more ink it would hold and the darker would be the apparent value of the color. There are probably other contributing factors as well, but the six variables listed above set the table to explain most of the reasons for the color variations.

Another cause for the varieties of shades, often postulated by collectors and students, was that the printers changed the pigments over the life of the five printings (from 1847 through 1851). Carroll Chase and many others thought different iron oxides were the basis for the inks. I was among those who held this opinion, reasoning iron oxide (rust in essence) is a red-brown color, and cheap. Some believed chromium-based pigments were used to produce the late-printing orange red and orange browns, providing the yellow necessary for those hues. Mercury-based pigments had also been hypothesized, because compounds of mercury are mostly red (with some yellow ones as well).

So what are the compositions of the 5¢ 1847 inks? Enter the Smithsonian National Postal Museum (NPM). Thomas Lera, the Blount Research Chair for the NPM, has assembled a formidable scientific analytical research lab over the last few years. What better place to start the investigation?

I asked Gordon Eubanks to allow me to borrow the "color wheel" page (Figure 1) from his Champion of Champions exhibit of the 1847 issue. This shows a broad and representative range of colors on the 5¢ 1847 stamps. Eubanks graciously consented and I was off to the NPM. Needless to say, the different processes, used there to determine the elemental composition of the inks, are non-destructive.

The Eubanks color wheel contains 15 very nice stamps showing some of the many shade varieties that can be found on the 5¢ 1847 stamp. For convenience in identification and discussion, we numbered the stamps #1-15. Enlargements of the 15 individual stamps, along with the arbitrary ID number, are shown in Figure 2. The broad range of shades is clearly visible.

