Direct observation and determination of the mechanisms governing mobility of asbestos in porous media

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American Geophysical Union

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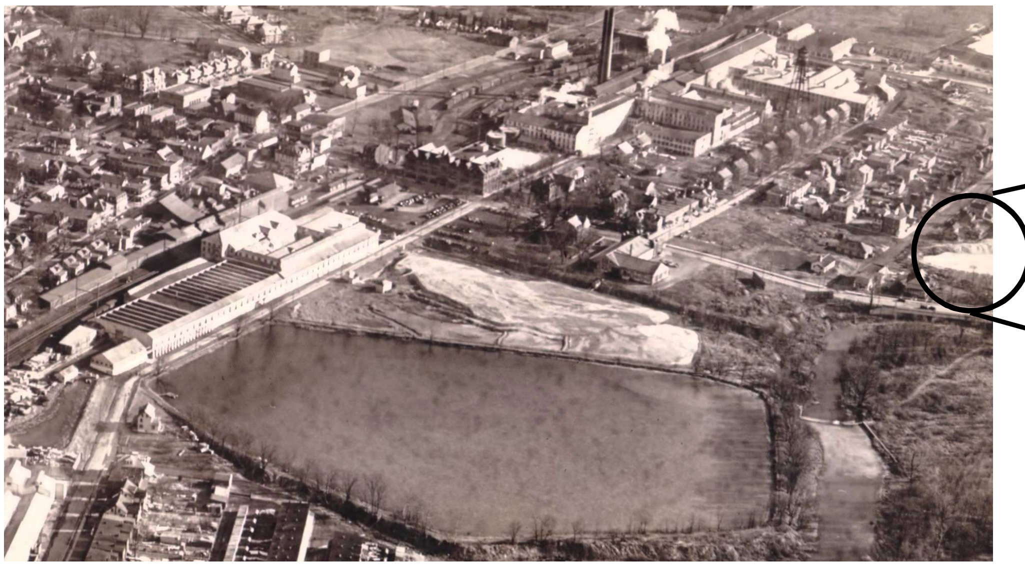
BoRit Asbestos Superfund Site

Asbestos-containing products factory
Ambler, PA (1881-1987).

White mountain



Common
building material
Containing
asbestos

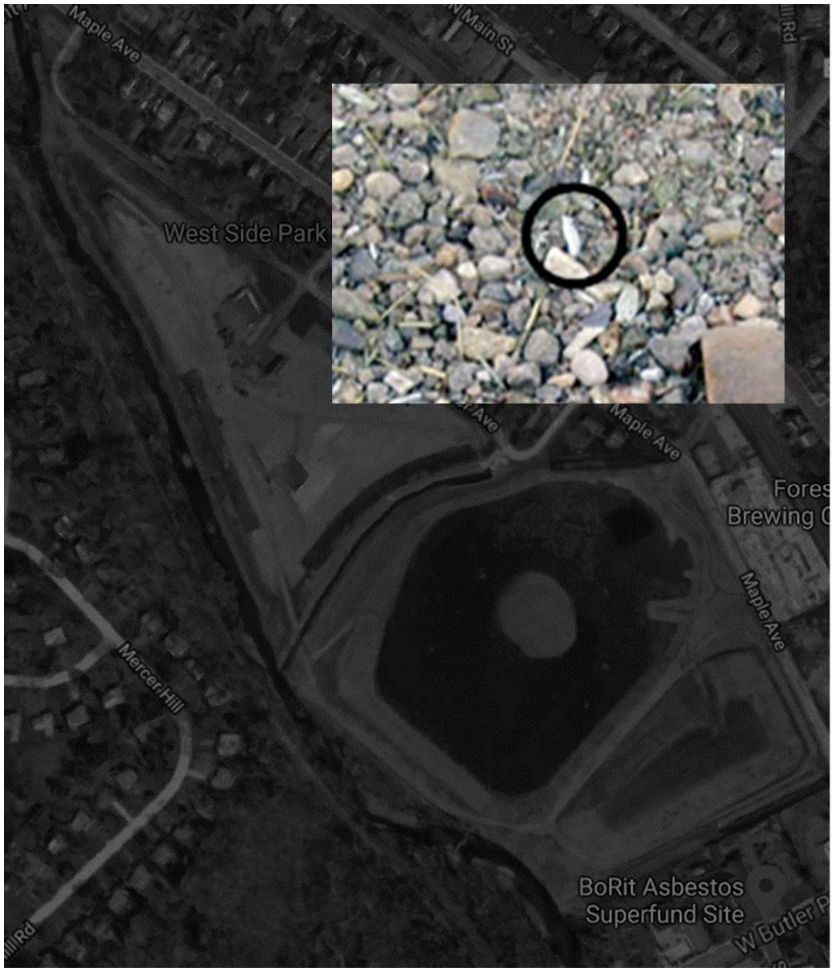
Dumping pile of Asbestos-
containing wastes,
(started in 1930) with total volume
1½ million cubic yards.

