Comments regarding:

Asbestos and Other Mineral Fibers: A Roadmap for Scientific Research

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Asbestos Credentials

- Twenty plus years experience in asbestos analysis and identification
- Participated in the development of several asbestos analytical methods:
  - Yamate Method – Member of peer review panel
  - Drafted the AHERA standard for the EPA
  - USA Representative to ISO
  - ASTM-D22 Dust Method
  - CARB 435
- Served on variety of committees and peer review panels:
  - Health Effects Institute-Asbestos Research Literature Review Panel
  - Participated on the committee tasked with defining clearance procedures following asbestos removal in schools
  - Several Environmental Protection Agency (EPA) Committees and peer review panels reviewing the results of EPA research programs and grants

Asbestos Credentials

- Examined and studied raw materials from all over the world
- Analyzed thousands of samples for asbestos determination by employing various analytical techniques
- Developed quantitative electron diffraction techniques
- Qualified expert in field of asbestos in State and Federal courts
- Accreditations:
  - American Industrial Hygiene Association (AIHA)
  - National Voluntary Laboratory Accreditation Program (NVLAP)
  - National Environmental Laboratory Accreditation Program (NELAP)
  - California ELAP
- Published over 50 technical papers in the asbestos related literature

Asbestos Identification

- Legal issues **should** prevent laboratories from classifying other species as asbestos:
  - In current regulations and analytical methods, ASBESTOS is defined as the asbestiform variety of six silicate minerals
    - Chrysotile asbestos
    - Crocidolite (riebeckite asbestos)
    - Amosite (cummingtonite-grunerite asbestos)
    - Anthophyllite asbestos
    - Tremolite asbestos
    - Actinolite asbestos
  - Methods simply specify size and shape of ASBESTOS to be counted

Asbestos Identification in the Real World

- Due to legal (liability) and commercial reasons:
  - Laboratories report anything and everything as asbestos
  - Laboratory methods are inadequate for non-commercial species
- Current analytical protocols designed to assess occupational exposure in the workplace:
  - Adequate when assumption can be made that the mineral fibers beneficiated from commercial asbestos deposits/products.
  - Commercial asbestos products have had most non-fibrous material removed
  - These methods are not adequate for naturally occurring mixed mineral environments.

NIOSH Review Overdue

- Issues have been discussed for *over 30 years* and need resolution
- Implications beyond current occupational issues

Reserve Mining Company

Homestake Gold Mine, South Dakota

R.T. Vanderbilt Co. New York Tremolitic Talc

El Dorado Hills, CA

Mixed Mineral Environments

- Need for coherent public policy regarding fiber definition and counting rules in mixed mineral environments
  - Lack of uniform policy and interpretation of rules has resulted in wide discrepancies in assessments and actions
  - Mineral identification and morphological class need to be clearly defined
  - Methods must maximize collection of relevant data

- What happens when the current analytical procedures are forced onto mixed mineral environments?
  - El Dorado Hills, CA
  - Vanderbilt Talc

Asbestos Reported in El Dorado Hills

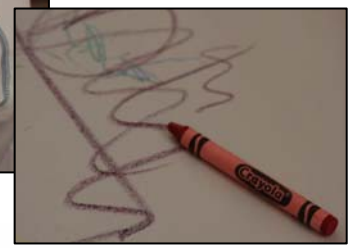
- EPA Analysis, *released May 2005*
  - Series of activity-based air sampling (hiking, biking, and simulated baseball game) and soil sampling
  - found "the presence of asbestos at elevated levels in air at breathing heights for children and adults"
  - tremolite-actinolite and chrysotile
- RJLG conducted peer review of EPA report and underlying data, *November 2005*
  - "Based on mineralogy, 63% of the amphibole particles identified as asbestos fibers can not be asbestos"
- U.S. Geological Survey reviewed RJLG report, *early 2006*
  - "approximately 40 percent of the particles are magnesiohornblende"
  - "the majority of the particles are prismatic, not fibrous"

- Recent mitigation efforts over alleged asbestos at Oak Ridge High School had a cost of over $1.7 million
- Cost related to mitigation efforts for a new elementary school has been in excess of $1.8 million.
- Images taken from http://www.epa.gov/region09/toxic/noa/eldorado/intro1.html

Mitigation Costs in El Dorado Hills, CA

- Recent mitigation efforts over alleged asbestos at Oak Ridge High School had a cost of over $1.7 million.
- Cost related to mitigation efforts for a new elementary school has been in excess of $1.8 million.
- Data from the adjoining community of Folsom, CA indicates that their cost will be in excess of $5 million to mitigate alleged naturally occurring asbestos (NOA) concerns during the construction of a new high school.

Asbestos Reported in Crayons



- RJLG analyses by PLM, PCM and TEM, *1999*
  - Fibrous and Non-Fibrous Talc
  - Nonasbestos Cleavage Fragments
  - ***No Asbestos Detected***
- US Consumer Product Safety Commission (CPSC), *2000*
  - Datachem and U.S. OSHA (Salt Lake City, UT)
  - *"The amount of asbestos is so small that it is scientifically insignificant"*
- Research Triangle Institute (RTI), *2003*
  - *"Criteria for clearly distinguishing between asbestos fibers and cleavage fragments need to be adopted by government agencies."*

- Aiden Lee Bunker – 2.041 years old

seattle P-I.com Special Reports

Tremolite: What our tests found, and what the risks are

Tuesday, May 30, 2000

This scanning electron micrograph (click to see larger image) is a representative example of the asbestos found in the crayons analyzed by Lab/Cor for the Post-Intelligencer. The fiber shown has a length of nearly 22 microns and a width of almost 3.4 microns, said Dr. Robert Fisher, president and chief scientist at Lab/Cor. This length-to-width ratio of 6.4 to 1 means that according to EPA protocol, this fiber must be counted as asbestos under the agency's regulation. Chemical examination confirmed the fiber was tremolite.

Asbestos Reported in Crayons

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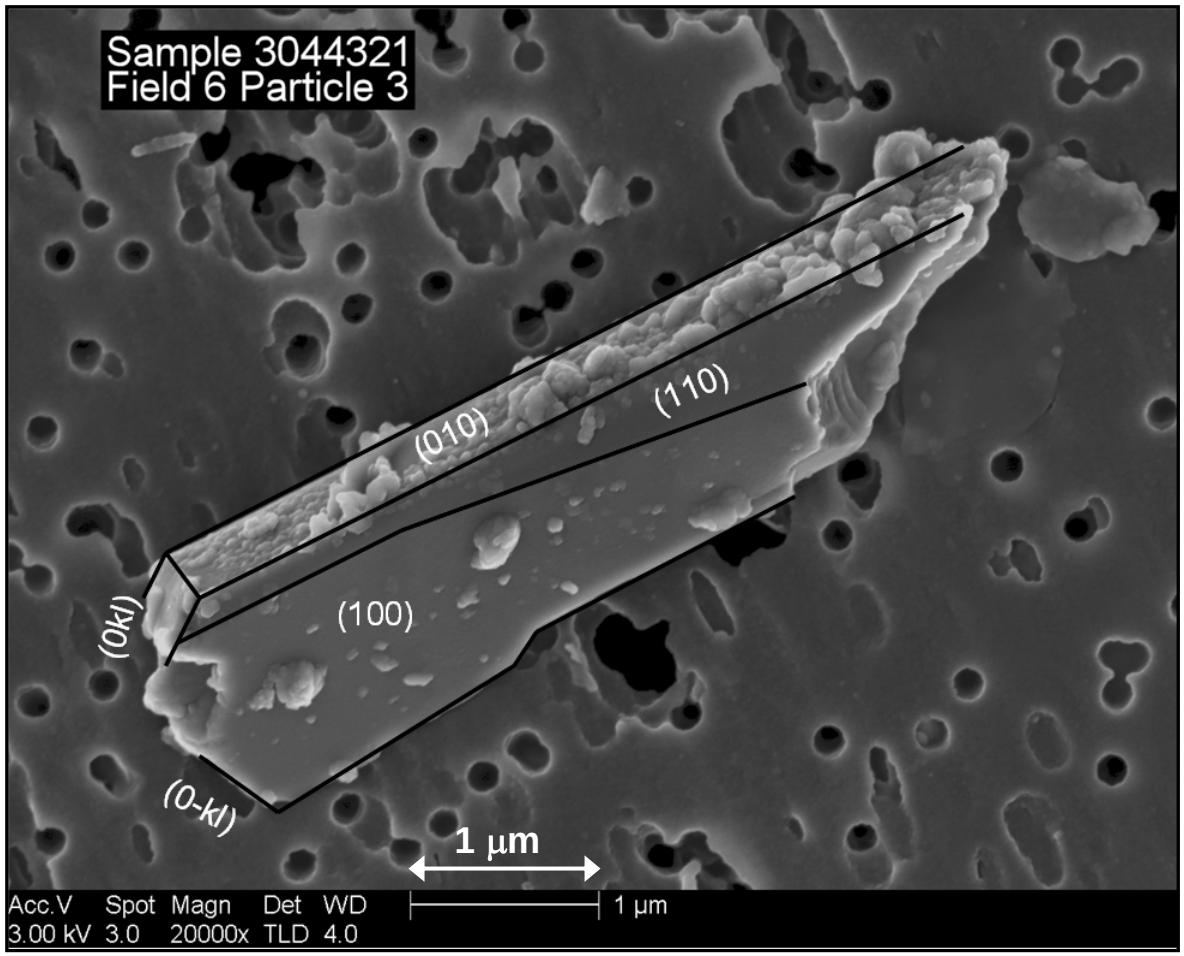
Amphibole Crystal from El Dorado Soil

- Most Particles in El Dorado soil have well developed cleavage faces

FESEM Image



Asbestos Research

- Current understanding is a result of 40 years of research
  - **F. Pott (1980)**, "Animal Experiments on Biological Effects of Mineral Fibres“, Biological Effects of Mineral Fibres, Vol. 1, Ed. J. C. Wagner, Tech. Ed. for IARC W. Davis, International Agency for Research on Cancer, Lyon, p. 261-272.
  - **M.F. Stanton et al. (1981)**, "Relation of Particle Dimension to Carcinogenicity in Amphibole Asbestoses and Other Fibrous Minerals“, J. Natl. Cancer Inst, 67, p. 965-975. – Long, thin, and durable fibers are toxic (8 μm in length and 0.25 μm or less in diameter)
  - **M. Lippmann (1988)**, "Asbestos Exposure Indices“, Env. Research, p. 86-106.
  - **B.T. Mossman (1990)**, “In Vitro Studies on the Biological Effects of Fibers: Correlation with In Vivo Bioassays”, Env. Health Perspectives, 88, p. 319-322.
  - **J.M. Davis et al. (1991)**, “Variations in the carcinogenicity of tremolite dust samples of differing morphology”, Ann. NY Acad. Sci., 643, p. 473-490.
  - **A.G. Wylie et al. (1993)**, "The Importance of Width in Asbestos Fiber Carcinogenicity and Its Implications for Public Policy," Am. Ind. Hyg. Assoc. J., Vol. 54, No. 5, p. 239-252.
  - **D.W. Berman and K.S. Crump (2003),** “Final Draft: Technical Support Document for a Protocol to Assess Asbestos-Related Risk”, US EPA
  - **E.D. Kuempel (NIOSH) et al. (2006)**, “Fiber Size-Specific Exposure Estimates and Updated Mortality Analysis of Chrysotile Asbestos Textile Workers,” presented at Society of Toxicology, San Diego, CA, March 6, 2006. (toxic fibers: > 40 μm length; < 0.3 μm width)

