Time to Rethink Dusts

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Traditional Focus of Forensic Particle Trace Evidence

- Comparative analysis in individual cases
- Target particle types (fibers, glass, paint…) (as opposed to all that are present)

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Good, necessary and appropriate,

… but it *has* limited our perspective

Motivations to Rethink

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Fundamental limitations on probative value of trace evidence

- Traces from mass-produced, manufactured materials
- Limitations to class associations
- Strength of association?
  - database
  - standard method
  - what's the relevant population?
  - our focus is on rare events (outliers)

Individuality Uncertainty Principle in Forensic Science

The smaller the frequency, the larger the population we need to estimate it.

Our population is small, with uncertain, heterogeneous composition.

We cannot test or reliably predict frequencies of these rare events.

Individuality Uncertainty Principle in Forensic Science

Our *provable* probabilities will be much, much more common than either our good science or common sense would allow.

Conundrum:

decreasing reliability of frequency estimates with increasing evidential value

More Motivations to Rethink

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Changes in forensic science practice

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  - Computer-assisted analytical methods

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Roux, Claude, et al. "Forensic Science in the 21st Century: Will Trace Evidence Ever Reach the Next Level?," Trace Evidence Symposium, Clearwater Beach, FL, June 16, 2007

More Motivations to Rethink

Changes in forensic science practice

- Professional changes
  - Standardization of methods, routine analyses
  - Increased specialization
  - Reduction of subjective elements
  - Accreditations and certifications
  - Pressure to get more "scientific" or more like other sciences & professions

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Changes in forensic science practice

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  - Increased specialization
  - Reduction of subjective elements
  - Accreditations and certifications
  - Get more "scientific" or more like other sciences & professions
- Greater community interest
  - scientists, legal community, public

Clues to Guide a New Approach

With respect to interpretations

- limitation of class association
- case-specific systematic variations that cannot be controlled
- individuality uncertainty principle

Clues to Guide a New Approach

With respect to interpretations

- limitation of class association
- case-specific systematic variations that cannot be controlled
- individuality uncertainty principle
- compellingly strong evidential value for
  - cases with multiple-transfer evidence
  - cases with many-layered paints

Clues to Guide a New Approach

With respect to soil analysis

- issues and approaches addressing combinations of small particles
- arising from a mixture of stochastic and deterministic processes

Clues to Guide a New Approach

With respect to DNA analysis

accepted theory and methodology for calculation of joint probabilities

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accepted theory and methodology for calculation of joint probabilities

for a set of *modestly rare* occurrences

where reliable bounds can be set on both individual frequencies and correlations

Clues to Guide a New Approach

Multiple transfers of a set of *moderately rare* particles can:

- break the barrier of "class association"
- address the "individuality uncertainty principle" conundrum as we can measure their frequencies and correlations

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Where do we get sets of particles?

The reality is: they are always there.

Very Small Particles are Everywhere

We know "VSP" are there

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We know "VSP" are there,
but we don't usually use them

