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

By Gwyneth Gordon, PhD, [1] Laura Wasylenki, PhD,[1,2] Carina Arrua, MS,[3] Det. Dave Hurt[4] and Ariel Anbar, PhD[1]

[1]School of Earth & Space Exploration, Arizona State University, Tempe, AZ
[2]now at Department of Geology, Indiana University, Bloomington, IN
[3]Department of Chemistry, University of Cordóba, Cordóba, Argentina
[4]Phoenix Police Department, Phoenix, AZ

ASU School of Earth & Space Exploration
Arizona State University

Indiana University Bloomington

UNC Universidad Nacional de Córdoba

Police Phoenix Arizona

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 any other sample?

15 samples provided to analyst, without knowledge of sample identity

How unique was the sample?

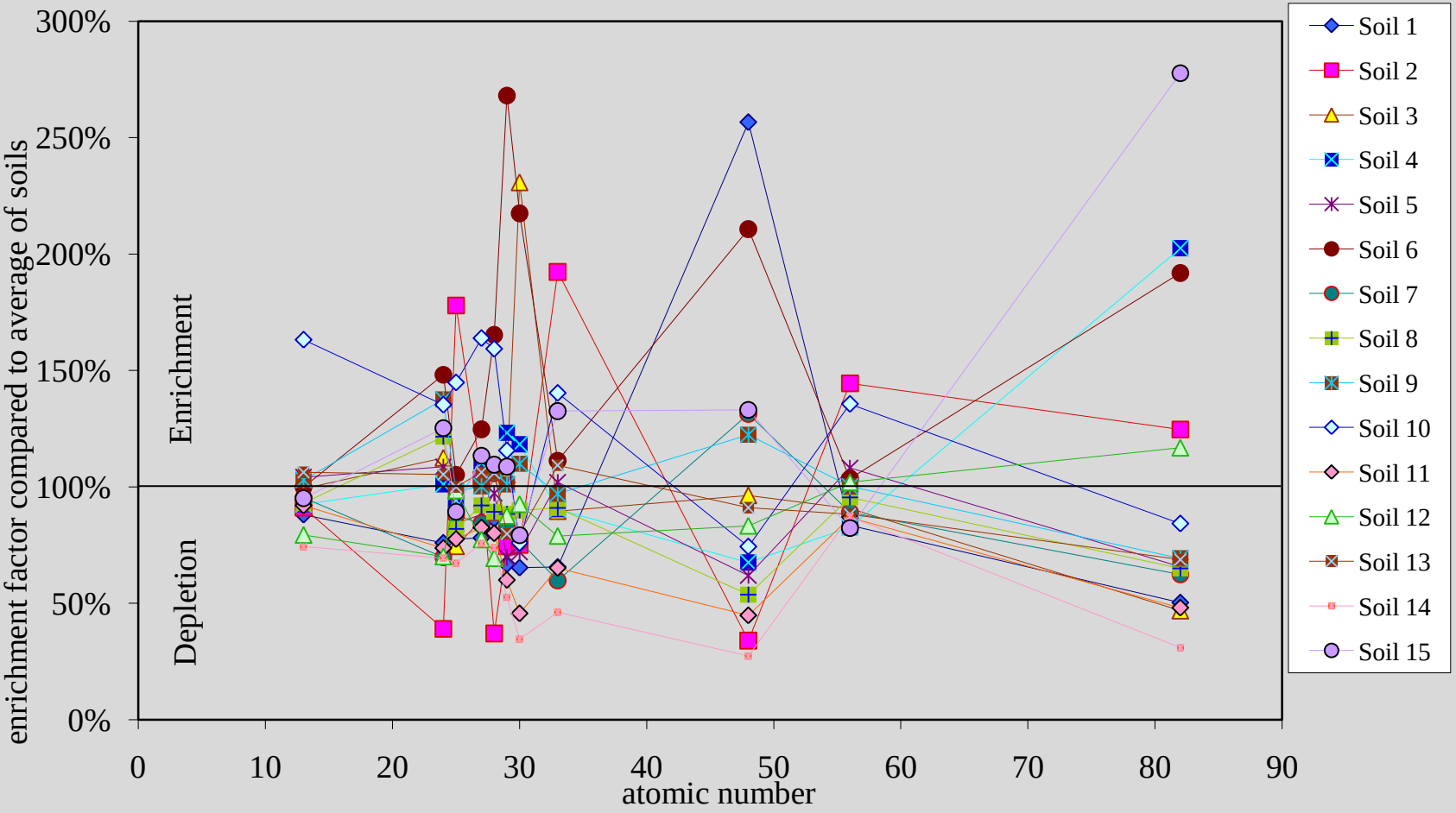
Analyses

- Visual analysis and photomicrographs
  - Munsell soil color
  - grain size, shape and sorting
  - mineral identification, exotic particles
- X-Ray Diffraction *on <150 μm*
  - 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

