B146 Differentiation of Sand Grains From Different Locations Using Image Analysis and Multivariate Statistics

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After attending this presentation, attendees will understand how to use photomicrography and image analysis coupled with multivariate statistics to compare and differentiate particulate samples from different locales.

This presentation will impact the forensic science community by showing how photomicrography and image analysis along with multivariate statistics can differentiate assemblages of particulate evidence from different sources.

Particulates appear as trace evidence in the investigations of a variety of crimes such as kidnapping, sexual assault, and homicide. Two questions are commonly asked of this type of evidence: (1) where could it have come from; and, (2) could it have come from a specific source? In the case of sand, investigators may want to know the type of environment (desert dune, river, or ocean) from which the sand came. If a crime scene or alibi location has been identified, investigators will inquire whether sand recovered from the clothing of a suspect or the suspect's vehicle could have come from that location. Laboratory examinations of sand samples commonly employ color determinations, X-ray diffraction, and polarized light microscopy to determine mineral content. Sizes, shapes, and textures of sand particles determined by light microscopy and scanning electron microscopy have been found to provide laboratory examiners with useful information about the environment from which the sand grains came.

The goal of this research was to determine if image analysis applied to photomicrographs of assemblages of sand grains could provide numerical estimates of the similarity or dissimilarity of pairs of sand specimens. Sand specimens were obtained from a variety of locations including deserts, rivers, lakes, and ocean beaches. Grab samples of sand grains were permanently mounted on microscope slides and photomicrographs of grains were captured with a 14-megapixel digital eyepiece camera. An open source image analysis program was used to process the images of the sand grains to obtain outlines of individual grains.

After much trial and error, it was determined that the best results were obtained using a mounting medium with a 1.54 refractive index and crossed polarizing filters. Because the sand samples were comprised primarily of quartz, the majority of the sand grains appeared bright against a black background. A montage of images was assembled for each sand sample and processed to obtain the values of a number of attributes of the sand grains, including area, perimeter, Feret diameters, circularity, aspect ratio, roundness, and solidity. Because many of these attributes are inter-correlated, Principal Component Analysis (PCA) was applied to the values of the grain attributes for pairs of sand samples. Factor plots for the first two extracted factors provided visual assessments of the similarity or dissimilarity the two sand samples. The extracted factors from the PCA were used to generate linear discriminant functions for assigning individual sand grains to their correct sample.

Preliminary results suggest that this approach can distinguish sand specimens from different locales. In particular, the desert sand specimen analyzed was very different from the two specimens from rivers, which in turn were different from a sand specimen from an ocean beach. Non-parametric tests (Kolmogorov-Smirnov, Mann-Whitney, and Kruskel-Wallace) were applied to the distributions of the discriminant values for the sand grains in each sample. For all pair-wise comparisons, the null hypothesis that the sand samples were drawn from the same population could be rejected at a confidence level greater than 95%.

These preliminary results demonstrate the potential of a simple, non-destructive method of analysis for the differentiation of particulate forensic evidence from different sources. The size and shape data derived from photomicrography can be combined for PCA with other numerical data, such as visible reflectance spectra and X-ray diffraction patterns for even greater differentiation of samples.

Polarized Light Microscopy, Image Analysis, Principal Component Analysis

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