Effects of multiple heating on the crystallographic changes to bone mineral

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Upon the recovery of remains in a forensic or archaeological setting, bone is often compromised through burning, fragmentation, or diagenesis. In such scenarios, identifying the species of origin is often extremely challenging and subjective. Applying a standardised heat treatment has been suggested as a diagnostic tool for species identification. However, the effects of multiple heating must be fully understood before this technique can incorporate previously burnt samples.

Femoral cortical bone was taken from bovine, ovine, and porcine specimens which were subjected to two successive heat treatments at either 300°C, 600°C or 900°C. The specimens were analysed after each heat treatment to measure species differentiating characteristics of the bone mineral, hydroxyapatite. X-ray diffraction and Fourier transform infrared spectroscopy were employed to measure "crystallinity", carbonate impurities within the crystal lattice, and to identify the presence of additional mineral phases formed due to the thermal degradation of hydroxyapatite.

As the temperature increased, the hydroxyapatite crystals became larger and more ordered, reducing crystallite strain through the expulsion of carbonate substitutions. The data indicates that secondary heating causes an additive effect, with specimens heated to 300°C and 600°C generating similar values to what was observed after first heating to 600°C and 900°C, respectively. This trend is reversed however for 900°C whereby following a second heating there is a decrease in "crystallinity" and an increase in the relative amount of carbonate to phosphate substitutions, possibly due to the onset of crystal melting.

Additional mineral phases in the form of β-whitlockite and periclase were observed in all porcine and most bovine specimens heated to 900°C for both first and second heating. Small levels of lime were also detected for bovine and ovine specimens, although less frequently after the second heat treatment. This may simply be due to its low weight percentage and high symmetry which helps to evade identification on a diffractogram.

The results suggest multiple heating does not provide reflection of maximum heating temperature, nor do the changes overall increase with temperature exposure. Therefore, a stronger understanding of the effects upon secondary heating of bone mineral is required before this technique can be implemented in routine investigations.

Keywords: Bone; Hydroxyapatite; Forensics; Archaeology