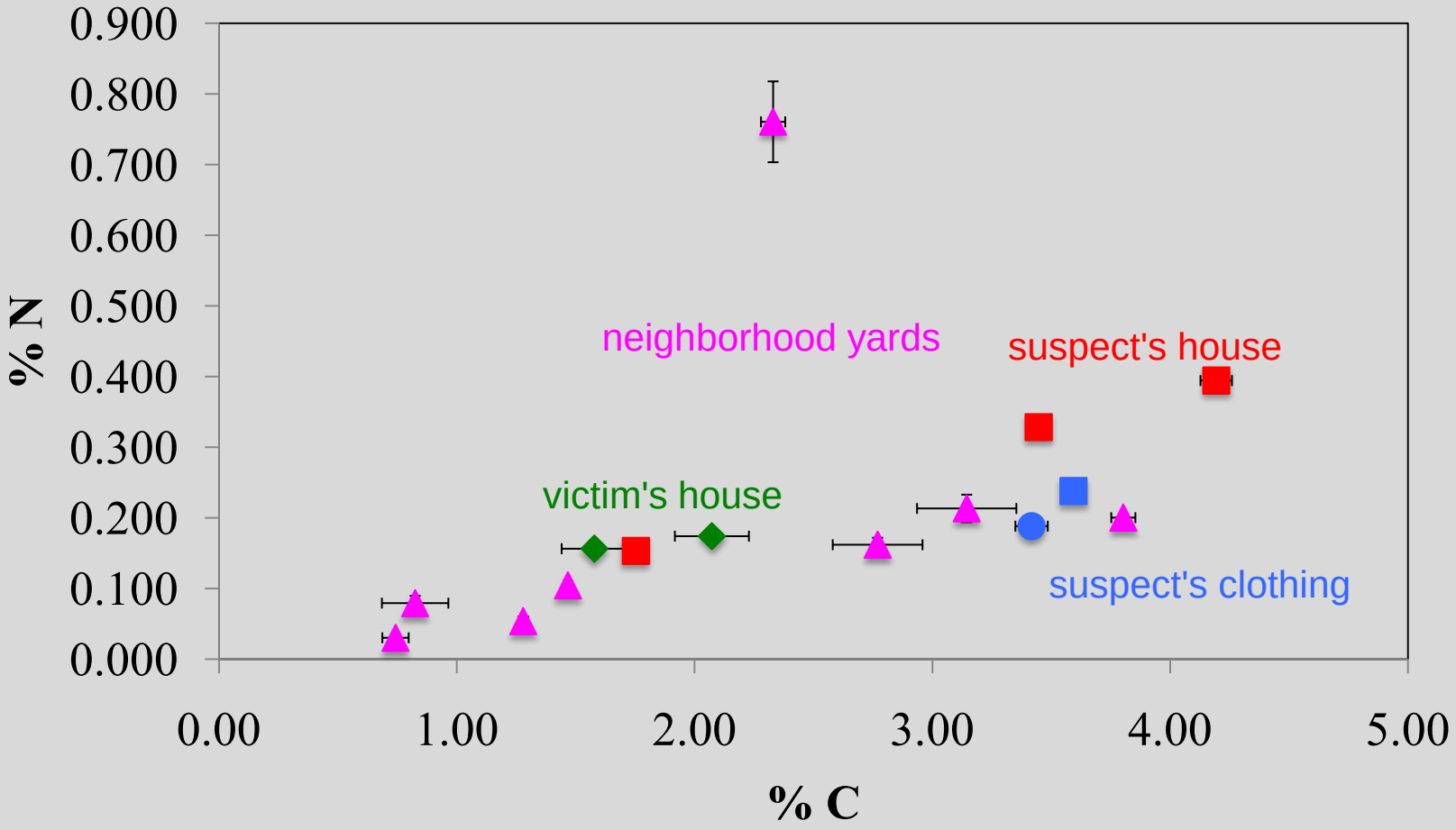
Sampling Considerations

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

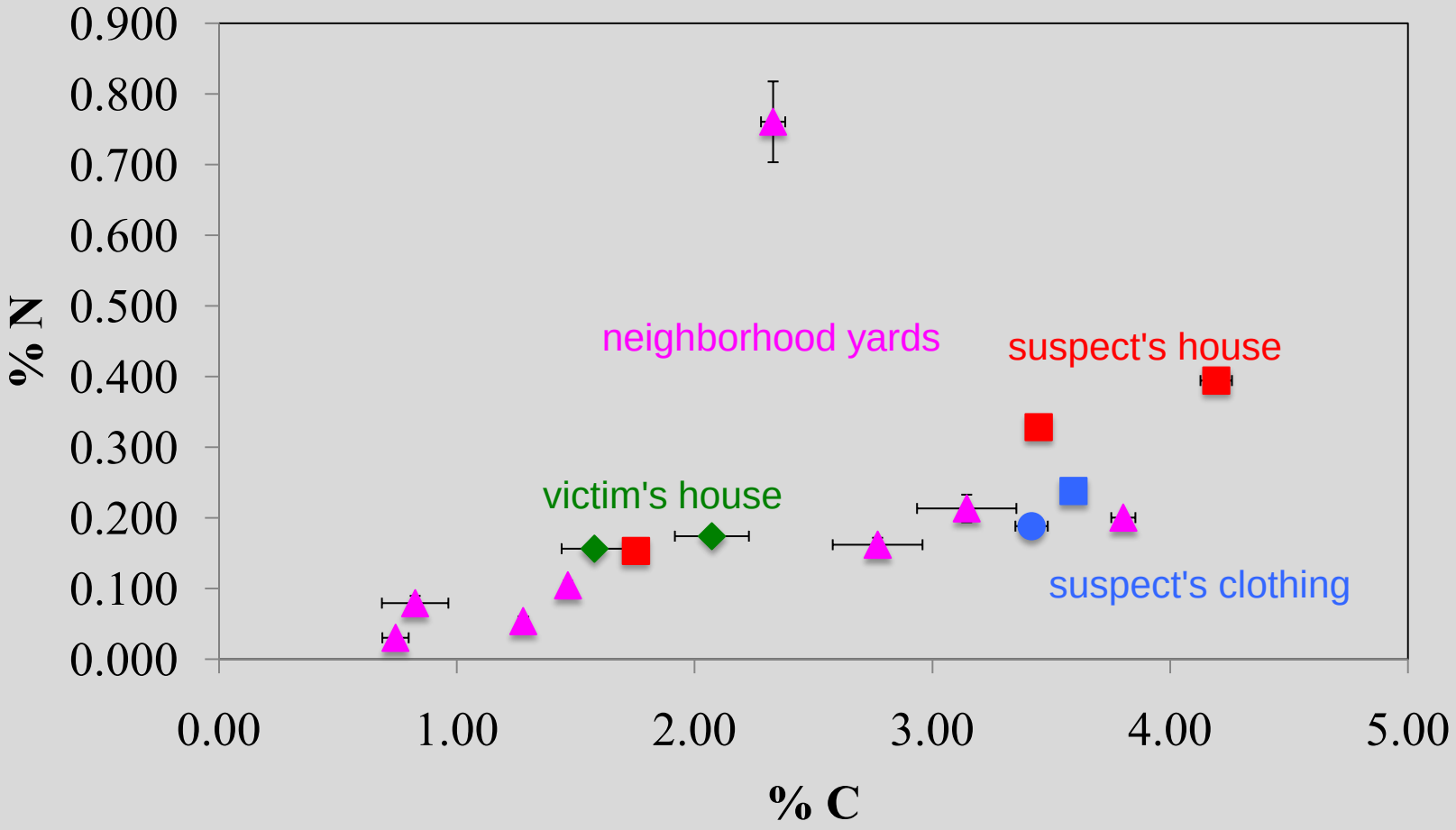
ICPMS


300%
250%
200%
150%
100%
50%
0%
enrichment factor compared to average of soils
Enrichment
Depletion
0
10
20
30
40
50
60
70
80
90
atomic number
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