Asbestos Research

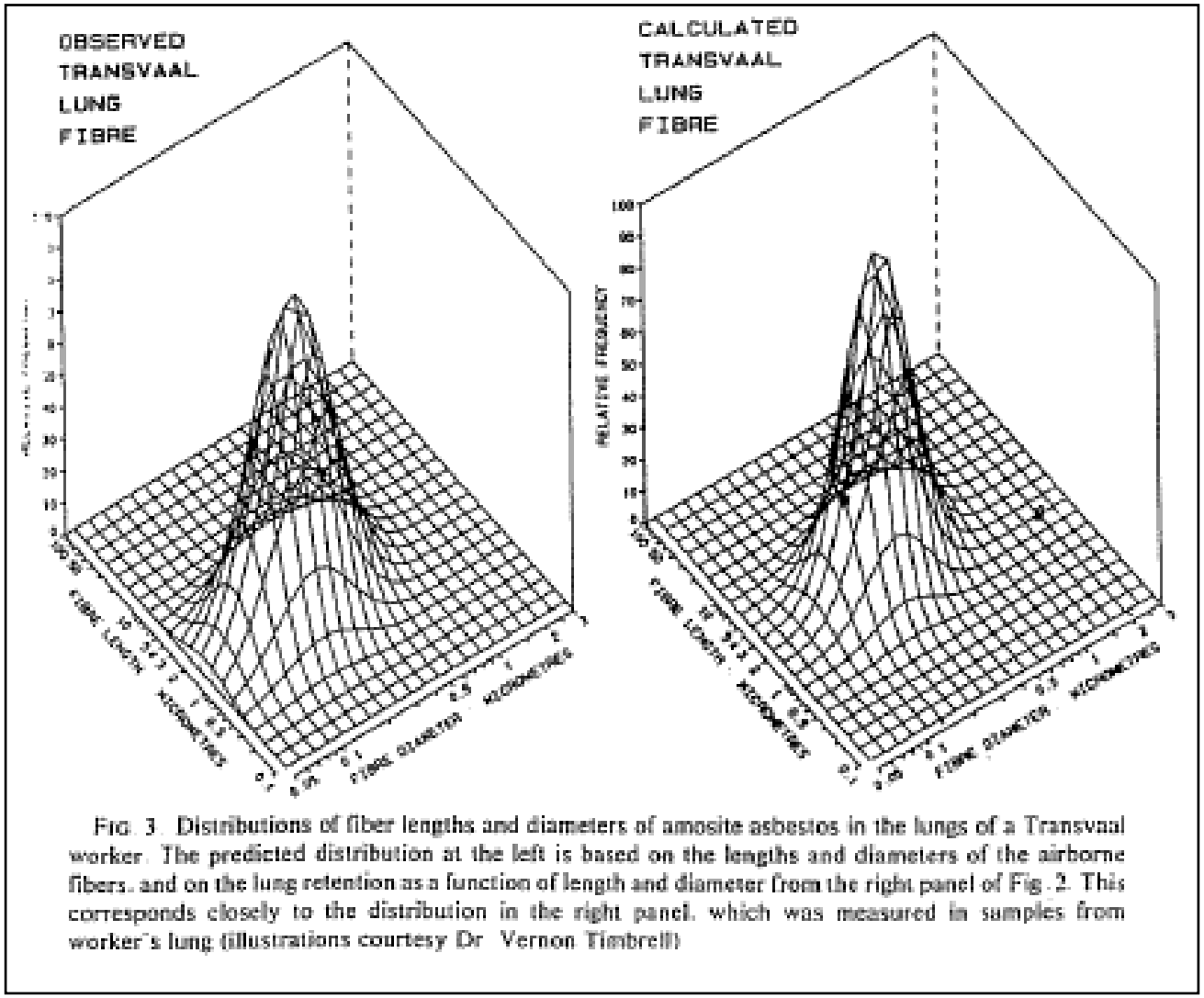


FIG. 3. Distributions of fiber lengths and diameters of amosite asbestos in the lungs of a Transvaal worker. The predicted distribution at the left is based on the lengths and diameters of the airborne fibers, and on the lung retention as a function of length and diameter from the right panel of Fig. 2. This corresponds closely to the distribution in the right panel, which was measured in samples from worker's lung (illustrations courtesy Dr. Vernon Timbrell)

M. Lippmann (1988), "Asbestos Exposure Indices", Env. Research, p. 86-106.

Asbestos Research

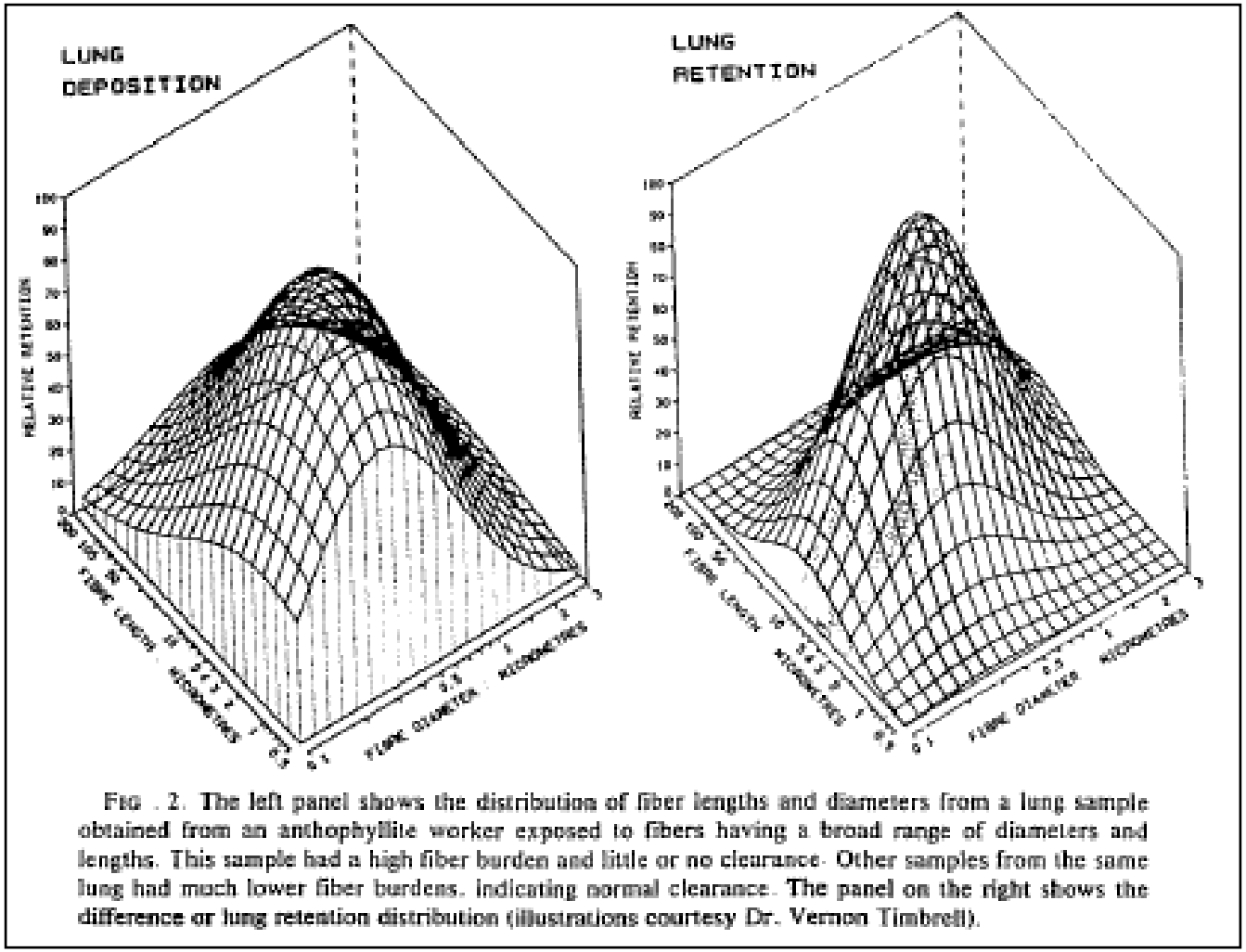
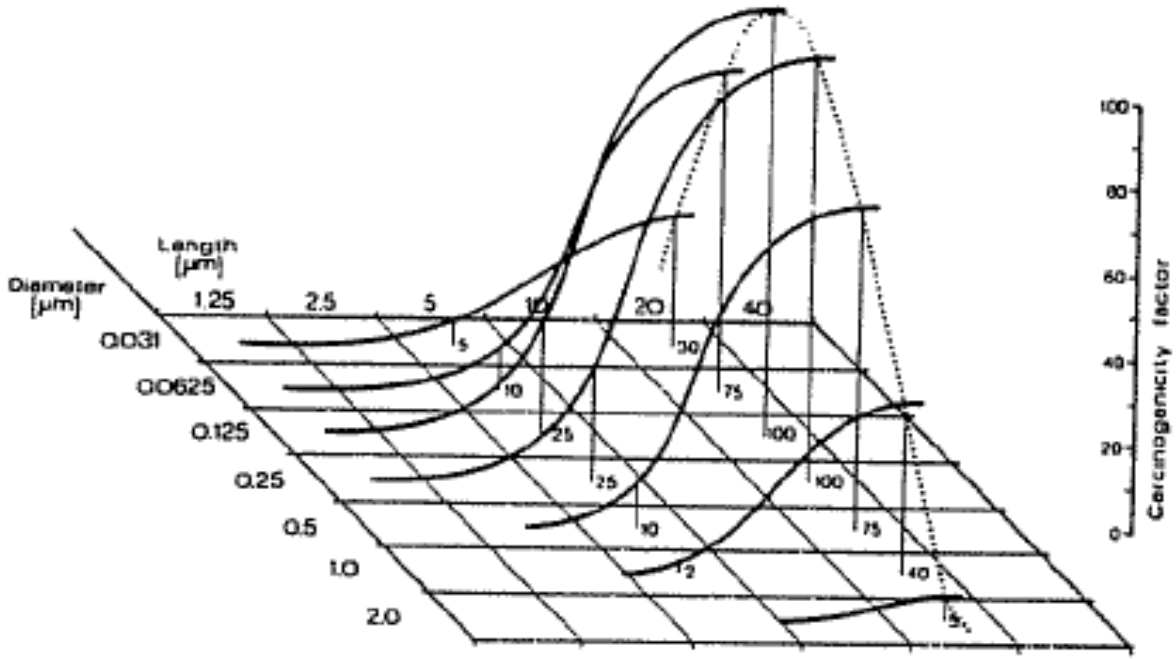


FIG . 2. The left panel shows the distribution of fiber lengths and diameters from a lung sample obtained from an anthophyllite worker exposed to fibers having a broad range of diameters and lengths. This sample had a high fiber burden and little or no clearance. Other samples from the same lung had much lower fiber burdens, indicating normal clearance. The panel on the right shows the difference or lung retention distribution (illustrations courtesy Dr. Vernon Timbrell).

M. Lippmann (1988), "Asbestos Exposure Indices", Env. Research, p. 86-106.

Asbestos Research

This three-dimensional model requires that the fibre size of a sample be divided into numerous categories; the size categories include three parameters: length, diameter and the length:diameter ratio.



