Work Placement: Analyzing Artwork with X-Ray Fluorescence Spectrometry (XRF)

This job placement was done through the help of Dr. Margaret Smith and Dr. Louisa Campbell of the University of Glasgow Technical Art History departments and the Hunterian Museum.

This work placement was primarily focused around The TAHG Lab's portable XRF instrument, used to analyze the materials of artworks. My mission was to write a user manual for new users and non-scientists without a background in XRF so that they may easily pick it up and utilize the scanner in art studies. The original intent was to use this equipment on the Antonine Wall, but with COVID restrictions, this was instead carried out on art replicas in the lab.

Figure 6, photo of the handling of the XRF on the painting, photo by Noa Leibson

What is XRF?

The device is a non-destructive analyzer that uses X-ray technology to identify the elemental makeup of the samples it is analyzing. While not without its drawbacks, a scan can offer a basic outline for the composition of things such as pigments and minerals. The scanner fires an X-ray beam at the artwork being analyzed. The area being fired at then becomes 'activated,' and the excited and unstable electrons in the artwork's materials dislodges its orbital shells. An electron from a different orbital shell takes up the vacancy, and this movement is captured by the XRF. The instrument can measure this and discern which elements are present in the sample, based off their movement and how they react. And once we know the elemental make-up of an artwork, one can discern which pigments were used in its creation.

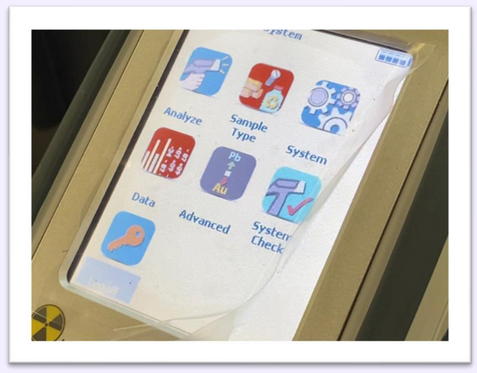

Figure 3, photograph of XRF user interface, photo taken by Noa Leibson

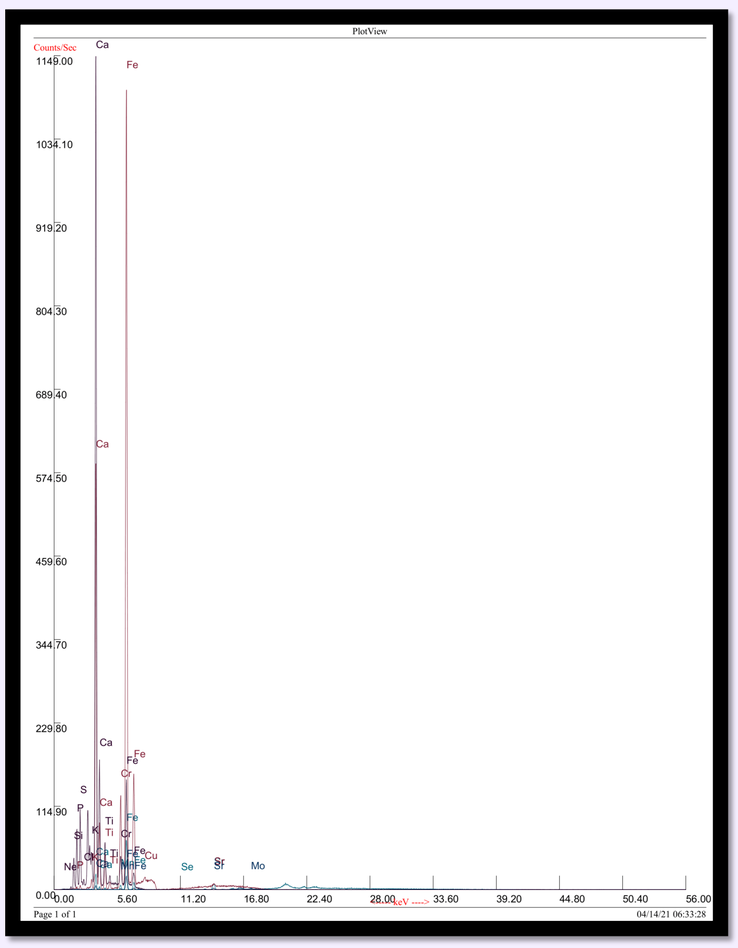

Figure 1, XRF Spectra of upper left back corner, scan and image created by Noa Leibson

Process

Learning the science and function behind the XRF was best done by getting hands-on with the instrument. It would be easier to follow along with the user manual if also paired with a case study that puts it all into practice.

