Down to the Crust: an Analysis of Ceramic Concretions from a Bronze Age Cemetery in Eastern Hungary

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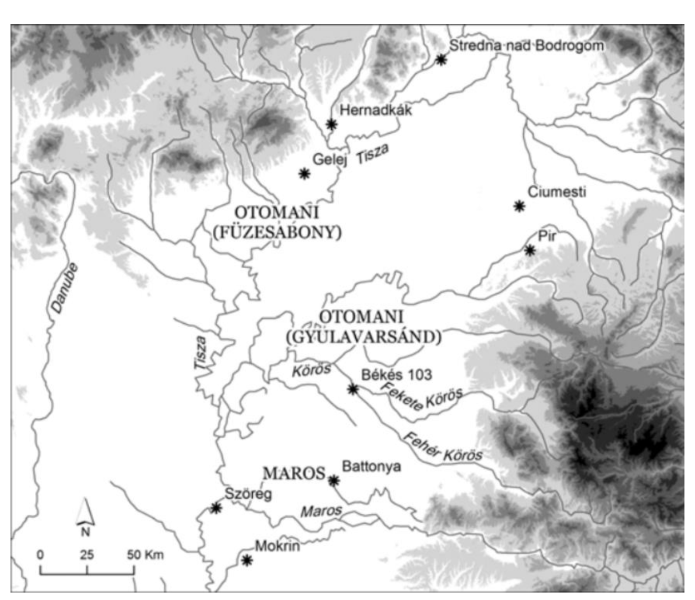
Introduction

Since 2011, the BAKOTA project has excavated Békés 103, a primarily urn cremation Bronze Age cemetery (intensive use period 1600-1280 BC) located along the Kettős-Körös paleomeander in present day Eastern Hungary in order to better understand trade, social inequality, and mortuary practices on the Great Hungarian Plain (Duffy et al., 2014, 2019; Paja et al., 2016). Past excavation seasons have produced a large number of burial vessels, many of which are covered by white concretions. The concretions could be the result of post-burial alteration or a deliberate cultural practice—there is contemporary evidence of this in Hungary (Parkinson et al. 2010). Chemical analysis by LA-ICP-MS also indicates elevated Ba concentrations in many of the Békés 103 sherds. Understanding the chemical composition and origins of these concretions is necessary for future provenience studies of ceramics and isotopic analysis of human remains.

Our Questions

- What is the chemical and mineralogical composition of the concretions on certain ceramic sherds?
- Are the concretions a result of post-depositional alteration or a cultural practice occurring before the vessels were placed in the earth?
- Does the chemical composition of the concretions affect ceramic provenance and future residue analysis at the Békés 103 site?



Map showing the Békés 103 site

Urn burial at the Békés 103 site

Sample and Methods

Sample: 50 ceramic samples from a variety of burial and settlement contexts were included in the study, either because they had visible surface concretions or because they had been previously characterized by LA-ICP-MS and petrography. 12 soil samples from burial contexts were analyzed, as were 10 control soil samples taken from sterile sediment on site at Békés 103.

XRF: All samples were run at the Notre Dame Archaeological X-ray Laboratory using a Bruker Tracer 5i handheld spectrometer. Ceramic samples were run in unaltered form and calibrated against 15 USGS rock standards prepared as pressed pellets. Soil samples were finely powdered and calibrated against the same standards in powder form. XRF was used to determine the major compositional components of surface concretions and check for elevated concentrations of mobile elements in burial soils (Holmqvist 2016).

FTIR: Concretions from five ceramic samples were analyzed at the Field Museum Elemental Analysis Facility using a Smiths IdentifyIR Single bounce FTIR spectrometer (ZnSe beamsplitter, DTGS detector, sample press with LED display force indicator). Sample spectra were automatically matched against an internal reference library of spectra to determine the best mineralogical match for concretion constituents (Shoval 2016).

XRD: One sample with surface concretions was analyzed by XRD at the Notre Dame Materials Characterization Facility using a D8 Advance Davinci XRD spectrometer with Bruker SOL-XE X-ray detector. The sample was run both in omega-twotheta geometry and by grazing incident angle scan to examine any possible differences in surface and bulk composition of the concretion.

