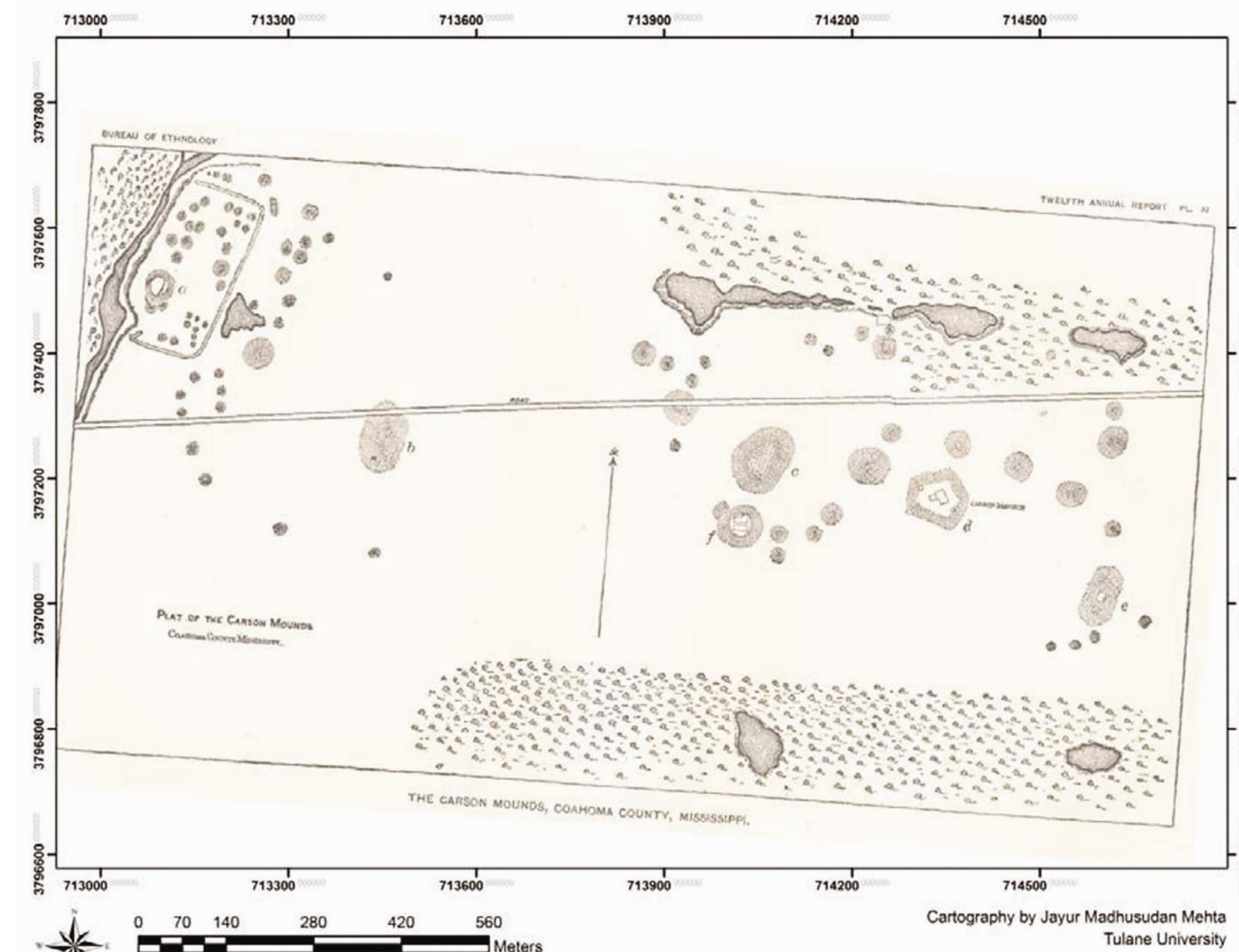


## Abstract

Mississippian culture has long been the subject of debate, with its trade networks being a focal point. The Carson Mounds site in Mississippi's Yazoo Basin is central to this as it contains pottery that is stylistically Cahokian. This study aims to determine the provenance of these "non-local" ceramics to distinguish between trade imports and stylistic diffusion and imitation. Using nondestructive portable x-ray fluorescence (pXRF) of 93 samples, this study identifies the chemical composition of both local pottery and Cahokian-style samples from Carson. These geochemical signatures were compared against Neutron Activation Analysis (NAA) databases from the University of Missouri's Archaeometry Lab to identify matches with known Mississippian clay sources.

