Amphibole: Is it asbestos? Is it hazardous? How is it identified?

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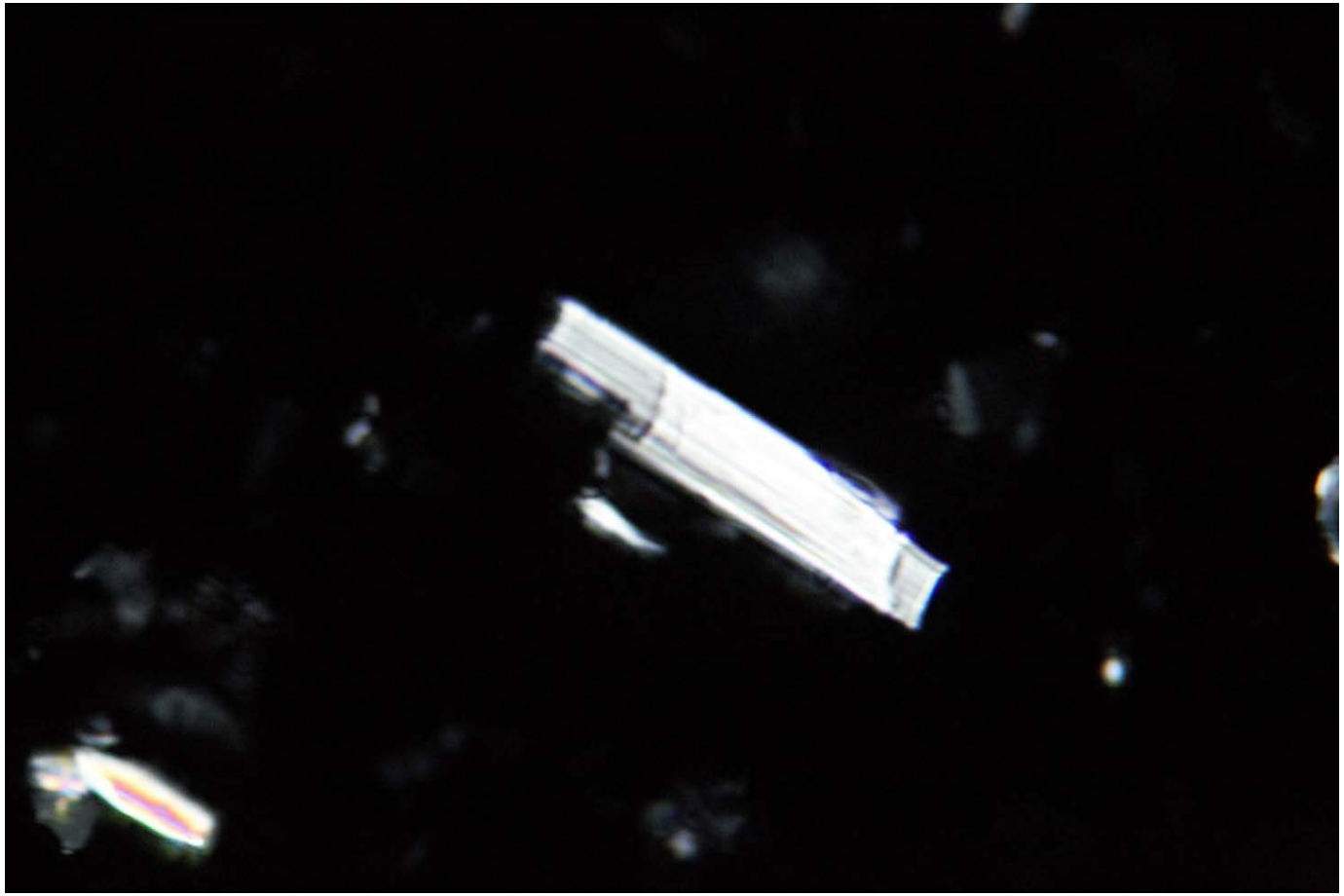
EMP characteristics known to influence development of asbestos-related disease

1. Dimension
2. Surface area
3. Chemical composition
4. Atomic structure

Tremolite in body powder

Tremolite in body powder: crossed polars



Tremolite-asbestos from Metsovo, Greece

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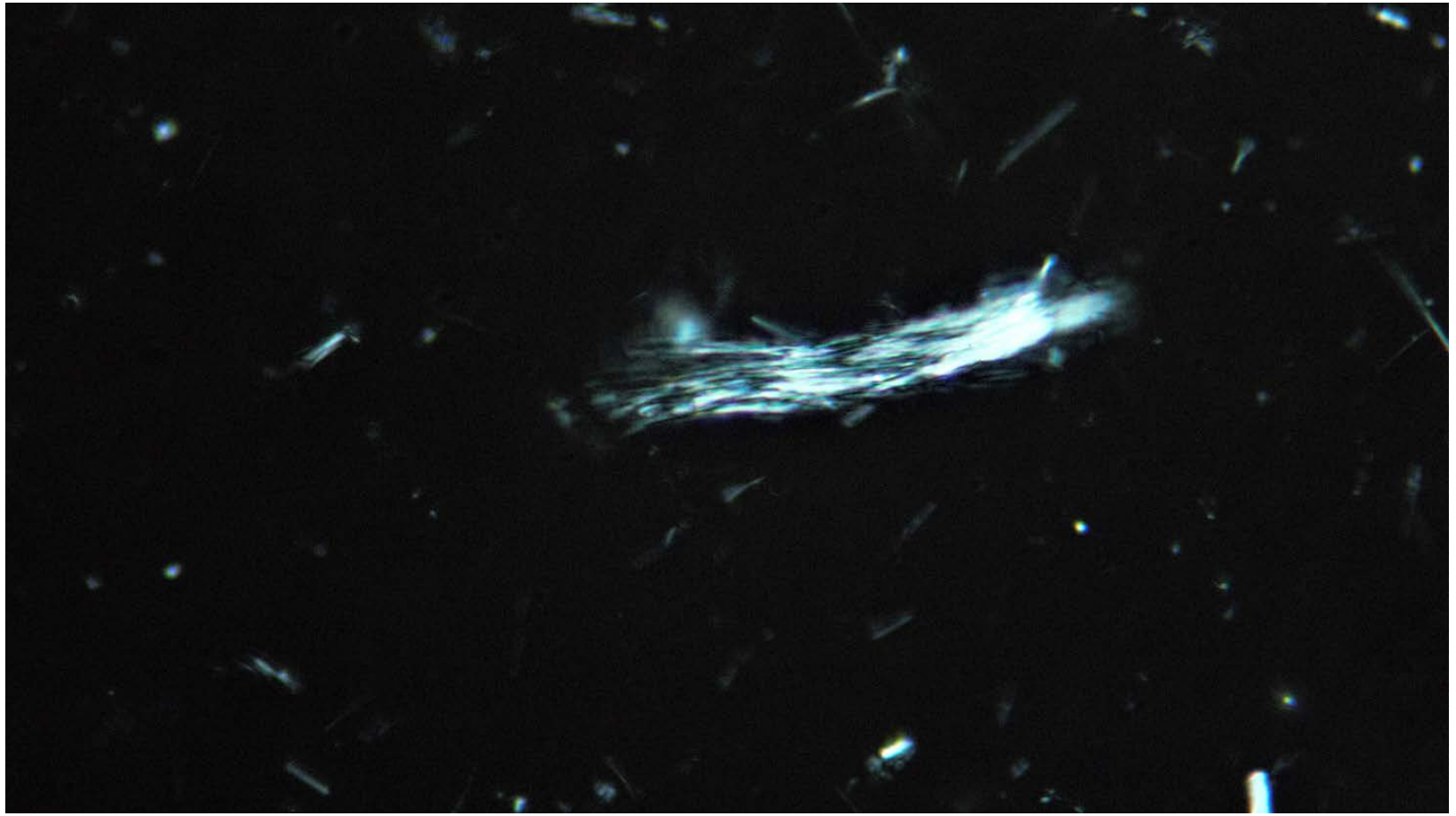


