

Elemental Characterization of Ancient Glass Tesserae via X-Ray Fluorescence Spectrometry

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Introduction

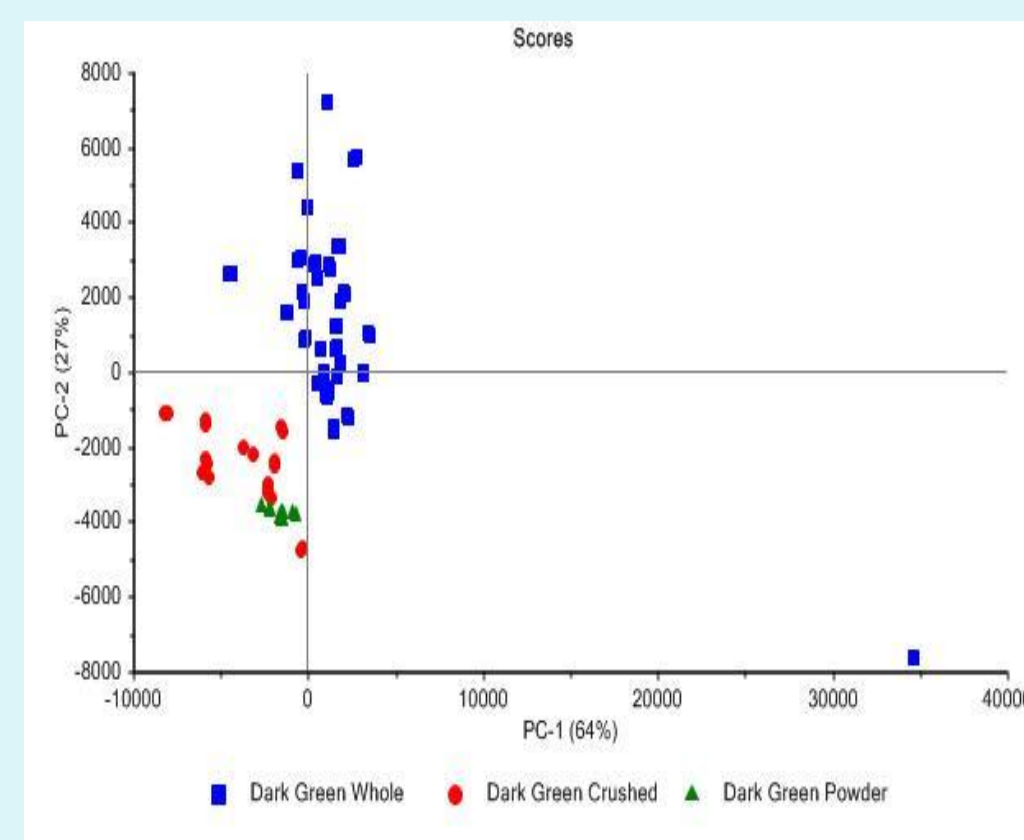
The tesserae used to create mosaics are primarily made out of stones, ceramics or glass. The tesserae examined in this study were of various glass colors including blues, greens, red, and black. Glasses can be characterized using various techniques including X-Ray Fluorescence Spectrometry (XRF), Raman Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), and Photoacoustic-FTIR Spectroscopy. In this case energy-dispersive XRF was chosen for its non-destructive nature, its portability, and its ability to characterize many of the elements present in glasses. The XRF data allowed for the identification of Ca, Mn, Fe, Cu, Pb and Sb as the main elements contributing to variations in the tesserae compositions and colors.