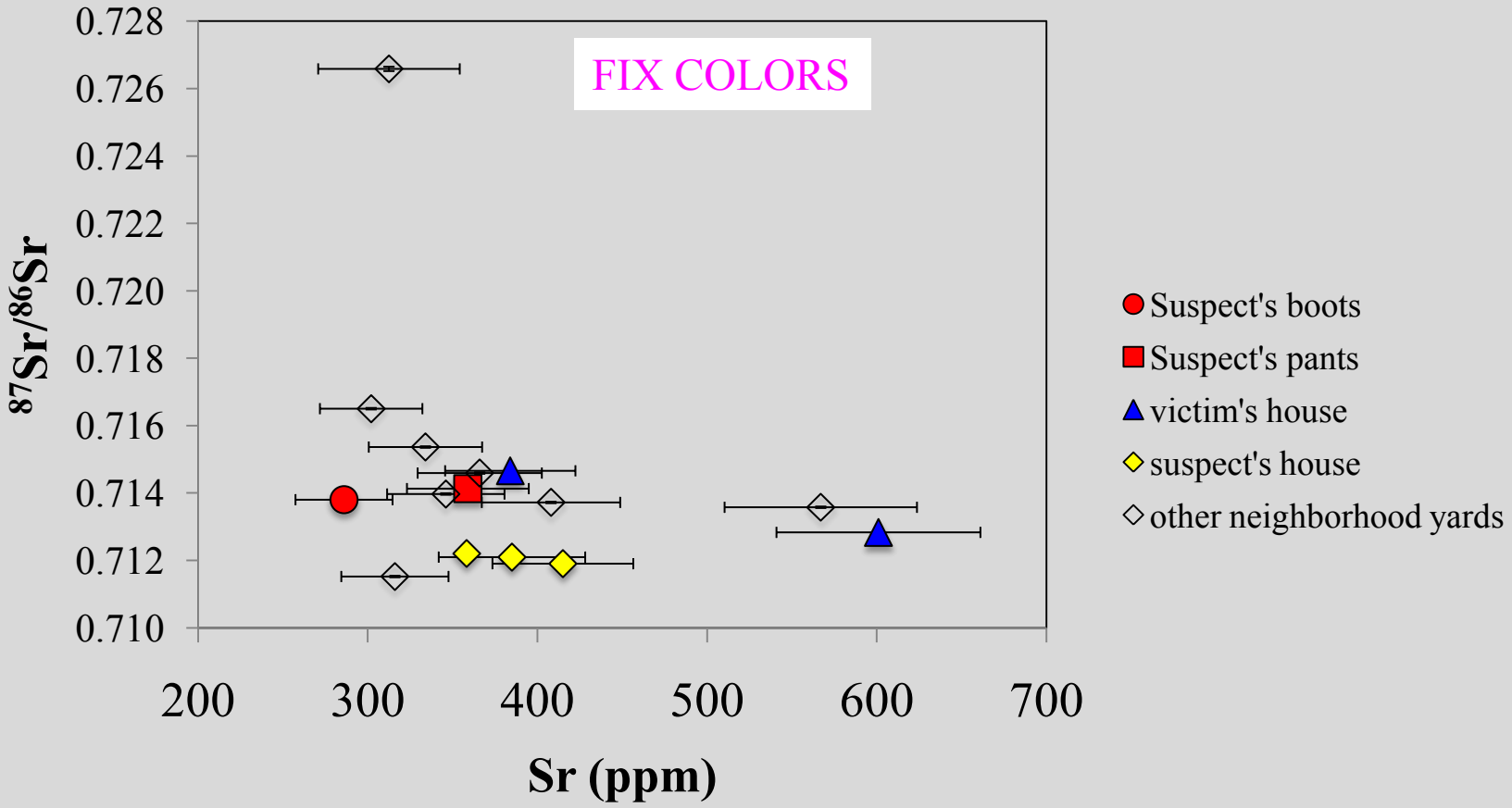
G-IRMS


0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
% N
neighborhood yards
suspect's house
victim's house
suspect's clothing
0.00
1.00
2.00
3.00
4.00
5.00
% C