SEM-EDS: Five samples with visible surface concretions were analyzed at the Notre Dame Integrated Imaging Facility using a Magellan 400 XHR SEM with a Bruker EDS system to produce elemental maps of sherd/concretion boundaries and the edges of voids, pores, and temper grains to examine chemical leaching and understand the structure and composition of the sherd/concretion interface (Höck and Ionescu 2016).

LA-ICP-MS: Three cross-sectioned sherds with variable Ba concentrations were chemically mapped with LA-ICP-MS at the Field Museum Elemental Analysis Facility (EAF) using a Thermo Quadrupole ICP-MS and NewWave UP213 laser. A raster grid of ablation spots was run from one side of the sherd to the other, and values in between ablation spots estimated by inverse distance weighting in ArcGIS. Samples were calibrated against NIST610 glass and NIST679 clay (Golitko and Dussubieux 2016; Golitko et al. 2012).

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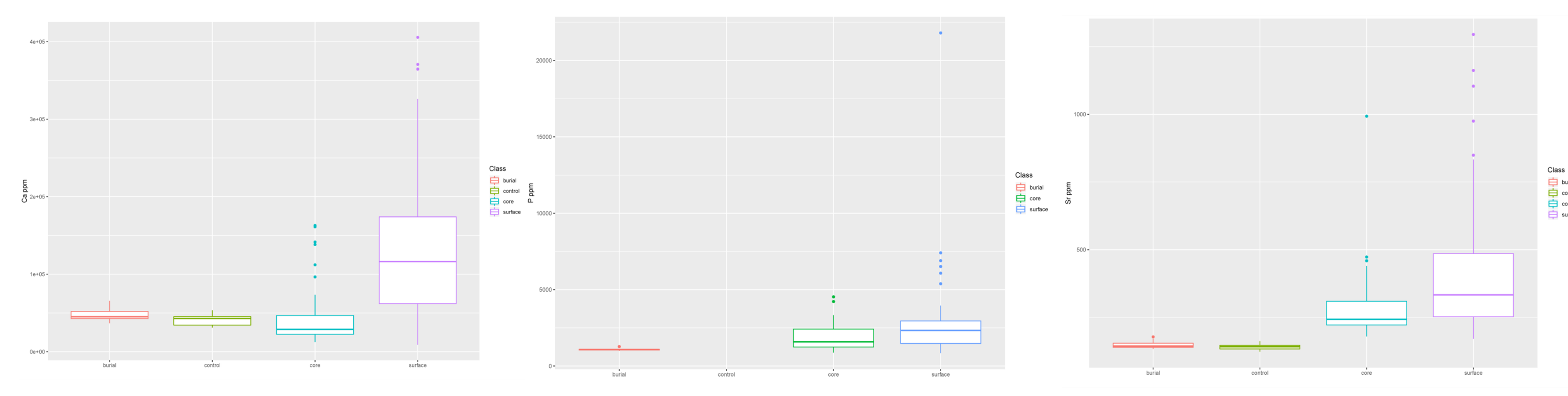
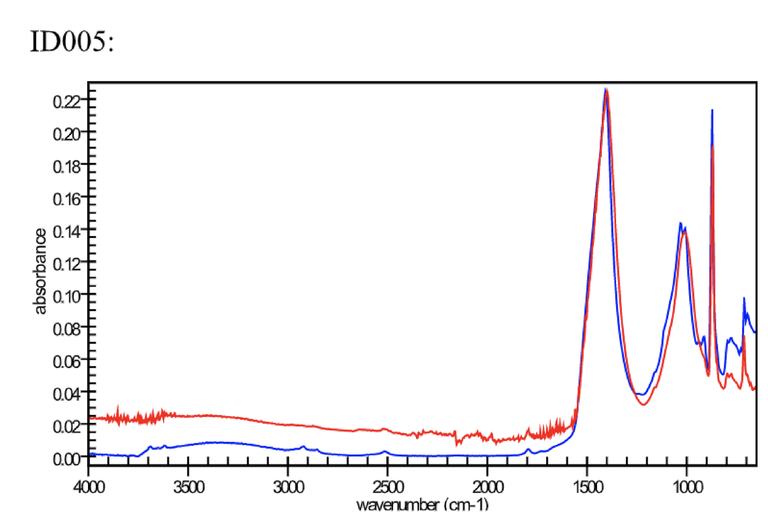
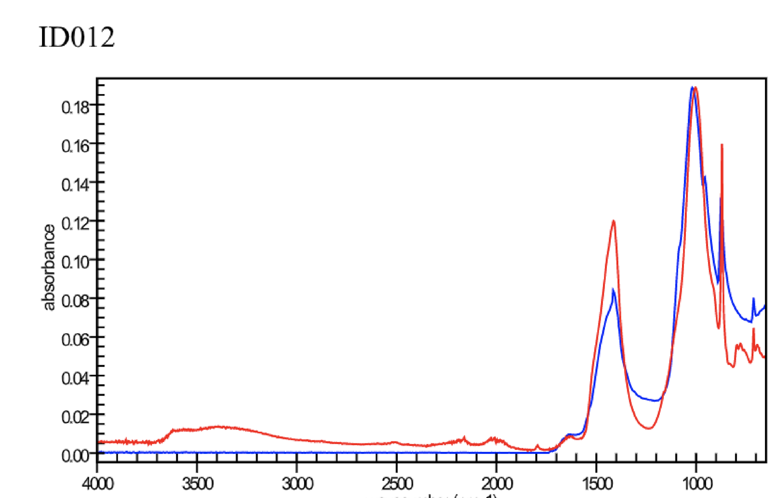
Results



