

# Elemental Analysis of Bucchero Pottery using Laser Induced Breakdown Spectroscopy

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## Abstract



Elemental analysis was conducted on bucchero, a type of ancient Etruscan ceramic, using portable laser induced breakdown spectroscopy (LIBS). The analysis was conducted *ex-situ* using a portable instrument at the excavation laboratory. The analysis compared two colors of bucchero (grey and black) from two archaeological sites (Cavita 254 and Crocifisso Del Tufo). Analysis of the spectral data permitted the identification of characteristic elements in the ceramics: Si, Al, Na, Fe, Ca, Mn, Ti, Sr, C, and Li. Principle component analysis of the LIBS intensity data showed that grey bucchero with and without inscriptions group separately. And all black bucchero group together.

## Background

Bucchero (Figure 1) is a style of Etruscan fine ware. It was made from the 7<sup>th</sup> century to the 5<sup>th</sup> century BCE in Etruria, a region of central Italy, and was typically used as tableware. There were two common forms of bucchero, grey bucchero and black bucchero. Both styles of bucchero were made from the same clay, but had different colors as a result of how they were fired. The bucchero examined in this study were excavated from two different site: 1) Cavita 254 (Figure 2) is a cave system discovered in 2011 in the basement of a house in the city of Orvieto; and 2) Crocifisso del Tufo (Figure 3) is an Etruscan necropolis which dates to the 6<sup>th</sup> century BCE and was first excavated in the 19<sup>th</sup> century.