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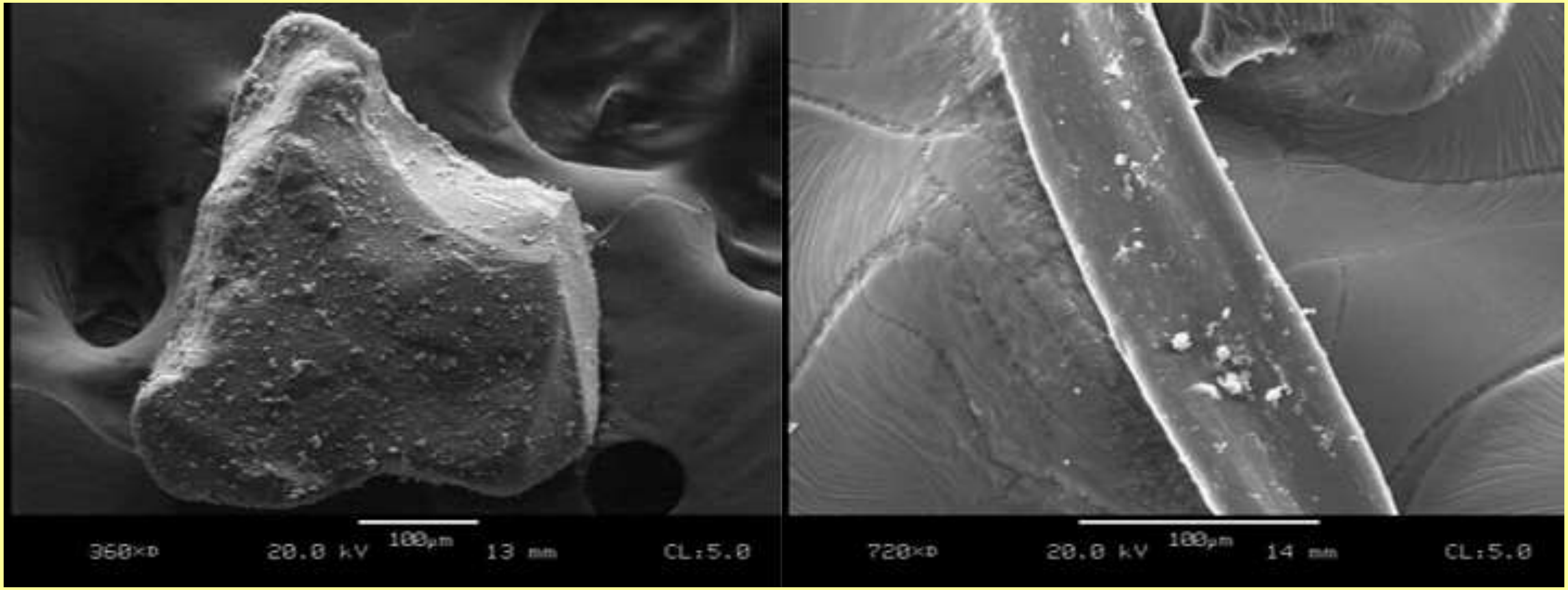
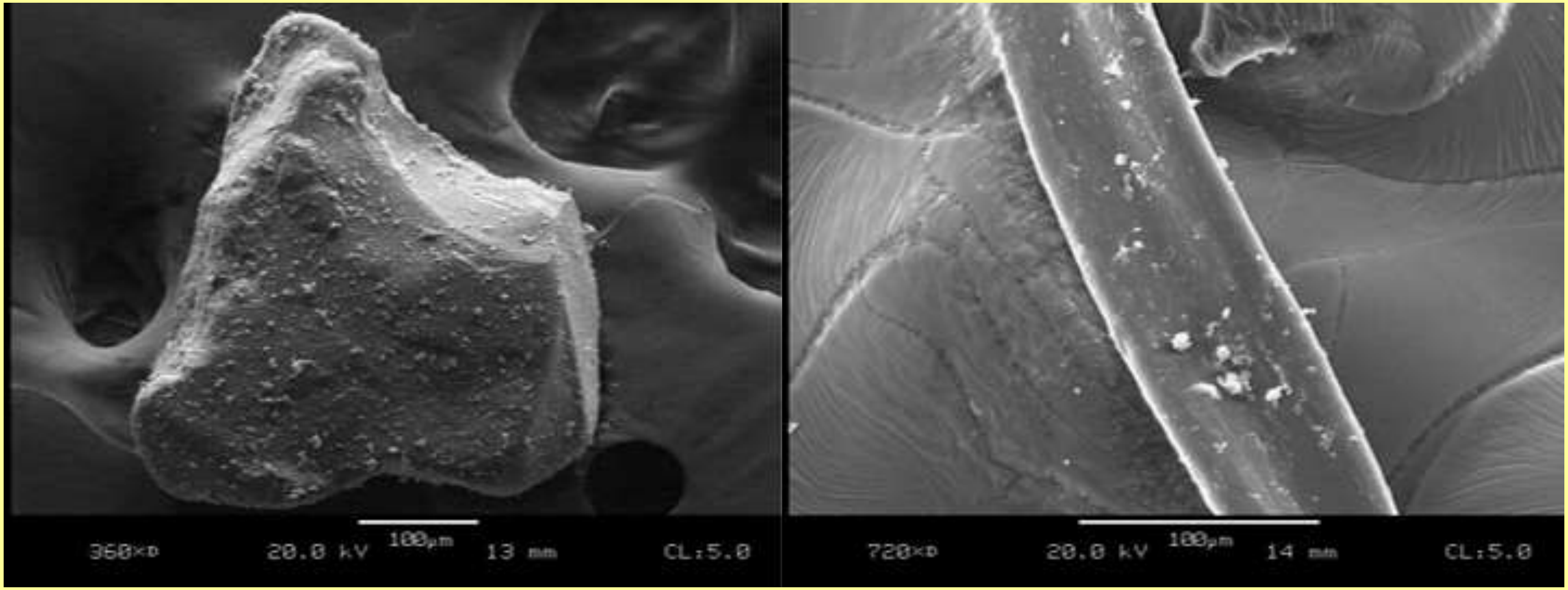
- We're mostly focused on larger, conventional traces
  - Exception: GSR particles
  - Exception: DNA