XRF: Sherd surfaces, cross-sections, and both burial and control soil samples were analyzed using pXRF. Results indicate elevated Ca levels on the surface of sherds and in burial soils, slightly elevated P levels on the surface of sherds and in burial soils, and elevated levels of Sr on the surface of sherds, suggesting that bone may contribute to the composition of surface concretions on the Békés 103 ceramics.



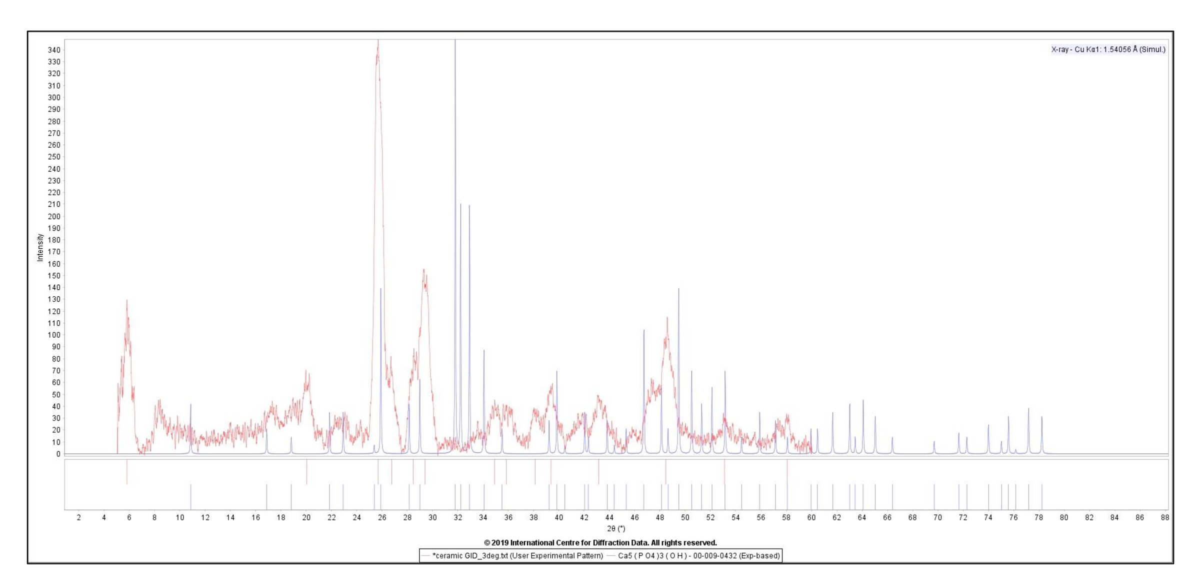
Sample (red) versus Drywall Dust (blue)