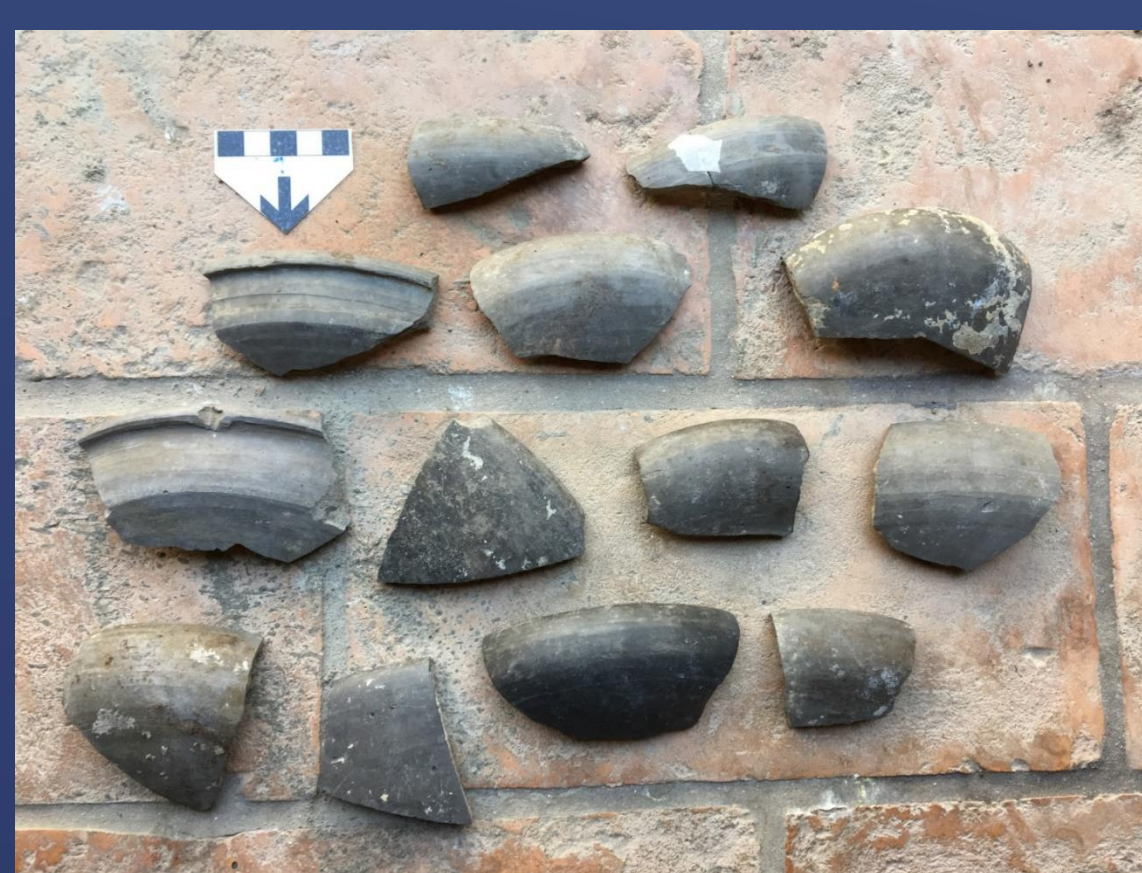


Figure 1: Grey Bucchero samples with 5 cm scale

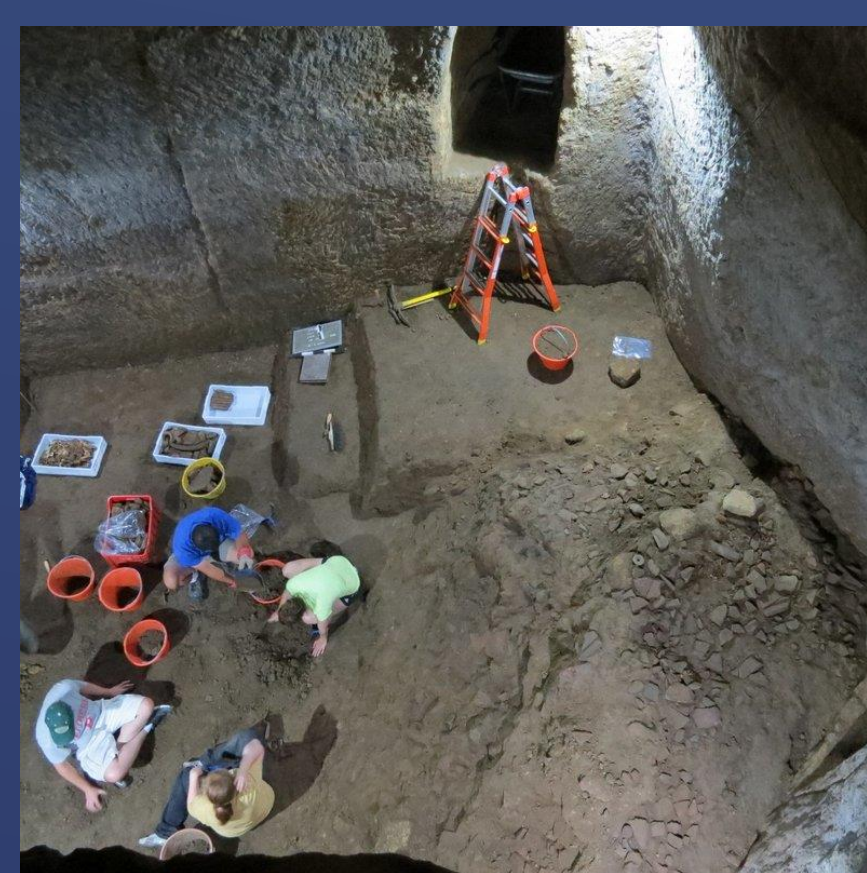


Figure 2: Cavita 254



Figure 3: Crocifisso del Tufo

## Instrumentation

- SciAps LIBZ500 portable LIBS spectrometer
- Geochem mode
- Laser: 5-6 mJ/pulse, 50 Hz frequency, 1ns pulse width
- Wavelengths measured: 190nm-850nm
- No argon flow
- Analysis time  $\approx$  6 seconds
- Analysis conducted on 4x3 grid
- 4 cleaning shots and 3 analysis shots per spot
- 3 Analyses per bucchero sherd on cut edge of pottery