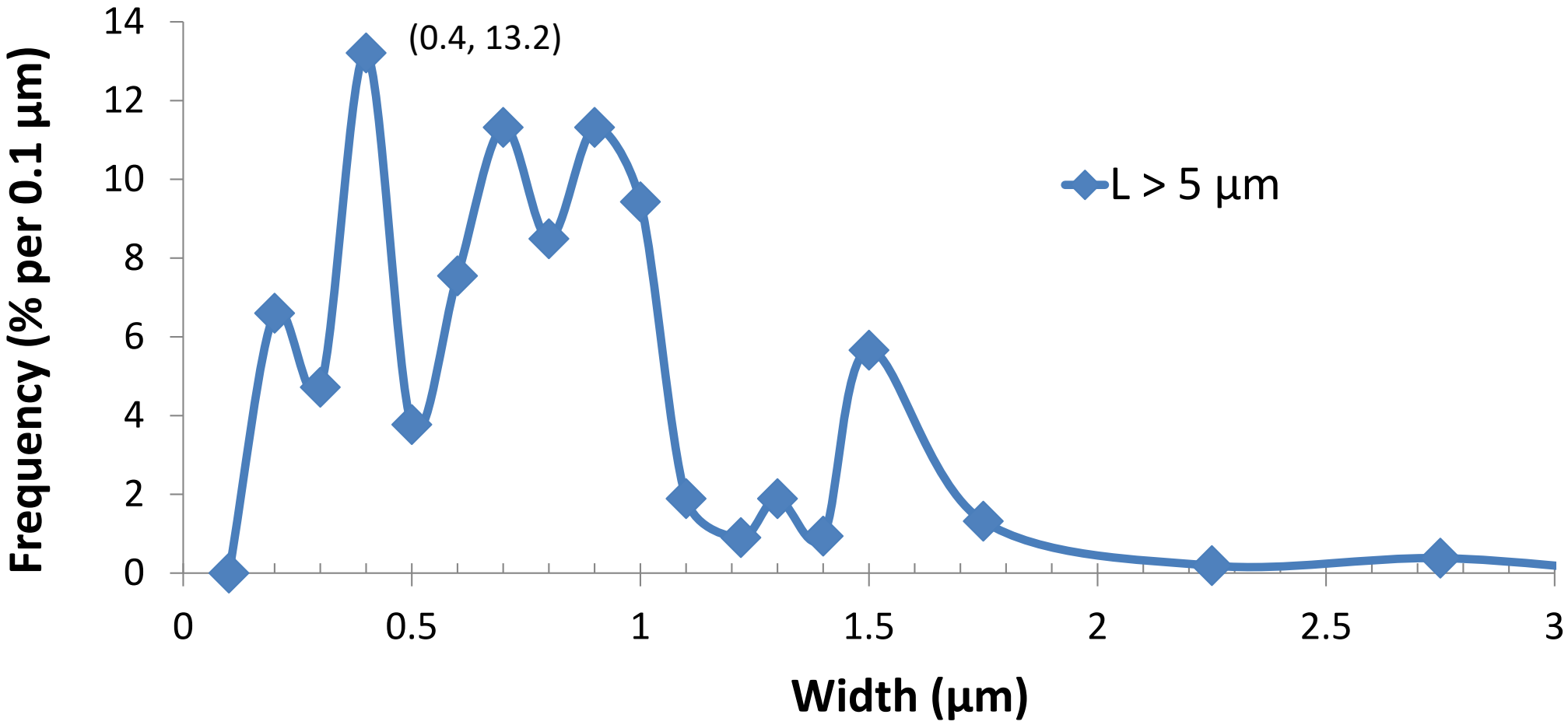
Width

- Epidemiological and experimental animal work have demonstrated that EMPs that cause asbestos-related diseases have very narrow widths.
- Narrow widths result in flexibility in fibers we call asbestos.
- Width and density control the aerodynamic behavior of fibers.
- Width controls the potential for deep penetration of the lung and pleura by EMPs.
- Migration through a fluid filled veins is influenced by width.

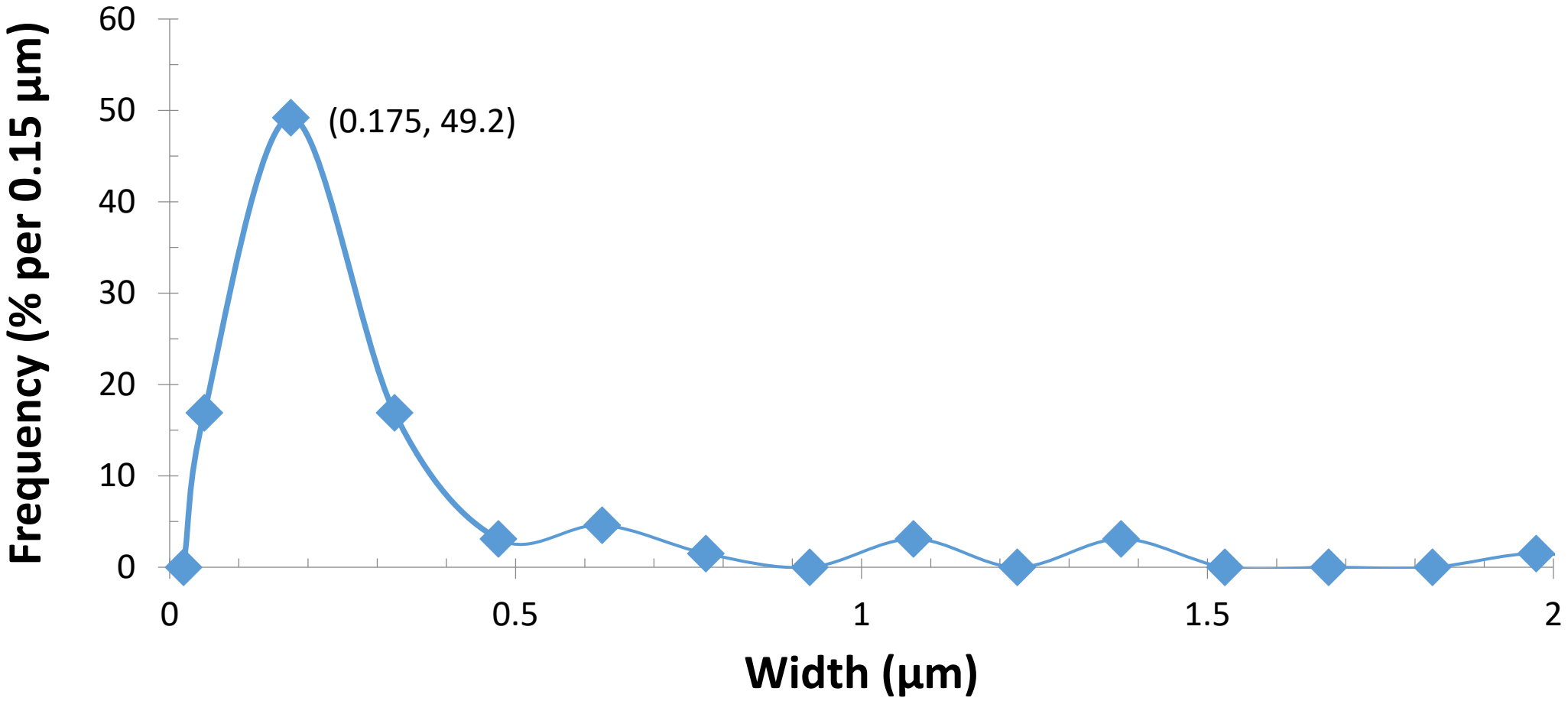
Length

- Epidemiological and experimental animal work have demonstrated that longer fibers are more carcinogenic, for example, fibers longer than 5μm (L5 EMPs)
- Lung burden studies of diseased patients find abundant L5 EMPs of asbestos.
- L5 EMPs of asbestos are retained preferentially in the lung.
- Occupational exposure is monitored by levels of L5 EMPs
- Aerosols of asbestos fiber are dominated by shorter fibers.
- The width characteristics of L5 and <L5 should be treated separately.

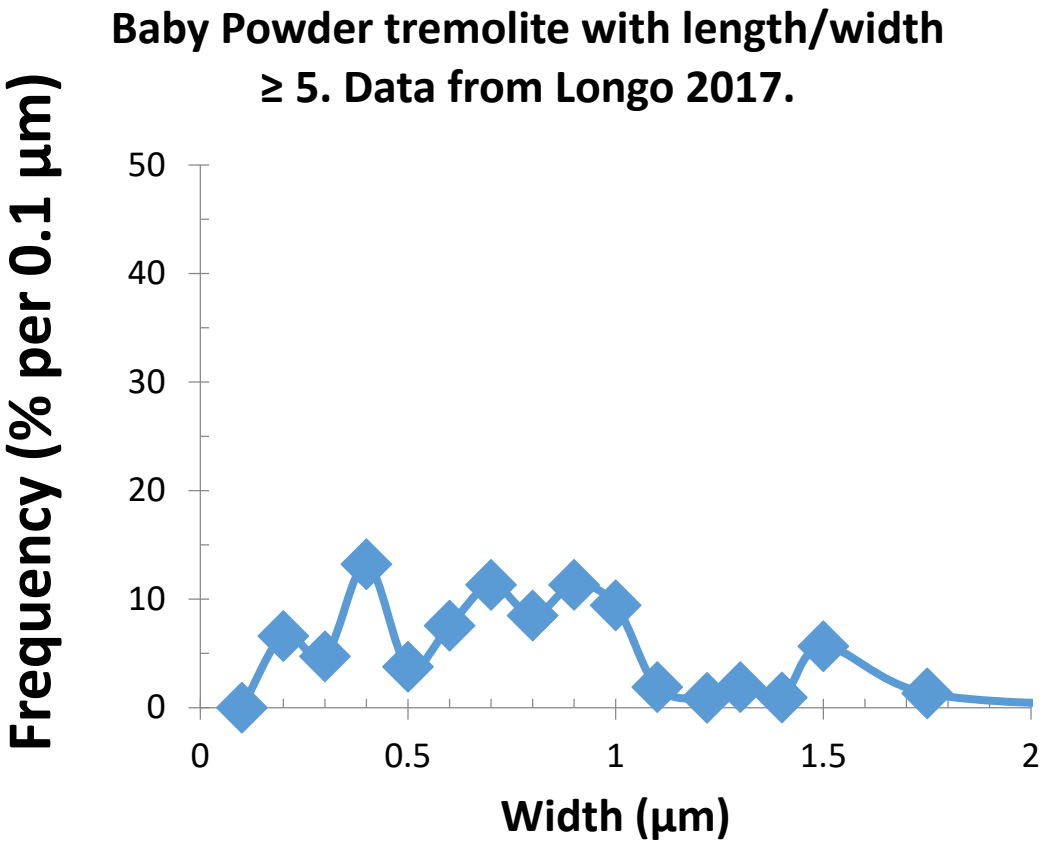
Tremolite L5 EMP in body powder (data from Longo 2017)