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The Issue

- The issue is ***not*** short – fat fibers ***(innocuous)***

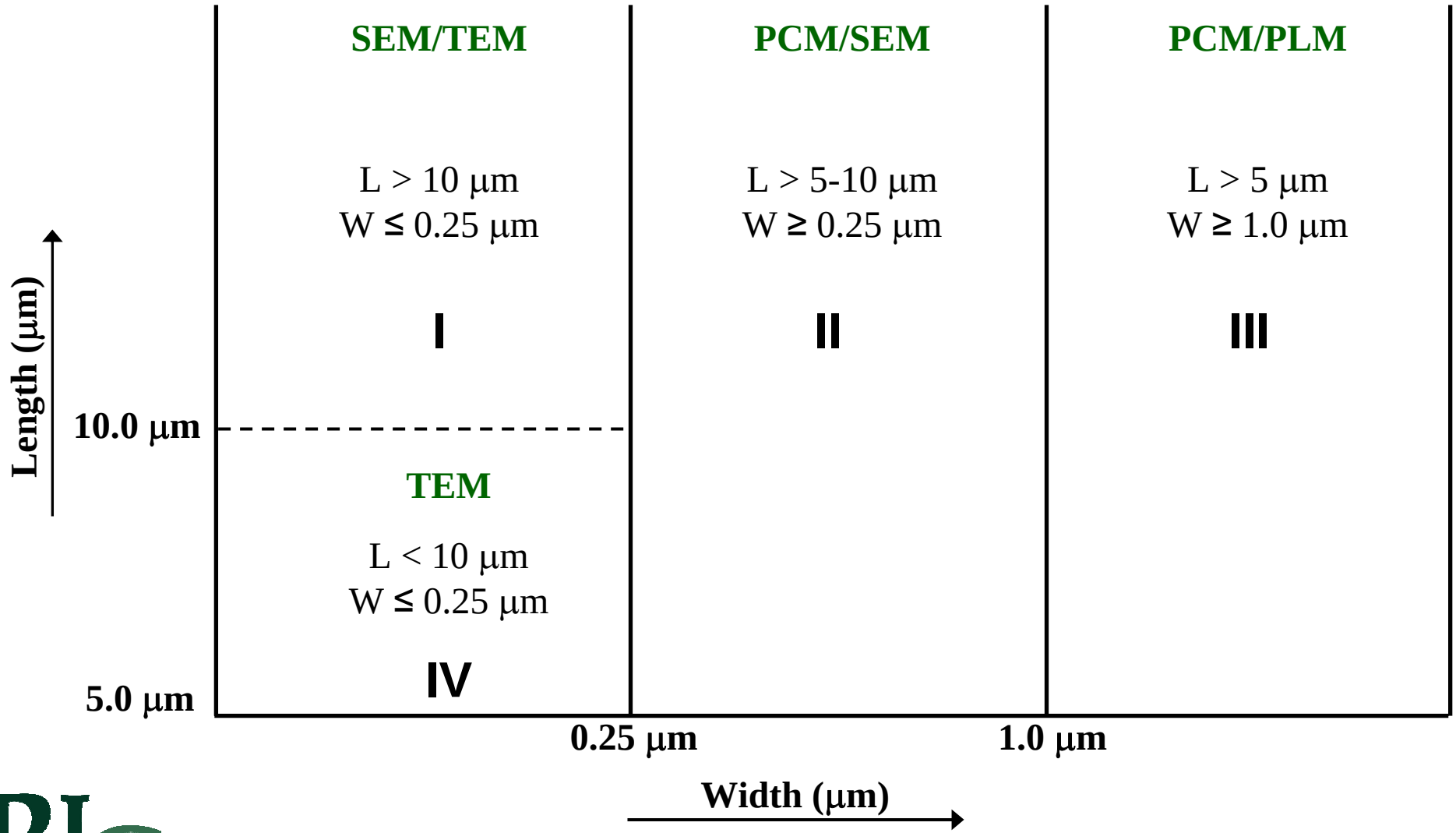
OR

- long, thin fibers ***(very toxic)***

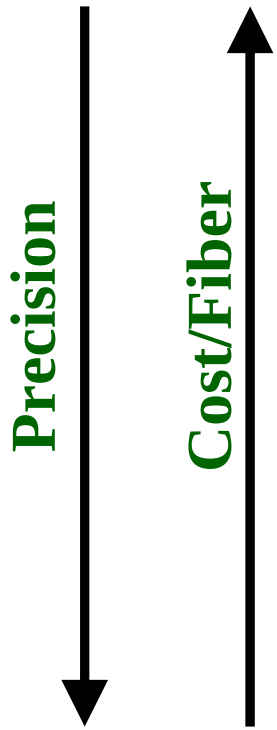
BUT

- Intermediate sized fibers → Greater than 5-10 μm in length and between 0.25μm and 1 μm in diameter

Optimal Measurement Process



Optimal Measurement Process



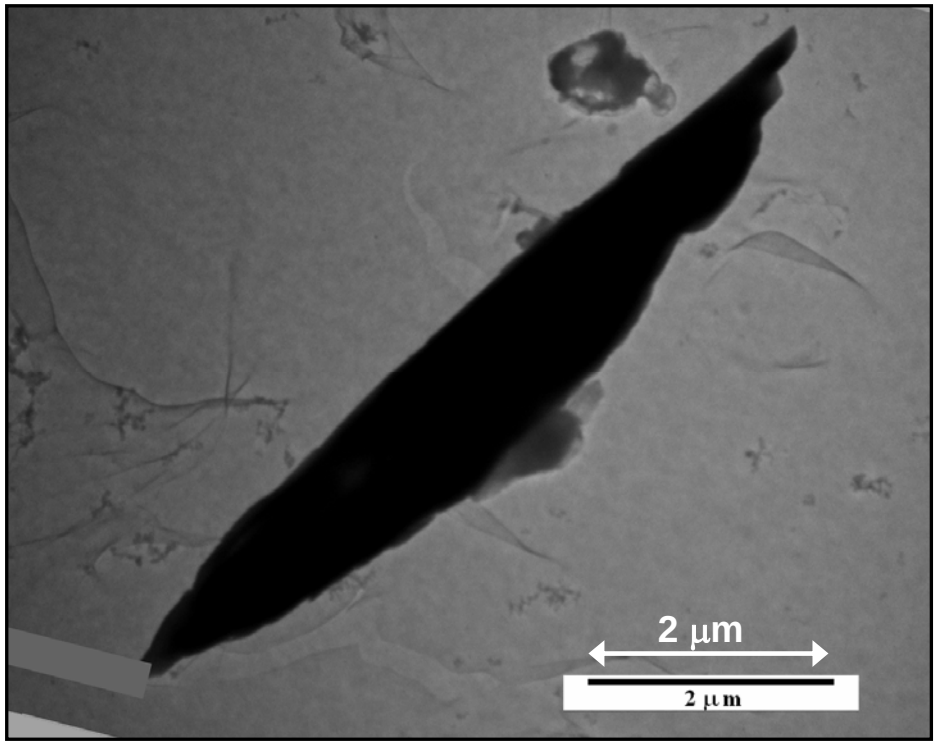
I	L > 10 μm and W ≤ 0.25 μm
II	L > 5-10 μm and W ≥ 0.25 μm
III	L > 5 μm and W ≥ 1.0 μm
IV	L < 10 μm and W ≤ 0.25 μm

TEM and SEM Techniques

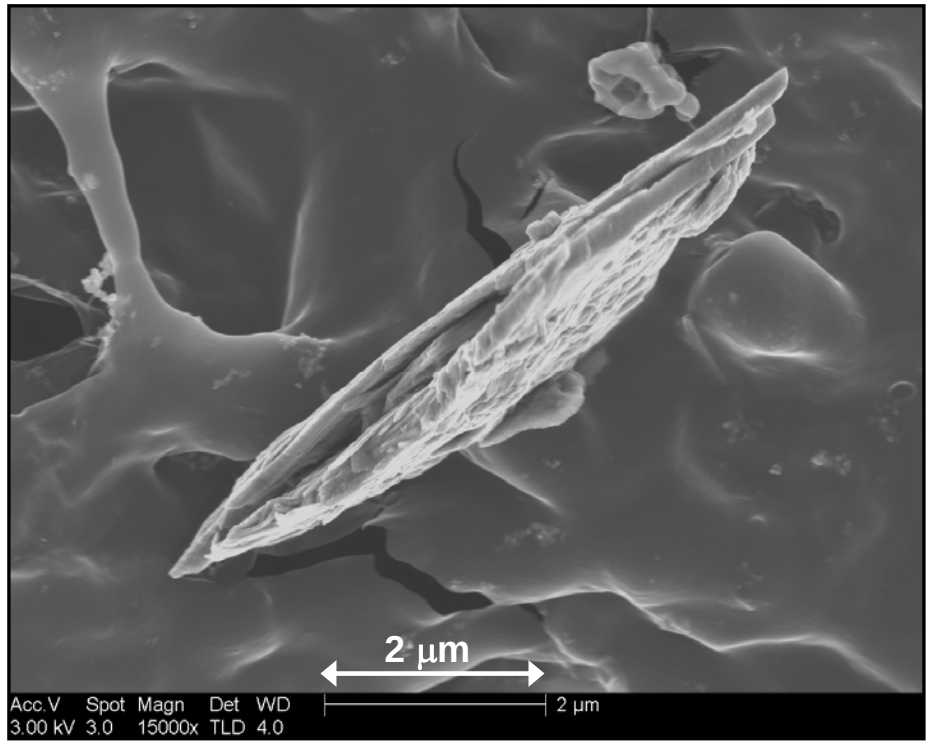
- ASTM D7200 needs to be supplemented by SEM
  - SEM superior at identifying long, thin fibers
  - SEM can be cost effective and available if demand exists
    - Several advancements in the SEM over the past 35 years have brought the SEM to the front line of cutting edge technology
      - Image Resolution no longer an issue
      - Digital imaging eliminates problems of previous generations
    - Can be used to observe features not observable in the TEM
      - Surface, ends, sides, dimensions, relation to filter
      - Three-dimensional imaging
    - SEM method of choice in Europe (ISO 14966)
  - TEM good at identifying short fibers
    - Confirm mineral chemistry (EDX) and crystallography (SAED)
    - Imaging limitations
      - Projected image - no surface details

Advantage of Using FESEM

TEM Image



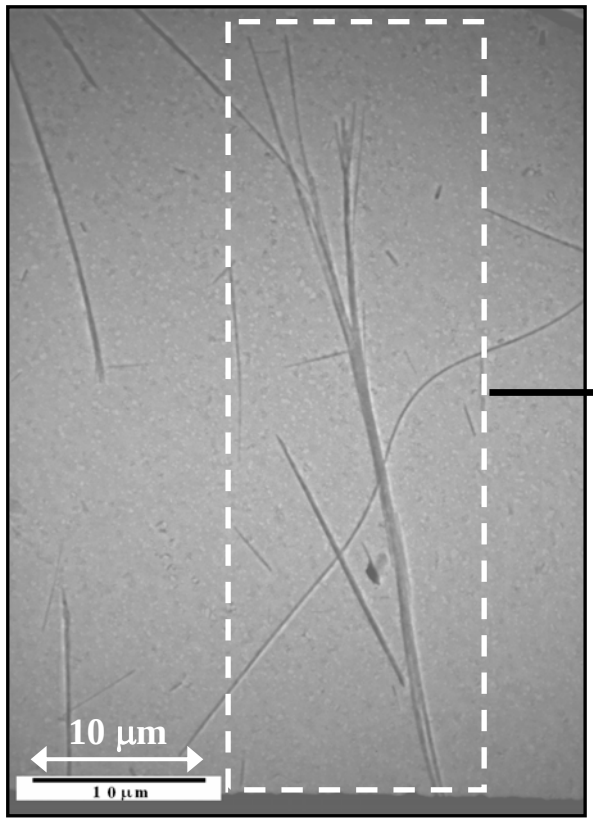
FESEM Image



- **What appears to be a long, thin particle in the TEM image is revealed in the FESEM image to be a plate-like sheet particle coming out of the plane of the projection screen; the particle is clearly not a fiber.**