Method

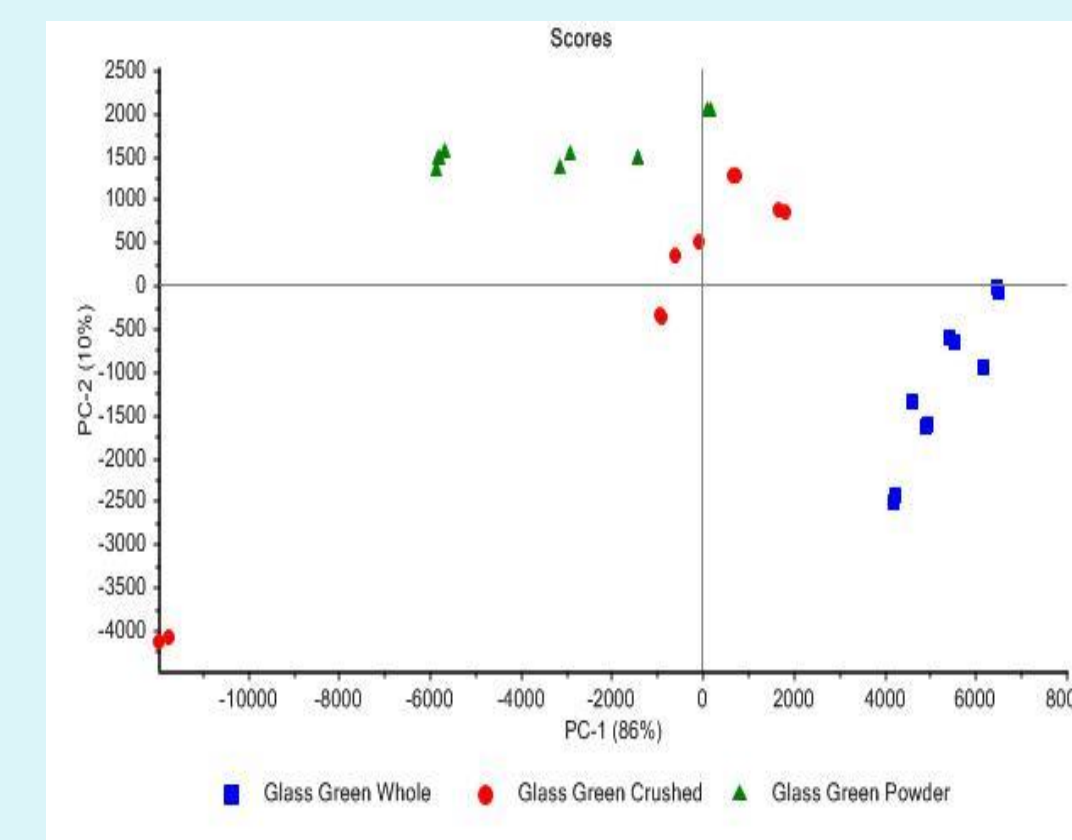
The tesserae were categorized by visual color and then analyzed using a Bruker Tracer III-V+ portable XRF. The whole tesserae were analyzed on five sides while the crushed and powdered samples were analyzed in different areas to investigate homogeneity. Each sample was analyzed a total of ten times with a 40 keV x-ray tube energy and 25 μ A tube current for 120 s. Spectra were exported into Excel then imported into and analyzed using The Unscrambler multivariate statistical software.