G-IRMS

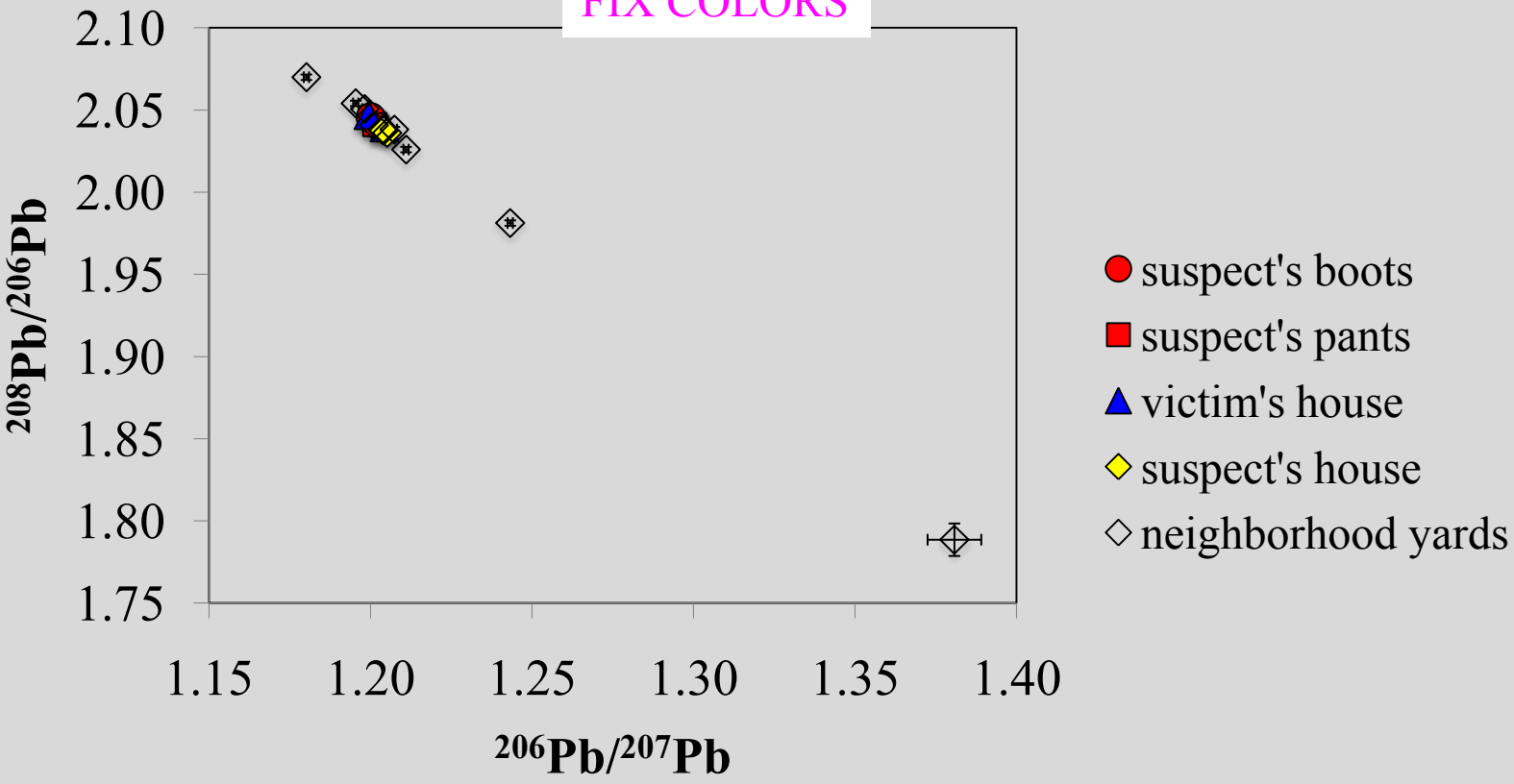

0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
% N
neighborhood yards
suspect's house
victim's house
suspect's clothing
0.00
1.00
2.00
3.00
4.00
5.00
% C