Results indicate Carson ceramics are significantly similar to the elemental fingerprints of Carson, Cahokia, and Moundville, indicating complex trade networks. As Carson remains an understudied site, this research fills a critical gap in the literature regarding the reach of the Cahokian sphere of influence and the connectedness of the Mississippian world. This data sheds light on Indigenous social structures and trade networks. Furthermore, this study addresses a methodological gap in ceramic studies. While pXRF is common in lithic and metal analysis, it is underutilized in archaeological ceramics studies. This research demonstrates how non-destructive pXRF can be effectively used in provenance research.



Georeferenced historic map of the Carson mounds site. (Mehta et. al 2012 Fig. 3).

## Introduction

Cahokia is the largest and one of the most influential of Mississippian sites (ca. 1000-1513 CE). Many artifacts and stylistic patterns from Cahokia have been found in other contexts. This phenomenon is the "Cahokia effect" (Pauketat 1998; Emerson 2002). The presence of Cahokian-style ceramics at Carson raises critical questions about long-distance trade, cultural emulation, and the movement of people.

Carson is a Mississippian center featuring mounds, a village, a bundle-burial mortuary complex, and non-local structures (Baltus et. al 2022). Determining if these 'non-local' vessels were imported or locally made reveals the degree of Carson's integration into and interaction with the broader Mississippian world. Previous stylistic analysis informs this project's local and non-local groupings (Antoniuk 2021).

This research seeks to answer the following questions:

- Based on compositional chemical analysis of local and non-local ceramic pastes, are the ceramics from Carson that resemble Cahokian ceramics non-local to the Carson Mounds Site?
- To what extent and by what means did individuals from Carson and Cahokia interact?
- How effective is pXRF as a method of analysis for provenance and overall study of archaeological ceramics?

## Materials & Methods

### Sampling Strategy

- Non-local samples selected based on Antoniuk's identification. Many are from Pit 434, and all are from the Pre-mound A village
- Local sherds were selected to prioritize shell tempered sherds and source from Mounds A and D.



TAC 51 Vessel 27 Pit 434 Non-Local



17-461 Vessel 1 Local



Powell plain rim sherds from pit 434. Image by John Connaway. (Mehta, Connaway 2020 Fig. 7)



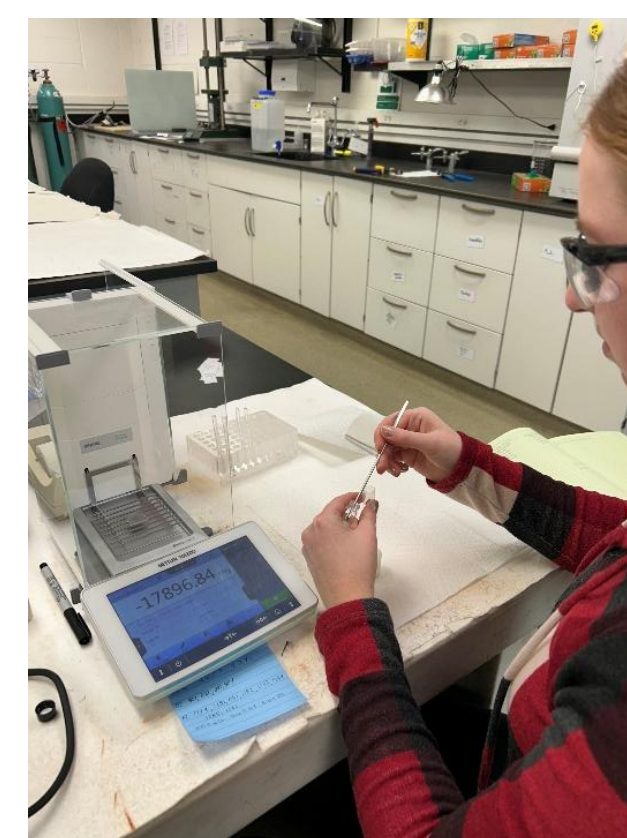
Bell Plain Bowl, rep. of local material, Chucalissa Museum at the University of Memphis.