Results

Dark Green Scores Plot

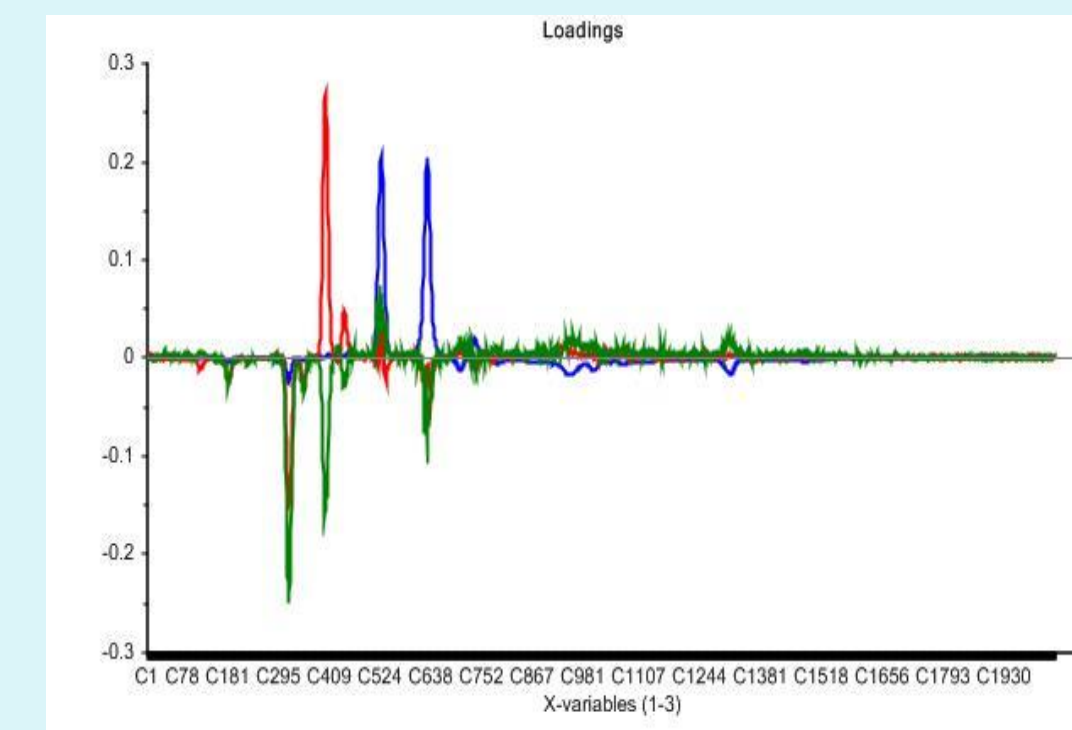
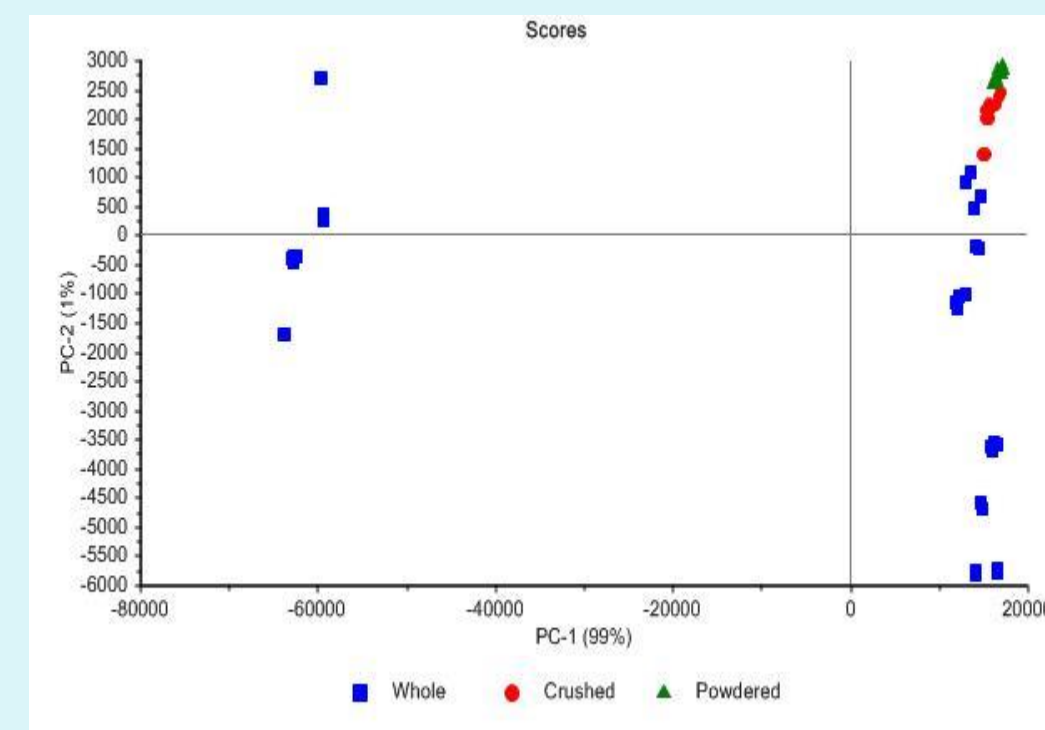