Radiogenic isotopes: $^{87}Sr/^{86}Sr$

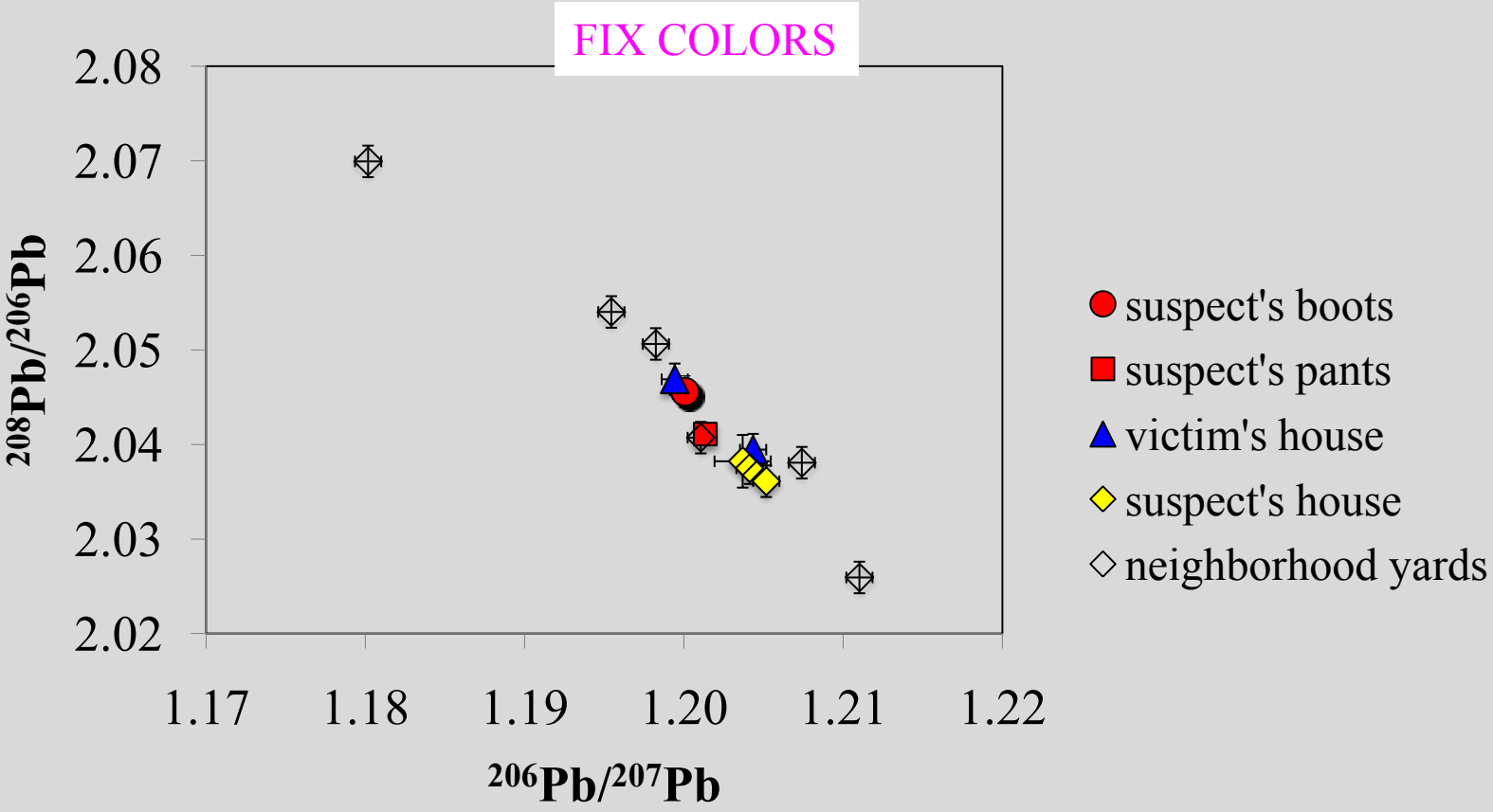


Radiogenic isotopes: $^{208}Pb/^{206}Pb$ and $^{206}Pb/^{207}Pb$

