

# Fiery Forensics

## The Impact of Accelerants on Burning Characteristics of Bone

Holly Marsh, Kai Michaluk, Grace Wicken (graciewicken@gmail.com)

University of Victoria, Victoria, British Columbia



### INTRODUCTION

Forensic anthropologists are faced with the task of identifying and classifying skeletal trauma. A variety of events can lead to the burning of human remains, including vehicle accidents, explosions, and earthquakes (Ubelaker 2009), and perpetrators of homicide commonly intentionally attempt to dispose of evidence by burning bodies (Byers 2011). Thus, forensic anthropologists must be able to differentiate between thermal modifications and other types of trauma/pathologies. There are three main process signatures to bone that can be seen when bodies are burned: colour change, fracture patterns, and body positioning (Symes et al. 2015). These process signatures can be used to determine the intensity and duration of the burning event.

In many cases of criminal burning, perpetrators will use accelerants to expedite the burning process (Symes et al. 2015); therefore, it is important for forensic anthropologists to understand how the use of an accelerant will affect the three process signatures to bone. Gasoline is an easily accessible and relatively inexpensive accelerant. Due to the frequent occurrence of burning within a forensic context, we formulated the following research question: will the use of a fire accelerant (gasoline) change the timing and presence of the three process signatures to bone? Preliminary research of relevant literature (Symes et al. 2015) led us to hypothesize that there would be no difference between the process signatures to bone in the non-accelerant and accelerant fires, but that there would be a minor difference in timing.

### MATERIALS & METHODS

Pig specimens (*Sus scrofa domesticus*) were obtained from The Village Butcher in Oak Bay. A right femur with patellar joint and proximal tibia and fibula were used in the non-accelerant fire. A left humerus with a portion of the glenoid fossa attached was used in the accelerant fire. We also obtained a portion of spinal column with the transverse and spinous processes removed, which was halved with an axe. One half was used in each fire. The specimens were not fully fleshed; however, some connective tissues were present.

Two 20x20x3 inch pine boxes were built to contain and separate the two fires. These were placed at opposite sides of the pre-existing burn plot, which was located on a property in Central Saanich. Each burn pile was prepared with equal amounts of kindling, newspaper and cardboard egg cartons. Each fire was marked with coloured tape (green for the non-accelerant fire and red for the accelerant fire) for clarity.

Two video cameras and two DSLR cameras on loan from the University of Victoria Library were each marked with red and green tape for the accelerant and non-accelerant fires, respectively, and used to visually document the experiment.



Figure 1. The burn site.

The burning events took place consecutively on November 6<sup>th</sup>, 2016. We observed each burn for 60 minutes, as active burning ceased within this time frame for both burns. The control burn was lit at several locations on the burn pile using matches.

For the accelerant fire, a team member poured one cup (250ml) of gasoline with gloved hands; immediately after, another team member lit the fire using a newspaper wick to establish distance between themselves and the point of ignition. The amount of gasoline was chosen for safety reasons.

No additional fuel (kindling, paper, accelerant) was added to either fire during the duration of the experiment.

Since each fire took place at a different time, detailed visual observations could be recorded on paper datasheets, including colour change, fractures, and shape and size of specimens. Corresponding fire and specimen temperatures (°C) were taken using a non-contact laser thermometer. Observations were made from the time of ignition until T = 60:00 minutes.

After cooling, specimens were carefully transferred into separate newspaper lined metal pots and transported to the University of Victoria Anthropology lab for further analysis. On November 14<sup>th</sup>, 2016, we conducted a comparative analysis of the modifications made to bone by the two fires.

