Introduction

Since 2011, the BAKOTA project has excavated Békés 103, a primarily urn cremation Bronze Age cemetery (intensive use period 1660-1280 BC) located along the Kettős-Körös paleomarsh 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; Pajka 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 considerable 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 sherd's. Understanding the chemical composition and origins of these concretions is necessary for future provenance 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?

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 previously been characterized by XRF-MDD and PIXE. 25 of samples from burial contexts were analyzed as were 30 control soil samples Békés from a modern archeological site near Békés.
- XRF-MDD: All samples were run at the Notre Dame Archaeological Research Laboratory using a Bruker Tracer S1 Handheld spectrometer. Ceramic samples were run in standard form and calibrated against 19 soils/rocks standard prepared as pressed pellets. Soil samples were run powdered and calibrated against the same standard of soil. In addition, a Bruker XFlash 5010/03 spectrometer was used to examine the major component's components of surface concretions and find the elevated concentrations of variable elements.
- FTIR: Selective pieces from ceramic samples were analyzed at the Field Museum Elemental Analysis facility using a Brucker IFS 66v single bounce FTIR spectrometer (Bruker Optics, Germany). FTIR spectra were automatically collected against a proprietary reference library of spectra to determine the best wavelength range for consistency conditions.
- SEM: One sample with surface concretions was analyzed by SEM at the Notre Dame Materials Characterization Facility using a FEI Quanta 650 plus instrument with Oxford EXF (ex situ) X-ray detectors. The sample was run in both EDS and EBSD modes. The EDS was used to examine the mineral character of the concretions. The EBSD was used to examine the crystallographic geometry of the concretions. The CT was used to examine the possibility of differences in surface and composition of the material.
- SEM-EDS: Thin samples with visible surface concretions were analyzed at the Notre Dame Integrating Imaging Facility using a NanoSEM 450 with a Bruker Quantax XRD system to produce elemental maps of microstructural composition and the phases of soils, pots, and brick, which is necessary chemical mapping and understanding the structure and composition of the concretion interface (Bekris and Senesi 2017).
- LA-ICP-MS: Three sherd-cross sections with visible white precipitations were chemically treated with LA-ICP-MS at the Provincetown Elemental Analysis Facility (PEAF) using a Thermo Scientific (QX 100) and Micromap (Hel >& 100) laser. A color filter of full spectrum was run from all sides of all the sherds to the other, and unless is between different sides refined by inverse distance weighting (IDW), samples were calibrated against NIST 2710a and IAEA-600a (Holmqvist et al. 2018)

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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.

XRD: Analysis of surface concretions on sample ID012 shows little evidence for hydroxapatite 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 sherd 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 (S5435) than in either the medium or high Ba level sherds (S5439 and S5919). 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

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