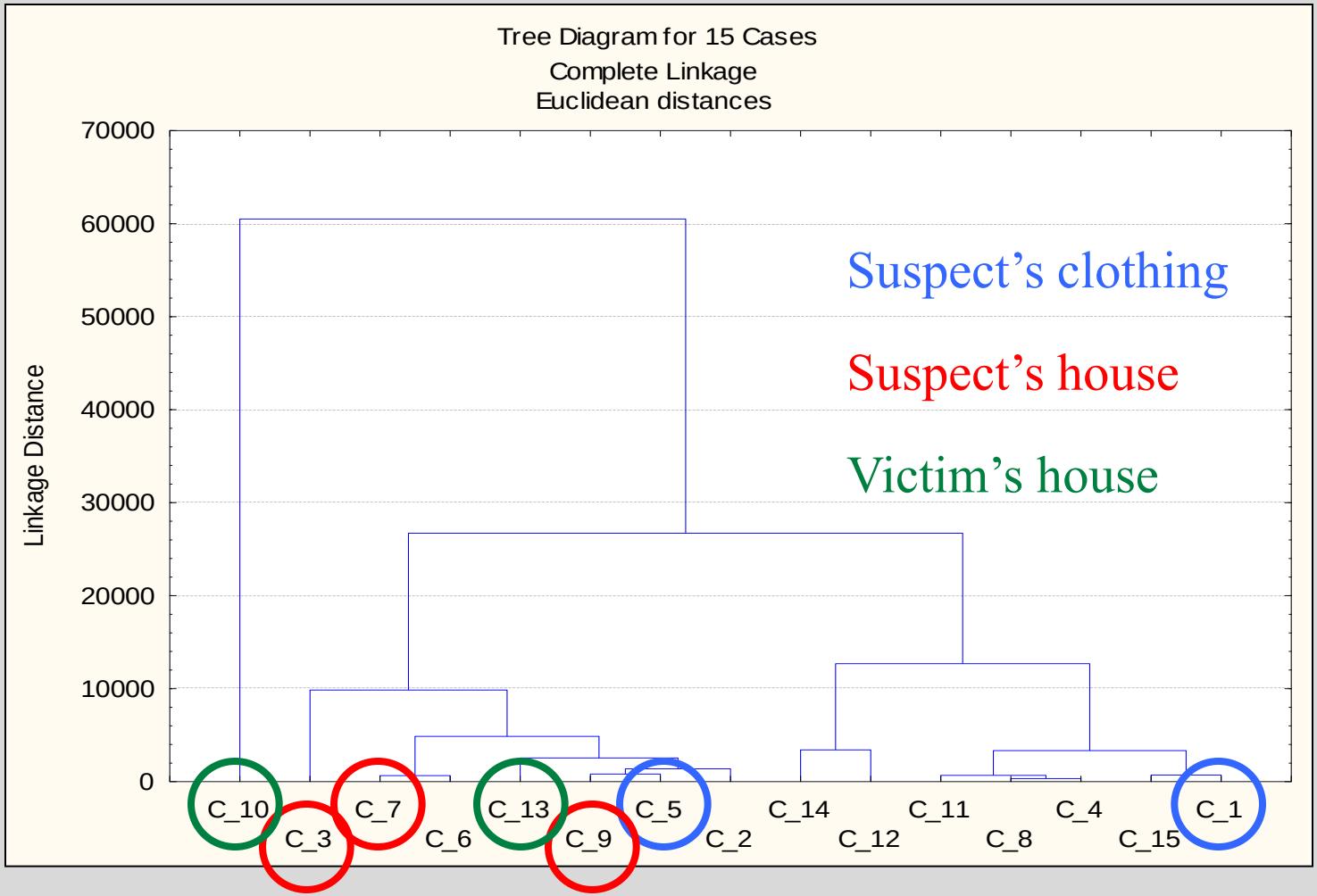
FIX COLORS



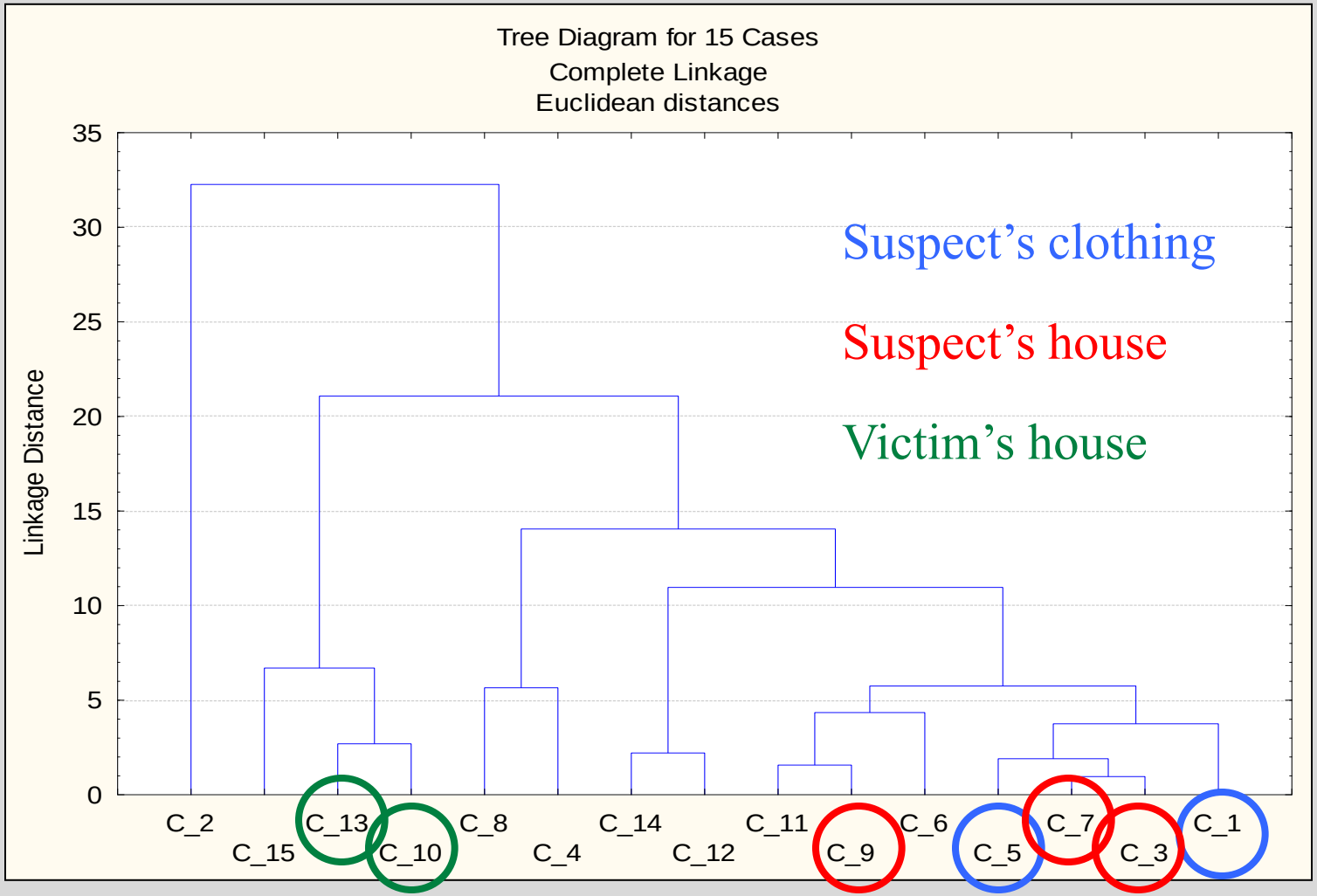
Radiogenic isotopes: $^{208}Pb/^{206}Pb$ and $^{206}Pb/^{207}Pb$



