30th EAA Annual Meeting in Rome, Italy 28 - 31 August 2024

Exploring the origins of grog with SEM-EDS: the Bronze age ceramics from Croatia

Natali Neral[1*], Andreja Kudelić[1] & Patrick Quinn[2]

[1]Institute of Archaeology, Jurjevska street 15, 10000 Zagreb, CROATIA

[2]Institute of Archaeology, University College London, 31-34 Gordon Square, London, WC1H0PY, UK

**natali.neral@iarh.hr*

INSTITUTE OF ARCHAEOLOGY · HRZZ Hrvatska zaklada za znanost · PREPOT · Funded by the European Union NextGenerationEU · UCL · EAA 2024 28-31 AUG ROME Persisting with change

Introduction

Studying the composition and origins of ancient pottery poses significant challenges, primarily due to ceramics typically comprising multiple components: raw clay and added tempering materials. Determining the origin of these pottery raw materials necessary imply analytical methods capable of accurately assessing the geochemical composition of both the clay matrix and the added tempers. Therefore, this research employs scanning electron microscopy equipped with energy dispersive X-ray spectroscopy (SEM-EDS) and ceramic petrography to analyze grog-tempered Bronze Age ceramics from two distinct archaeological sites: Biranj in Central Dalmatia and Molve-Topolova in Continental Croatia.

Research aims

By comparing the geochemical compositions of ceramic matrix and grog, **the aim of this study** is:

- To consider whether the grog is foreign or originates from the same source as the clay.
- To examine the variations in grog practice among communities exposed to different cultural influences.

Materials

- Five Early and Middle Bronze age ceramic sherds from Biranj site situated in Central Dalmatia
- Seven Middle/Late Bronze age ceramics from Molve-Topolova site situated in Continental Croatia

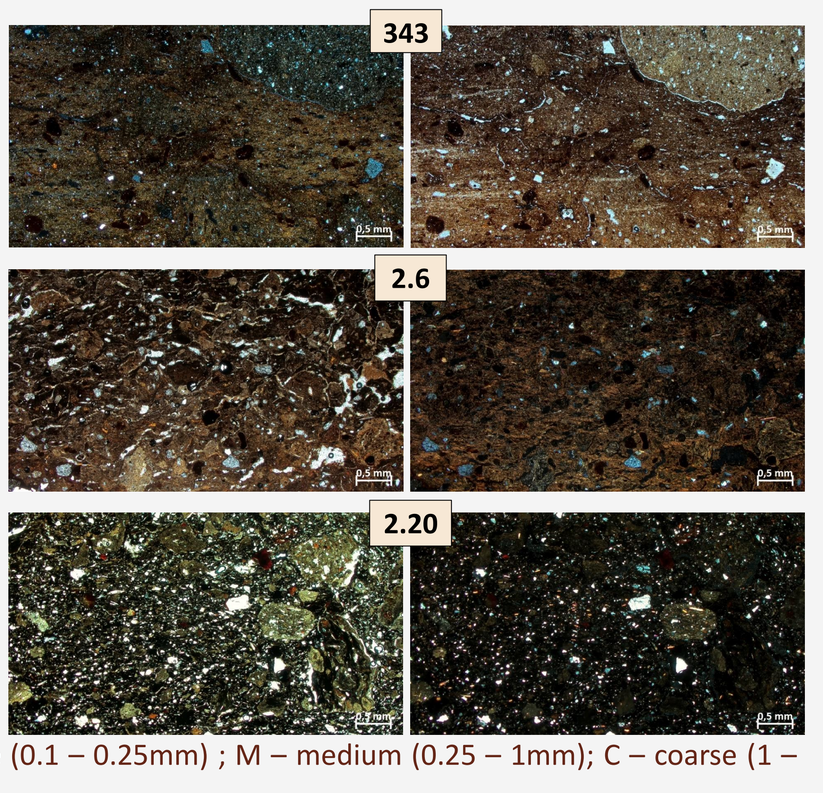
Methods

- Optical microscopy of ceramic thin sections (**OM**)
- Determination of geochemical composition of grog and ceramic matrix by scanning electron microscopy equipped with energy dispersive X-ray spectroscopy (**SEM-EDS**)