BoRit Asbestos Superfund Site

Cap the site with soils/vegetation
(mesh and geotextiles)

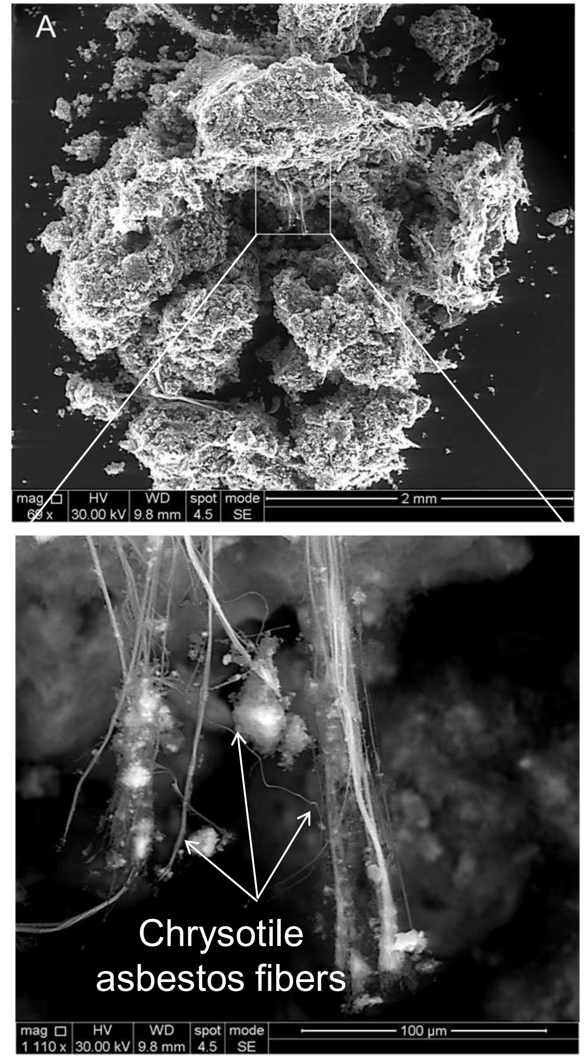
Erosion control system

BoRit Asbestos Superfund Site



Cap the site with soils/vegetation
(mesh and geotextiles)