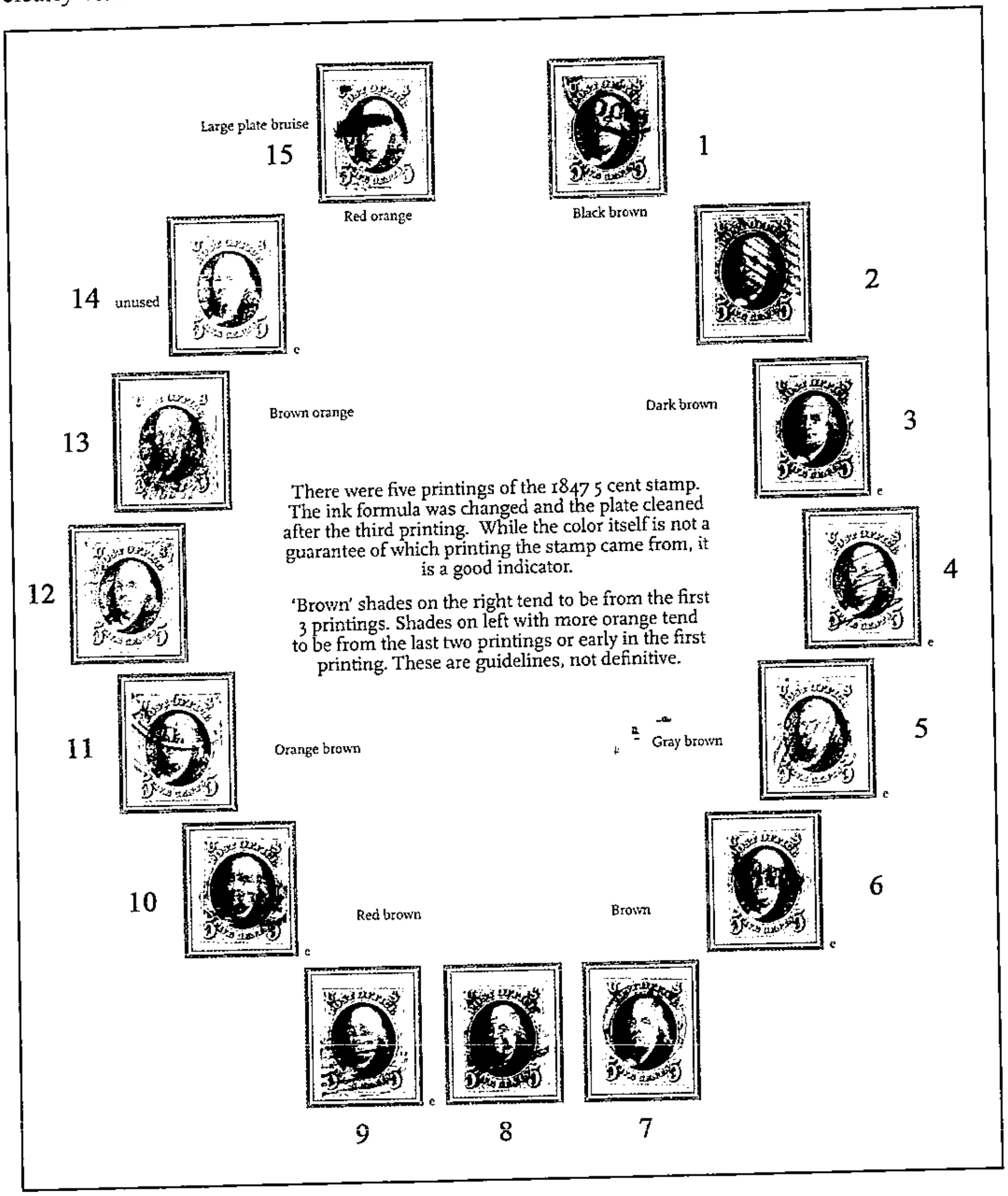

Figure 1 (above). This page from Gordon Eubanks' award-winning exhibit of the U.S. 1847 issue contains 5¢ 1847 stamps in a broad and representative range of shades, which were examined on sophisticated (and non-destructive) electronic devices at the Smithsonian National Postal Museum. For convenience in identification and discussion, the stamps were numbered #1-15. In Figure 2 (at right), the 15 stamps from the Figure 1 album page are shown enlarged. The numbers are keyed to the color descriptions in the text. The wide range of shades is clearly evident.

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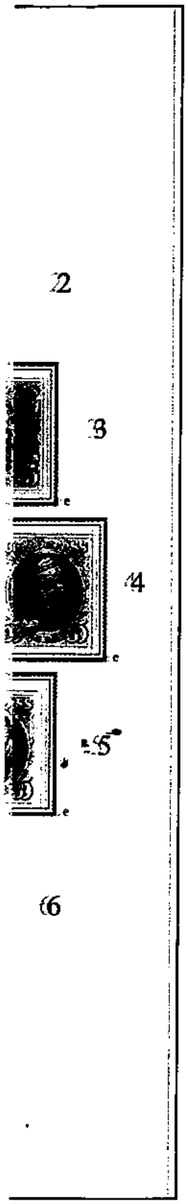