As such, over the course of the project the XRF scans were carried out the XRF on a replica of a painting by Guido Reni's workshop. A replica is a great way to learn XRF, since we likely know the materials used and can complete a cross-comparison with the findings.

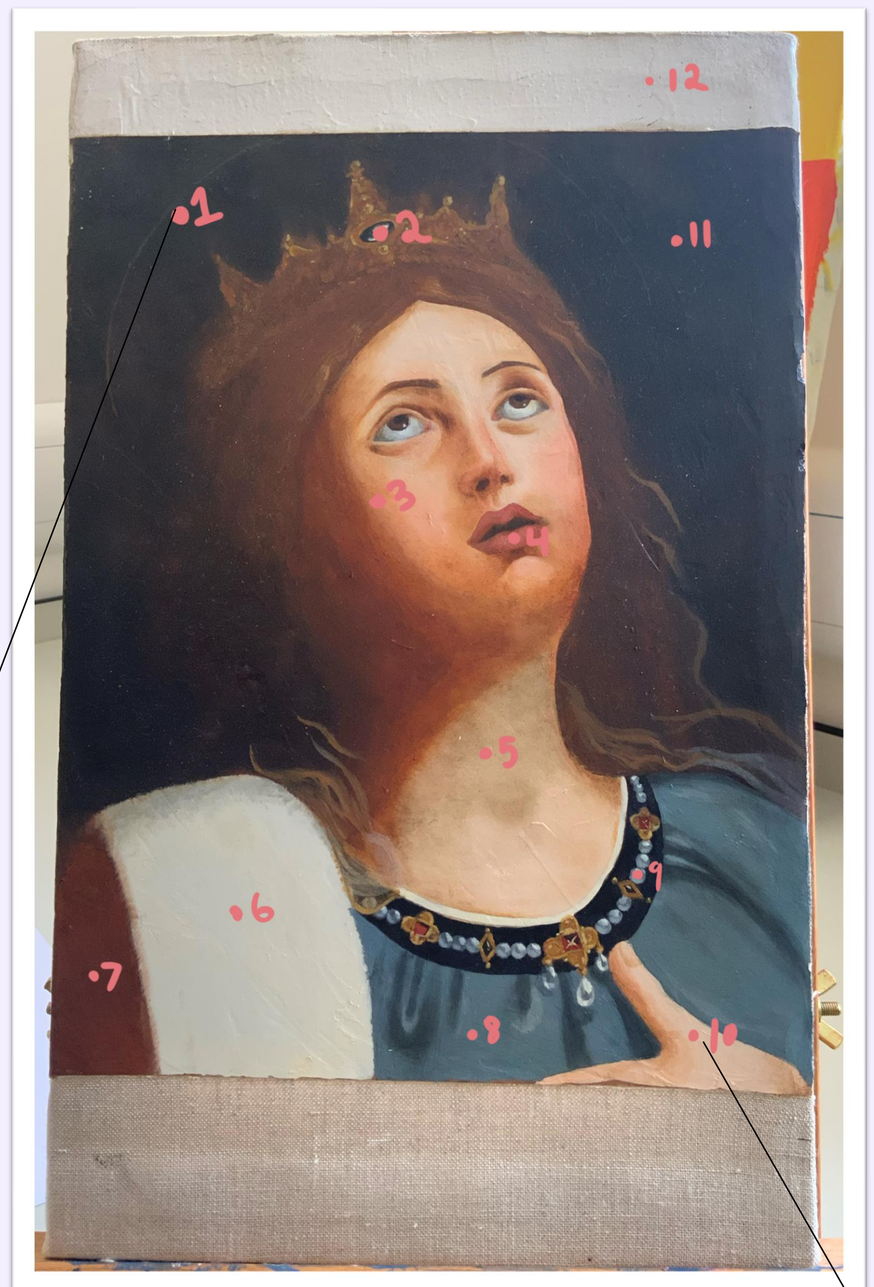

Figure 4, replica of portrait from Guido Reni's workshop, oil on canvas. Numbered points represent the sample sites and were added by Noa Leibson

The analysis for the user manual consisted of twelve different scans of the painting. For the user manual, amongst the explanations of how to use the XRF, this project provided interpretations of two of the samples taken. Figure 1 was a scan of the upper left background, at Point 1, and Figure 2 was a scan of her visible hand, at Point 10.