### TEMPERATURE

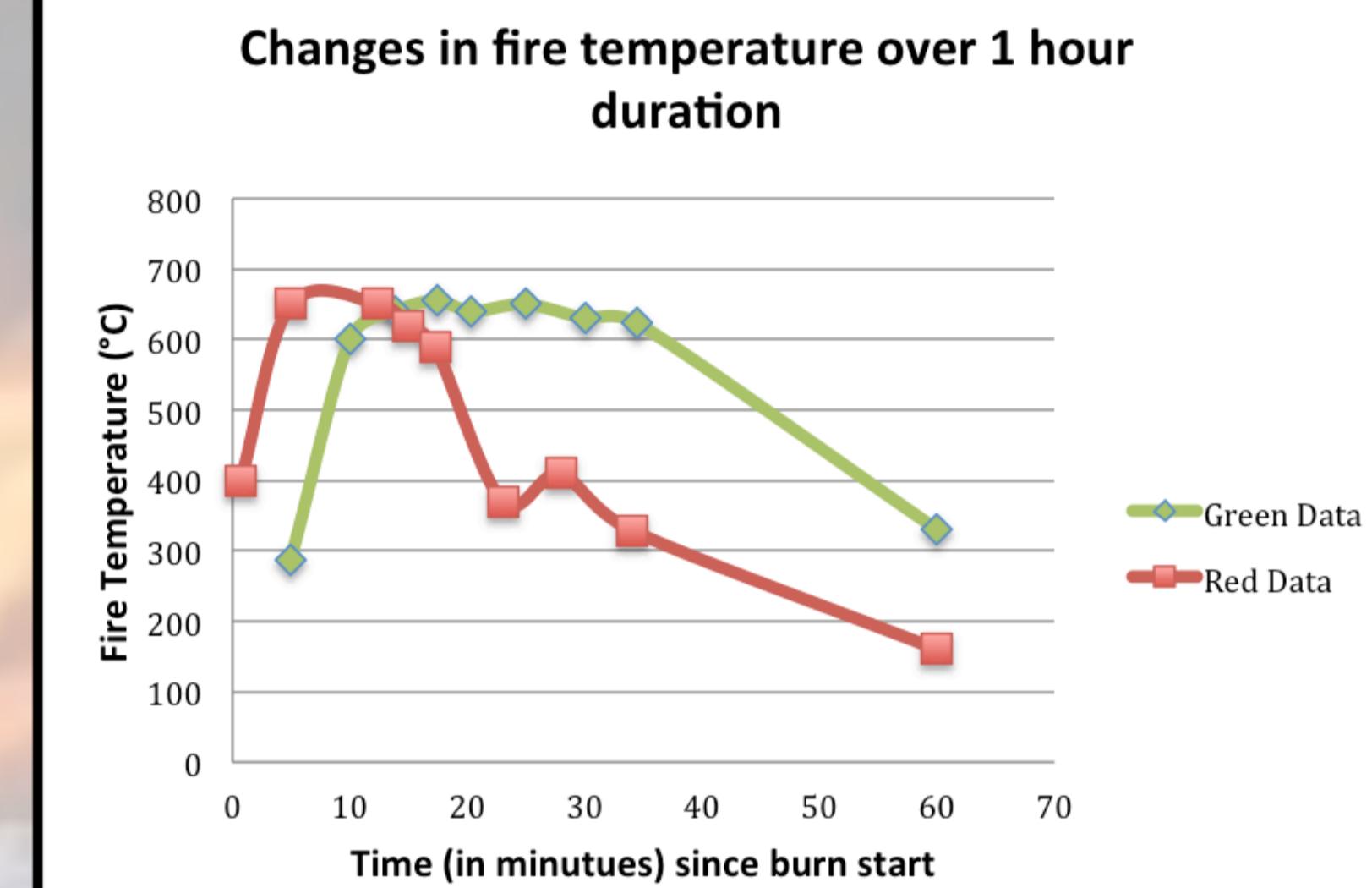


Figure 2. Difference in fire temperatures between the non-accelerant (green data) and accelerant (red data) burns over time.

We observed a difference in fire temperature over time between the two fires. The accelerant fire reached a maximum temperature of 650°C at T = 5:00 while the non-accelerant fire reached the same maximum temperature at T = 17:23. The accelerant fire also decreased from its maximum temperature at around T = 16:25 significantly faster than the non-accelerant fire, which remained at a peak temperature until at least T = 30:00.

