Species identification of compromised bone: An analytical study

Hannah Cross, Charlene Greenwood
h.l.cross@keele.ac.uk, c.e.greenwood@keele.ac.uk
Department of Forensic Science, Keele University, Newcastle-under-Lyme, Staffordshire, ST5 5BG, United Kingdom

Keele UNIVERSITY

Upon the recovery of burnt remains in a forensic or archaeological context, bone is often fragmented and commingled, making species identification extremely challenging and subjective. This research project will examine the modifications to bone from the macro through to the nanoscale, across a wide range of species. This multi scale investigation has not previously been considered for heated bone. Factors such as temperature exposure, heating & cooling duration, and the presence/absence of soft tissue, will be explored. Each variable will be investigated to measure its effect on the physical and chemical properties of bone, and to determine whether these modifications can be parameterised for species identification.

The primary aim of this research project is to establish whether burnt human bone can be differentiated from other species relevant to a UK environment.

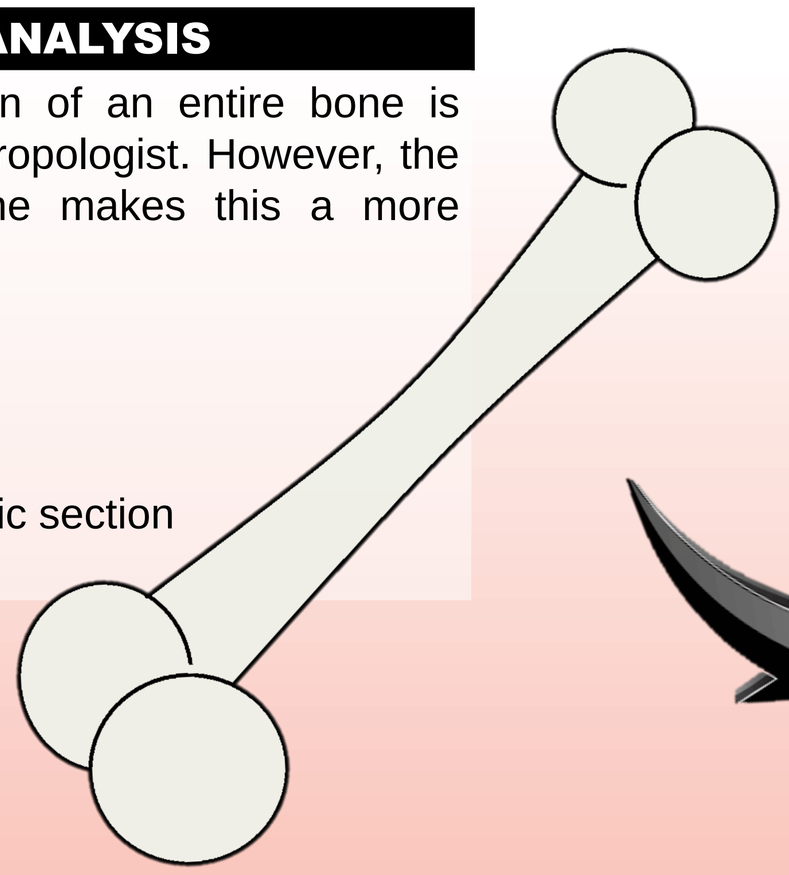
This could aid forensic investigations including mass disasters such as the 911 terrorist attacks, USA, 2001 [1] and the Grenfell Tower disaster, UK, 2017 [2] whereby human bone was burnt, highly fragmented, and commingled amongst debris and bone fragments from additional species. This research could also aid murder investigations such as the April Jones case, UK, 2012 [3] whereby anthropologists disputed whether burnt bone fragments found in the suspect's fireplace were human or animal.

Clockwise from top right: 911 Terrorist attacks [1], Grenfell Tower Disaster [2], April Jones [3].

MACROSCOPIC ANALYSIS

Determining the species of origin of an entire bone is relatively simple to a trained anthropologist. However, the fragmented nature of burnt bone makes this a more challenging and subjective task