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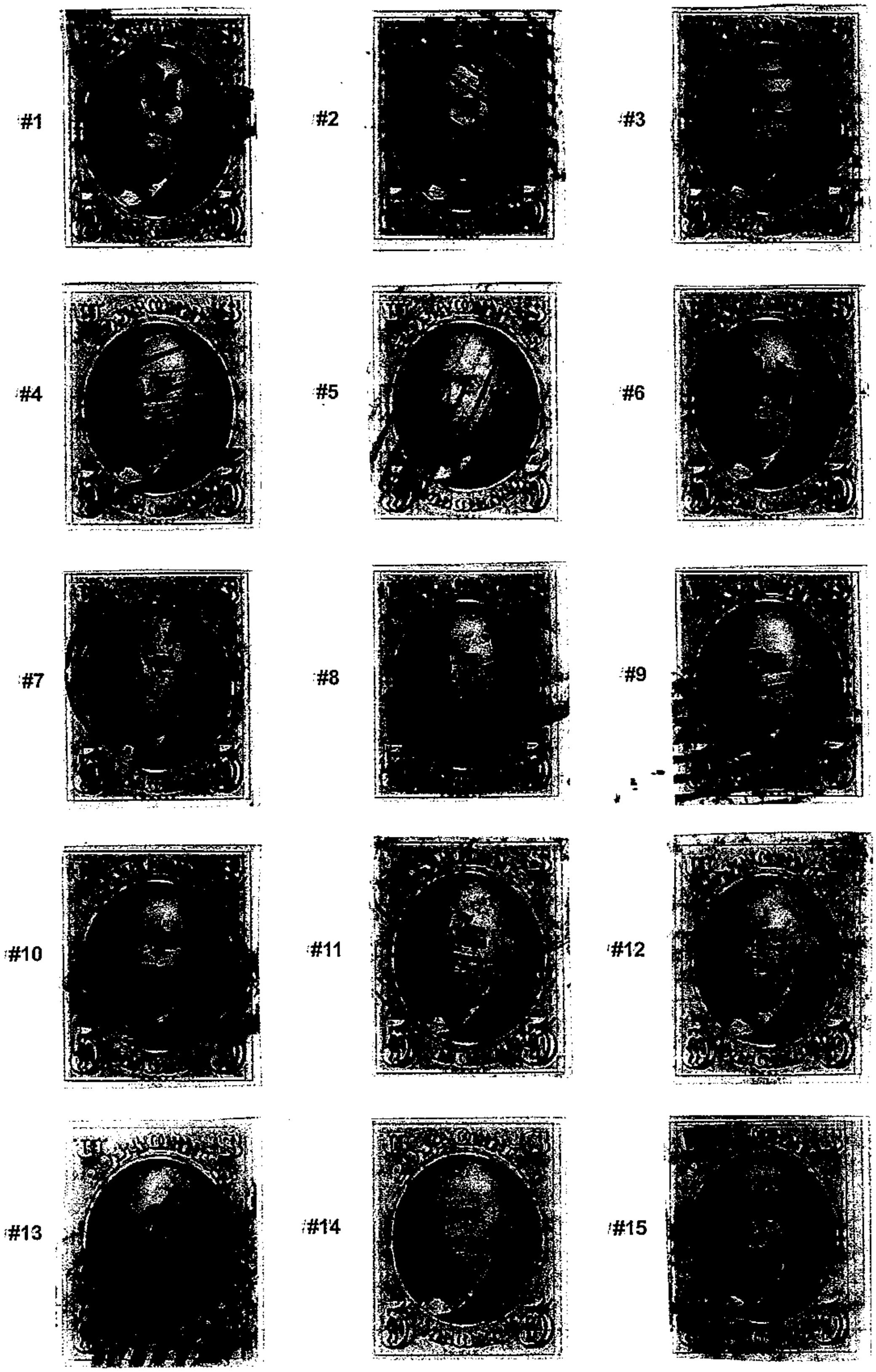

After removing the stamps from their exhibit page, Lera and I examined each stamp using two different pieces of equipment; the Bruker X-Ray Fluorescence (XRF) analyzer[2] and the Foster+Freeman Video Spectral Comparator-6000 (VSC-6000).[3] The XRF employs X-Ray fluorescence (refraction, passing through a sample) to identify the elements that comprise that sample. X-Rays bombard the elemental electron shells of the atoms in the sample, dislodging electrons and releasing energy. The detector reads those energy levels, which are unique to each chemical element. Without getting into scientific detail that is beyond the scope of this article, suffice to say that only elements with an atomic number higher than 11 can be identified by the detector using this process. The 11 lightest elements, including carbon, are not distinguishable using this process.[4]

The result from the XRF was quite a surprise. Figure 3 shows the composite peaks for the 15 samples. The predominant elements were lead (Pb) and sulfur (S). Iron (Fe) was found only in minute quantities except for one stamp (#8), where the lead content was also among the highest. As is evident in Figure 2, this was the darkest of all the samples and likely has the largest concentration of ink on it, hence the higher readings. The rhodium (Rh), trace nickel (Ni) and trace copper (Cu) peaks are caused by the tube that produces the X-Rays; the read-outs for those elements are normal with this process. The stamps that bear red cancels (#3, #5, #7, #9 and #13) showed some mercury (Hg), but this is attributable to the vermillion (also known as cinnabar or Mercuric Sulfide—HgS) used to formulate the canceling ink. The calcium (Ca) probably indicates calcium carbonate, a common paper filler. Note that lead (Pb) has several peaks which are characteristic, since it is a predominant element and can lose electrons from various shells.