### COLOUR CHANGE

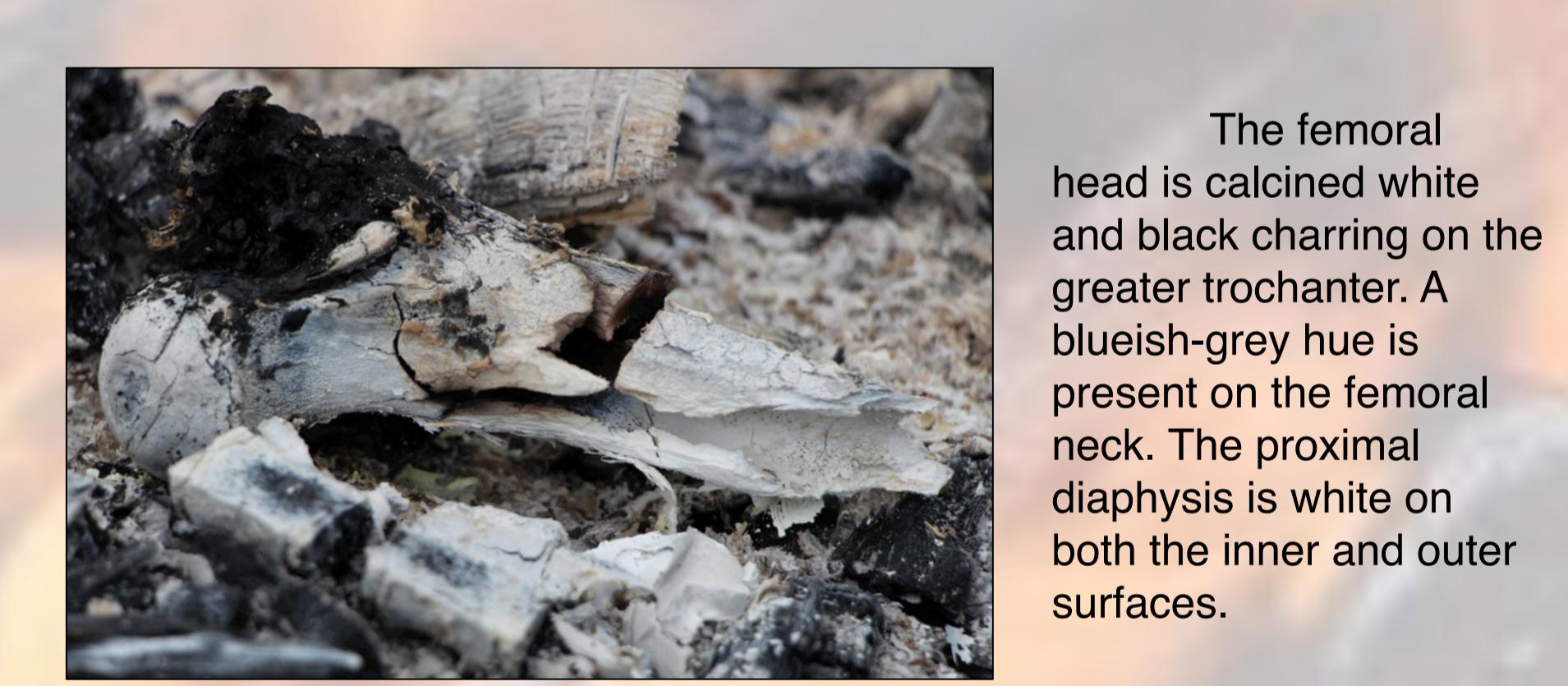


Figure 3. Proximal femur end from non-accelerant fire.



Figure 4. Proximal humeral diaphysis from accelerant fire.

Both sets of specimens exhibit the expected range of colour changes. The vertebral bodies in both fires were all calcined white/grey. The long bones both showed blackness and charring at areas of thicker flesh such as the patellar joint and the areas adjacent to the heads of both long bones. The humerus exhibited charring inside the medullary cavity while the femur was calcined both inside and outside of the diaphysis. This difference was caused by the complete breakage of the femoral diaphysis during the fire, which exposed the medullary cavity to longer and more intense thermal modification. The humerus, which did not fracture completely during the fire, showed less internal calcination. The epiphyses of both long bones were all calcined white/grey.

There were orange/brown patches of unknown origin present superior to the olecranon fossa, medial posterior humeral diaphysis, medial femoral metaphysis and the distal femoral epiphysis.