The Potential



The Potential



Use fine “piggy-back” particles, on the surface of traditional trace evidence, to test for common source.

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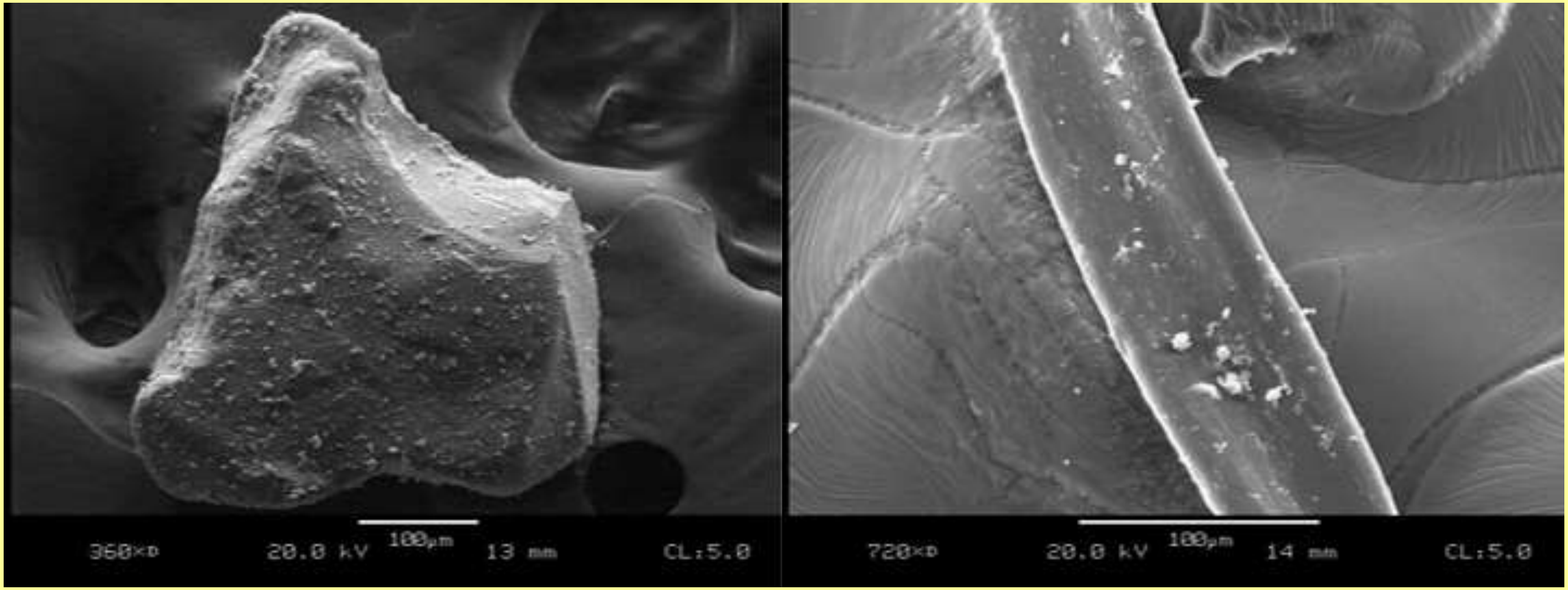