Light Green Scores Plot



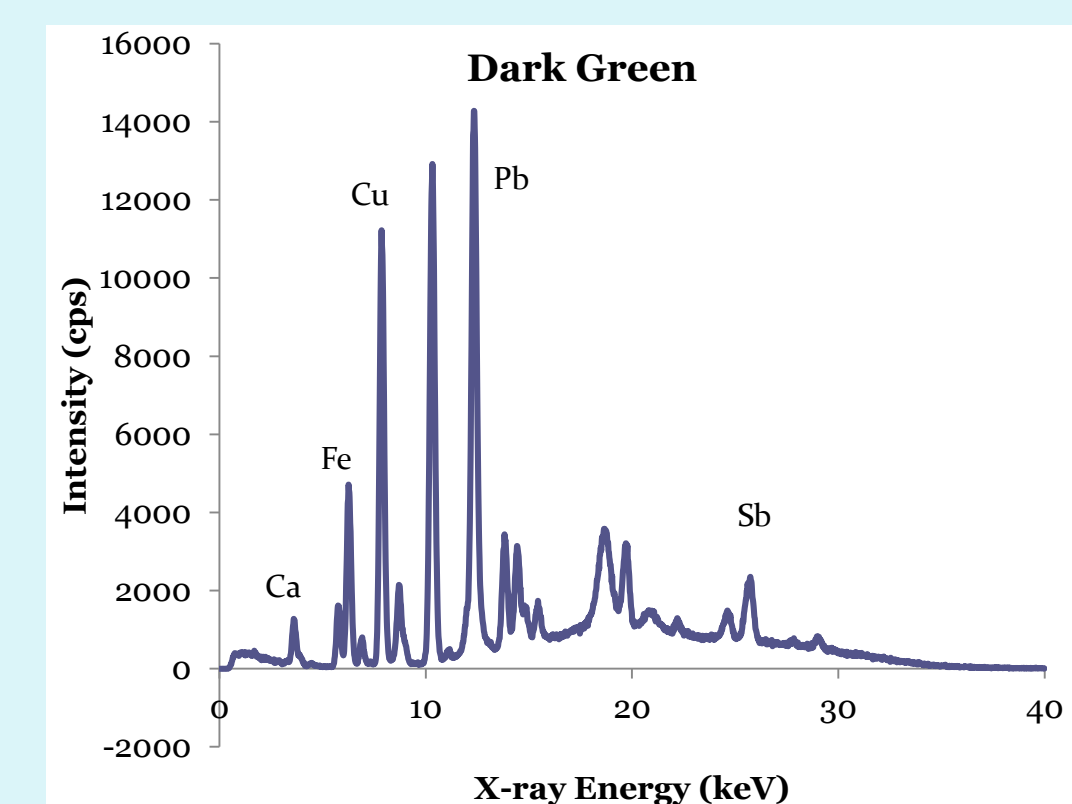
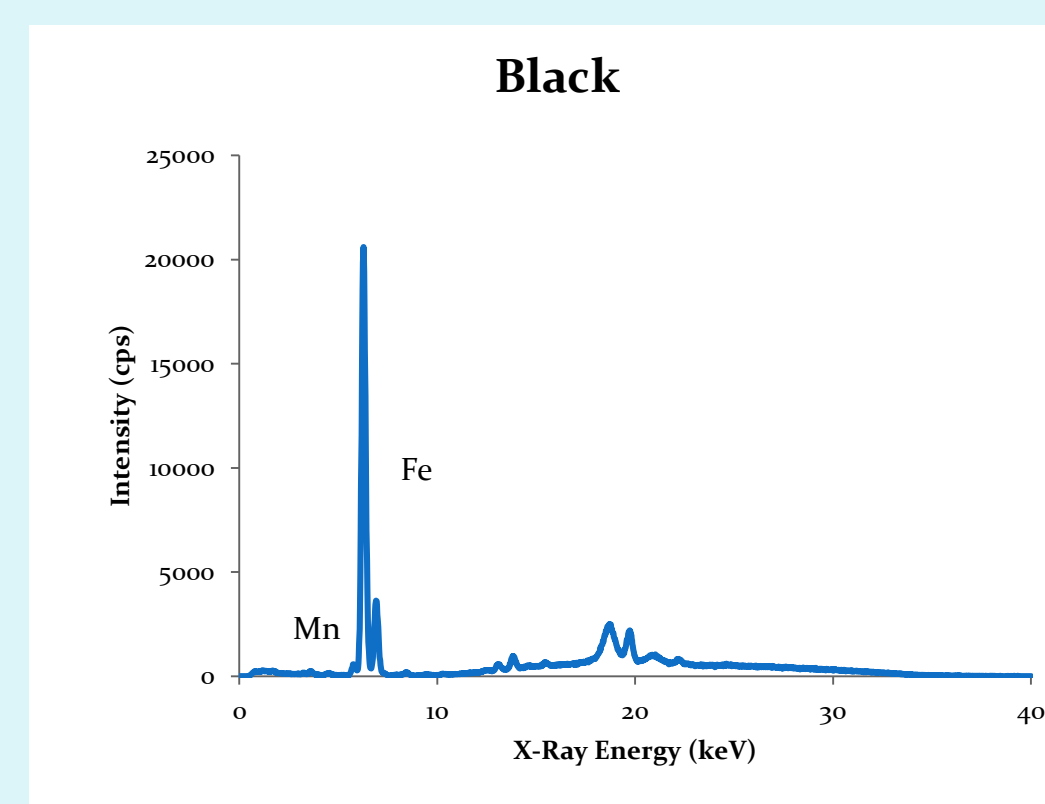
- The sample form (Whole vs Crushed vs Powder) contributes to differences in clustering