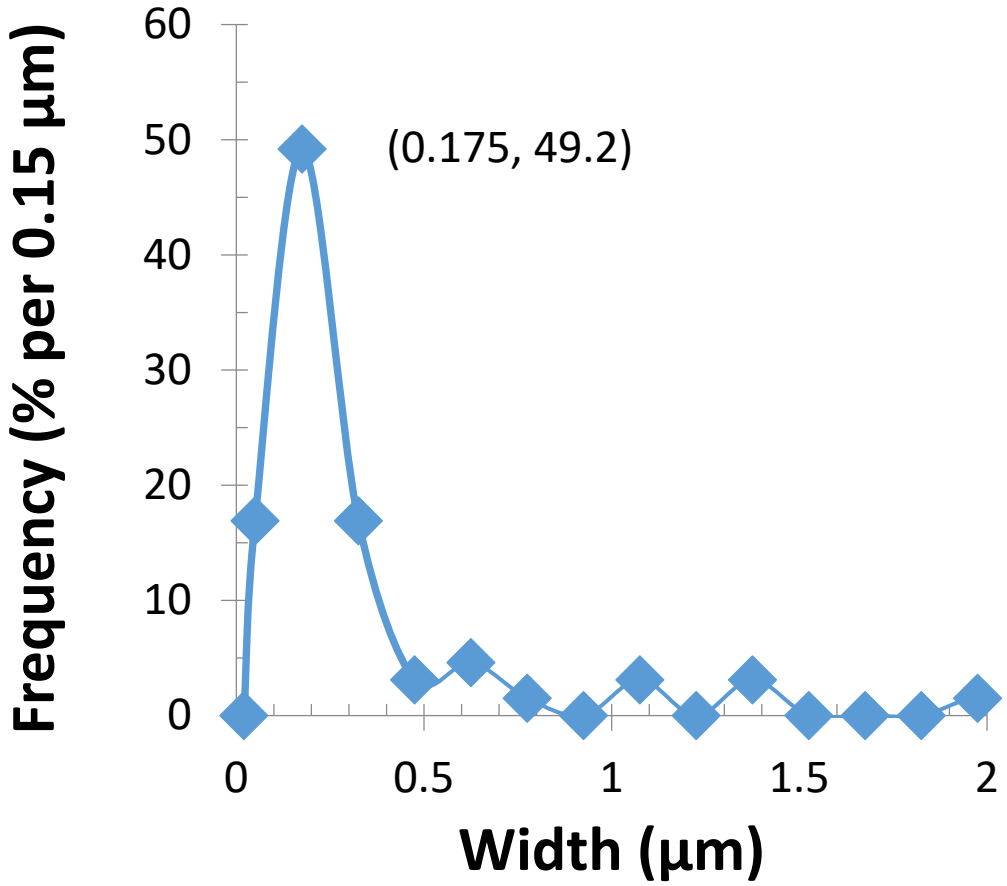


Width frequency of tremolite-asbestos L5 EMP from Metsovo, Greece (Segrave)

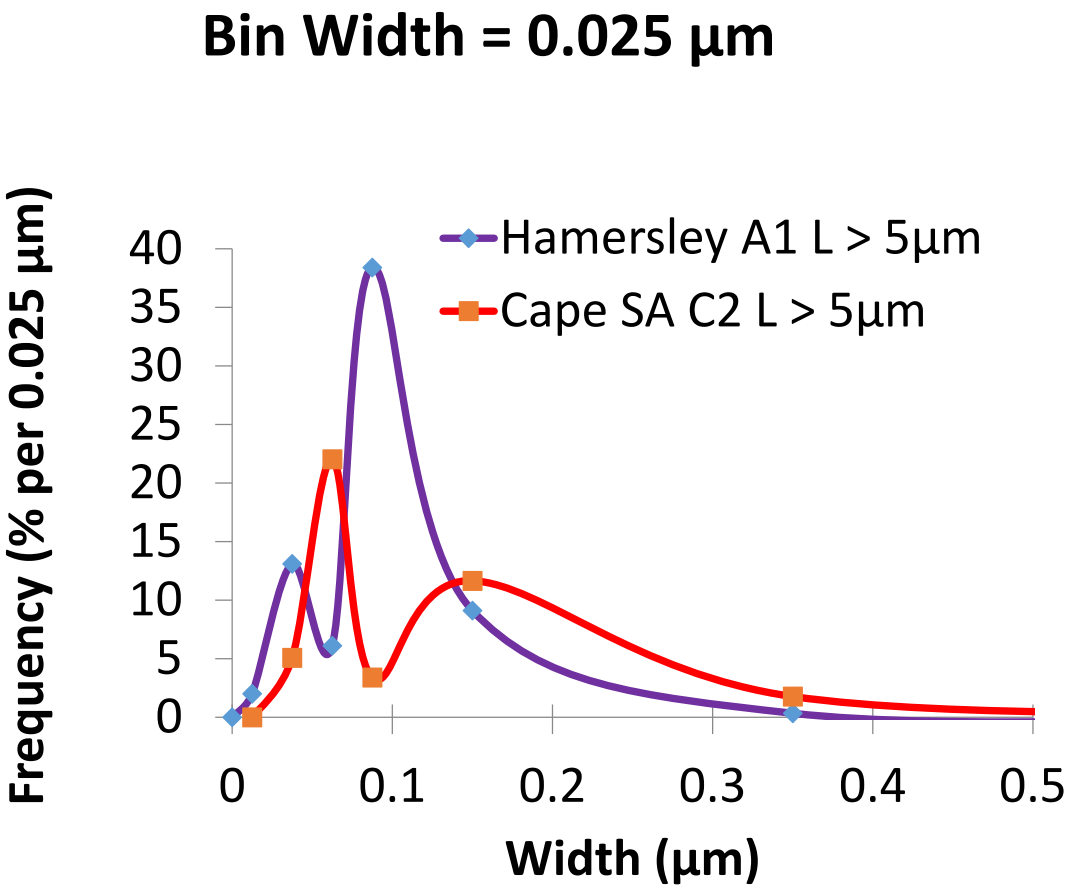


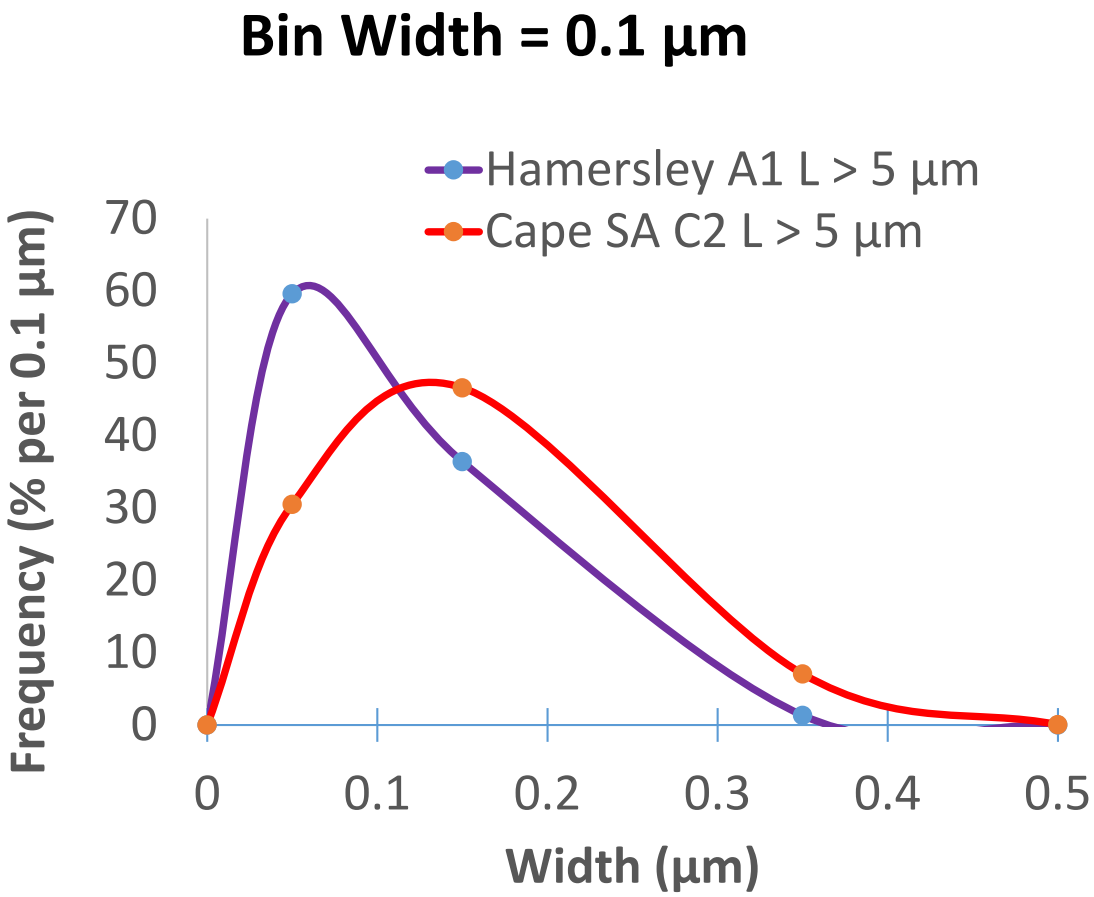
Body Powder tremolite (Longo) vs Metsovo tremolite-asbestos (Segrave) : L5 EMPs