SEM Visibility and Resolution Adequate

TEM Image



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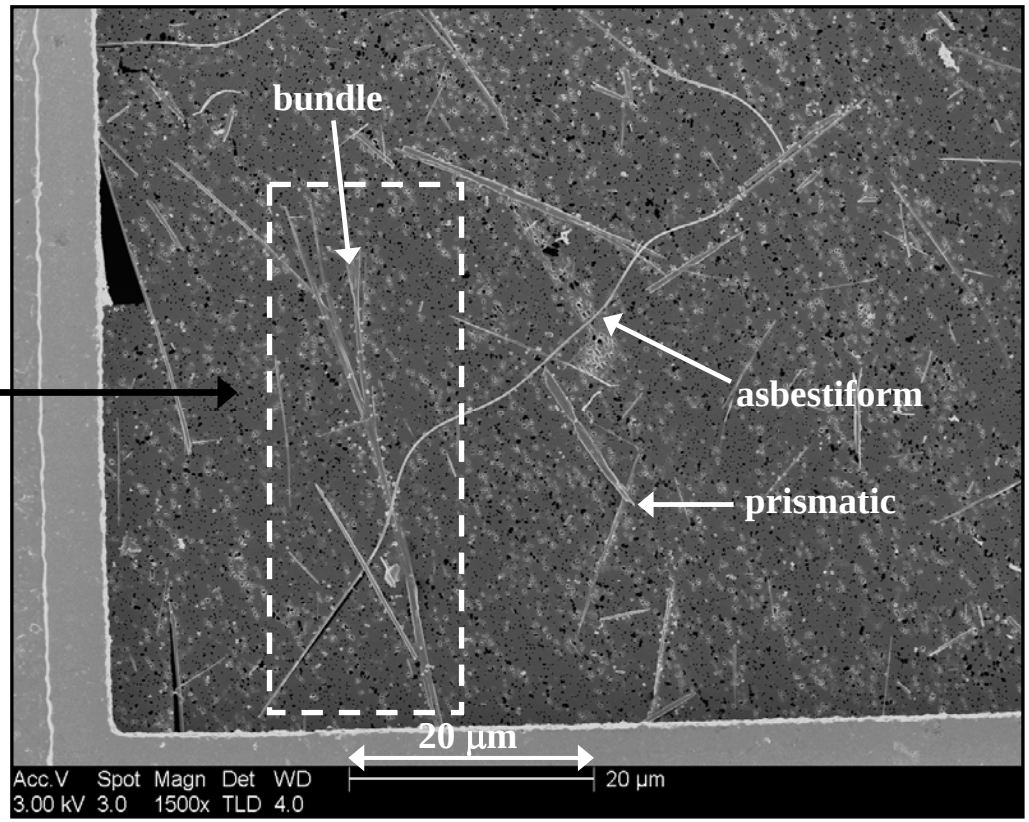
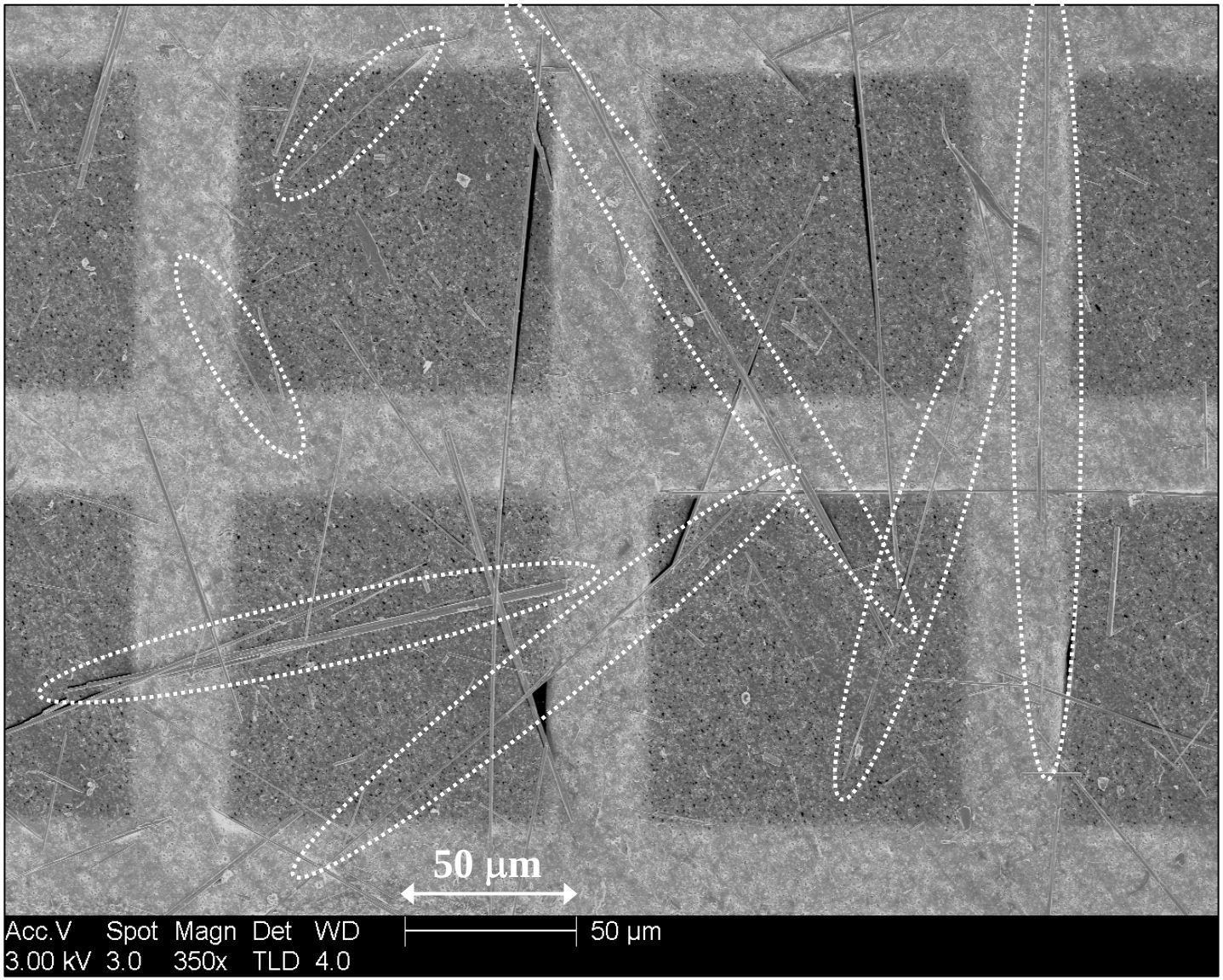


SEM optimum for long and thin fibers



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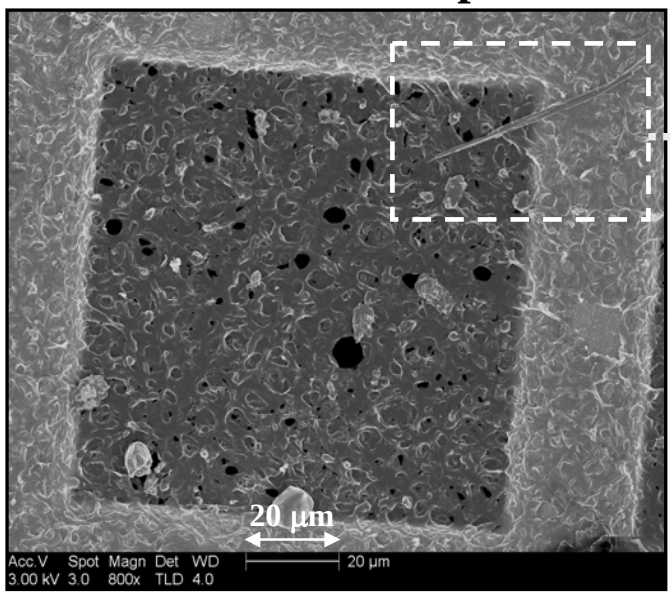
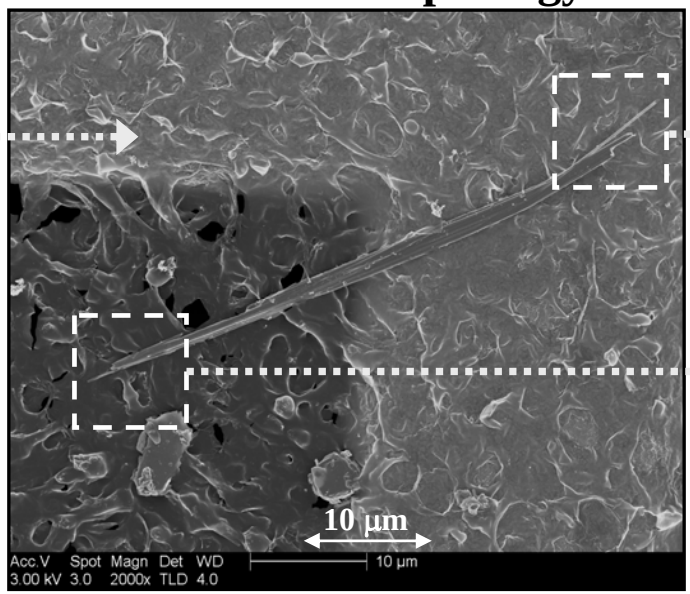
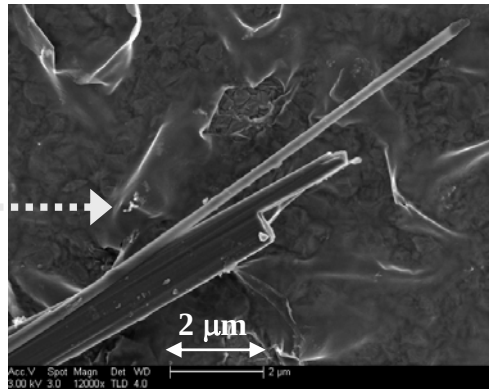
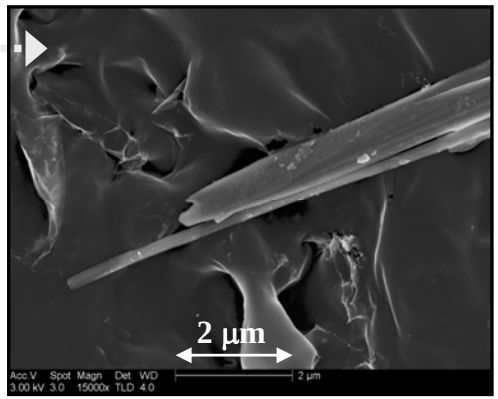
FESEM - Shape



