Bone Calcination in Cremation Burials from Bronze Age Hungary

Heleinna Abigael Cruz[1], Jaime Ullinger[1], Julia Giblin[1], László Paja[2]

[1]Quinnipiac University, [2]University of Szeged

Introduction and Background

In the Great Hungarian Plain during the Bronze Age, there was a general shift from egalitarian societies to more complex societies; many have reasoned that the shift was due to the advancement of trading networks (Kristiansen et al. 2015). The Bronze Age Körös Off-Tell Archaeology (BAKOTA) Project focuses on the Békés 103 site, a Bronze Age cemetery in the Körös region of Hungary. Excavations conducted in the cemetery have uncovered 68 burials, of which 58 are cremations interred in ceramic funerary urns. This study will present preliminary analysis of color patterns of the burned human bone found in the cemetery.

Previous studies on bone color show a correlation between the temperature of the pyre and the color of the burned bone (de Becdelievre et al. 2015; Devlin and Herrmann 2015; Ellingham et al. 2014; Lim et al. 2015; Shipman et al. 1984; Subirà et al. 2011; Walker et al. 2008). At lower temperatures, the yellowish white color of bone will turn tan. As the temperature rises, the tan color of bone will turn dark brown, black, and blue-grey (Figure 4). Finally, when a certain high temperature is achieved the bone will calcine and turn white and/or blue-white (Figures 1-3) (de Becdelievre et al. 2015; Ellingham et al. 2014; Lim et al. 2015; Walker et al. 2008). The Munsell score of N9.5/0 White is most closely associated with the total loss of organic matter, or calcination, from bone (Bennett 1999; Ellingham et al. 2014; Munsell Color Company Inc., 1954; Shipman et al. 1984).

Data analysis of the cremated bone was conducted on a sequence of discrete "levels" that were micro-excavated from each human burial in order to look for spatial patterns within each urn. Levels were excavated from top to bottom, at two to four centimeters intervals (Paja et al. 2016). This study also aims to analyze bone calcination and color in order to compare data across different age groups within the cemetery. The results of this research may show a difference in how the young and old were treated in Bronze Age Hungary.

Methodology

In order to accurately and objectively observe human burned bone color of the Bronze Age, Munsell Soil Color Charts were used (Munsell Color Company Inc., 1954). Munsell Soil Color Charts contain tools that aid in identifying a burned bone fragment's hue, value, and chroma. The hue measures the observed color (ie. red, blue, green, yellow or a combination of two), the value measures the lightness of color, and the chroma measures the richness of color (Devlin and Herrmann 2015). One predominant color was chosen and recorded as well as other minor colors found on the bone (Shipman et al. 1984; Bennett 1999). A color score was identified as predominant if the color covered the majority of the bone's outer surface.

Figure 1 – HB28.70
Calcined Occipital Bone

Figure 2 – HB28.134
Calcined Ectocranial Bone

Figure 3 – HB28.134
Calcined Endocranial Bone with Some Surface Non-calcined

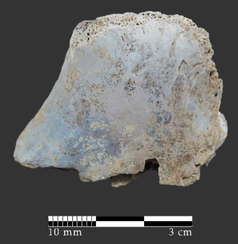

Figure 4 – HB11.1
Non-Calcined Scapula

Method of Observation

Artificial lighting was used with natural lighting coming through the window while observing burned bone color. Cranial vault bones were observed on both the endocranial and ectocranial surfaces because bone burns from the outside to inside, leading to a possible discrepancy between the two surfaces (Figures 2 and 3) (Bontrager and Nawrocki 2015; Ellingham et al. 2014). Some cranial bones had surfaces that were unidentifiable, and were scored once as an indeterminable side.

The bones scored included seven cremation burials from Block 39 and three from Block 29. One cremation burial from Block 32 and one from Block 38 were scored as well.

Method of Analysis

Urn Levels:

The bone color data was evaluated and was scored as a "White" data point if there was any presence of white on the bone regardless if it was predominant or a minor color. Only the ectocranial portion of the bone was analyzed for the cranial bones if both surfaces were scored. Bones were then analyzed by comparing the presence of white within each cremation urn by level. Nine of the 12 human burials (HB) were analyzed (HB11, HB12, HB13, HB21, HB46, HB47, HB48, HB49, HB54) by level. Three of the human burials were excluded from this portion of the analysis because they lacked level data (HB50, HB51, HB53).

