A111 The Potential Effects of Differential Transfer and Persistence on Forensic Soil Comparison

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After attending this presentation, attendees will understand how physical properties of mineral grains such as size, density, and shape could potentially affect their differential transfer to and persistence on evidence. The implications of this with respect to appropriate selection of soil comparison methodology will be discussed.

This presentation will impact the forensic science community by introducing a phenomenon that is well established in the geological literature and has the potential to significantly impact forensic soil comparisons, but has yet to be addressed in the forensic science literature or by many published forensic soil comparison methods.

A tremendous variety of methods have been advocated for forensic soil comparison in the forensic science literature. These include comparison of soil color, particle size distribution, bulk chemical composition, pH of water extracts, isotopic composition, pollen content, enzymatic activity, mineralogy determined by polarized light microscopy, SEM/EDS, or x-ray diffraction, FTIR spectroscopy, UV-Vis spectrophotometry, microbial DNA profiling, analysis of organic components by GC/MS, and many more. While a handful of these methods involve analysis of soil particles of one type or another by microscopic methods, the majority of the published methods involve analysis of bulk soil properties.

Despite the common use of bulk methods for forensic soil comparison, there are some reasons why these methods may not be appropriate in some forensic scenarios (particularly those involving very small sample sizes). Sedimentary geologists have put a significant amount of effort into understanding the behavior of different mineral grains in sediments that are transported and deposited by wind and water. They have developed mathematical models that describe the behavior of mineral grains having different size, density and shape being transported and deposited by a variety of fluids. A garnet sand grain with a density of 4.0 g/cm^3 would settle in water at the same rate as a quartz sand grain (density of 2.65 g/cm^3) roughly one and a half times larger. This phenomenon produces many sediment samples containing coarse grains of light minerals along with fine grains of heavy minerals. Shape is important primarily for platy minerals like muscovite and biotite, which sort with coarser fractions of other minerals of similar size and density. Given that mineral grains with different size, density, and shape behave differently during transport and deposition in fluids, they may well behave differently during transfer from a source to an evidence item and may have different persistence on evidence after transfer. It is expected that coarser grains, denser grains, and more equant grains are less likely to be transferred to evidence, and less likely to persist on evidence, than their finer, less dense, and platy counterparts. If this is in fact the case, it has the potential to change the modal mineralogy and particle size distribution of soil evidence relative to its source, particularly in cases where the amount of soil transferred is quite small. While it is common practice for forensic soil comparison to be performed on a limited size fraction of soil, fractionation due to differences in density and shape are unaccounted for in most published methods and have the potential to produce false negatives during comparison of bulk properties.

Methods based on microscopic analysis of the soil particles themselves (e.g., minerals, pollen) enable analysts to directly observe the particles and determine whether the questioned and known samples have particle assemblages consistent with each other. Both the identities of the particles (mineral types, pollen taxa) and their character (mineral varieties, state of preservation of pollen) can be observed and compared along with their relative abundance. These methods have the potential to be more robust to the differential transfer and persistence of minerals, especially if research is conducted that provides insights into expected trends, such as an increase in platy minerals and decrease in dense minerals in a given size fraction on evidence relative to source soil. Methods based on microscopic analysis of soil particles described in the literature include optical mineralogy, automated SEM/EDS analysis (QEMSCAN®), SEM analysis of quartz surface texture, palynology, mycology and cathodoluminescence of minerals.

With the exception of an article discussing changes of particle size distribution before and after transfer to the sole of a shoe, virtually no research has been conducted in the area of how transfer and persistence issues might affect forensic soil comparison. Additional research should be conducted to determine the effects of differential transfer and persistence of different mineral types in forensic scenarios. The results of such research would likely provide insights into the appropriate selection of methodology for conducting forensic soil comparisons.

Soil, Minerals, Transfer and Persistence

 ** Presenting Author*