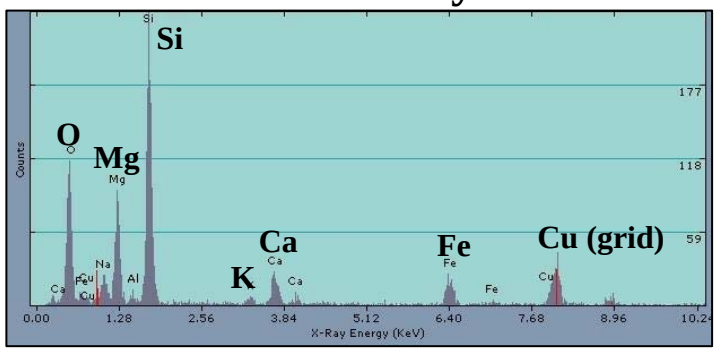
FESEM - Morphology



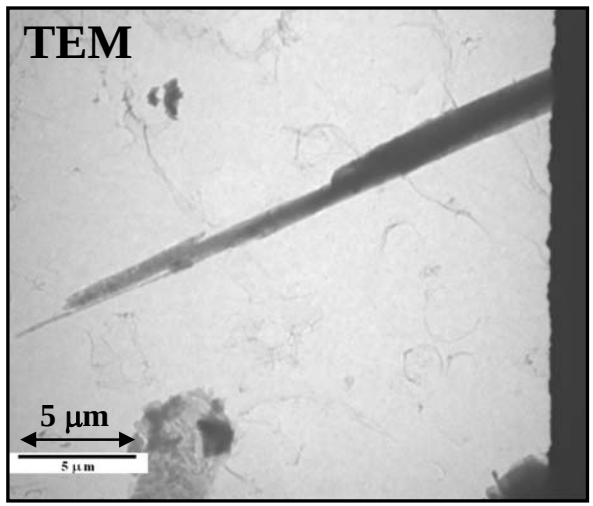




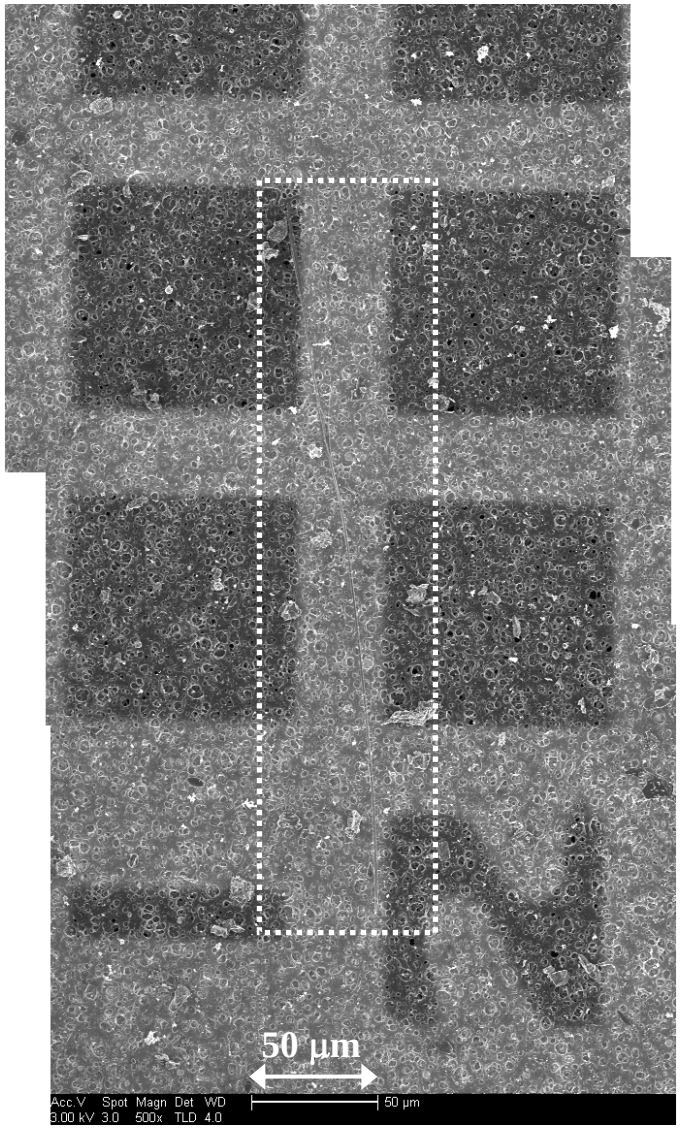
Chemistry



TEM

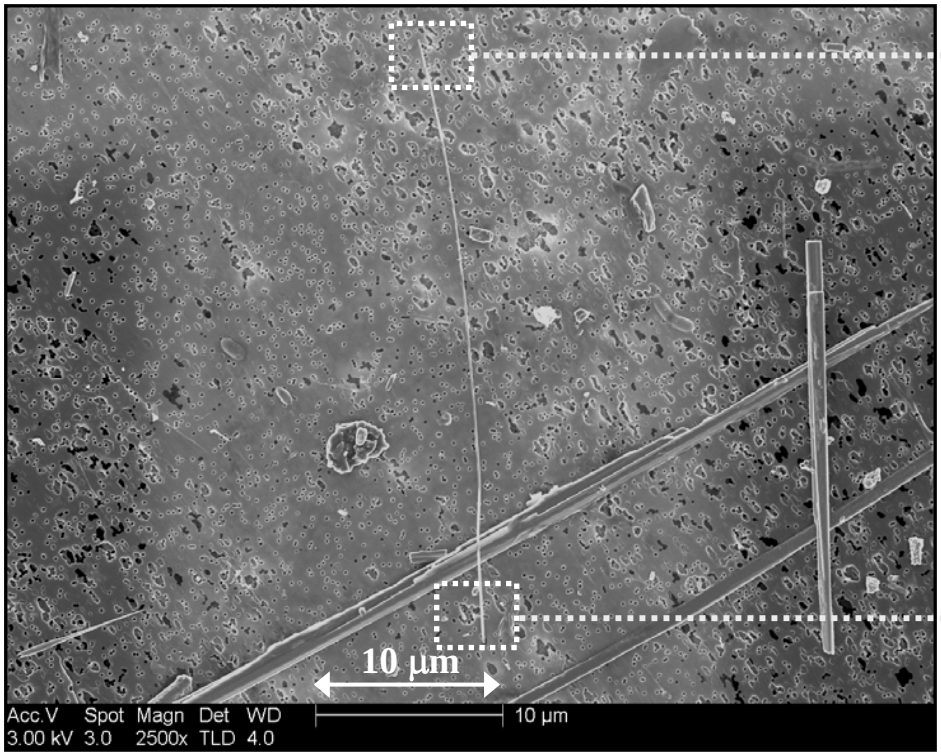


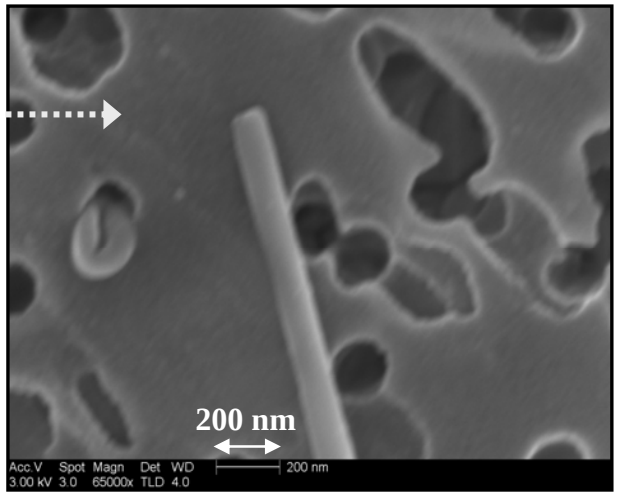
SEM optimum for long and thin fibers

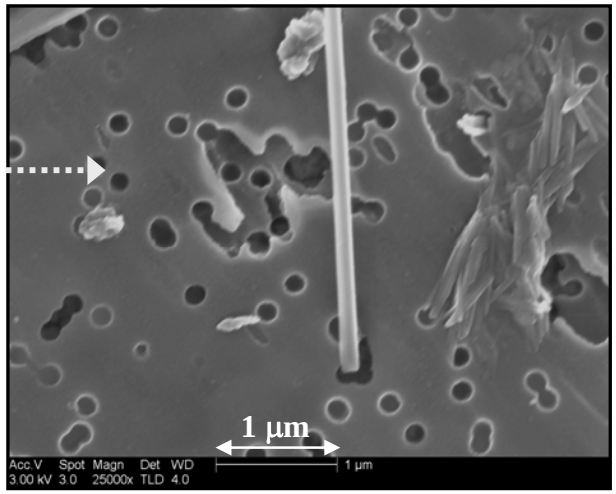


- **Long, thin fiber traverses ~2.5 grid squares, traveling along the grid bar so that it is not visible in the TEM**

SEM optimum for long and thin fibers



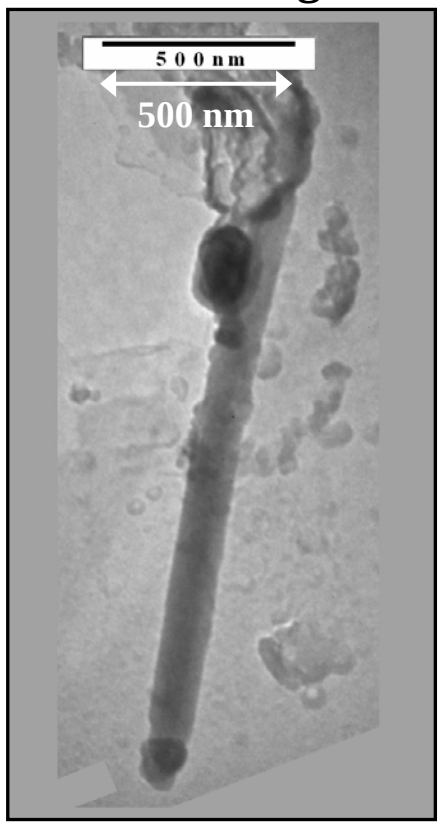




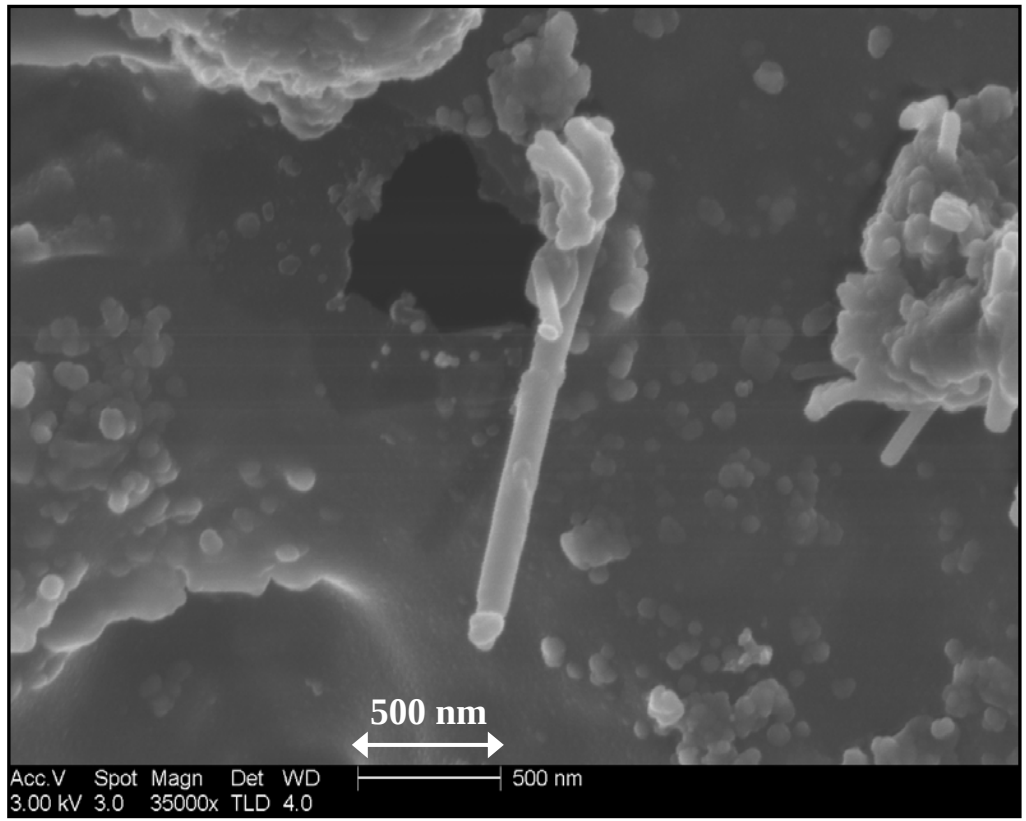
- **Long, thin fiber on grid bar, not viewable by TEM**
- **(L ~ 35µm, W < 0.25 µm)**

