A Blind Comparison of Multiple Analytical Methods for Soil Comparison in a Home Invasion Robbery Double Shooting Case in Urban Phoenix, AZ

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Case information

- Home invasion, robbery and shooting of two victims in metro Phoenix
- Shoe impressions in dirt outside of victim’s window
- Suspect identified
- When questioned, suspect was wearing boots with soil adhering to soles
- Suspect stated he was gardening in his yard
Samples collected by police detectives:

- Suspect’s clothing
- Victim’s house (multiple samples)
- Suspect’s house (multiple samples)
- Other neighborhood yards (multiple samples)

**Question:**

Was suspect’s clothing sample consistent with other samples?

How unique was the sample?
Analyses

- Visual analysis and photomicrographs
  - Munsell soil color
  - grain size, shape and sorting
  - mineral identification, exotic particles
- X-Ray Diffraction on <150 $\mu$m
  - Mineral content, including clays
  - Mineral ratios
- Elemental composition (ICP-MS) 39 elements
- G-IRMS
  - C, N content, $\delta^{13}$C
- MC-ICPMS
  - Sr and Pb radiogenic isotopes
Sampling Considerations

- Chain of custody
- Sample bias due to collection time
  - Sample bias due to transfer
    - Sample heterogeneity
      - Particle size
      - Sample size
  - Preservation of sample
ICPMS

Soil 1
Soil 2
Soil 3
Soil 4
Soil 5
Soil 6
Soil 7
Soil 8
Soil 9
Soil 10
Soil 11
Soil 12
Soil 13
Soil 14
Soil 15

enrichment factor compared to average of soils
Radiogenic isotopes: $^{87}\text{Sr}/^{86}\text{Sr}$

![Graph showing Sr isotopes from different locations.]

- Suspect's boots
- Suspect's pants
- Victim's house
- Suspect's house
- Other neighborhood yards

Fix colors.
Radiogenic isotopes: \(^{208}\text{Pb}/^{206}\text{Pb}\) and \(^{206}\text{Pb}/^{207}\text{Pb}\)
Radiogenic isotopes: $^{208}\text{Pb}/^{206}\text{Pb}$ and $^{206}\text{Pb}/^{207}\text{Pb}$
Cluster analysis, ICPMS data

Tree Diagram for 15 Cases
Complete Linkage
Euclidean distances

Suspect’s clothing
Suspect’s house
Victim’s house
Cluster analysis, XRD, isotopes

Tree Diagram for 15 Cases
Complete Linkage
Euclidean distances

C_15, C_13, C_10, C_8, C_4, C_14, C_12, C_11, C_9, C_6, C_5, C_7, C_3, C_1

Linkage Distance

Suspect’s clothing
Suspect’s house
Victim’s house
Munsell color, size & sorting

Root 1 vs. Root 2

-3 -2 -1 0 1 2 3 4

Root 2

-2 -1 0 1 2 3 4 5

Other neighborhood

Suspect boots

Suspect house

Victim’s house

G_1:1
G_2:2
G_3:3
G_4:4

-6 -4 -2 0 2 4 6 8 10

Root 1

Other neighborhood

Suspect house

Victim’s house

G_1:1
G_2:2
G_3:3
G_4:4
Linear discriminate analysis: X-Ray diffraction
Linear Discriminate analysis: Isotopes and X-Ray diffraction

![Graph](image-url)
Linear Discriminate analysis:
ICPMS data

Graph showing the distribution of data points for different categories such as Victim's house, Suspect boots, Suspect house, Other yards, and Other neighborhood.
Conclusions

• Samples from suspect’s boots and pants are not consistent with samples from the victim’s house
• Samples from suspect’s boots and pants are similar to samples from the suspect’s house
• In LDA, color, size and sorting did as well as more expensive analytical techniques