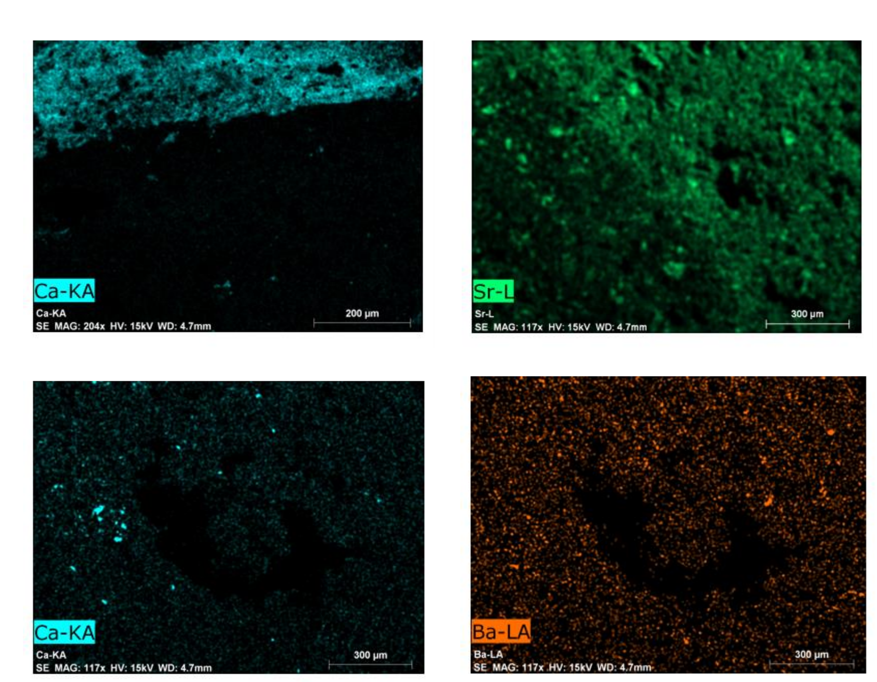
Sample (red) versus Human Tooth Enamel Powdered (blue)

