H43 Elemental Characterization of Skeletal Remains Using Laser-Induced Breakdown Spectroscopy (LIBS)

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The goal of this presentation is to discuss unique elemental profiles differentiating human and animal bone which could accelerate skeletal element identification in the field through the use of laser-induced breakdown spectroscopy (LIBS).

This presentation will impact the forensic community and/or humanity by allowing the forensic community to become aware of an extremely useful forensic tool with many applications and advantages, which could be used in the field for evidence analysis with real time results. It is expected that this presentation will make the forensic community, criminal investigators, and the legal community aware of the potential value of LIBS and hopefully, they will adopt this technology for future use in their organizations.

The first question asked of the forensic anthropologist and/or medical examiner when presented with skeletal remains is, "Are they human?" Identification as human initiates legal investigation whilst animal does not. An individual experienced in mammalian osteology can readily make the distinction when presented with as little as a single fragmentary bone. More difficult is the separation of remains by less experienced osteologists or in cases of unidentifiable, or extremely fragmented, remains. Traditional methods of differentiating human from animal bone rely on macroscopic and microscopic evaluation; however, the margin of error associated with these methods is dependent upon experience and some fragments are indistinguishable to even skilled osteologists. Additionally, microscopic evaluation is time consuming and destructive to the specimen. Given the legal ramifications involved in accurate identification of skeletal remains, a more reliable means by which to distinguish human from animal bone is desirable. This research utilized Laser-induced breakdown spectroscopy (LIBS) for nondestructive characterization and separation of elemental bone composition profiles from several commonly recovered mammalian species.

LIBS is an established, versatile method of determining elemental compositions. Laser pulses are delivered to the sample from a laser spark, or plasma, for vaporization and atomization of the target material. Spectroscopic detection of the light released from the plasma contains the emission spectra which permits identification of the elements through their unique spectral signatures. Advantages of LIBS compared to conventional methods of elemental analysis include:

- Rapid (seconds) sampling
- Minimally destructive (1.0 - 0.1 mm diameter)
- Simultaneous multi-element detection
- Low detection limits
- Little or no sample preparation
- Ability to remove surface contaminants and provide depth-profile Eight adult human femora (two of each: male, female, African

American, European American) and a tibia or femur from 14 skeletally mature animals - pig, gray fox, raccoon, dogs, bear, pig, rabbit, cows, deer, and sheep - were selected from the William M. Bass Forensic Skeletal Collection for LIBS analysis. Mammals selected represent a continuum of dietary trophic levels and commonly recovered species in forensic cases involving skeletal remains. The outer cortical shaft of bone was targeted by the Nd-YAG laser and multiple shots were delivered over a representative area to ensure adequate sampling. Adult cortical bone contains less intraindividual variation than cancellous and is more stable having a slower turnover rate (3-5% turnover rate per year) ensuring greater representation of an individual's lifetime. Preliminary comparison of spectral data showed sufficiently significant elemental differences among humans and between humans and animal bone. It was specifically noted that there was a significant amount of titanium present in white male and female bones but not in black female bones. The amount of barium was also quite substantial in the white female, present in small amounts in the black female but noticeably absent in the white male bones. These differences could be attributed to the uptake capacities of the different elements based on their respective bone densities and porosities. This would lead to the identification of the bones based on gender, sex, and race in the case of human bones.

Identification of compositional differences between human and animal remains may provide an elemental fingerprint by which to distinguish human from animal bone for more efficient and rapid identification of fragmentary remains. As a minimally destructive method of elemental analysis, LIBS provides many benefits for use in a variety of trace evidence analyses.

Bone, LIBS, Elemental Analysis

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