A94 Bone Diagenesis in the Marine Environment: Trace Element Distribution in Mammalian Bones Recovered From Shipwrecks

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Learning Overview: The goal of this presentation is to describe the principles of bone diagenesis and their potential application to forensic science, the distinction between biogenic and diagenetic chemical signals in bones, the correlation between macroscopic and chemical characteristics of bone diagenesis, and an example of trace element analysis in a set of archaeological bones submerged for a known length of time in a marine environment.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by describing how the establishment of a correlation between macroscopic alterations and trace element concentrations and distributions in bones recovered from a marine environment will prove essential for members of the forensic science community involved in taphonomic assessments.

Bone diagenesis is the global effect of the physical, biological, and chemical transformations that bones undergo between death and discovery in the archaeological or geological record. Diagenetic transformations, macroscopic and microscopic, are influenced by the physics, chemistry, and biology of the depositional environment. In living organisms, chemical processes are affected by diet, mobility, and pathologies. While studies of the diagenetic modifications and chemical composition of buried bones are extensively featured in the scientific literature, geochemical signatures characteristic of underwater bone diagenesis have not been studied in detail. This study investigated whether a geochemical fingerprint of the interaction between 11 archaeological mammalian bones and seawater and/or marine sediment could be discerned.

The analyzed mammalian bones belong to a museum collection of underwater archaeological materials excavated from four submerged shipwreck sites off the Western Australia coast: Batavia (1629), Vergulde Draeck (1656), Zeewijk (1727) and Rapid (1811). The underwater excavations were conducted between 1968 and 1980, and bones from the four wrecks had been submerged in seawater and/or sediment for 347, 316, 241, and 169 years, respectively. With one exception, all of archaeological bones were fragmented, some were also heavily stained, and in two samples, the damage to the protective cortical layer was particularly extensive. Bone trace element chemistry was compared to that of a modern sheep bone *(Ovis aries)*. Laser ablation-inductively coupled plasma/mass spectrometry was undertaken across bones mounted in epoxy rounds. Cross-sectional spot transverses followed a path from the cortical layer (exterior) through the trabecular bone in the interior.

In the modern sheep bone, several trace elements showed bulk concentrations close to, or at, the limit of detection (Chromium [Cr], Cobalt [Co], Nickel [Ni], Copper [Cu], Yttrium[Y], Rare-Earth Element [REE], Thorium [Th], and Uranium [U]). In contrast, in the submerged bones, Lithium (Li), Cr, Cu, and U were elevated relative to the modern sheep bone, whereas Rubidium (Rb) and Barium (Ba) were depleted. Normalized trace element patterns in modern bone were flat, whereas in the archaeological samples, the normalized trace element pattern in the only whole sample (from Batavia) was different from that of the damaged bones from the other wrecks. Most elements with altered bulk concentrations in the archaeological bones are non-essential to biological life (Cu being the exception), supported by their low concentration in the modern sheep bone. However, Ba is usually enriched in bone by reason of known para-physiological metabolic processes. Since Li, Cr, Cu, U, Rb, and Ba are present in seawater in very low concentrations (<1ppm), it is reasonable to assume that in the archaeological bones, the relevant increase in bulk concentrations of Li, Cr, Cu, and U is entirely diagenetic in origin, perhaps due to protracted chemical exchange with sediment. The depletion of bulk concentrations of Rb and Ba is also diagenetic in origin and can be explained by protracted exposure to seawater and sediment. Furthermore, since the structure of cortical bone is denser than that of trabecular bone, cortical bone is less susceptible to alteration. This is reflected in the flat normalized element distribution profiles in bones where the cortical layer is missing or heavily damaged. As a consequence, the bulk chemical composition resulting from diagenetic chemical exchange in bone appears to be more uniformly distributed if the cortical layer is heavily damaged or missing, as reflected by the flat normalized elemental distribution profiles. In the only undamaged sample, the profiles of Li, Ba, Magnesium (Mg), Strontium (Sr), and Rb showed a gradual decrease in concentration from the outer surface toward the interior of the cortical bone. The overall conclusion is that macroscopic diagenetic alterations influence elemental concentrations and patterns of elemental distribution in bones, and their analysis allows the reconstruction of different taphonomic pathways.

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