Since the XRF can identify only elements in the samples and not the compounds those elements may comprise, we must look for the likely candidates. We know lead and sulfur are present in large quantities, but in what forms are uncertain. Table 1 presents a list of various compounds that are used as pigments in paint and ink. These were found in a 500-page reference book, *The Pigment Compendium*.[5]

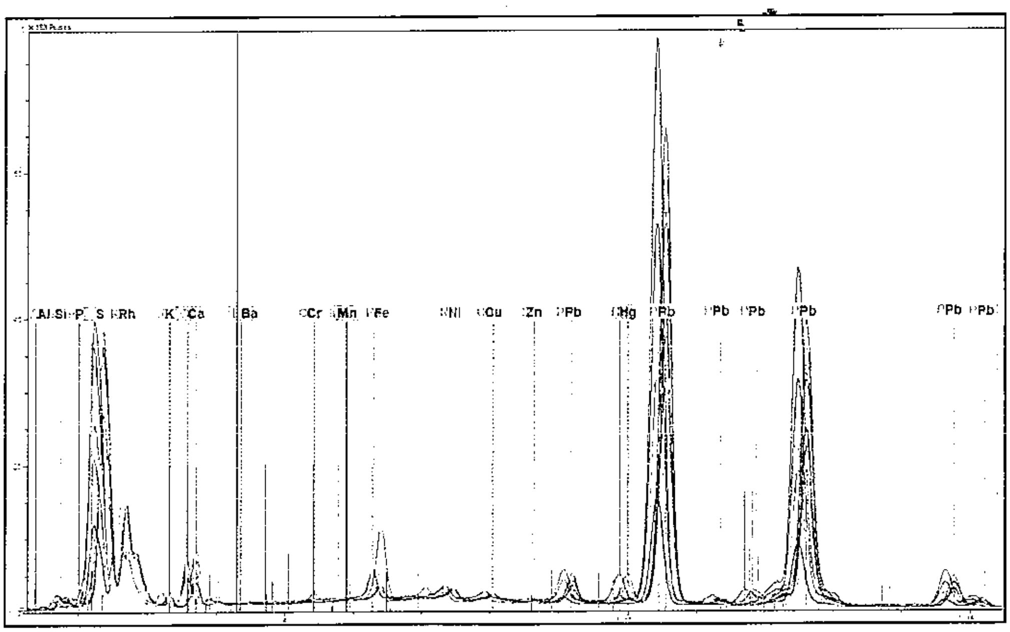

Figure 3. Results of the X-Ray fluorescence (XRF) analysis of the 15 subject stamps. The composite peaks are quite similar. The predominant elements were lead (Pb) and sulfur (S). Iron (Fe) was found only in minute quantities, except for one stamp (#8).

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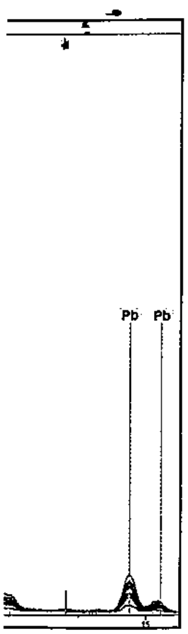

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Chemical Name	Formula	Common Name	Color
Lead Oxide	PbO	Litharge	Yellow
Lead Oxide	Pb_3O_4	Red Lead	Red
Lead Oxide	PbO_2	Plattnerite	Brown
Lead Sulfate	$PbSO_4$	White Lead	White
Lead Sulfite	$PbSO_3$	White Lead	White
Lead Sulfide	PbS	Galena	Dark Gray
Iron Oxide	Fe_3O_4	Iron Oxide Black	Black
Iron Sulfide	FeS	Ferrous Sulfide, Black Iron Sulfide	Black
Carbon	C	Lamp Black, Graphite	Black

Table 1. Common lead and sulfur compounds traditionally used as pigments in paint and ink. The data shows the chemical name of the compound, its chemical formula, its common name and the color it can be used to create.