Figure 4: LIBZ500

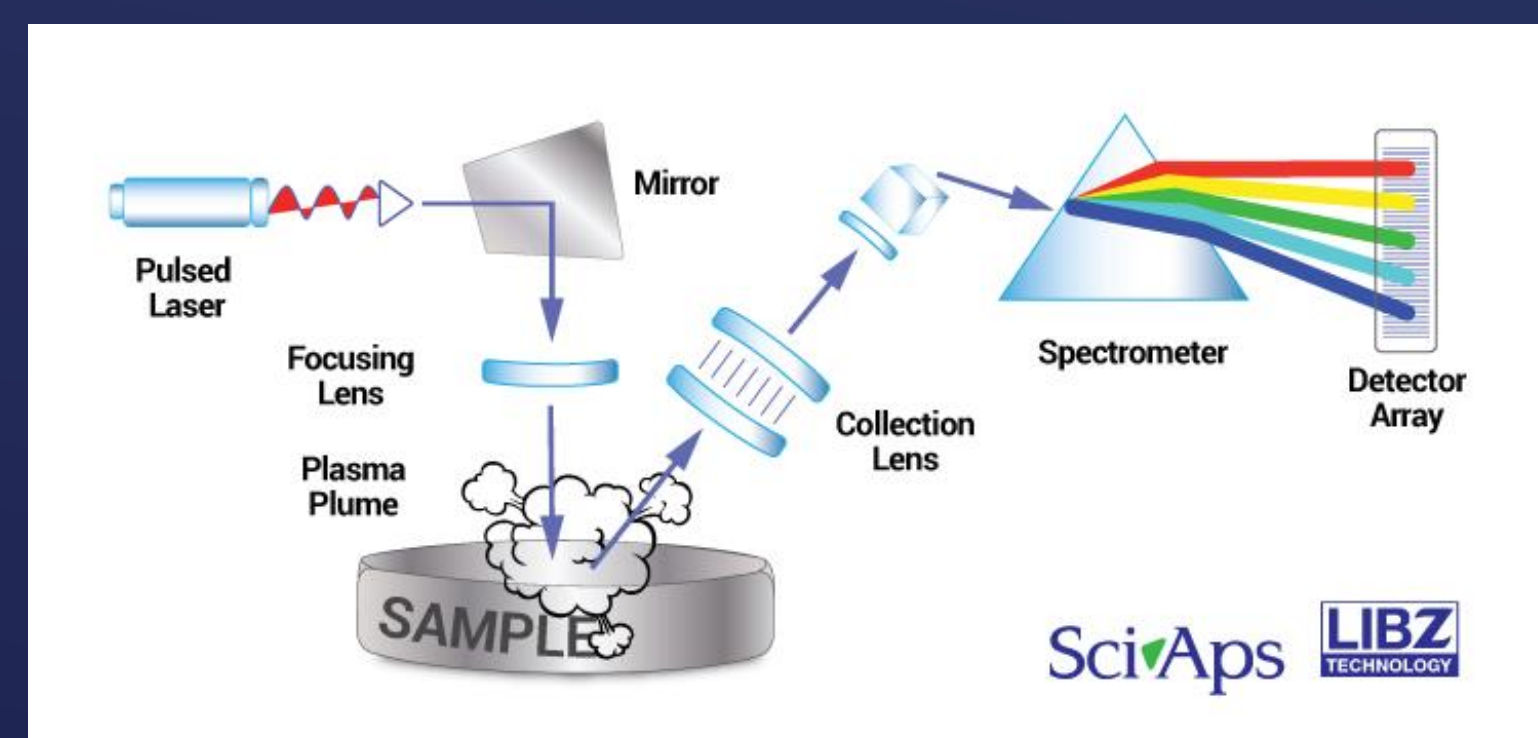


Figure 5: LIBS Instrument Diagram

## Results

Element	Emission Peak (nm)	Element	Emission Peak (nm)
Si	288.16	Mn	478.34
Al	394.4	Ti	499.11
Na	589.59	Sr	407.78
Fe	404.58	C	247.86
Ca	396.85	Li	670.79
Mg	518.36		