### Analysis Methods

- pXRF: Irradiates sample with beams of X-rays, displacing electrons from inner orbitals. Outer electrons move to fill lower orbitals, emitting X-ray photons as energy that is read to identify and quantify the elements. Prior to scanning, sherds were sanded, washed in distilled water, and air dried. The Bruker TRACER 5i was set to Geo Exploration in air mode. Sherds were scanned 3 times on an interior spot and 3 on an exterior spot.

### Statistical Methods

- Principal Component Analysis: Reduces overlapping variables into principal components and to two-dimensions. PCA identified the two principal components that contribute to variation.
- Multivariate Analysis of Variance (Manova): Determines significance of differences between groups across multiple dependent variables. Showed that the overall chemical difference between local and non-local is highly significant.
- Bivariate Plotting: Visualizes relationship between two variables. Used to plot specific ratios of element pairs that were identified through PCA as the strongest discriminators between groups.
- NAA: Irradiates samples with neutrons in a nuclear reactor. Measures gamma rays emitted by radioactive isotopes as atoms are activated by irradiation decay. This data can be used to quantify and identify elements in the sample. pXRF data was compared to NAA data from various Mississippian sites to identify commonalities between the chemical compositions of ceramic pastes.



Weighing out powdered, dehydrated samples for irradiation vials at MURR.

## Results

- Raw pXRF data is output in parts per million (ppm). Data was log10 transformed to mitigate the 'closure problem' inherent in compositional datasets and to normalize the log-normal distribution of trace elements.
- Titanium, chromium, iron, zinc, barium, lead, thorium, and uranium were identified as strong contributors and used in statistical analysis.