Subadults and Adults:

The predominant bone color data was evaluated and scored into one of three categories: White, Grays, or Blacks/Browns/Yellows.

The data was analyzed in order to conclude whether there is a difference in the presence of white between the five adult (HB46, HB47, HB48, HB49, HB54) and five subadult burials (HB11, HB12, HB13, HB21, HB50) . Chi-square analysis was used for comparisons, unless its assumptions were violated, in which case a Fisher's Exact Test was utilized.

Munsell Color Scores of Subadults and Adults

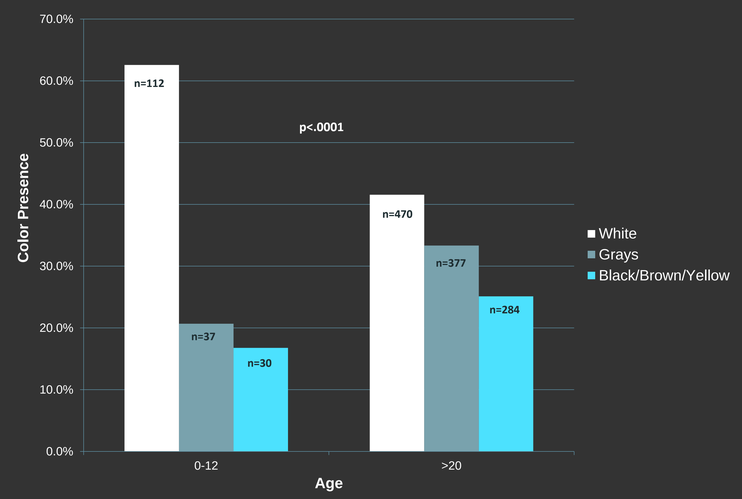

Figure 5. Comparison bar graph of Munsell Color Scores between subadults and adults. Bones were scored in each category based on the predominant color description of the bone surface.

Presence of Calcination by Urn Level

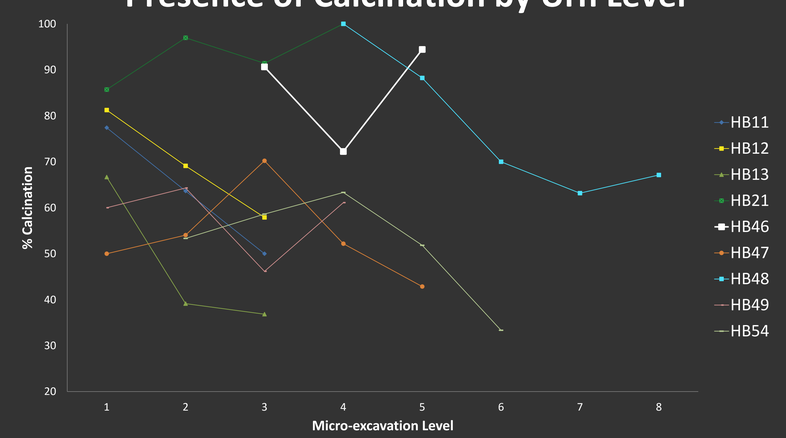

Figure 6. Line graph comparing calcination percentages across levels in single Human Burials. Level 1 = the top of the urn. Burials that start on higher numbers had no bone in the first levels. HB46 (shown as the white line) is the human burial who showed a statistically significant difference in calcination percentages between the levels.

Results

- The null hypothesis stating that there is no difference in the presence of white between subadults and adults is rejected (χ^2=27.7, df=2, p<.0001)

When analyzing bone color by level of excavation, the results were:

- No subadult burials had any statistical significant difference in the presence of white between levels (p>0.05).
- In adults, only one burial (HB46) had a statistical significant difference in the presence of white between its levels (p<0.05).

Discussion and Conclusion

This study focuses on color analysis of 12 human burials found in the Békés 103 Cemetery.