Figure 6: Emission Lines of Observed Elements

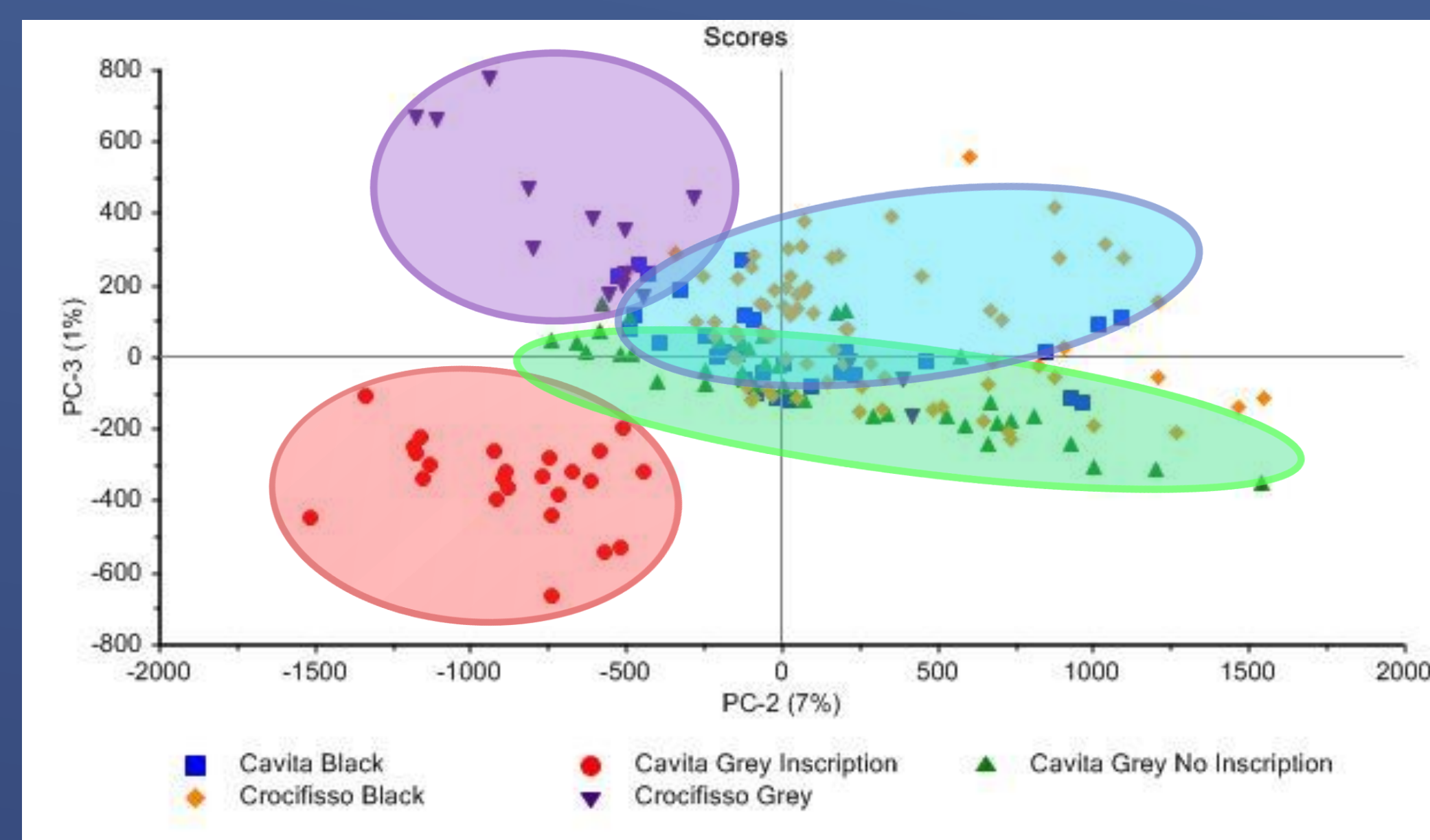


Figure 7: PCA Standard

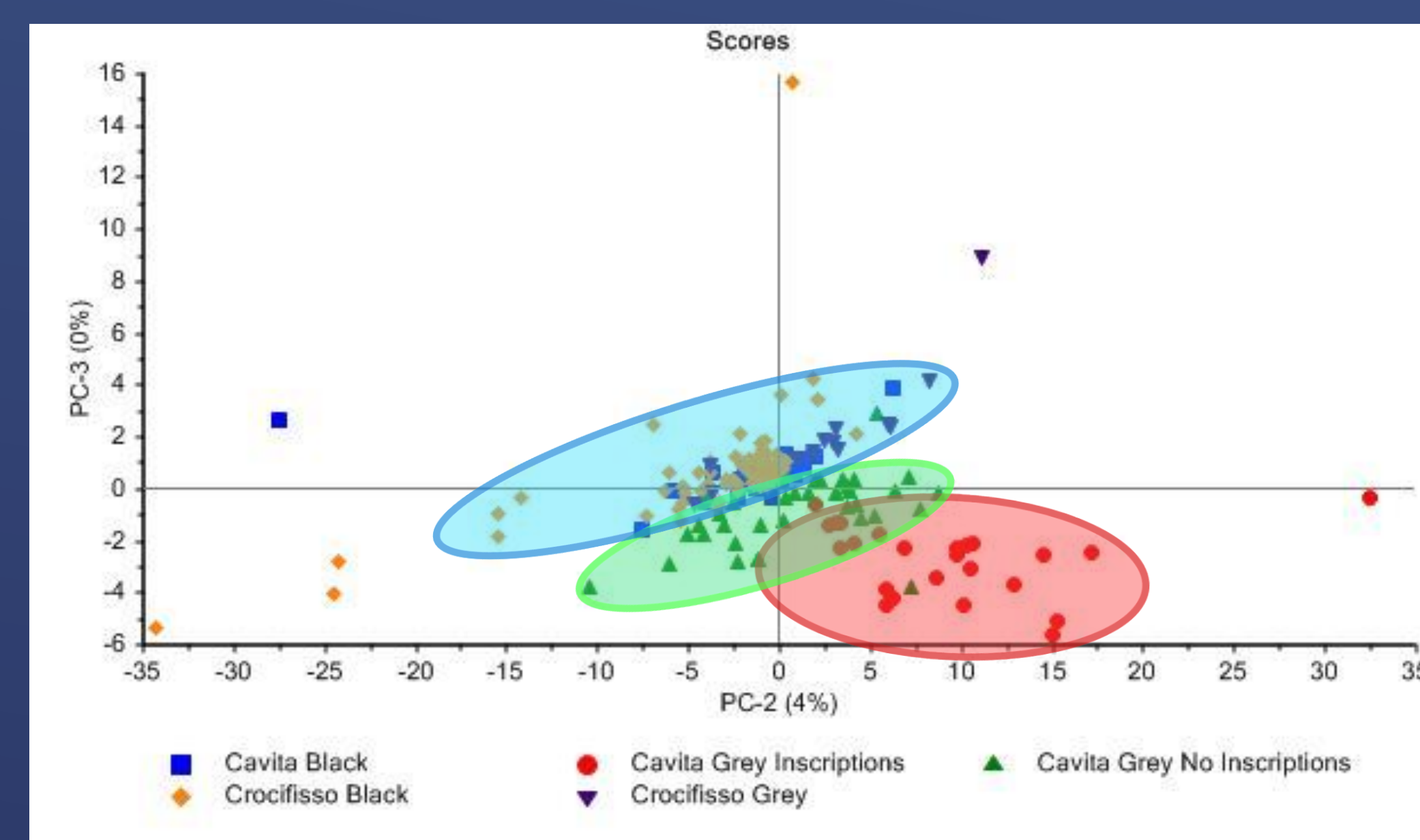


Figure 8: PCA of Data Normalized to Silicon

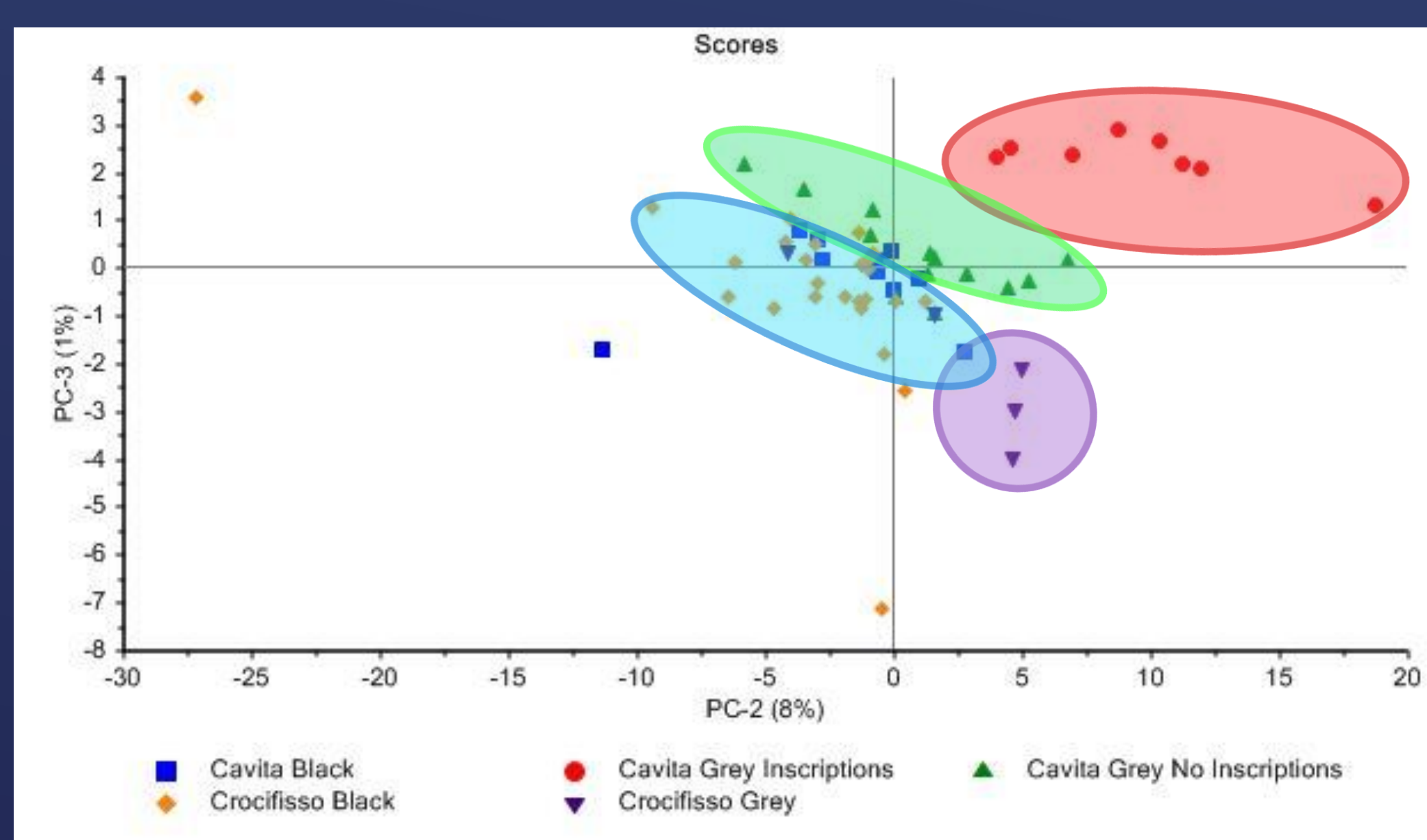


Figure 9: PCA of Data Normalized to Silicon and Averaged

## Results (cont.)

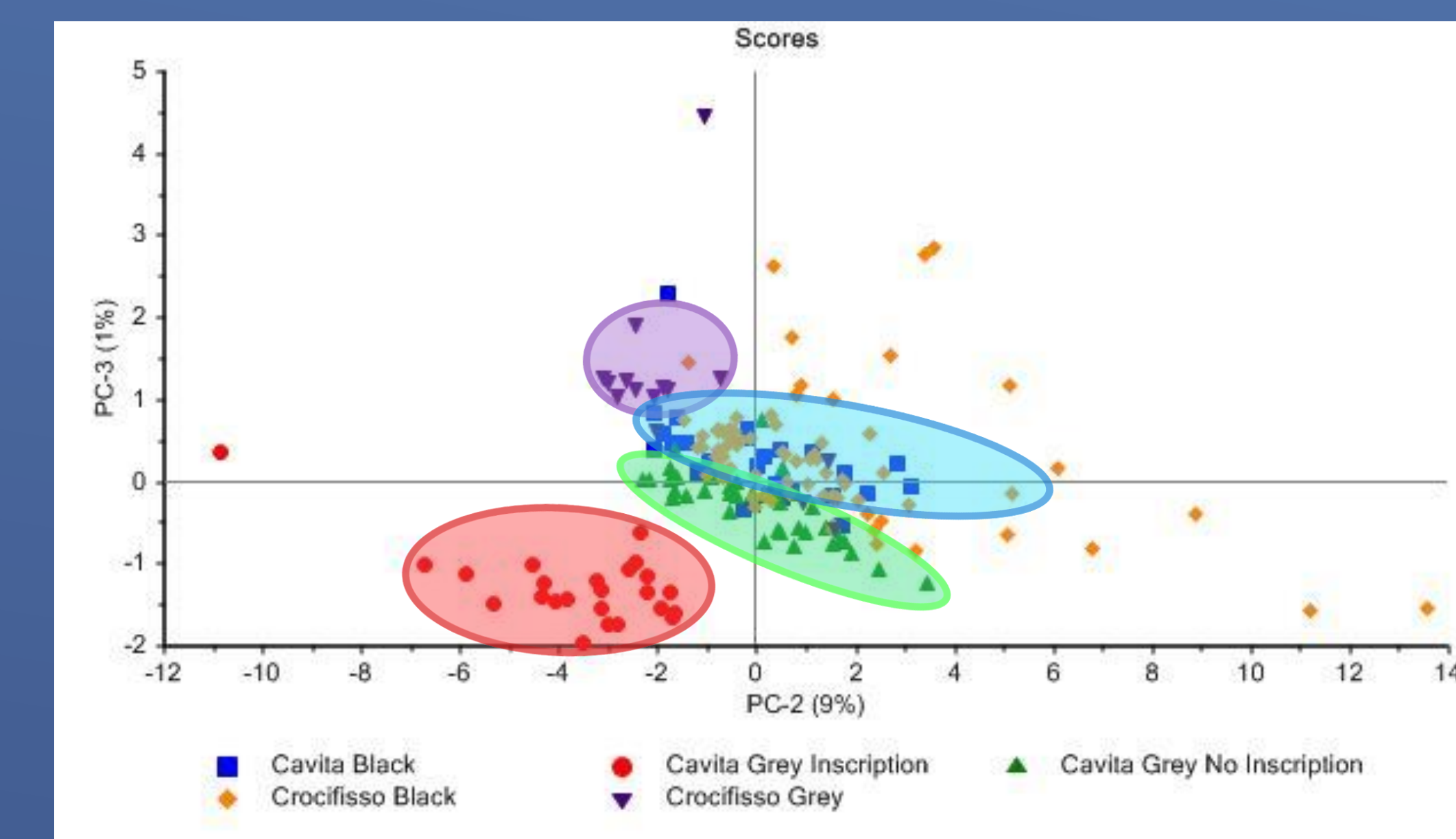


Figure 10: PCA of Data Normalized to Calcium

## Conclusions

- Figure 7 Intensity Data Not Normalized
  - Cavita grey with inscriptions (red ellipse) and Cavita grey without inscriptions (green ellipse) are distinct and separate each other
  - Crocifisso grey is a separate group (purple ellipse)
  - Cavita black and crocifisso black group together
- Figure 8 Intensity Data Normalized to Si
  - Cavita grey with inscriptions (red ellipse) mostly but not completely separated from Cavita grey without inscriptions (green ellipse)
  - All other groups clustered together
- Figure 9 Intensity Data Normalized to Si with Averaging
  - Similar groupings as those found in Figure 7
  - Less data points
- Figure 10 Intensity Data Normalized to Ca
  - Similar groups as those found in Figure 7
  - More tightly clustered groups
- Connecting to the Archaeology
  - The separation of Cavita with inscriptions and Cavita without inscriptions implies these different ceramic groups were brought from "somewhere else" and that they were dedicatory.
  - The Crocifisso grey sherds, which are a very small set, are a separate groups from all others which implies they may be sourced locally
  - All black bucchero cluster together, implying their production for a specific use, likely funerary.

## Acknowledgements

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