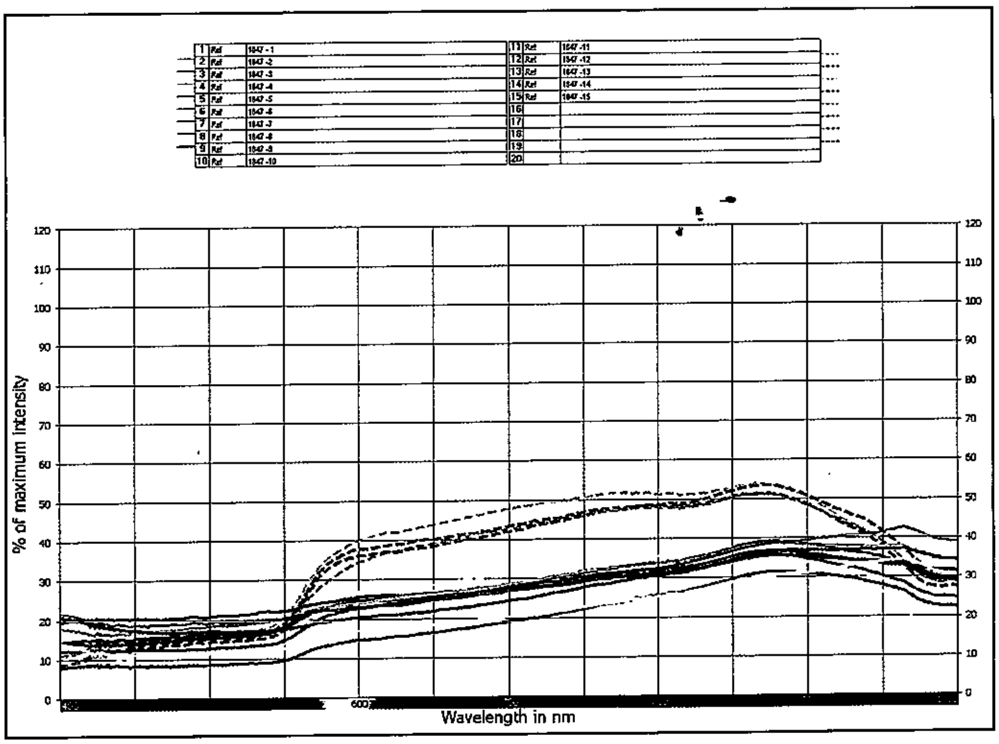

Figure 4. Results of the analysis of the 15 stamps on the Visual Spectral Comparator (VSC-6000), which uses reflected light to determine color and luminescence of the sample. The data at top relates individual lines to specific stamps. The grouping of dotted lines represent stamps #12-#15 (brown oranges and red oranges), which seem to have their own path and are thus shown to be more luminescent than the others.

It is likely that the pigments listed in Table 1, when mixed in the proper proportions, could produce any of the 5¢ 1847 shades that exist. I added carbon (C) to the list of possible pigments because it was used to print the 10¢ 1847 stamp, even though the XRF is unable to identify carbon, of which the atomic number is 6.

This is a first step in the scientific analysis of the ink composition of the 5¢ 1847 stamps. Further testing can be done to ascertain the lead compounds that comprise each of the different color inks.

The VSC-6000 uses reflected light (reflection-bounced off a sample) to determine color and luminescence of the sample. It can measure and map the color coordinates onto a chart for comparison of samples. The 15 samples were analyzed by this digital imaging system and the results are shown in Figure 4. Visible light is between 400 nanometers (nm) and 700 nm, shown on the x-axis. Violet is at 400nm through red at 700mn. The y-axis shows luminosity or brightness. Samples #1 through #11 track similarly, but #12 through #15 form their own group and track separately between 600nm and 950nm. These are the Brown Oranges and the Red Oranges, which are shown to be more luminescent than the others.

Conclusion

The inks used to print the 5¢ 1847 stamps were all lead based, regardless of when they were printed or delivered. The luminosity of the Brown Oranges and the Red Oranges is greater than the other shades. It is likely the late printing of the Orange Brown would be in this small group too, but as there was no sample of this shade to test, this is just conjecture.

Endnotes

1. Wade E. Saadi, "The 5¢ and 10¢ Stamps of 1847—The First General Issue of the United States, Part II," *The American Philatelist*, April 1997; "The Five Printings of the Five-Cent 1847 Stamp and the Impressions They Left Behind," *Chronicle* 237.
2. http://www.bruker.com/products. Last viewed 5-13-2013.
3. http://www.fosterfreeman.com. Last viewed 5-13-2013.
4. The light elements, not detectable, are hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon and sodium.
5. Nicholas Eastaugh, Valentine Walsh, Tracey Chaplin and Ruth Siddall, *The Pigment Compendium*, Elsevier Butterworth-Heinemann, Oxford, England, 2004. ■