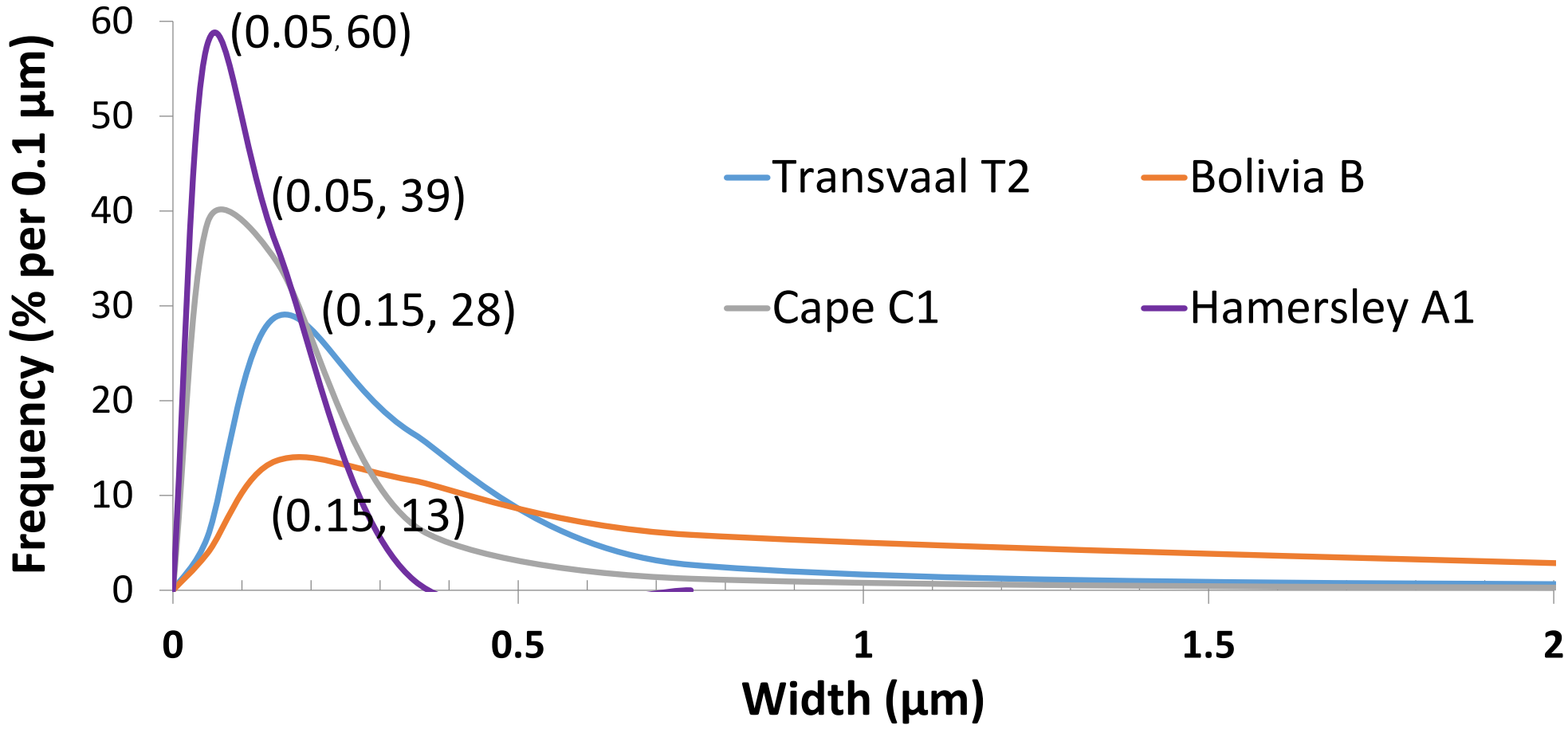


What is the width of crocidolite? (Data from Shedd 1985)