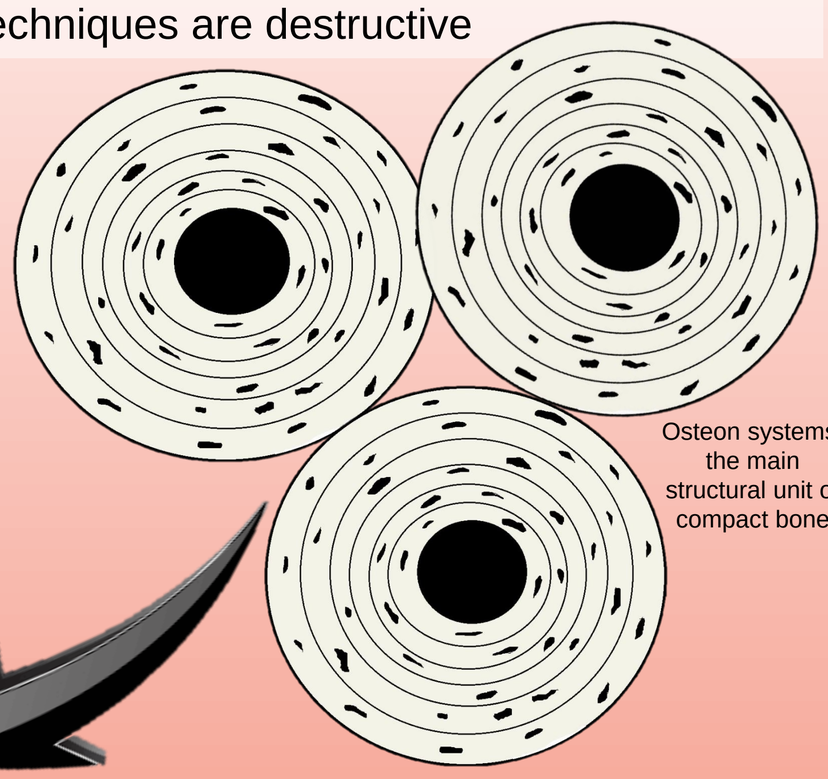
Pro's and Con's
- ✓ Rapid
- ✓ Inexpensive
- ✘ Require whole bone or a specific section



MICROSCOPIC ANALYSIS

The size, shape and frequency of certain microscopic features of bone have been observed to differ between species [4].

Pro's and Con's
- ✓ Inexpensive
- ✘ Can require extensive sample preparation
- ✘ Loss of features occurs at extreme temperatures
- ✘ Some techniques are destructive

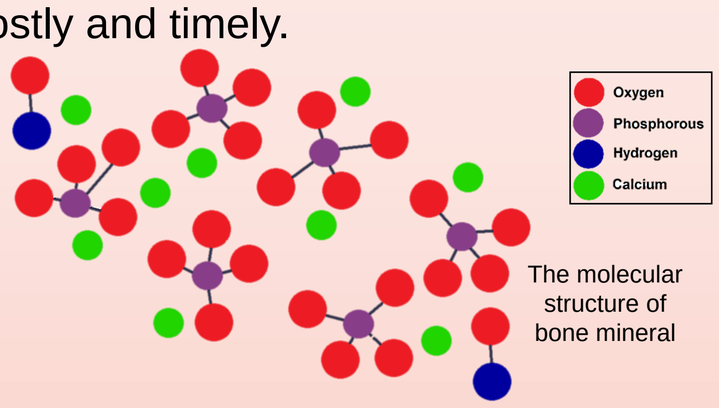


Osteon systems: the main structural unit of compact bone

NANOSCOPIC ANALYSIS

The fundamental physical and chemical properties of bone mineral differ between species, although in its native, unheated state, these differences are difficult to detect. Upon heating, however, the mineral undergoes a number of significant changes and crystallographic differences between species become distinctly apparent [5, 6, 7]. The structure and composition of bone mineral can be measured by X-ray and infrared radiation. Biological techniques, such as DNA analysis, could also be considered at the nanoscale, however these techniques are not successful in heated bone due to due to degradation of the organic components at high temperatures and are costly and timely.

Pro's and Con's
- ✓ Less subjective
- ✓ Non-destructive
- ✓ Limited/no sample preparation
- ✓ Requires a small sample size for analysis
- ✘ Requires appropriate laboratory instrumentation and software for analysis



The molecular structure of bone mineral

To confidently identify burnt bone as human or animal, the nature and extent that heating has on bone's physical and chemical properties must be fully understood. Through investigating the effects of multiple variables, across a number of different species, parameters can be established for an accurate identification.

References:
[1] Bergen PL. "September 11 attacks"; 2019 [Available from: https://www.britannica.com/event/September-11-attacks.
[2] "Grenfell Tower: What happened": BBC; 2019 [Available from: https://www.bbc.co.uk/news/uk-40301289.
[3] Morris S. "April Jones murder: how detectives pieced together her final hours": The Guardian; 2013 [Available from: https://www.theguardian.com/uk/2013/may/30/april-jones-murderfinal-hours.
[4] Cattaneo C, Porta D, Gibelli D, Gamba C. Histological Determination of the Human Origin of Bone Fragments. Journal of Forensic Science. 2009;54(3):531-3.
[5] Beckett S, Rogers KD, Clement JG. "Inter-Species Variation in Bone Mineral Behavior upon Heating". Journal of Forensic Sciences. 2011;56(3):571-9.
[6] Greenwood C, Rogers K, Beckett S, Clement J. "Initial observations of dynamically heated bone". Crystal Research and Technology. 2013;48(12):1073-82.
[7] Londoño-Restrepo SM, Jeronimo-Cruz R, Millán-Malo BM, Rivera-Muñoz EM, RodriguezGarcía ME. "Effect of the Nano Crystal Size on the X-ray Diffraction Patterns of Biogenic Hydroxyapatite from Human, Bovine, and Porcine Bones". Scientific Reports. 2019;9(5915):1-12.