Results and discussion

Optical microscopy

			Matrix			Temper			
Site	Sample number	Period	Optical acitivity	Very fine and fine inclusions (%)	Mineral composition	„Calcite ghosts" (%)*	Grog amount (%)	Grog size	Grog roundness
Biranj	337	EBA	MH	~25	Q, Kfs, Pl, Mca	-	15	F/C	SR
	340	EBA	H	~15	Q, Kfs, Pl, Mca	15	10	F/M	SA/SR
	341	EBA	MH	~30	Q, Kfs, Pl, Mca	20	10	F/M	SA/SR
	342	EBA	H	~25	Q, Kfs, Pl, Mca	20	10	F/M	SA
	343	MBA	MH	~10	Q, Kfs, Pl, Mca	-	25	M/C	SA
	347	MBA	MH	~35	Q, Kfs, Pl, Mca	-	25	F/C	SA/SR
	348	LBA	MH	~5	Q, Kfs, Pl, Mca	20	10	F/C	SA/SR
Molve-Topolova	2.6	MBA/LBA	MH	~10	Q, Mca	-	30	M/C	SR
	2.9	MBA/LBA	H	~10	Q, Mca, Kfs	-	20	M/C	SA/SR
	2.11	MBA/LBA	H	~7	Q, Mca	-	30	M/C	SA/SR
	2.14	MBA/LBA	MH	~7	Q, Mca	-	20	M/C	SA/SR
	2.20	MBA/LBA	L	~30	Q, Mca, Kfs	-	20	M	SA/SR

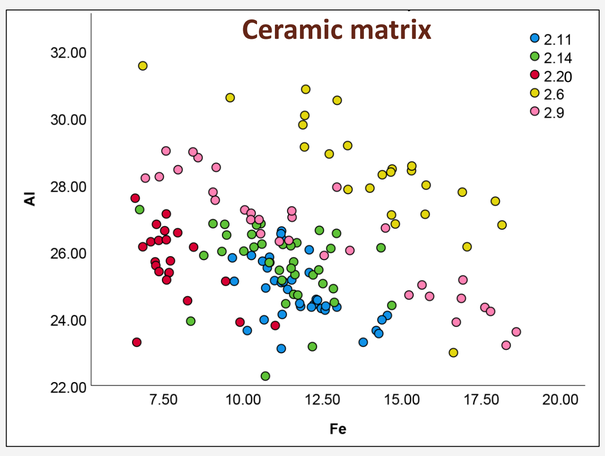


EBA – Early Bronze Age; MBA – Middle Bronze Age; LBA – Late Bronze Age; H – high; MH – medium high; L – low; F – fine (0.1 – 0.25mm) ; M – medium (0.25 – 1mm); C – coarse (1 – 3mm); SA – subangular; SR – subrounded;

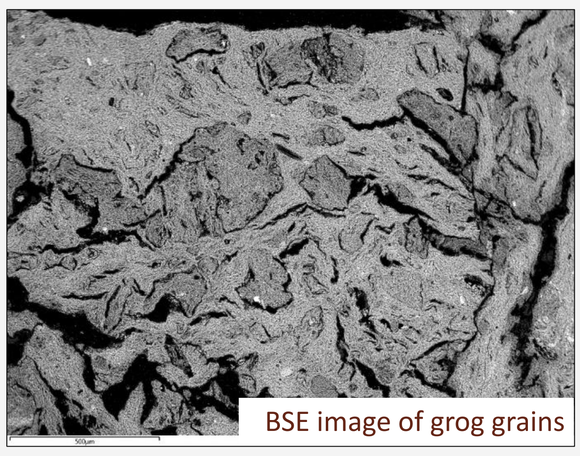
Ceramic petrography enabled the characterization of raw materials and determination of paste recipes used in the ancient pottery production. The results indicate a preferential use of "sandy clay" (clay with a large amount of naturally present inclusions) among potters from the Biranj site, while the ancient potters from the Molve-Topolova site preferred inclusion-poor clay. Considering the tempering materials, the addition of a large amount of medium to coarse-sized grog grains is characteristic of all the samples from the Molve-Topolova site. In contrast, the samples from the Biranj site contain only a small amount of mostly fine to medium-sized grog. Additionally, most of the samples from the Biranj site are characterized by calcite temper (readily available in karst environment), although due to the technological process or post-burial acidic conditions, the samples only contain voids formed in place of the initial calcite grains after their dissolution („calcite ghosts"*).