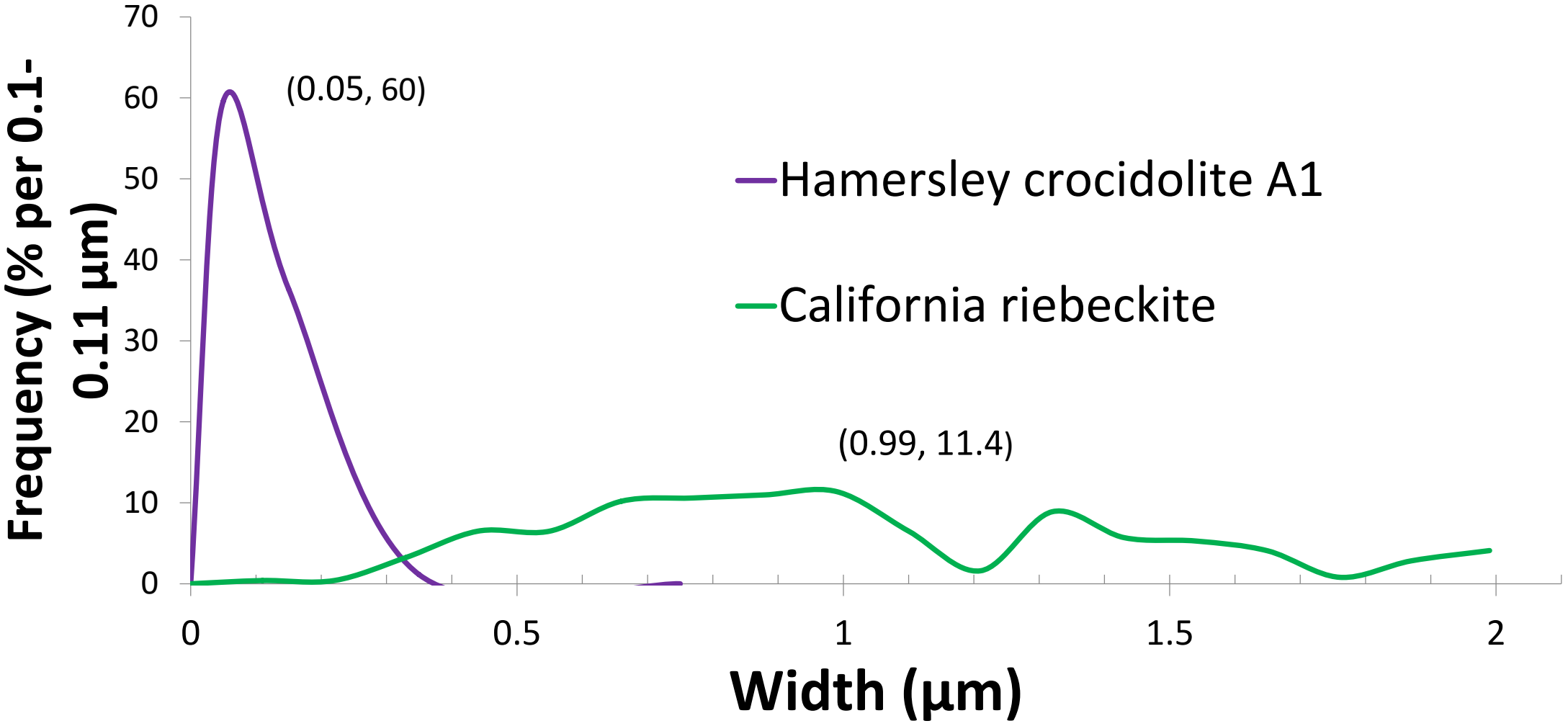




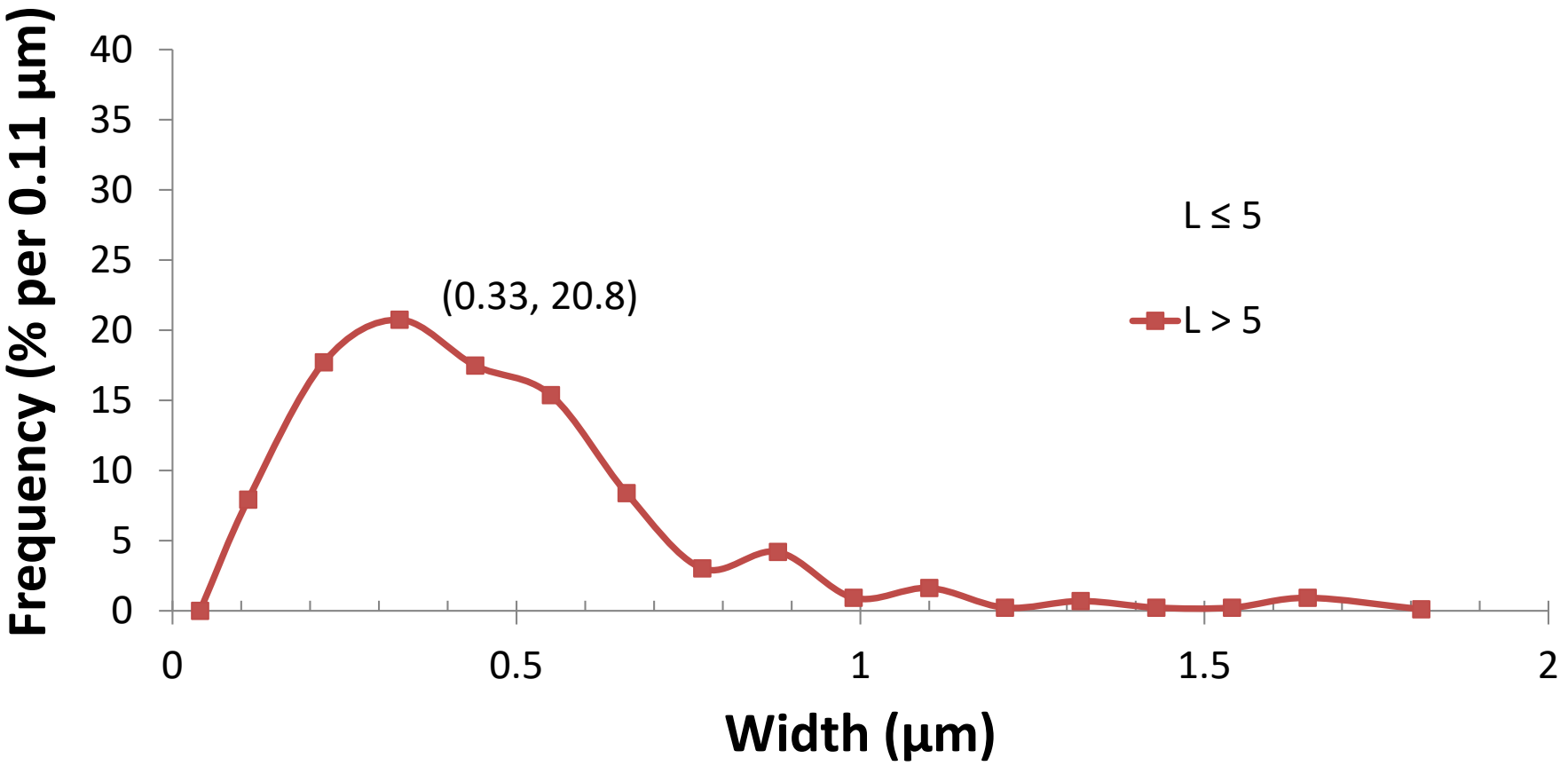
Mineral specific asbestos varies widely: The case of crocidolite EMP L > 5 µm (data from Shedd 1985)



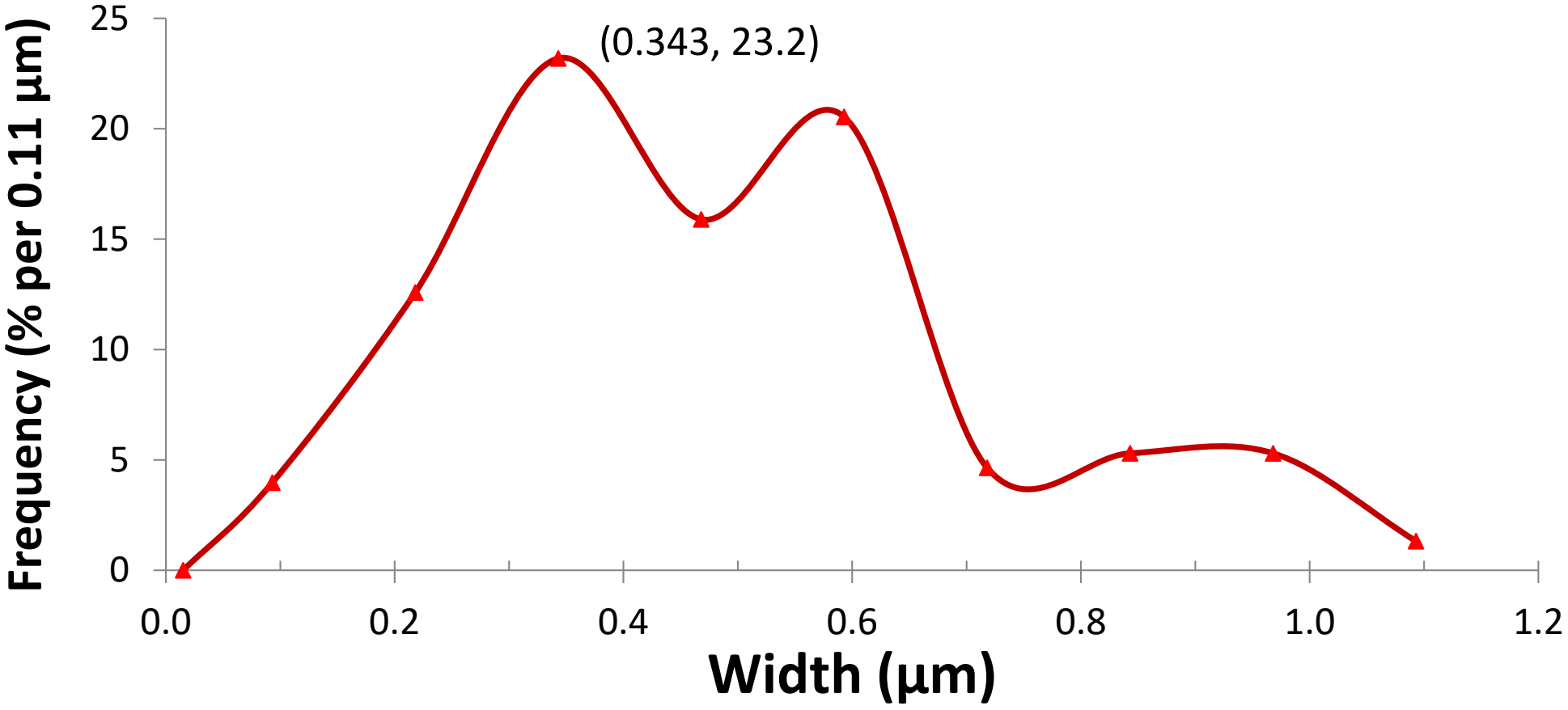
Width variation among L5 EMP riebeckite of different habits