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Every case becomes a multiple-transfer case

The Potential

There is extensive air monitoring and environmental health experience in this area

- Study of respirable or near respirable dusts
- Frequencies of occurrence and local monitoring
- Tracing of airborne pollutants to their source
- Automated analysis methods

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There is also forensic experience in this area

- GSR

The Potential

It is of revolutionary significance that, when working with complex particle mixtures, co-occurring particles can be used to

- independently and quantitatively test alternative attribution hypotheses
- achieve high levels of individuality that cannot be reached through single-particle frequency estimates

Fundamentally Different Approach

It differs from:

- looking for a specific target particle based on the case context
- monitoring for specific particle types
  environmental hazards, pollutants, security threats
- tracing the source of pollutants
- determining what is happening at a given site

Particle Combination Analysis (PCA)

Use of co-occurring particles to independently and quantitatively test alternative attribution hypotheses

Testing the Approach: Carpet Fibers

Long-term exposures in one place

Very large exposed surface area

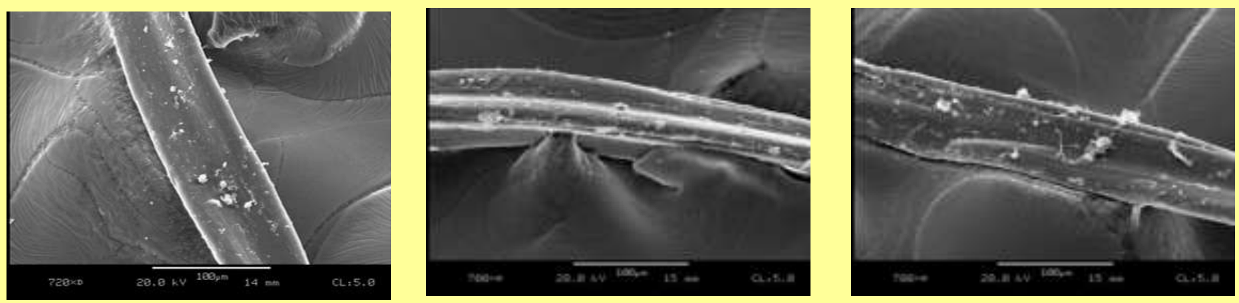
Designed to trap small particles

Indoor environments highly variable

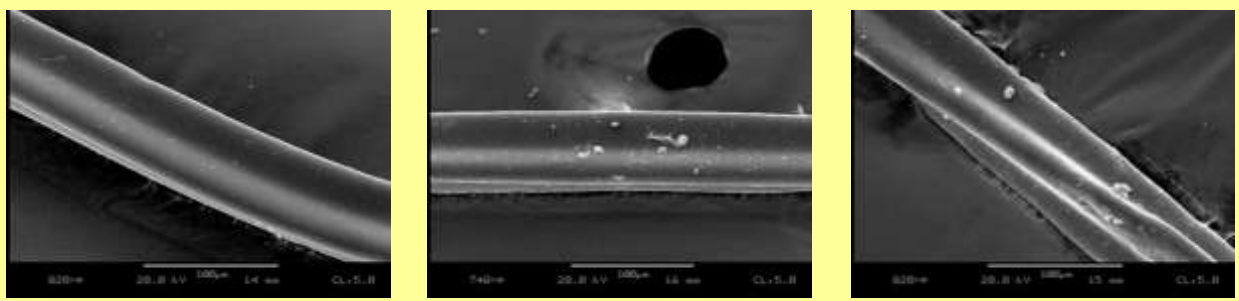
Testing the Approach: Carpet Fibers

Method to recover fine particles

Unwashed



Washed



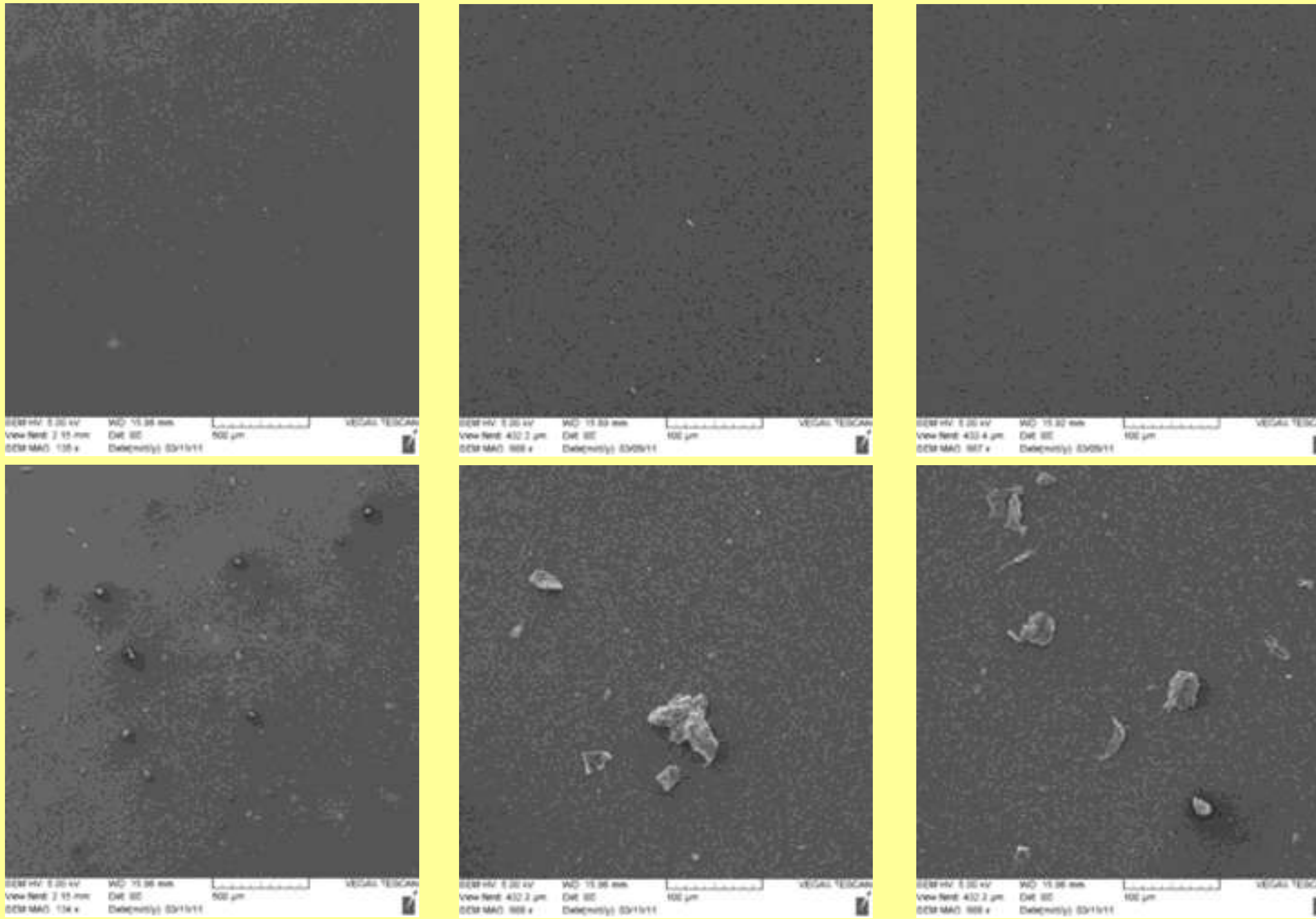
Method to Recover Fine Particles

- Clean bench, filtered reagent 95% ethanol
- 0.5mL ethanol + fiber in 1.5 mL micro-centrifuge tube
- Sonication for 10 minutes, fiber removal
- Vacuum filtration using a 0.4μm polycarbonate membrane filter cut to a 5 mm x 5 mm square
- Filter to carbon tape, carbon coating
- Blank process / solvent control