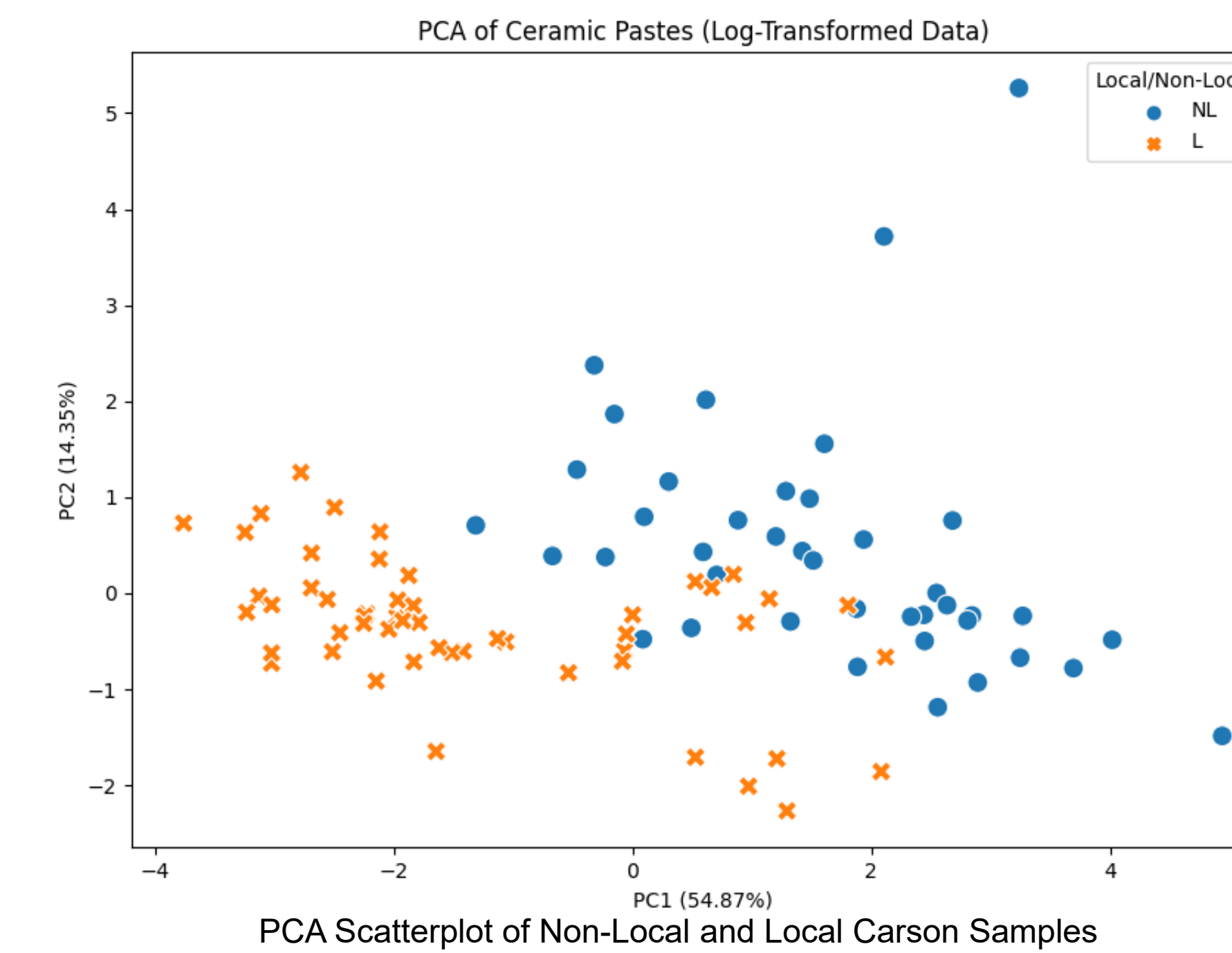
Example of Log10 transformed pXRF data

Temper	Type	Context	Location	N/NL	Ti	Cr	Fe	Zn	Ba	Pb	Th	U
	Old Town		Pre-Mound A									
shell	Red	Pit 434	Village	NL	-0.408	-2.059	0.515	1.622	0.632	2.829	3.377	<LOD
	Bell Plain		Mound A									
Shell	var., Bell	HS 31	Village	L	-0.511	-2.071	0.568	1.706	0.614	2.839	3.347	<LOD

## Results

### PCA of Local and Non-Local

- Shows local and non-local samples are significantly different.
- PC1 and PC2 explain 69.2% of variance
- PC1: strongly influenced by Ti, Cr, and Fe
- PC2: strongly influenced by Ba, Zn, and Pb
- Local samples are higher in Ti, Cr, Fe, Th, and U concentrations while non-local samples have higher concentrations of Zn, Ba, and Pb