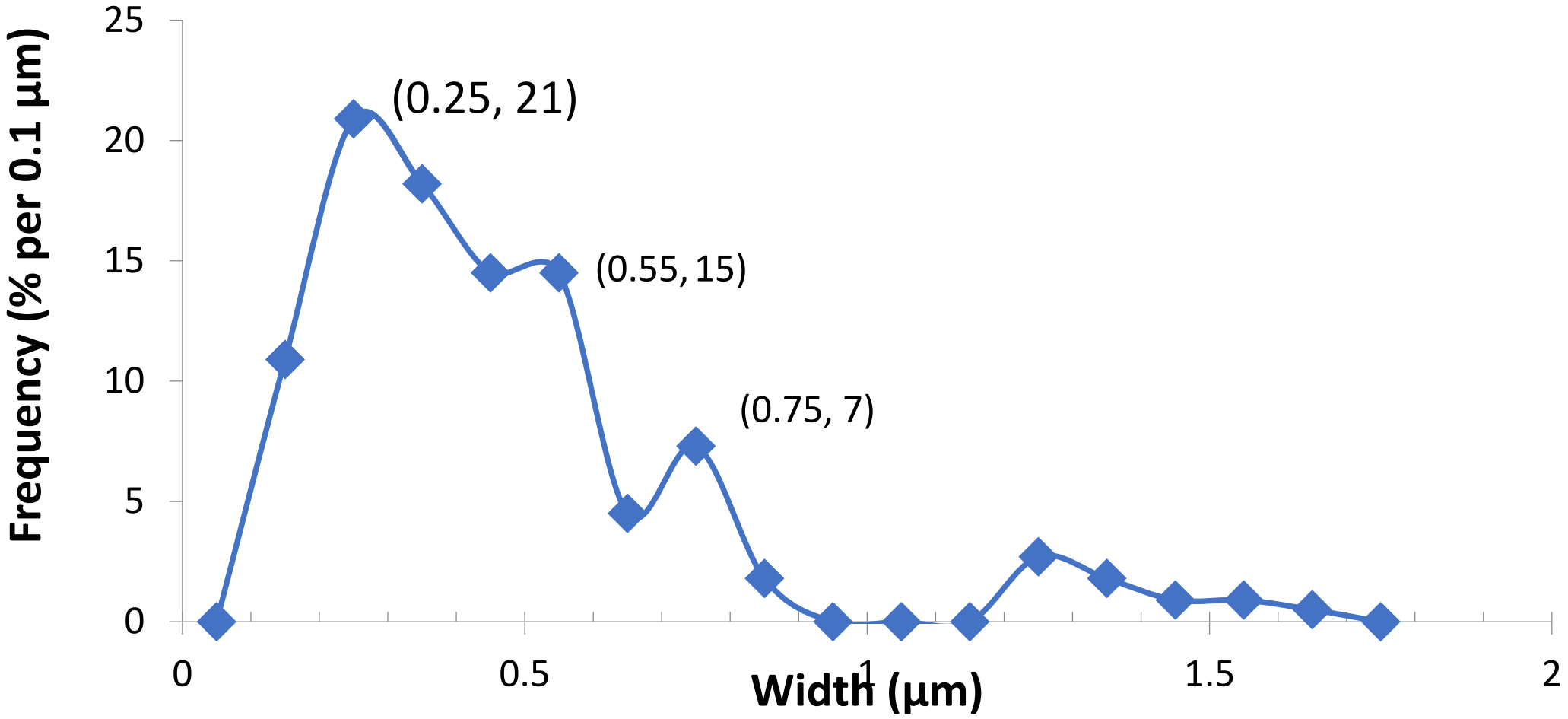
Airborne Amosite L5 EMP from occupational monitoring of shipyard.



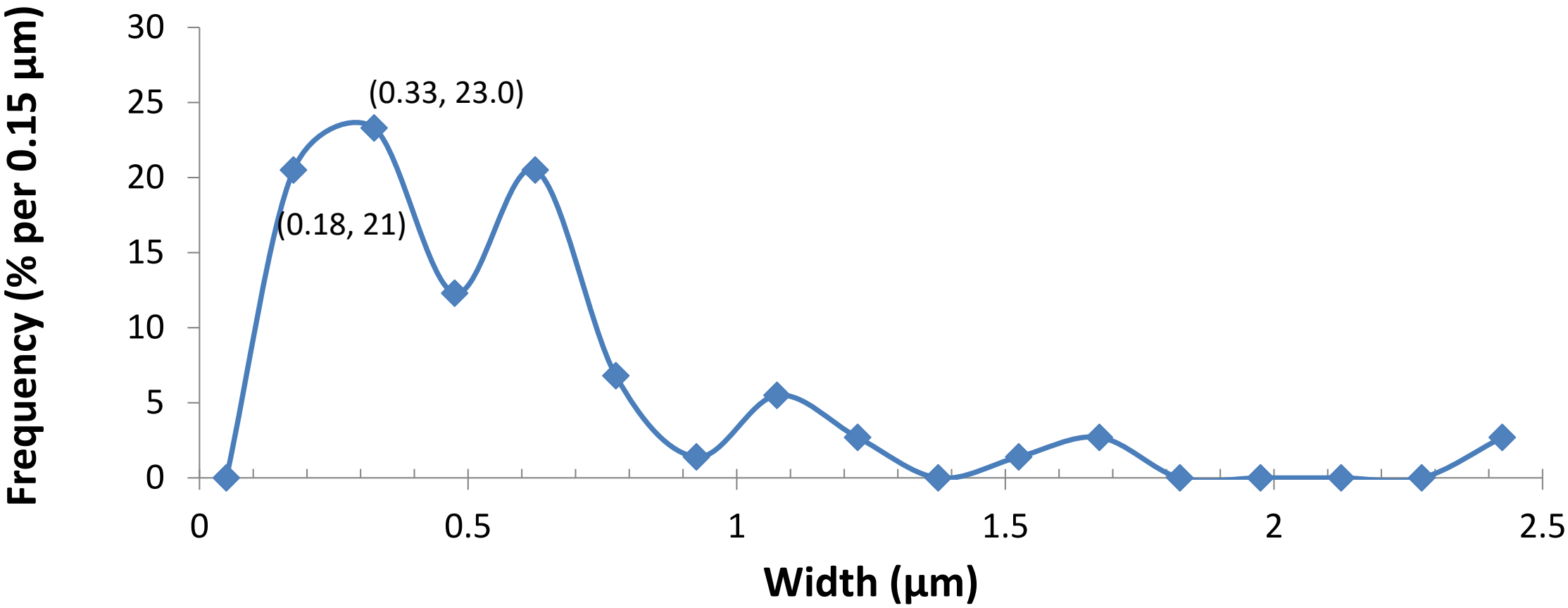
Width frequency of L5 EMP winchite- and richterite-asbestos from mine and mill products, Libby, MT (MRI, 1980)



Width frequency of fluoro-edenite L5 EMP from Biancavilla air (data from Paoletti and Bruni 2009)



Width frequency of anthophyllite-asbestos L5 EMP from Paakkila, Finland (Segrave)



Mesothelioma Mortality

- Most studies are of individuals exposed to many types of asbestos.
- Estimates of Rmeso (% of all expected deaths per fiber(L5 EMP) /cc-year) for crocidolite and amosite were published by Hodgson and Darnton in 2000.
- Garabrant and Pastula (2018) have published an update, and added, among others, the mining populations at Homestake, SD, and Libby, MT.
- Additional studies are becoming available

For the same occupational exposure mesothelioma mortality varies by asbestos type and occurrence

Fiber dimension

Fiber durability

Fiber chemical composition

Some other yet unrecognized property

% total expected mortality due to mesothelioma per fiber (L5 EMP)/cc-year of exposure (Garabrant and Pastula 2018)

Asbestos type and location	*Rmeso (%)*
• Overall crocidolite, Cape SA and Hamersley AU	**0.451**(0.397-0.510)
• Overall amosite, Transvaal SA	**0.0987**(0.062-0.147)
• Winchite- and richterite-asbestos, vermiculite workers, Libby MT	**0.028**(0.016-0.047)
• Overall chrysotile	**0.0012**(0.0009-0.0016)
• Fragmented grunerite, Homestake Gold Mine, Lead South Dakota	**no excess disease**

Toward a metrological index for the toxicity of durable mineral fiber

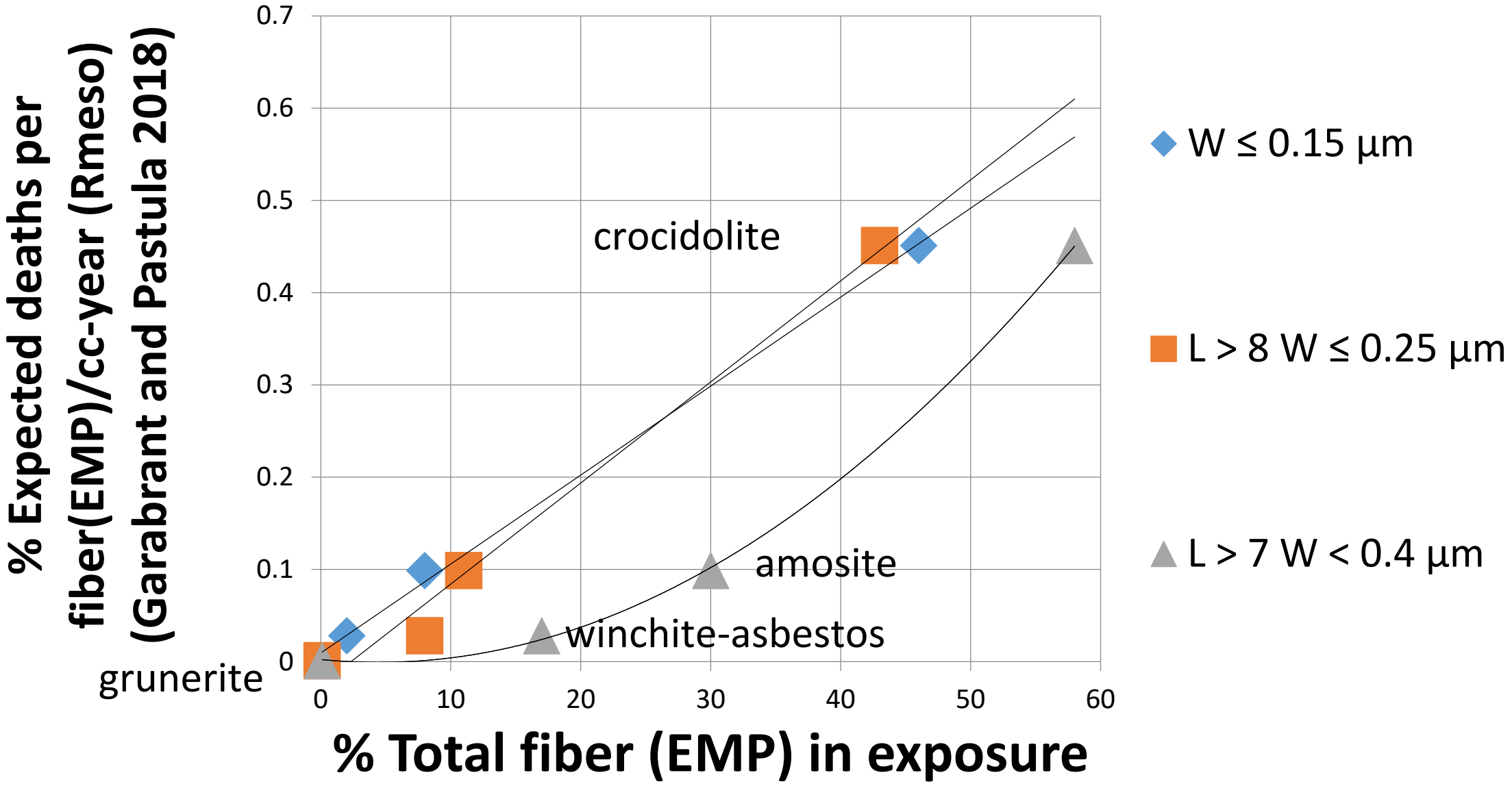
1. % of the L5 EMPs that have a width equal to or less than 0.15 µm