SEM-EDS

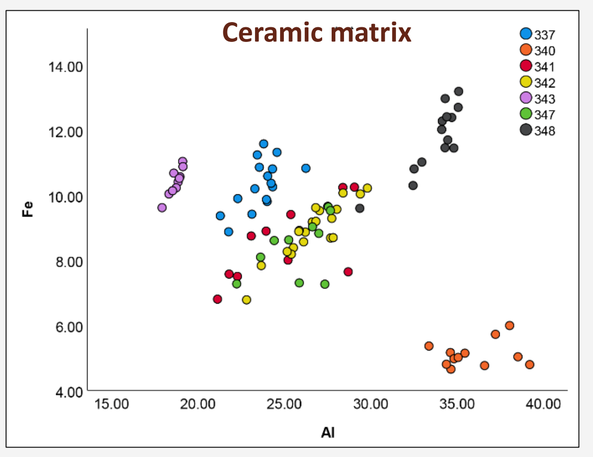
Molve-Topolva site

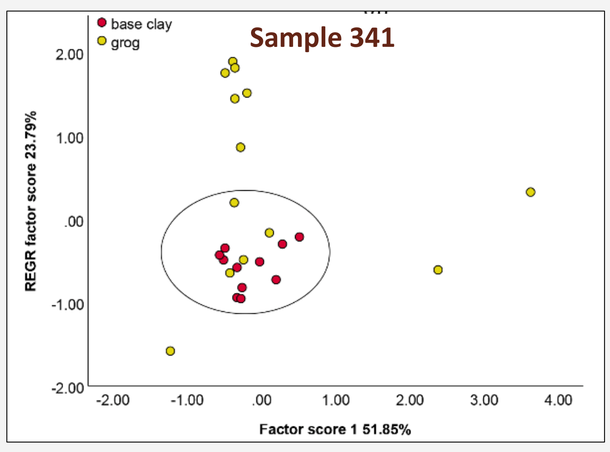


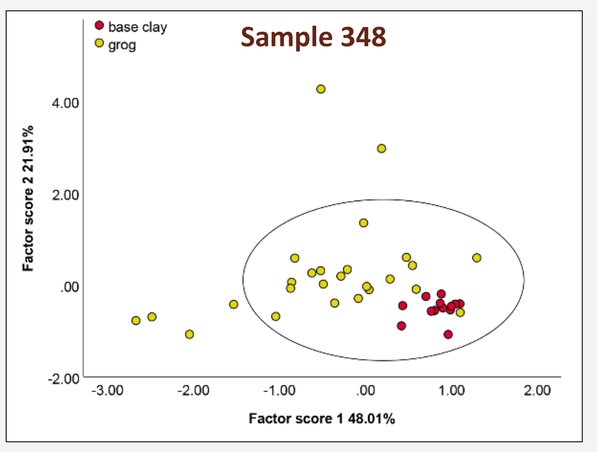
Considering the geochemical composition of the **ceramic matrix** via SEM-EDS, the results reveal a uniform matrix composition among samples from the Biranj site. In contrast, a more pronounced variety, particularly in the Fe and Al concentrations, was observed in samples from the Molve-Topolova site. This is especially notable in the samples 2.6 and 2.9 which indicates a mixing of different clay sources and/or post-depositional alterations.



Biranj site







The principal component analysis (PCA) of **grog** from the Molve-Topolova site reveals a single compositional group with several outliers, suggesting a largely consistent geochemical composition across most samples. Further PCA of both grog and clay matrix performed on each sample indicates that the grog likely originates from the same source as the clay. The only exception is **sample 2.20**, which, according to PCA, contains grog of a different origin. In contrast, the same procedure applied to samples from the Biranj site indicates a more pronounced variety of grog grains, suggesting diverse origins of grog. The composition of grog in samples 341 and 348, particularly in terms of Na, Ca, and Mg concentrations, strongly suggests that these samples (at least) contain grog of different origin if compared to the base clay.

Conclusion

The preliminary SEM-EDS results revealed significant variations in grog utilisation among communities influenced by distinct cultural factors. Intensive grog tempering was notably prevalent in continental Croatia during the Middle and Late Bronze Age. Conversely, along the eastern Adriatic coast, the practice predominantly involved adding small amounts of grog across the Early and Middle Bronze Age. The close correspondence observed between grog and the ceramic matrix in continental Croatia (Molve-Topolova site) suggests technological motivations for grog tempering. Specifically, locally crafted pots were likely recycled to temper new vessels, thereby enhancing their physical properties. Conversely, the pronounced variability in grog composition observed in samples from the eastern Adriatic coast (Biranj site) suggests a potential use of imported materials i.e. the movement of potters and/or pottery, probably driven by diverse cultural or socio-economic factors.

Supported by: Croatian Science Foundation project: *Technological features and cultural practices in prehistoric pottery traditions in Croatia* (UIP-2020-02-3637), and the European Union-NextGeneration EU project *Synergy of Diversity: Landscape Archeology and Technological Traditions in Continental and Adriatic Croatia (SirAkt)* of the Institute of Archaeology in Zagreb. The SEM-EDS was conducted within *the Mobility program – outgoing mobility of assistants (MOBDOK-2023) founded by Croatia Science foundation.*