### Manova

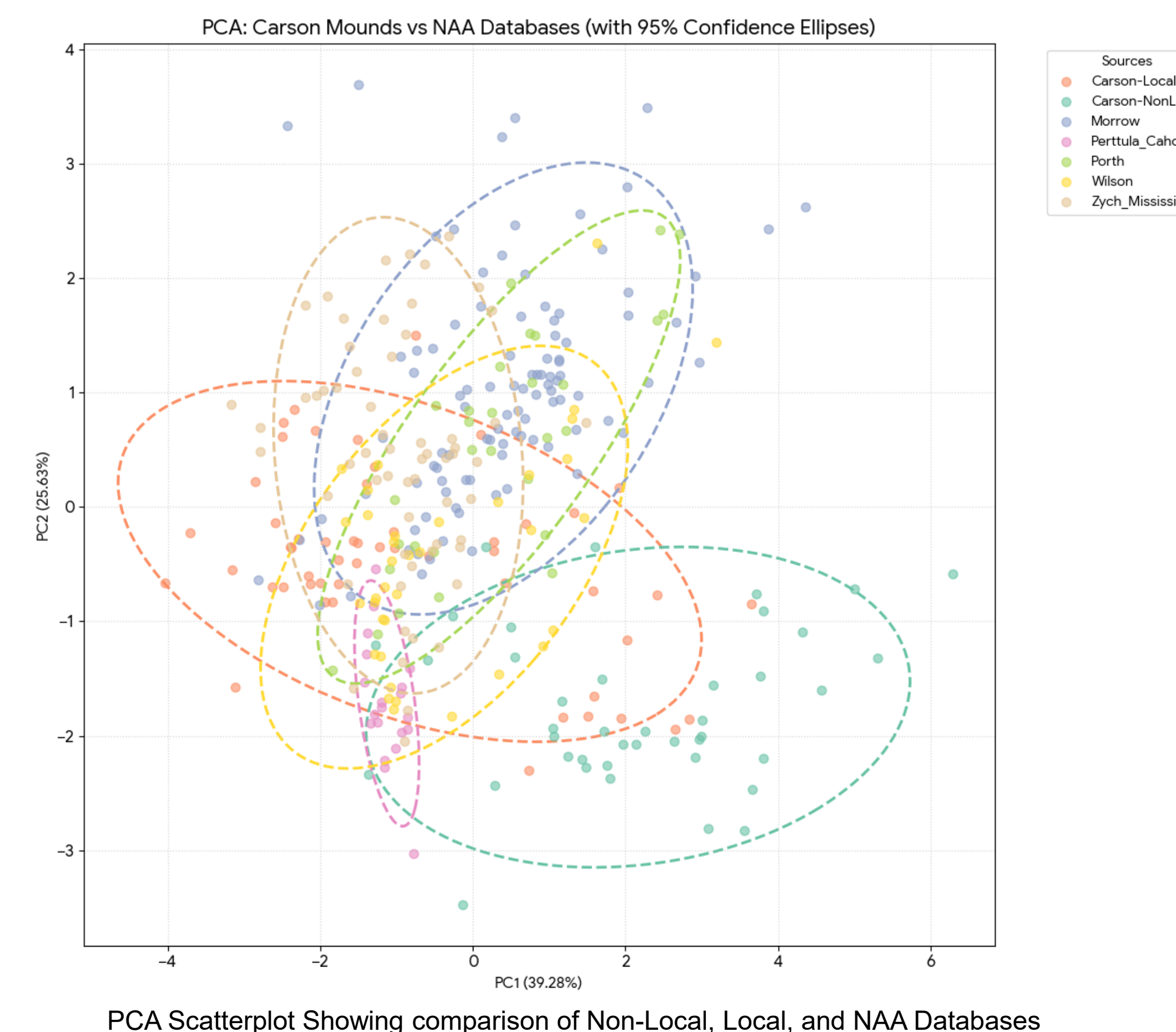
- Shows the chemical difference between local and non-local is statistically significant, indicating distinct clay sources.

### Bivariate Plotting

- Shows the ratio between Zn and Ba is very diagnostic of the provenance of the clay paste. In the Bivariate plot of Zn vs. Ba, the non-local data is shifted to the upper right, as they have more Ba and Zn compared to the local material.

### PCA of Carson (NL and L) and NAA Databases

- To compare pXRF and NAA data, unit and z-score standardization was done, ensuring the same units are compared and analysis is based on chemical patterns, not absolute values.
- 51.2% of the non-local samples match Cahokia the most. 36.6% clusters with Moundville.
- Local ceramic paste is chemically distinct from Cahokia and Moundville, indicating a unique, local paste and process.



## Discussion

The Geochemical overlap between non-local samples and the Cahokia (Wilson) database confirms that these vessels were not just stylistic copies, but likely direct imports. The presence of a strong local ceramic paste suggests a local ceramic tradition using consistent local geological sources. Overlap with the Moundville (Porth) database further indicates a probable triangular trade network between Carson, Cahokia, and Moundville. Carson may have operated as a cosmopolitan hub, facilitating trade across the region. The correlation between the non-local wares being fine ware further indicates an expansive trade network. The significant difference between the chemical compositions of fine and utilitarian ware suggests the intentional selection of specific clays to fulfill societal functions. Further research should be done to identify possible ceramics that are non-local to Moundville and Cahokia. While most ceramics labeled non-local aligned with non-local pastes, some matched the composition of local pastes, indicating that local potters were adapting Cahokian styles into production. NAA would bolster the accuracy of this study and provide insight into the relative accuracy of pXRF in the study of ceramics. Nevertheless, this research attests to the use of pXRF as a viable, non-destructive way to analyze archaeological ceramics and to screen assemblages before pursuing further, expensive methods of analysis like NAA.



Map showing locations of Carson, Cahokia, Moundville, and other Mississippian Sites. (Mehta, Connaway 2020 Fig. 1)

## References



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