Chrysotile Single Fiber

TEM Image

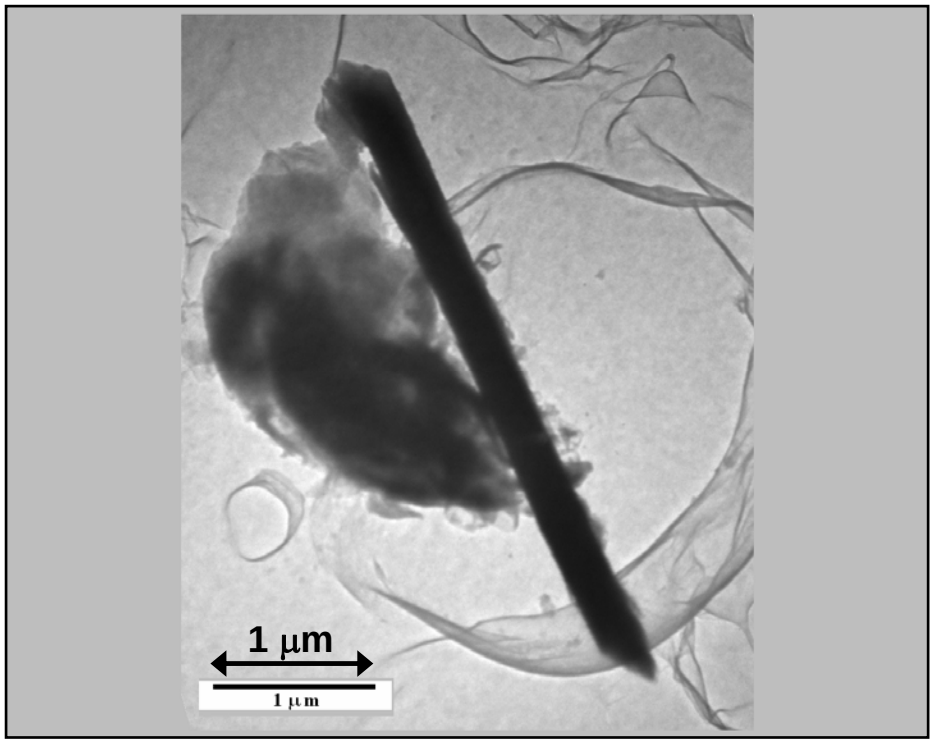


FESEM Image



Advantage of Using FESEM

TEM Image



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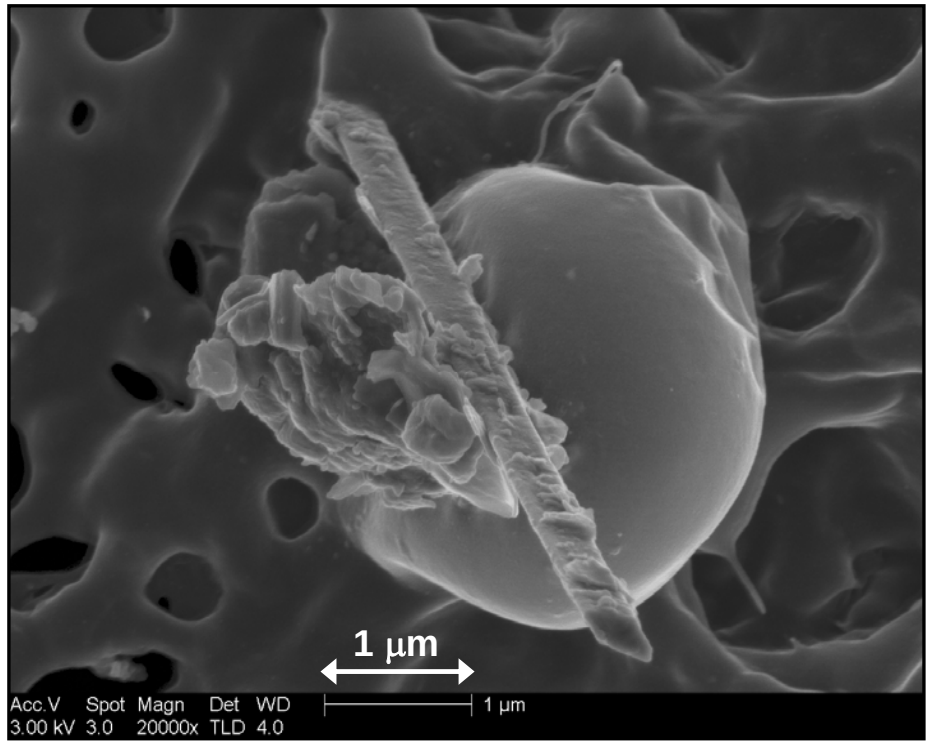

- **What appears to be a long, thin fiber in the TEM image is revealed in the FESEM image to be a prismatic particle coming out of the plane of the projection screen; the particle is clearly not asbestiform.**

Advantage of Using FESEM

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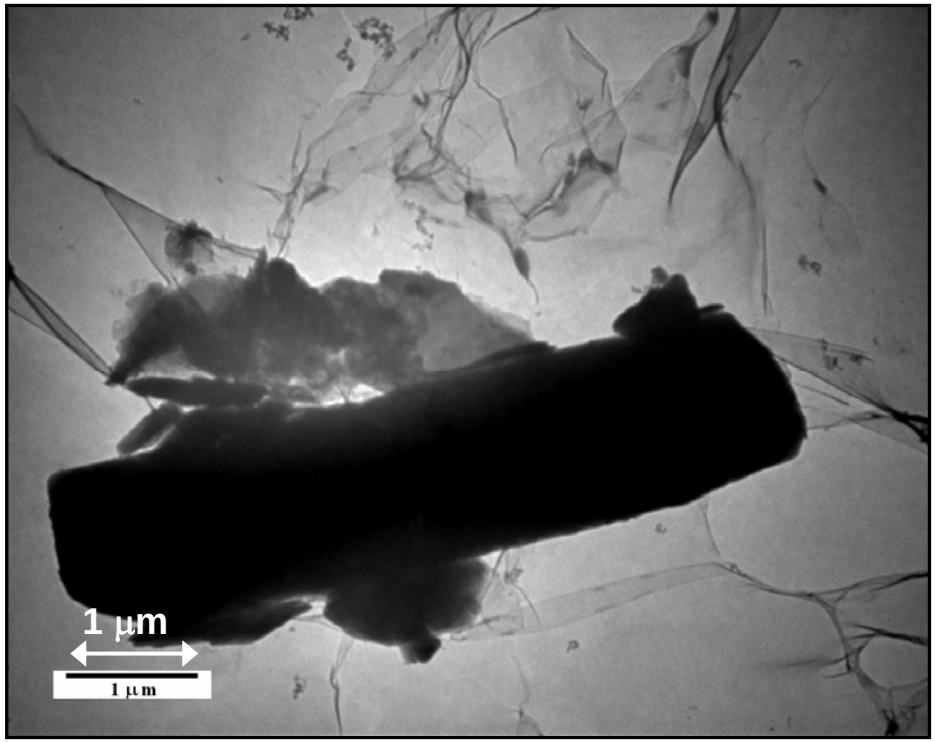

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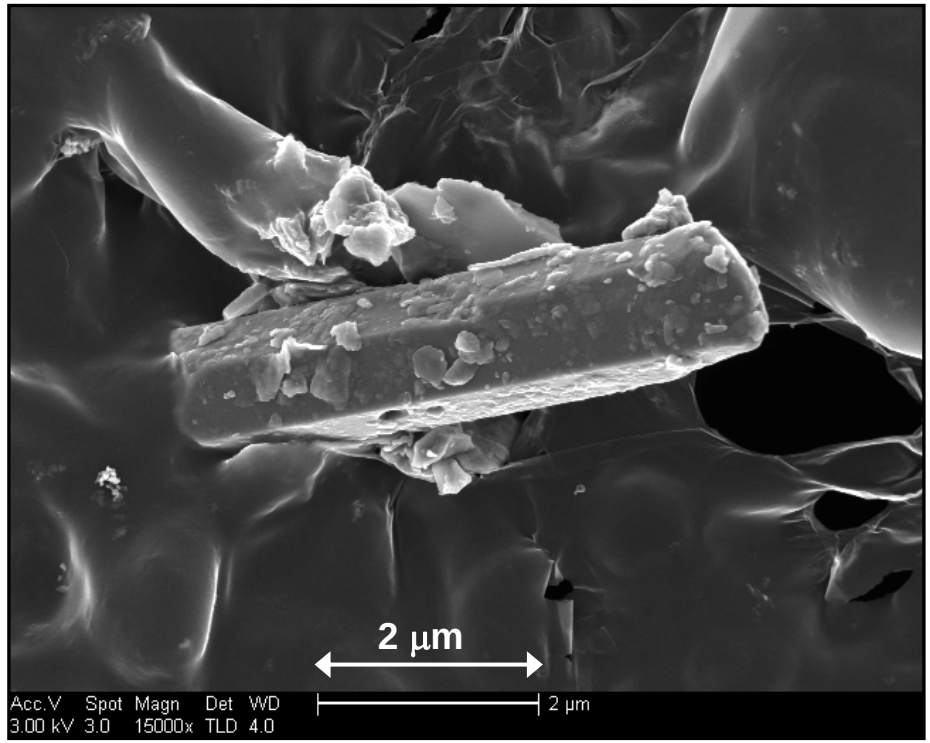

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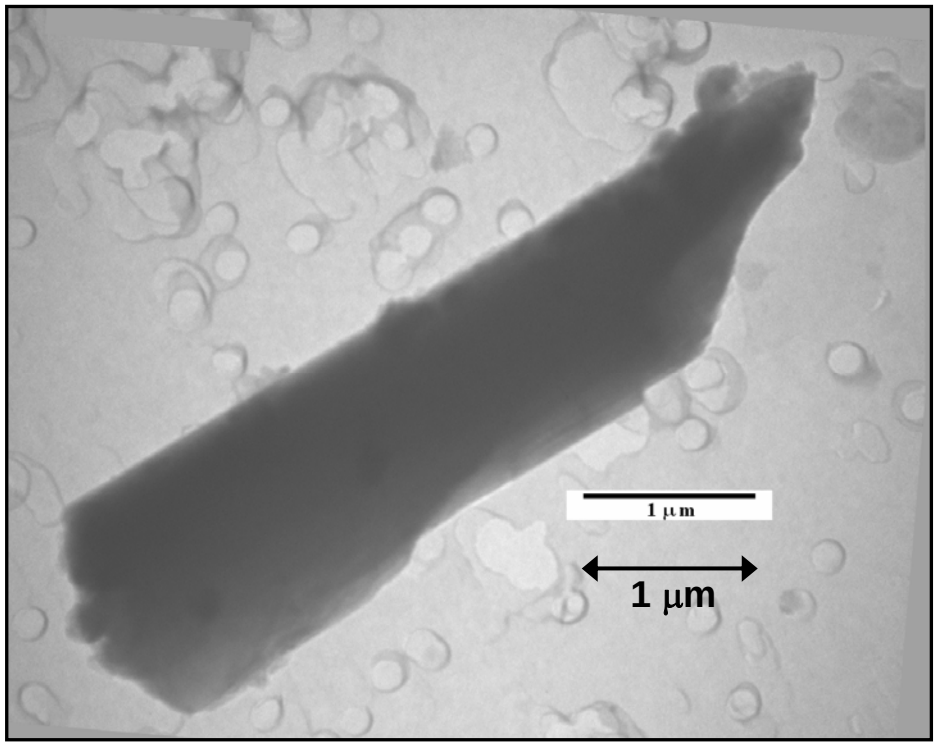

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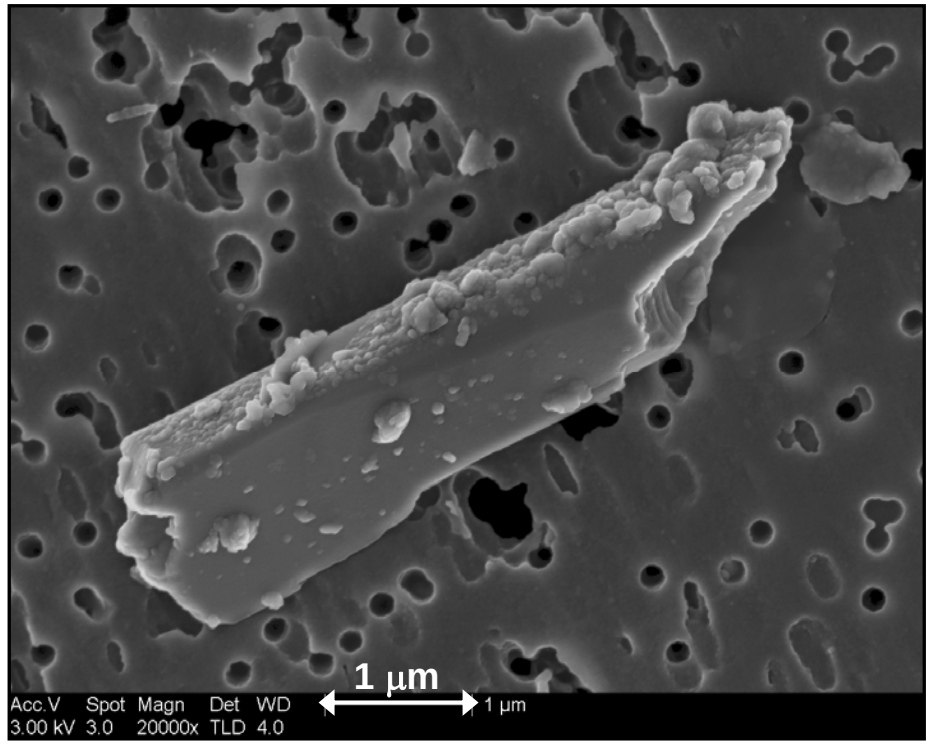