All but one human burial out of nine showed no difference in calcination among levels within cremation urns. This is important to note because it can be inferred that bone was consistently burned throughout the burial, and level (or placement of bones in the urn) does not play a role in color changes. This compares with a study done of Bronze Age cremations from the Iberian Peninsula (Subirà et al. 2011).

One main aspect of color analysis that was studied extensively was the frequency of color in three categories [White, Grays, Blacks/Browns/Yellows] among subadults and adults of the subsample taken from the cemetery. There was a higher percentage of calcinated bone in urns containing subadults than in those that held adults. This may be due to a higher degree of calcification of bone in adults than subadults (Rogers et al. 1952). This finding may contribute to discussions about varying funerary practices by age.

Some ideas for future research that would be of interest:

- Conduct an experimental study to explore the difference in degree of calcination between subadults and adults (using animal models).
- Gather color data of more human burials in the cemetery that can be used with previously collected data and analyze for differences between calcination among sex.
- Explore whether different areas within the cemetery exhibit varying calcination percentages among the burials.
- If so, could this indicate that the Békés 103 cemetery was in fact two separate cemeteries? Or, might it illustrate temporal or status differences within the same burial ground?
- Explore the chronology of the cemetery and compare the human burials and ceramics studied with the approximated time period of the burial.

Acknowledgments

We would like to acknowledge Quinnipiac University, the National Science Foundation (Award Abstract #1460820), and the BAKOTA Project for making this study possible. We would like to thank Dr. Elayne Pope and Dr. Christopher Schmidt for their contribution concerning the comparison of burned states between subadults and adults. We would also like to thank Györgyi Parditka for her contribution in regards to ideas of future research.

References

Bennett JL. 1999 Thermal Alteration of Buried Bone. J Archaeol Sci 26: 1-8.
Bontrager AB, Nawrocki SP. 2015 A Taphonomic Analysis of Human Cremains from the Fox Hollow Farm Serial Homicide Site. In: C Schmidt, S Symes. Analysis of Burned Human Remains, 2nd ed. London: Elsevier. p. 229-245.
de Becdelievre C, Thiol S, Santos F, Rottier S. 2015. From fire-induced alterations on human bones to the original circumstances of the fire: An integrated approach of human cremains drawn from a Neolithic collective burial Journal of Archaeological Science: Reports 4: 210-225.
Devlin JB., Herrmann NP. 2015 Bone Colour. In: C Schmidt, S Symes. Analysis of Burned Human Remains, 2nd ed. London: Elsevier. p. 119-138.
Ellingham, STD, Thompson TJU, Islam M, Taylor G. 2014 Estimating temperature exposure of burnt bone-A methodological review
Kristiansen K, Smejda L, Turek J. 2015 Paradigm found : Archaeological Theory Present, Past and Future : Essays in Honour of Evžen Neustupny. Oxford Philadelphia: Oxbow Books.
Lim DS, Woo EJ, Bae J-H, Kim Y, Lee NL, Hwangbo K, Oh CS, Kim Y-S, Cha SC, Shin DH. 2015. Anthropological Study on the Cremated Bones of the Late Silla Kingdom Period in Korean History. Anthropologist 19(1): 131-138.
Munsell Color Company, Inc. (1954). Munsell Soil Color Charts. Baltimore, Maryland.
Rogers H.J., M. Weidmann and A. Parkinson 1952. The Collagen Content of Bones from Rabbits, Oxen, and Humans. Biochem J 50(4): 537-542.
Shipman P, Foster G, Schoeninger M. 1984 Burnt bones and teeth: an experimental study of color, morphology, crystal structure and shrinkage. Journal of Archaeological Science 11: 307-325.
Subirà ME, Ruiz J, Guardiola-Bufi M 2011. Fire and bones: Bronze Age III in the north-eastern Iberian Peninsula. Coll Antropol 35(2): 565-576.
Paja L, Duffy P, Parditka G, Giblin J 2016. Bioanthropological analysis of Békés 103 (Jégvermi-kert, Lipcsei-tanya), a Bronze Age cemetery from southeastern Hungary. Acta Biologica Szegediensis 60(2): 183-192.
Walker, P.L., Miller KWP, Richman R. 2008 Time, temperature, and oxygen availability: an experimental study on the effects of environmental conditions on the color and organic content of cremated bone.