Red Tesserae Scores/Loadings Plots

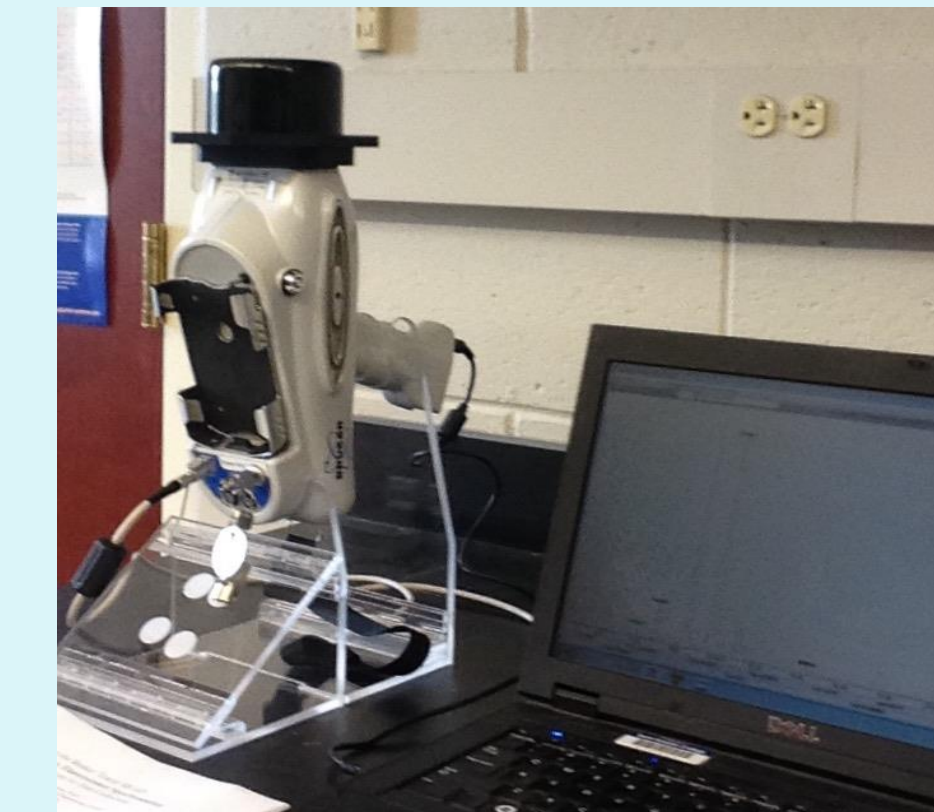


- PC-1:Pb PC-2: Fe PC-3: Ca
- Some Reds (left) have different Pb than other Reds (right)

XRF Spectra



Instrument Setup



Conclusions

- XRF analysis and principal component analyses (PCA) allowed for the identification of the main elements contributing to variations among the different colors
- Results for different colors agreed with published data for Roman glasses
- Variations within color sets were found
 - Some colors more rare (Red, Black) than others (Blues and Greens)
- Form of sample matters
 - Tesserae are not homogeneous
 - Differences on surface versus bulk glass

Acknowledgements

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References

- Redente, M. Saint Anselm College Chemistry Department Senior Thesis, December 2013.