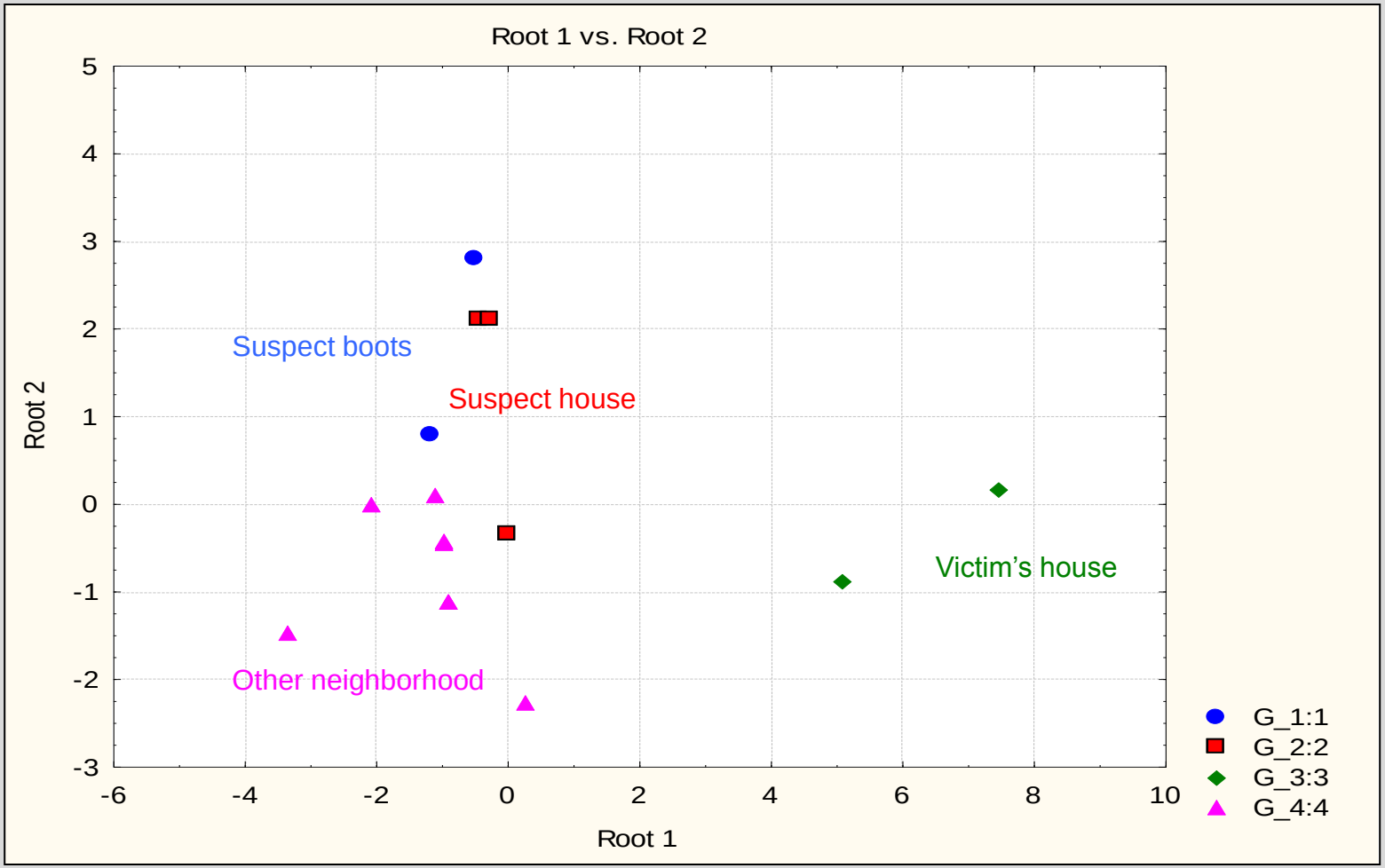
Cluster analysis, ICPMS data



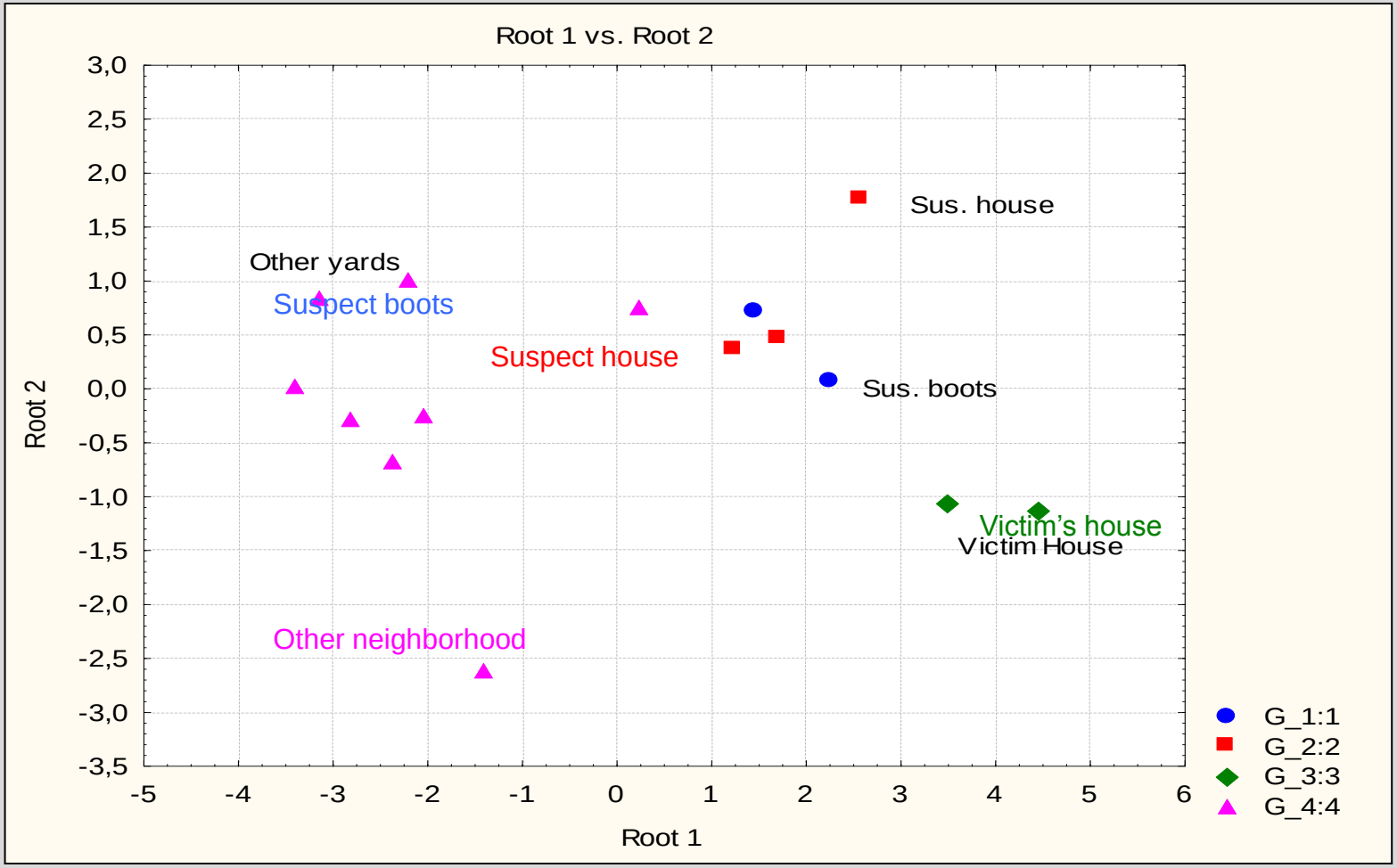
Cluster analysis, XRD, isotopes



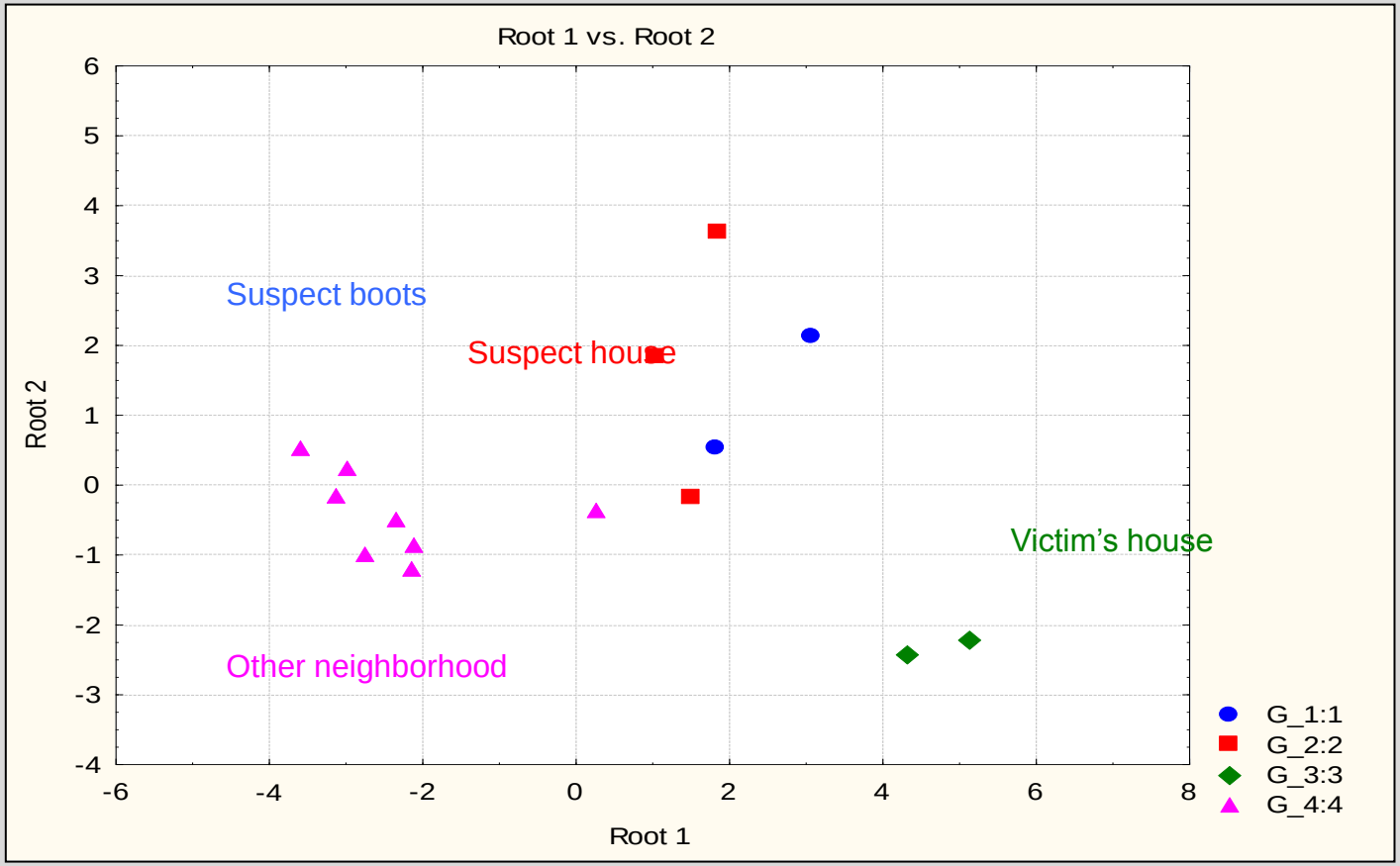
Munsell color, size & sorting