Results

Figure 1: What jumps out first in an XRF sample is usually the peak, or the highest point of the sample. In this case, we see that calcium (Ce) and iron (Fe) comprise the two largest peaks of the sample. Smaller peaks included calcium and strontium. As this is a black/brown area, These readings were compared to pigments with known elemental footprints and deduced this was most likely ivory black mixed with an earth-based brown pigment, possibly raw umber or burnt sienna. Bone black is also possible, but zinc was not detected.

Figure 2: In this case, shows an overwhelming amount of titanium, with the next elemental peaks being calcium and iron. The hand appears to have been painted with a lot of white. Titanium white is the only major white that has, obviously, titanium, and has traces of calcium as well. It appears very clear that a dominant pigment used here was titanium white. It was also likely mixed with small amounts of an earth-based brown pigment to give the flesh tones, explaining the iron, and/or a red like alizarin, which can offer some of the traces of calcium.

Looking Forward

Performing this case study and using the XRF instrument in a lab setting allowed those involved to not only get practical experience with this technical process, but also enrich the user manual and hopefully set up future readers in using and interpreting XRF analyses. Beyond the Reni able to be studied, the user manual now exists as a reference, and is accessible to perform more interpretations in settings in the future.

Figure 5. photograph of the portable XRF instrument used in the study, photo taken by Noa Leibson

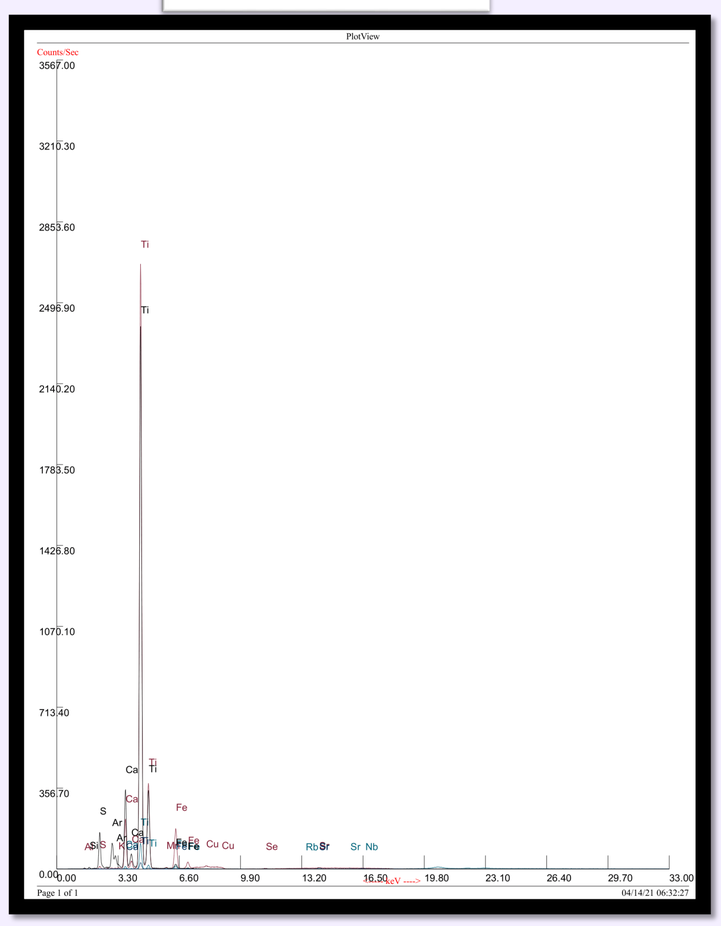

Figure 2, XRF Spectra of bottom visible hand, scan and image created by Noa Leibson

Niton User Manual. TTTenviro. (n.d.). https://www.tttenviro.com/wp-content/uploads/Manual-XL3-Series-v7.0.11.
Shugar, A. N. (2017). *Handheld Xrf for art and archaeology*. Leuven University Press.