### FRACTURES



Figure 5. Vertebral body and the trochlea of the humerus from accelerant fire.

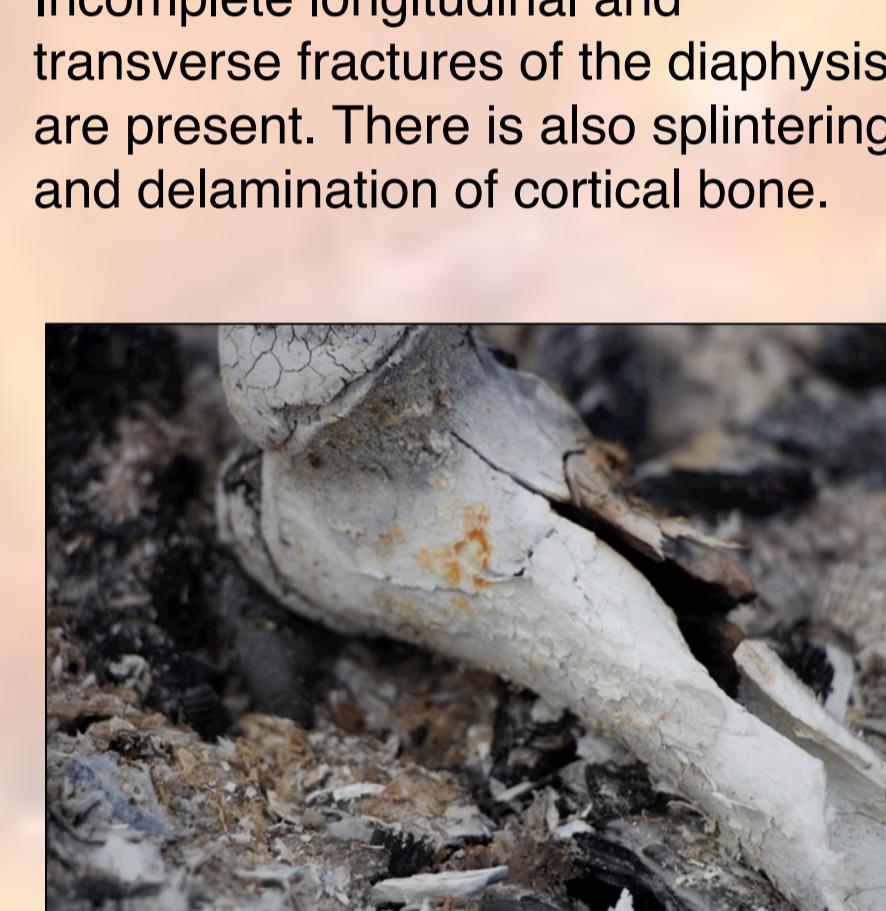


Figure 6. Humerus from accelerant fire.  
A) charring, B) patina fracture of diaphysis, C) longitudinal and transverse fractures.



Figure 7. Proximal femur from non-accelerant fire.

### TABLE OF FRACTURES

Both sets of specimens exhibited similarities in fracture patterning. The vertebral bodies in both fires exhibited the same fractures. The long bones differed slightly in the degree of fracturing present. The femur sustained complete longitudinal and transverse fractures while the humerus sustained incomplete longitudinal and transverse fractures. While the humerus did not sustain epiphyseal separation, the epiphysis of the femoral head detached from the metaphysis. No curved transverse fractures were found on any of the specimens.

| Fracture types                  | Non-accelerant – Vertebral bodies | Non-accelerant – Femur | Accelerant – Vertebral bodies | Accelerant – Humerus |
|---------------------------------|-----------------------------------|------------------------|-------------------------------|----------------------|
| Epiphyseal                      | ✓                                 | ✓                      | ✓                             |                      |
| Transverse (complete) fractures |                                   | ✓                      |                               |                      |
| Transverse (incomplete)         | ✓                                 |                        | ✓                             | ✓                    |
| Longitudinal (complete)         |                                   | ✓                      |                               |                      |
| Longitudinal (incomplete)       | ✓                                 | ✓                      | ✓                             | ✓                    |
| Patina                          |                                   | ✓                      |                               | ✓                    |
| Splintering                     | ✓                                 | ✓                      | ✓                             | ✓                    |
| Delamination                    | ✓                                 | ✓                      | ✓                             | ✓                    |
| Step                            | ✓                                 | ✓                      | ✓                             | ✓                    |
| Curved transverse               |                                   |                        |                               |                      |

Figure 8. Presence/absence chart of fracture types between non-accelerant and accelerant specimens.