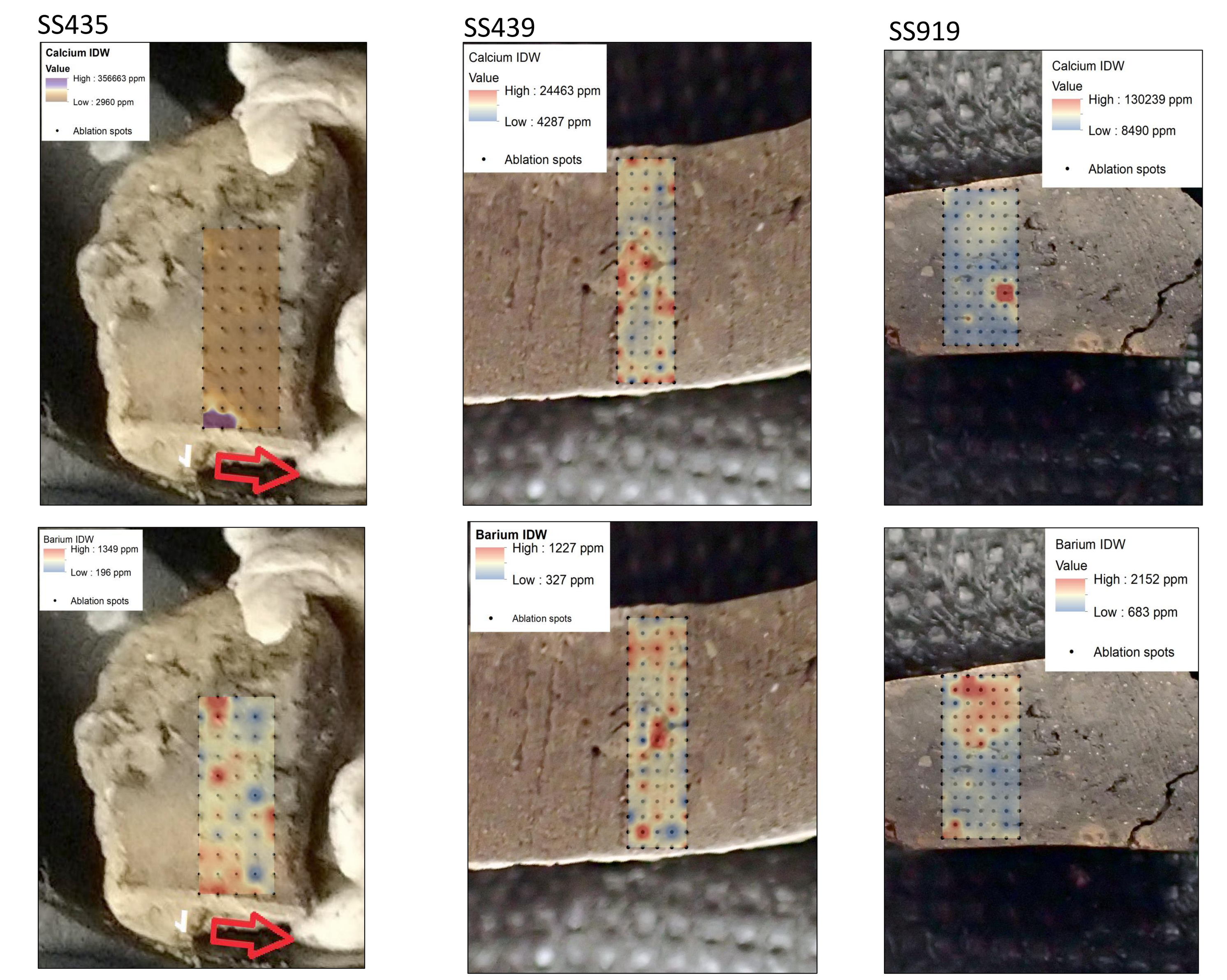
FTIR: Concretions from five samples were analyzed by FTIR. Results showed close matches to drywall dust (gypsum, sample ID005), and powdered human tooth enamel (hydroxyapatite, sample ID012), suggesting that both post-burial alteration or deliberate surface treatment with powdered or crushed bone could have produced the concretions.

XRD: Analysis of surface concretions on sample ID012 shows little evidence for hydroxyapatite as a primary constituent. The concretion is composed primarily of gypsum, clay minerals, and Sr-rich phases, indicating likely recrystallization of bone on sherd surfaces.



SEM-EDS: Five sherds with dense surface concretions were analyzed using SEM-EDS. Results show that the concretions were primarily made of Ca, P, and Sr (top). There is a clean and distinct edge between the concretions and the sherd itself, which would be expected if the concretions were deposited after firing. Examination of pore boundaries shows little evidence for elevated concentrations of potentially mobile elements including Ca and Sr (bottom).





LA-ICP-MS: Three sherd cross-sections were raster mapped using LA-ICP-MS: one with a low measured Ba content, one with average relative Ba levels, and one high Ba concentrations. In contrast to SEM-EDS results, LA-ICP-MS analysis (using inverse distance weighting to interpolate values between raster spots) shows distinct areas of elevated Ca and Ba content in all three sherds, although this is less pronounced in the low Ba sherd (SS435) than in either the medium or high Ba level sherds (SS439 and SS919). This suggests that mobile elements may have entered the fabric of the sherd during the process of concretion deposition and therefore impact the ability to use these elements in future sourcing studies.

Summary	1	2	3
Results	Concretions are high in Ca, P and Sr, soil adjacent to burials also shows elevated levels	The concretions appear to be largely derived from bone recrystallized into gypsum and Sr-rich minerals	Areas of elevated Ca and Ba content in sherd cross-sections suggest post-depositional leaching into fabric
Conclusion	Concretions are likely derived from bone either after burial or as a deliberate added surface treatment	Concretions are derived from cremains through post-depositional processes	Provenience studies should not use mobile elements, bone isotopic analysis may be impacted as well

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