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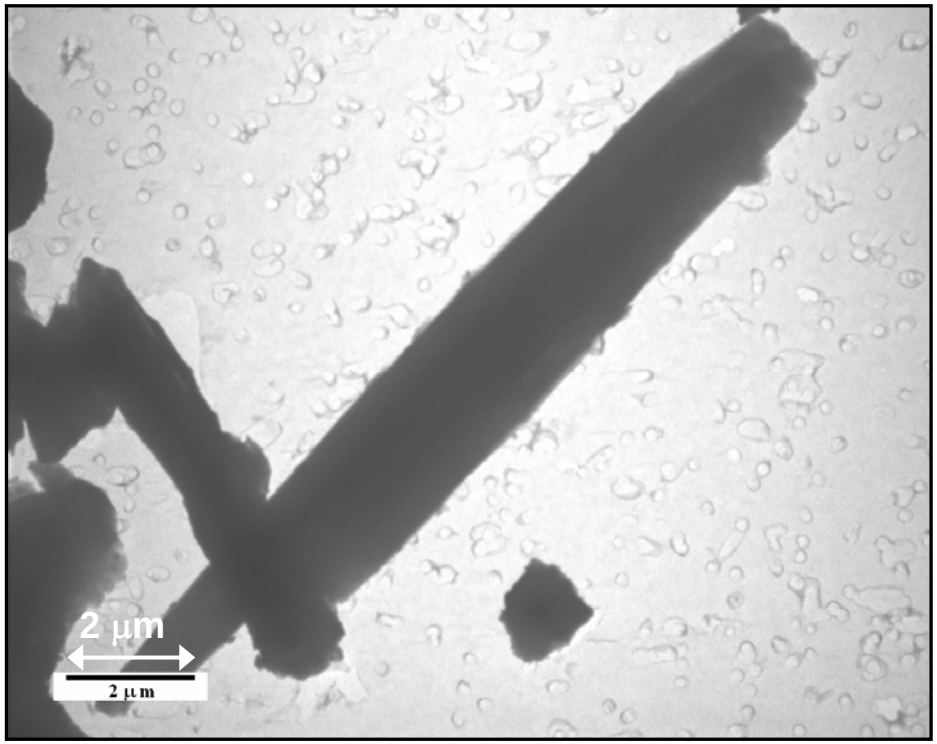

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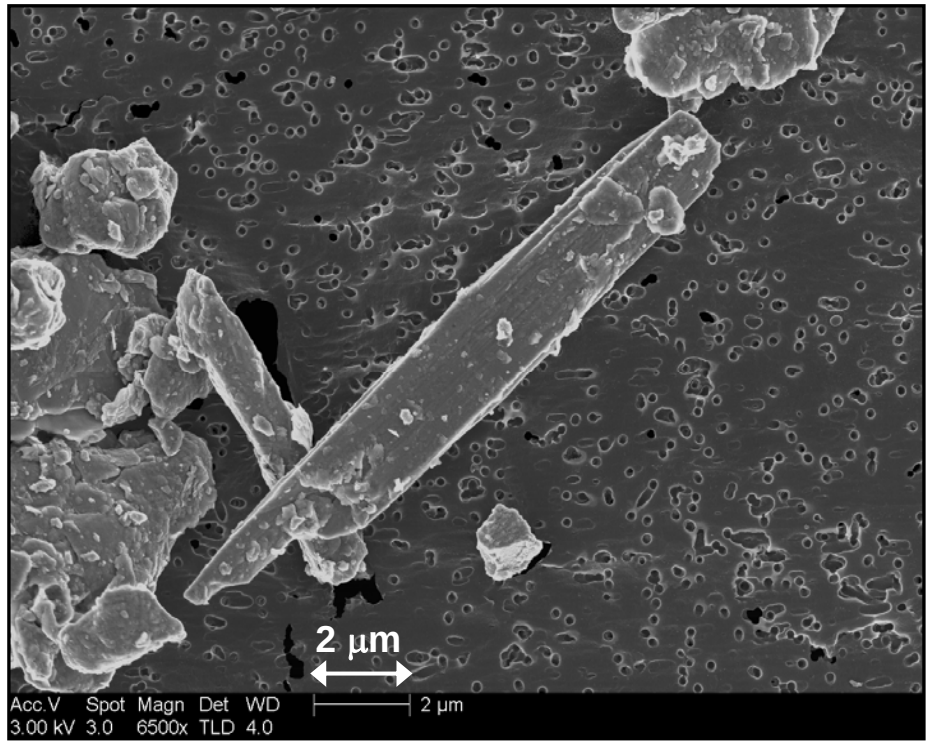

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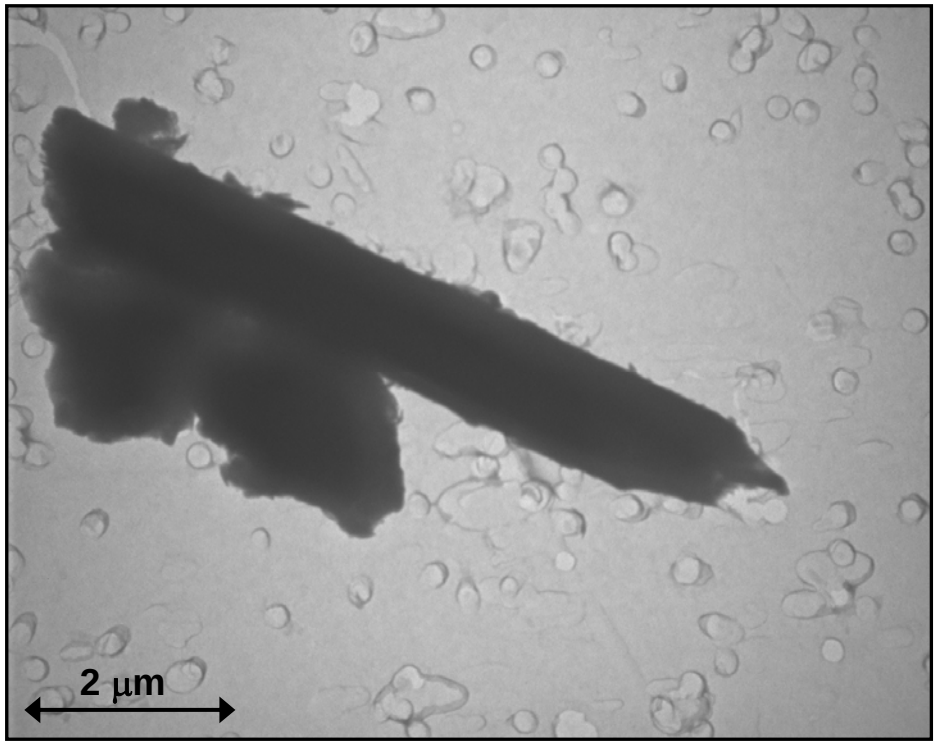

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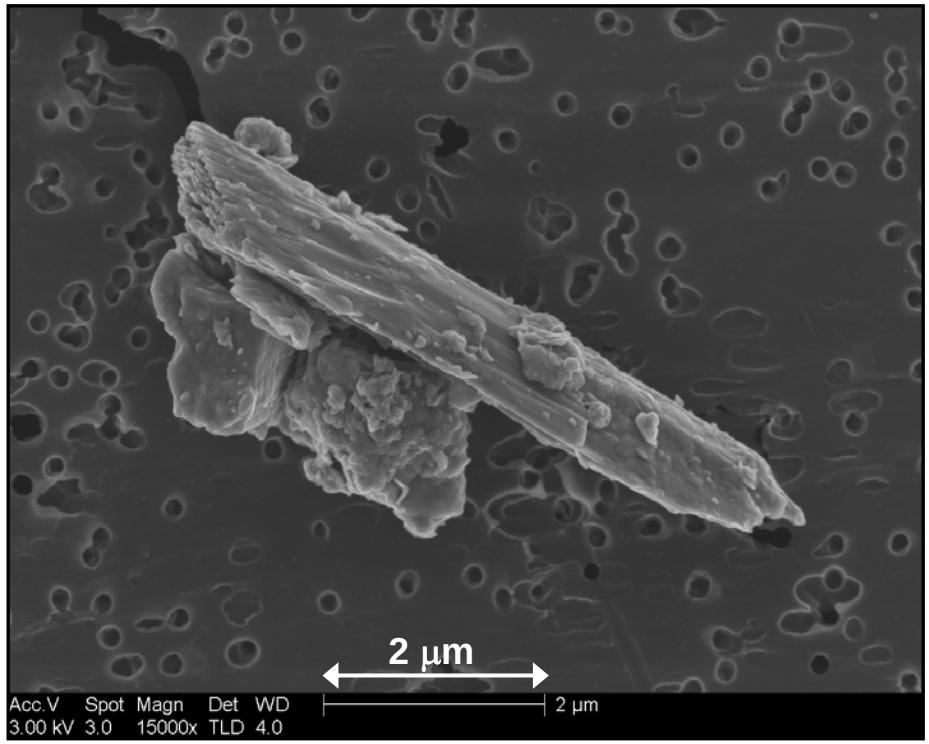

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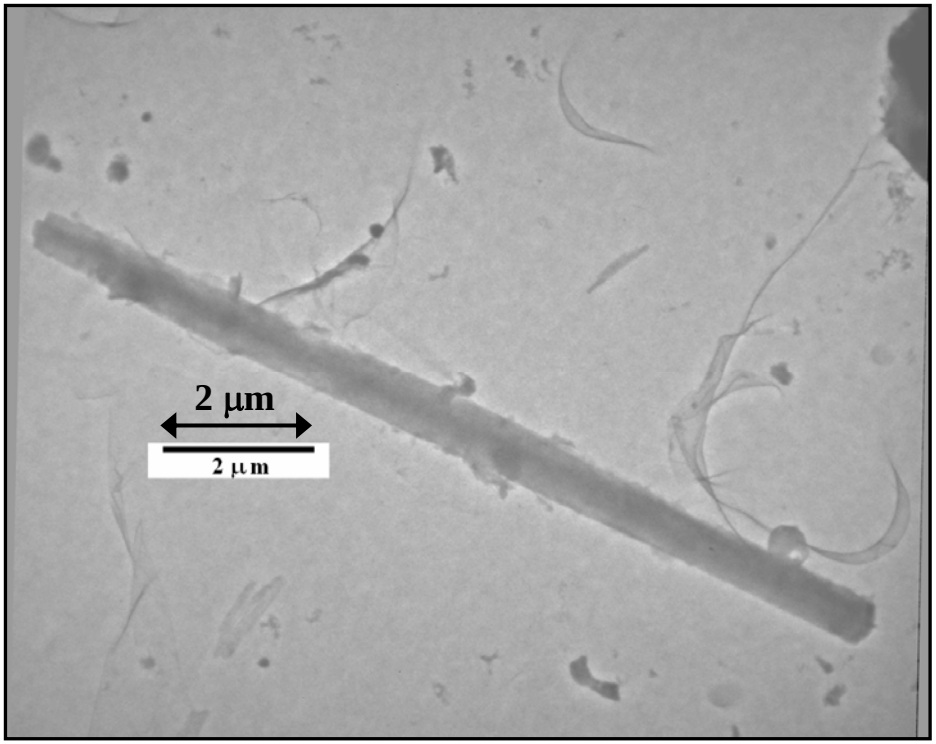
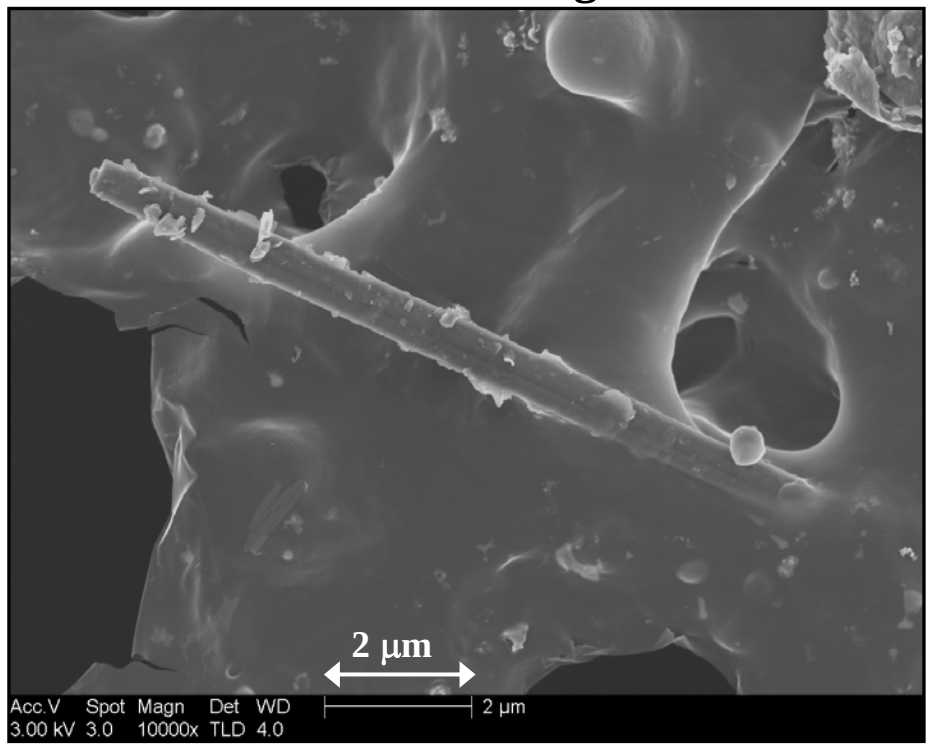