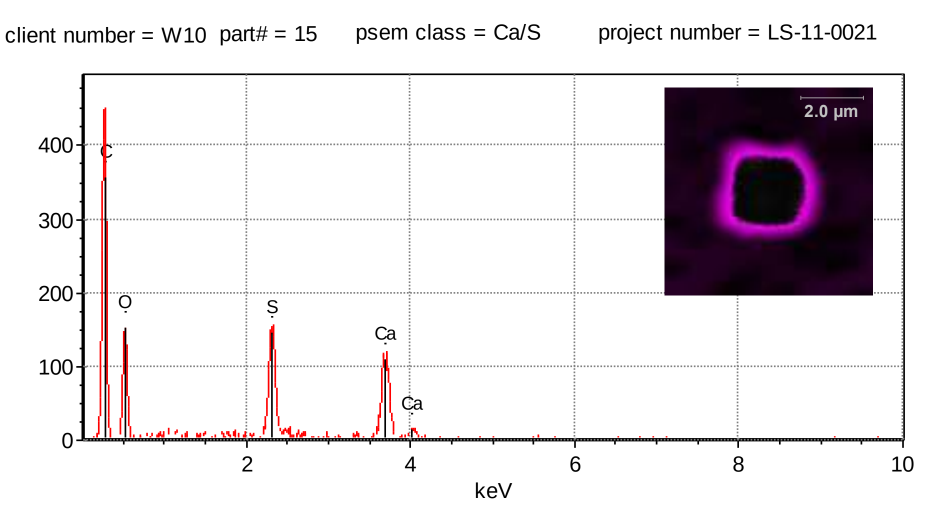
Recovered Particles Ready for Computer-controlled SEM

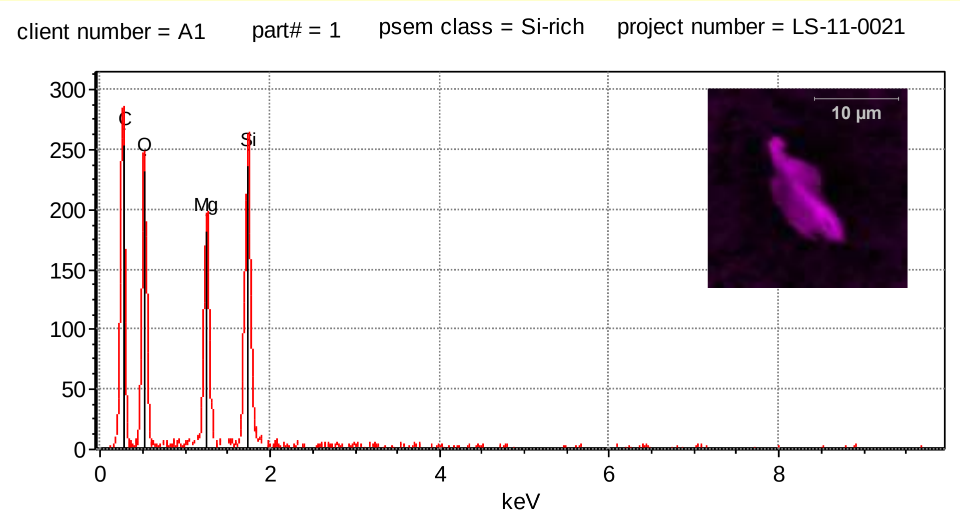
Blank

Sample



Example CCSEM Data





Research Currently Underway

Within and between item variability

- Sets of 10 fibers (reference carpet)
- Individual fibers ("transferred fiber")
- Nylon household carpets
- Nylon automobile carpets

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To be tested: how likely is a measured particle profile to have originated as a randomly selected profile from the reference population

(multinomial distribution with maximum-likelihood estimation and chi-square)

Stay Tuned

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David Exline

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