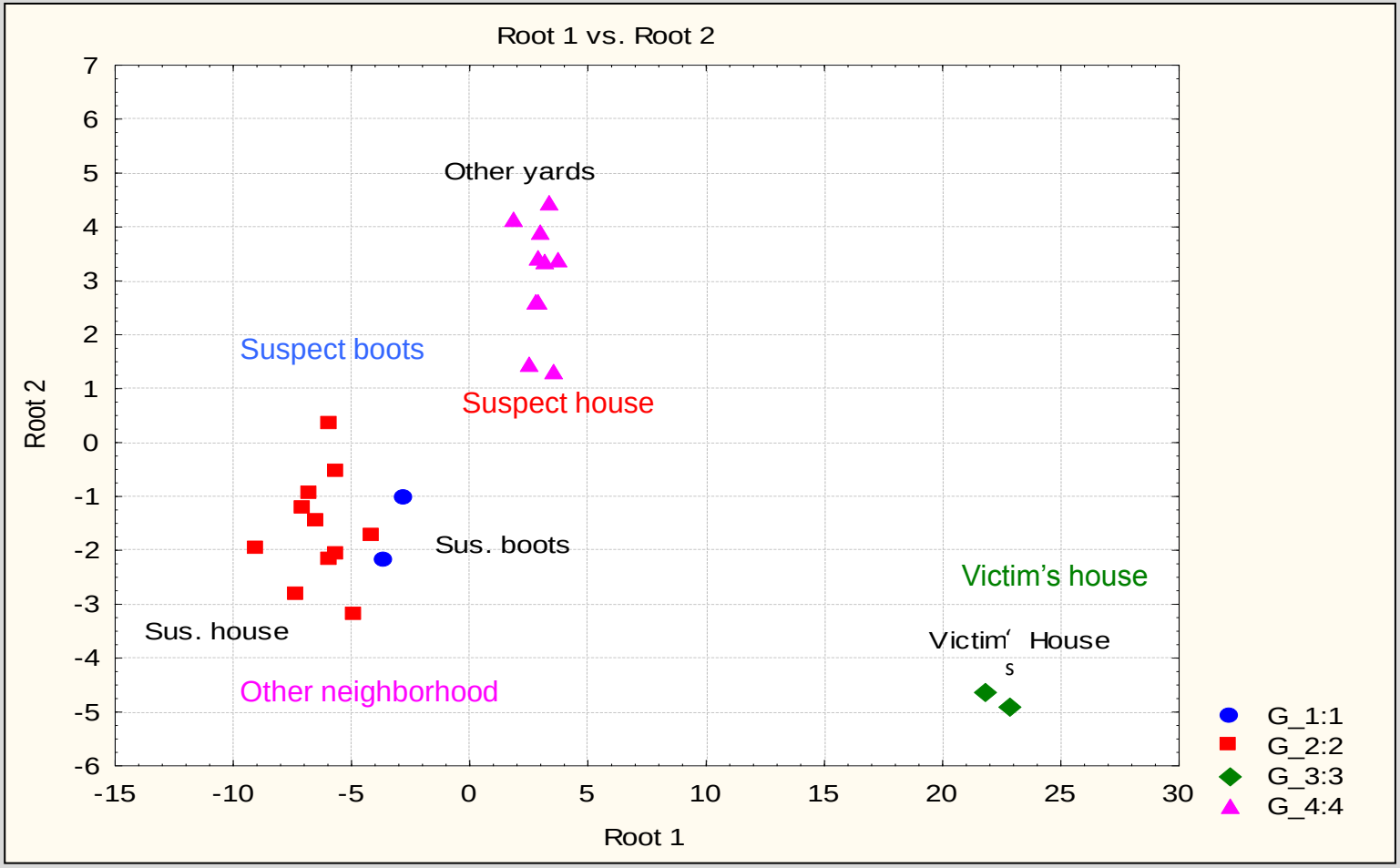
Linear discriminate analysis: X-Ray diffraction



Linear Discriminate analysis: Isotopes and X-Ray diffraction



Linear Discriminate analysis: ICPMS data



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