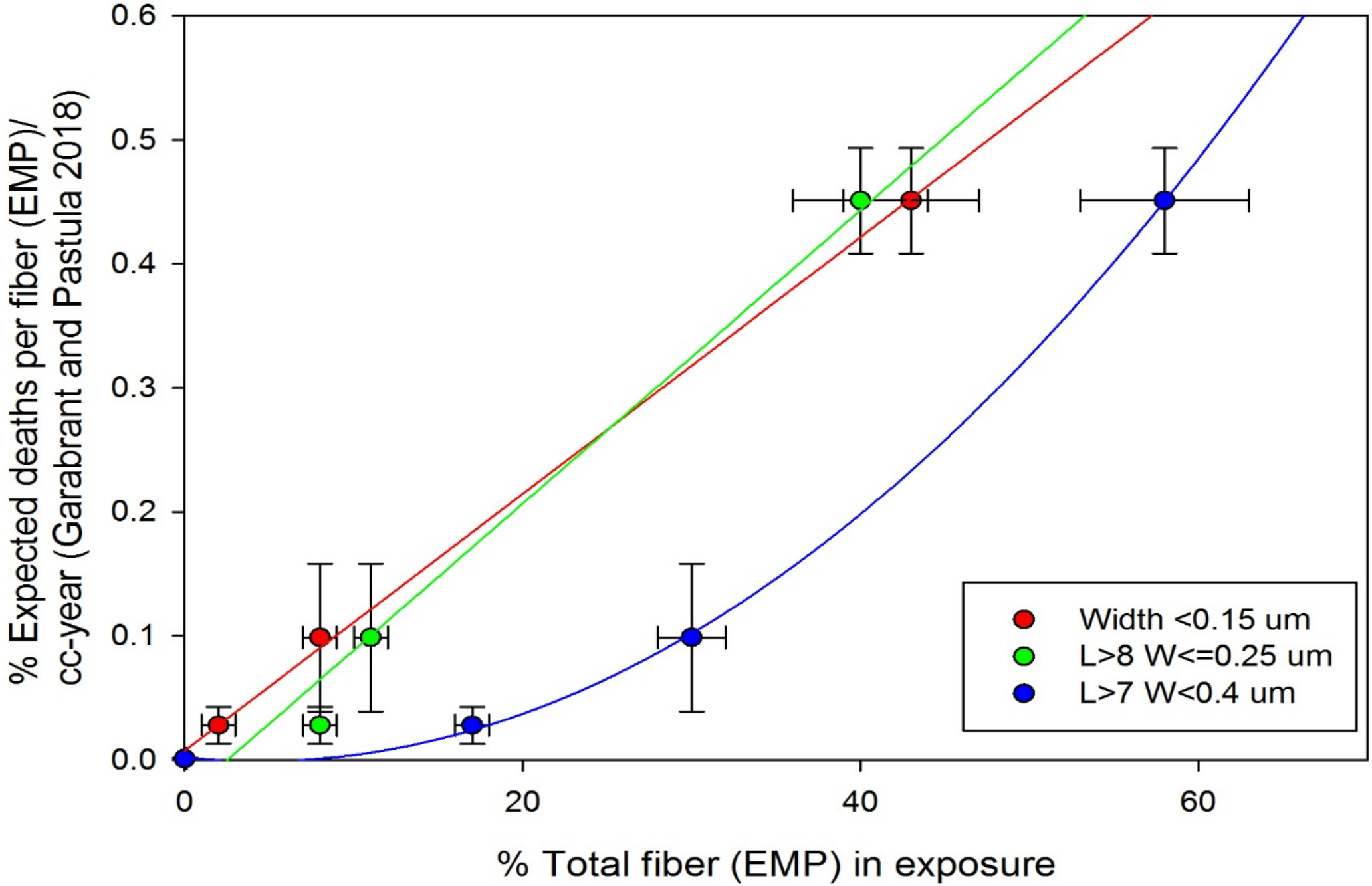
2. % of L5 EMPs that are also longer than 8 µm and have a width equal to or less than 0.25 µm.

3. % of L5-EMPs that are also longer than 7 µm and have w < 0.40 µm

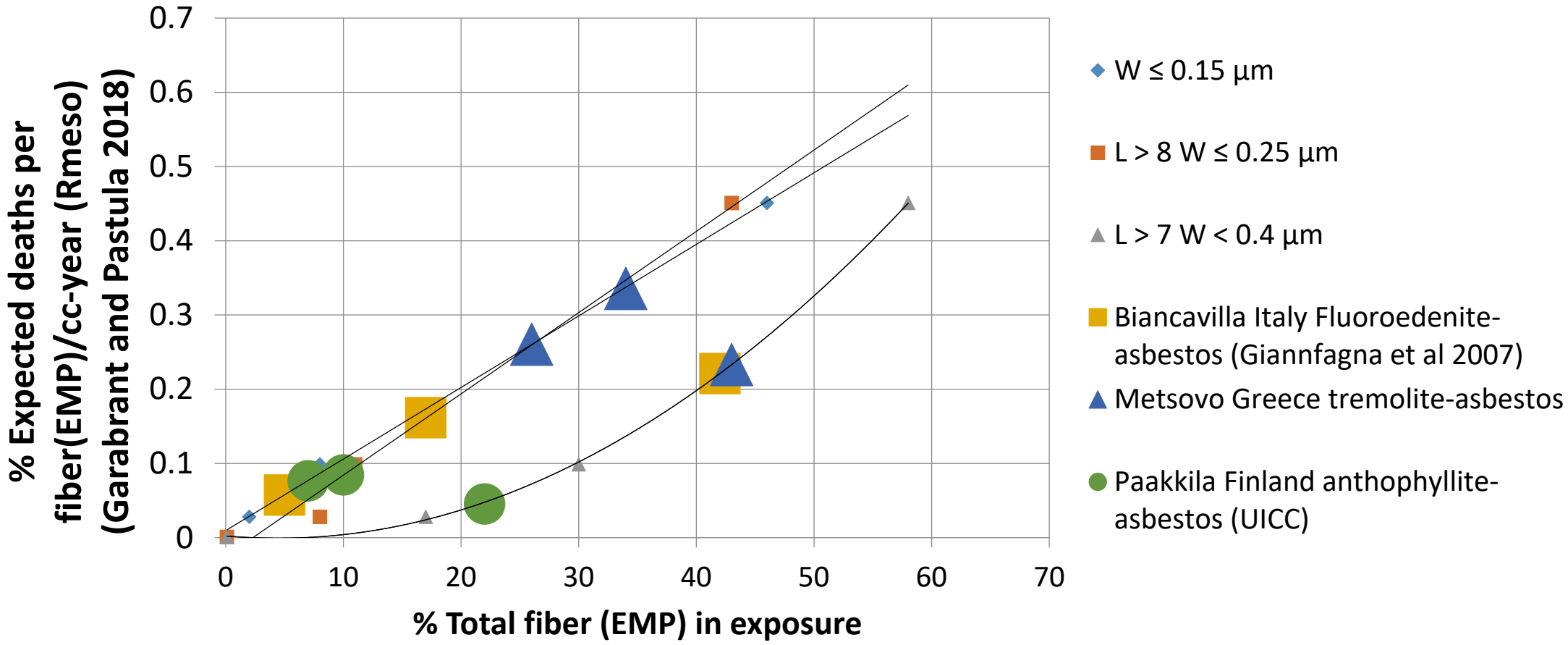
- Others?