Figure 9. Distal femur from non-accelerant fire.  
Delamination and patina fracturing are present.

### CONCLUSION

We confirmed our hypothesis that the use of an accelerant (gasoline) would not significantly impact the three process signatures to burned bone. The presence of the process signatures was consistent between both sets of specimens. Slight colour and fracture differences between the two long bones cannot be attributed to the presence or absence of an accelerant. Since two different long bones were used, the differences in thermal modifications may be due to slight variations in the biomechanical properties of the two bones. The absence of curved transverse fractures, which can indicate directionality of fire, was predicted due to lack of flesh on the specimens. There was no evidence of the third process signature, body positioning, in either burn event. Characteristic body positioning is caused by differential muscle shrinkage (Symes et al. 2015); therefore, absence of muscles on the specimens prevented this process from occurring.

A significant difference that we did observe between the two burns was the timing of the two process signatures. Bone modification processes happened significantly earlier in the accelerant fire than in the non-accelerant fire.

| Process signature     | Non-accelerant – Femur | Accelerant – Humerus |
|-----------------------|------------------------|----------------------|
| Black/charred         | 5:00                   | 2:06                 |
| Grey                  | 17:23                  | 12:42                |
| White (diaphysis)     | 20:23                  | 13:45                |
| Longitudinal fracture | 20:30                  | N/A                  |
| Splintering           | 24:33                  | 16:25                |
| Delamination          | 26:56                  | Unknown              |
| Patina fracture       | 37:12                  | 17:25                |

Figure 10. Time since start of burn (in minutes) of process signatures for non-accelerant and accelerant specimens.

One unexpected result was the orange/brown patches of colour found in several places on the specimens. Possible explanations include differential oxygen availability or temperature fluctuations (Walker et al. 2008; Ubelaker 2009).

From our experiment, we found that it is not possible to determine whether gasoline was used as a fire accelerant by visual observation of recovered remains alone. It is possible to use chemical analysis to detect accelerant use (Vergeer et al. 2014); however, forensic anthropologists do not always have access to this technology. Future avenues of research could include studying the effects of larger amounts and different types of accelerants on burning characteristics of bone.



Figure 11. The observation and recording process.

### REFERENCES

Byers, Steven N. 2011. *Introduction to Forensic Anthropology*. Boston: Prentice Hall.

Symes, Steven A., Christopher W. Rainwater, Erin N. Chapman, Desina R. Gipson, and Andrea L. Piper. 2015. "Patterned Thermal Destruction in a Forensic Setting," in *The Analysis of Burned Human Remains*, edited by Christopher W. Schmidt and Steven A. Symes, 17-58. Second ed. London: Academic Press/Elsevier.

Ubelaker, Douglas H. 2009. "The Forensic Evaluation of Burned Skeletal Remains: A Synthesis." *Forensic Science International* 183(1-3): 1-5.

Vergeer, P., A. Boelck, L.J.C. Peschier, C.E.H. Berger, J.N. Hendrikse. 2014. "Likelihood ratio methods for forensic comparison of evaporated gasoline residues." *Science and Justice* 54: 401-411.

Walker, Phillip L., Kevin W. P. Miller, and Rebecca Richman. 2008. "Time, Temperature, and Oxygen Availability: An Experimental Study of the Effects of Environmental Conditions on the Color and Organic Content of Cremated Bones" in *The Analysis of Burned Human Remains*, edited by Christopher W. Schmidt and Steven A. Symes, 129-135. Second ed. London: Academic Press/Elsevier.

We would like to thank Meaghan Efford, Becky Wigen, Doug Marsh, and Dr. Stephanie Calce for their guidance and assistance in making this experiment possible.