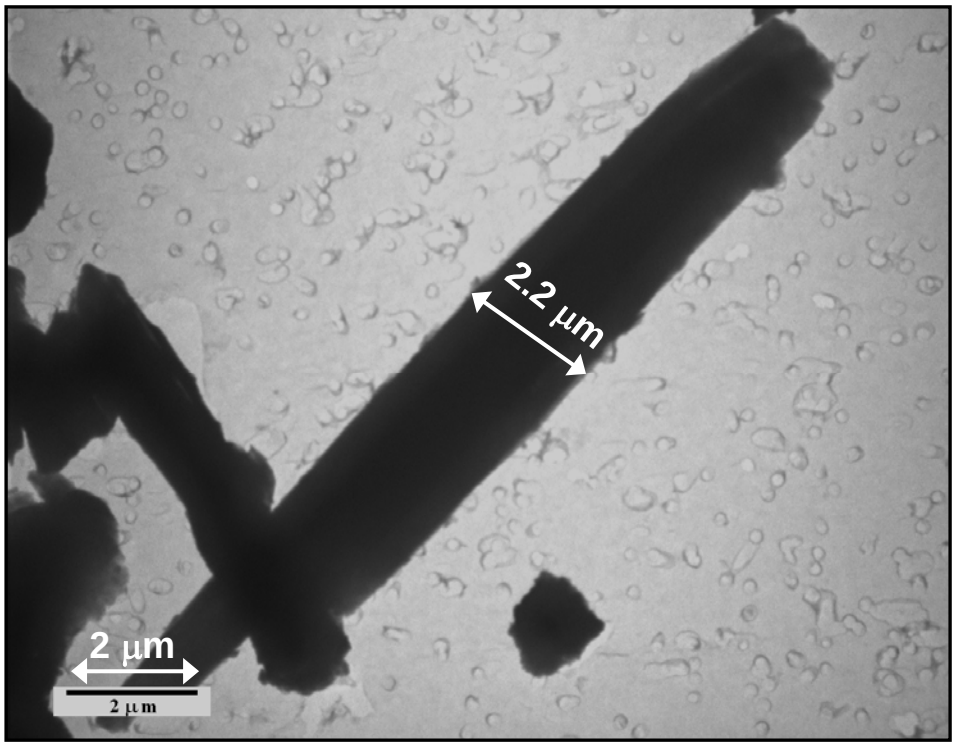
FESEM Image



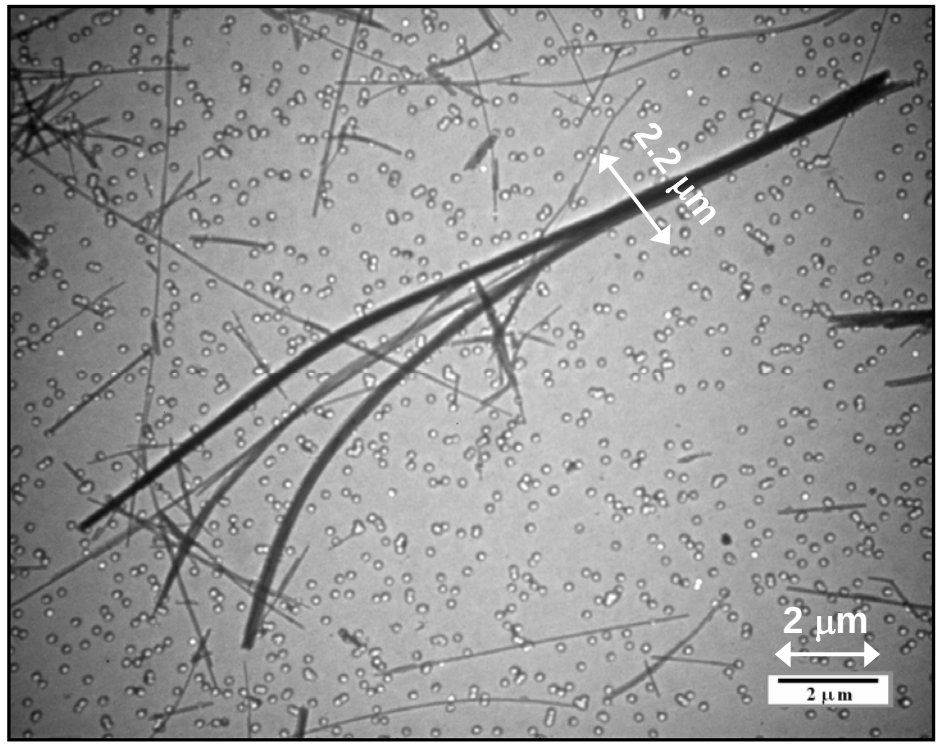
- **What appears to be a long, thin fiber in the TEM image is revealed in the FESEM image to be a particle coming out of the plane of the projection screen; the particle is clearly not asbestiform.**

Advantage of Using FESEM

TEM Image – Cleavage Fragment



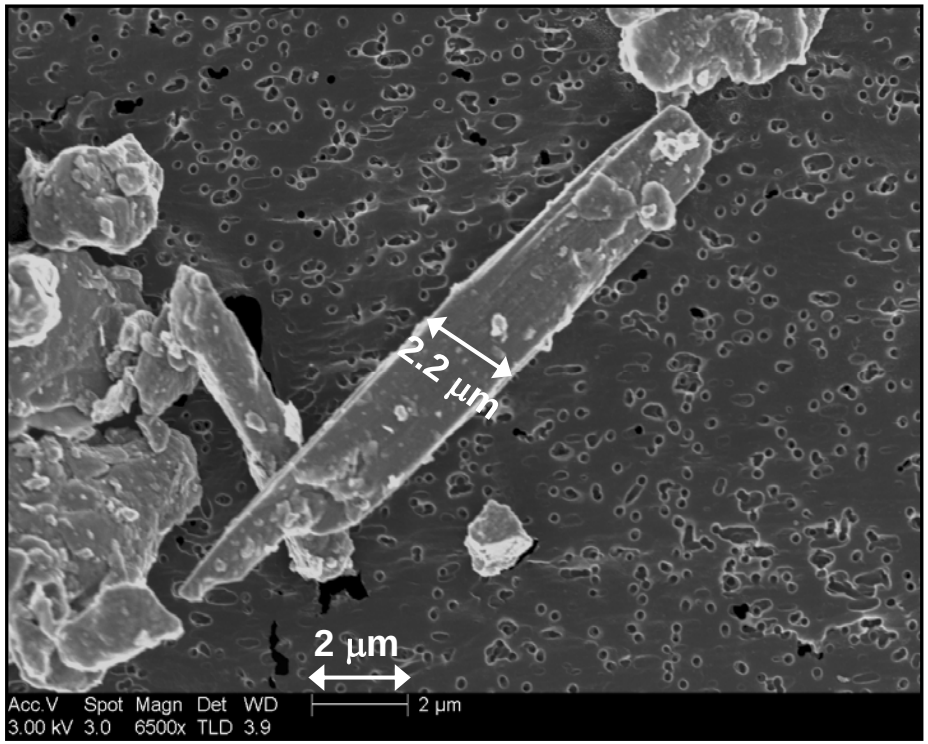
TEM Image – Chrysotile Bundle



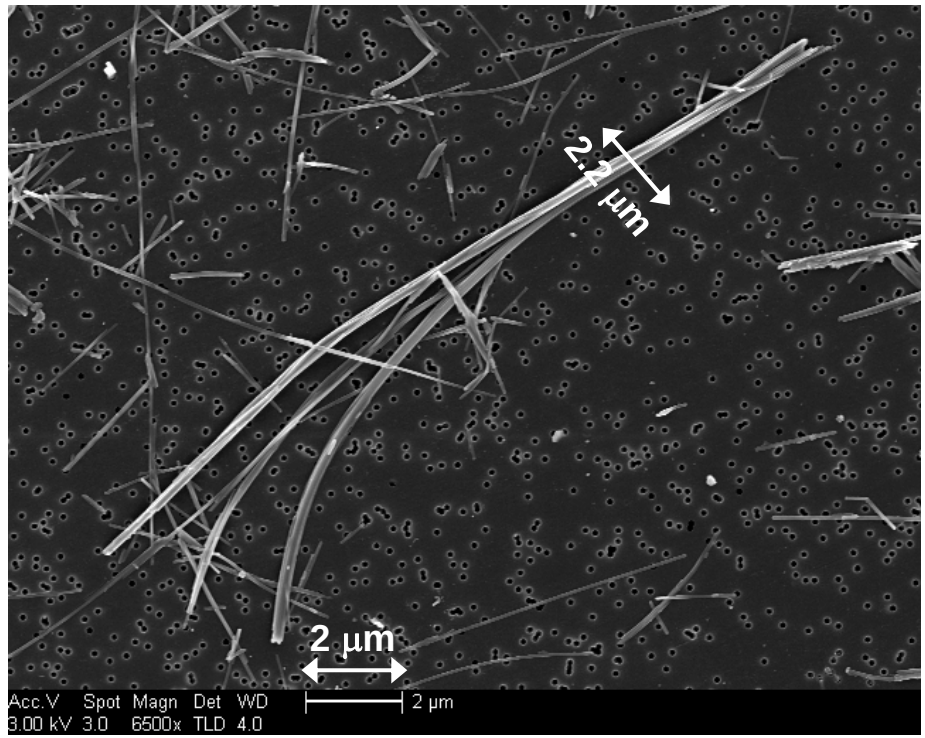
- **The concept that a significant portion of cleavage fragments have the same diameter as airborne asbestos fibers is a myth.**

Advantage of Using FESEM

FESEM Image – Cleavage Fragment



FESEM Image – Chrysotile Bundle



- **The concept that a significant portion of cleavage fragments have the same diameter as airborne asbestos fibers is a myth.**