Modeling amphibole potency




% Expected deaths per fiber (EMP)/
cc-year (Garabrant and Pastula 2018)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
% Total fiber (EMP) in exposure
Width <0.15 um
L>8 W<=0.25 um
L>7 W<0.4 um

Predicting Amphibole Potency



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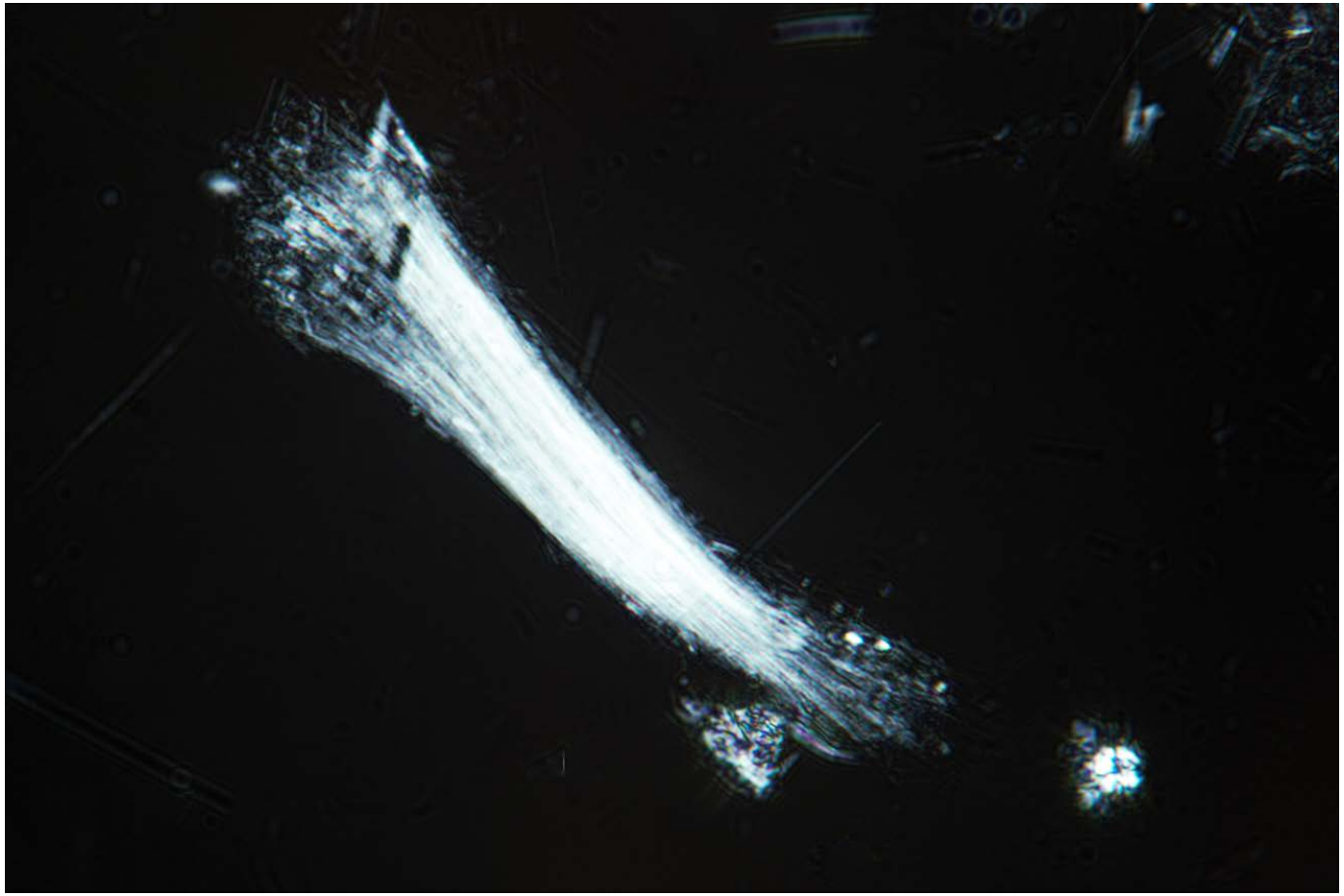


Tremolite cleavage fragment from body powder

Analysis issues in cosmetic talc

1. Is the amphibole found in talc asbestos?

2. Does the talc contain chrysotile?

3. Distinguishing anthophyllite asbestos from fibrous talc

Analysis Issues in Cosmetic Talc (cont.)

Is the amphibole asbestiform?

- Polarized light microscopy: are there fiber bundles?
  - Large particle size (75µm)
  - High tensile strength enhances fiber length and bundle formation
- If measurements of individual EMPs are made only by EM:
  - Would 1% or more of the L5 EMPs have $W \leq 0.15$ µm?
  - Would 5% or more of L5 EMPs have $L > 8$ and $W < 0.25$ µm?
  - Would 10% or more L5 EMPs have $L > 7$ and $W < 0.4$µm?

Analysis Issues in Cosmetic Talc (cont.)

- Is there chrysotile in talc?
  - Is serpentine found in the talc?
  - Is chrysotile evident by light microscopy?
  - Has TEM found evidence of chrysotile?

Fibrous talc is not anthophyllite-asbestos

Analysis issues in cosmetic talc (cont.)

Distinguishing anthophyllite asbestos from fibrous talc

- Morphology and chemistry of individual grains normally **indistinguishable** by SEM or TEM.
- Particle size in cosmetic talc lends itself to analysis by light microscopy.
- These two types of mineral particle are easily distinguished by index of refraction: magnitude and birefringence.
- By TEM, to overcome ambiguity, zone axis patterns must be tested for consistency with asbestos and **for inconsistency with the crystal structures of other minerals of similar composition (ISO 10312)**

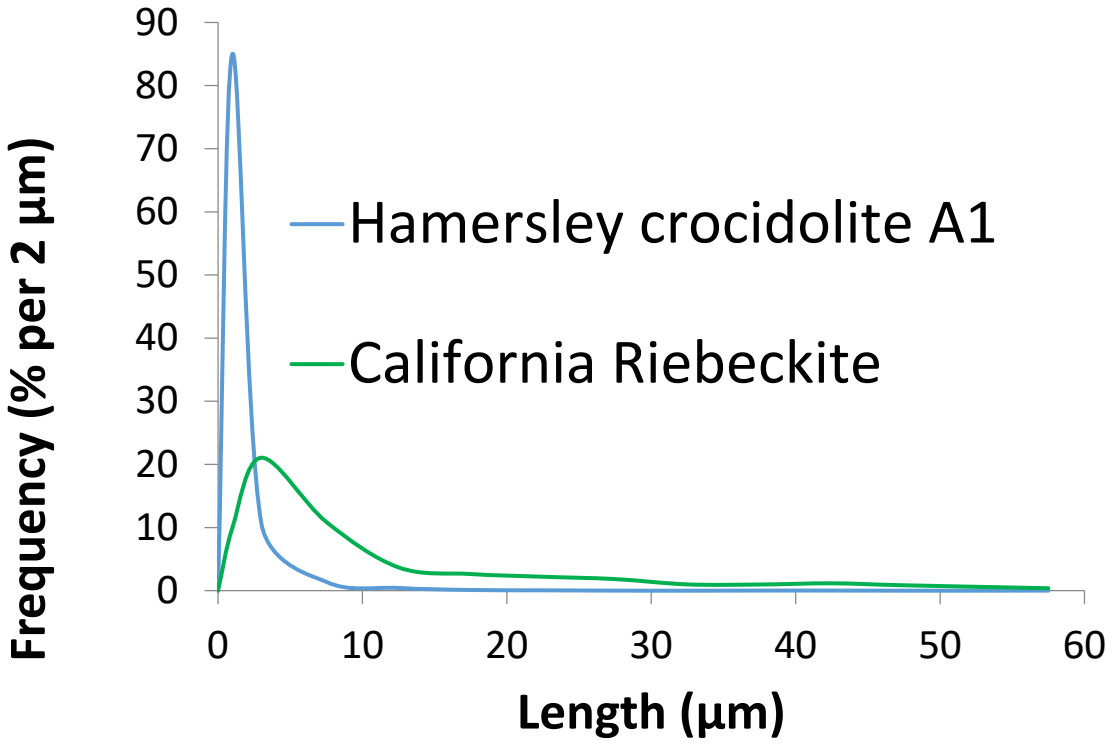
Weight percent vs particle number/mass

- Analysis of sample KNOWN to contain asbestos- 2 Step process.
- Identification of the hazard and measurement of its abundance should be separated.
- Levels normally very low in samples of interest.
- Because optical techniques examine large amounts of material, they could form the basis for a detection limit of 0.1 or 0.01% or less by weight since weight is concentrated in the largest fiber bundles.
- Fiber number per unit mass is normally done by SEM or TEM but multiple definitions of “fiber” are in use.

Questions?

Length variations among EMPS (Shedd 1985, Wylie 2016)

Frequencies of all lengths



Frequencies of length ≥ 5 µm