Asbestos
containing
wastes



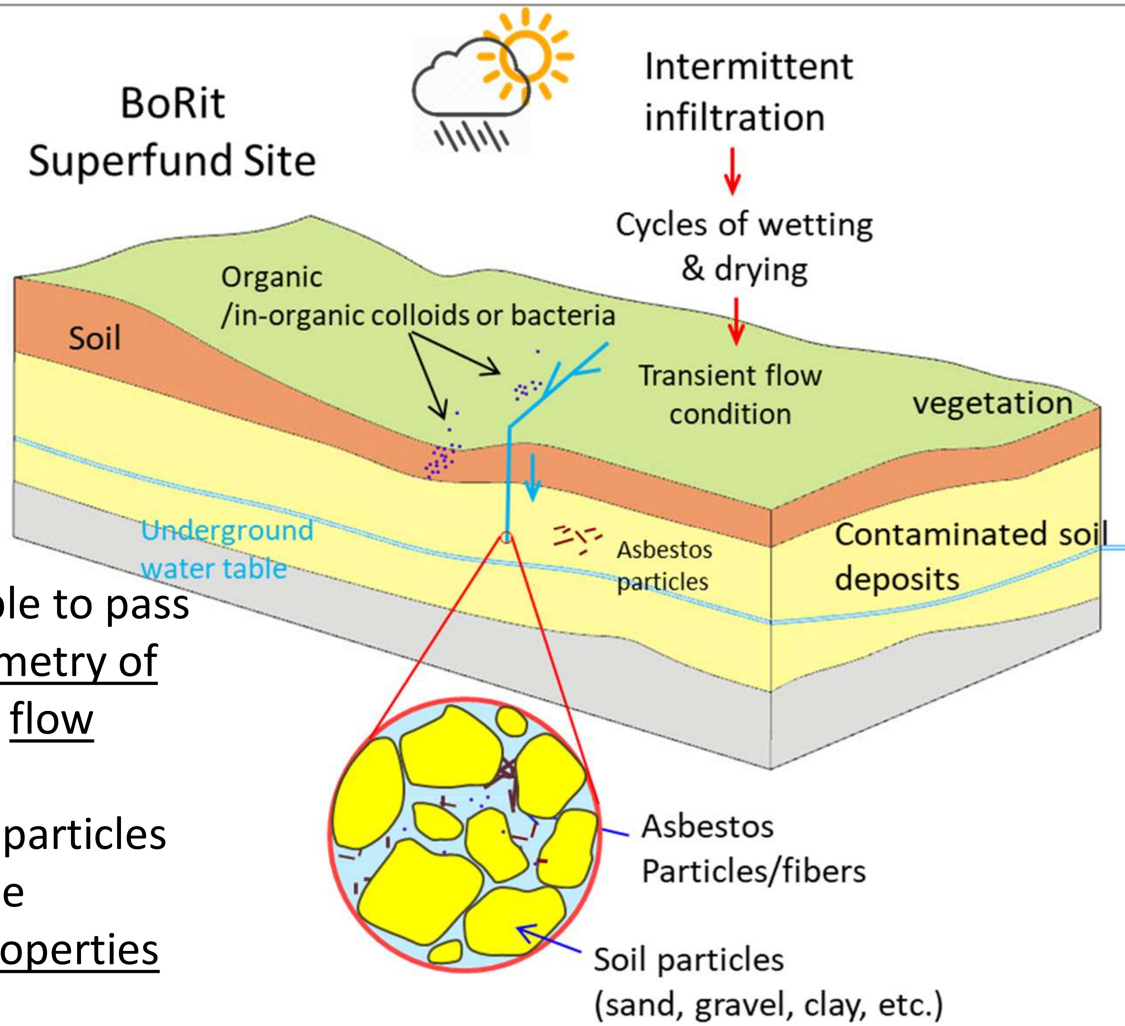
Transport in porous media

Main question:

How far the Asbestos particles migrate and what are the processes that dictate their mobility?

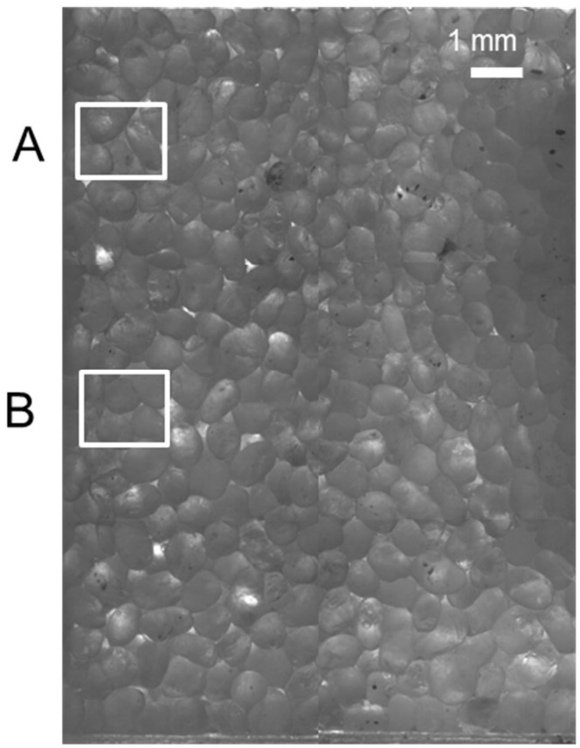
Dominating factors:

1) **Physical factors :** Are particle able to pass through pores? dictated by <u>geometry of the pores</u> (soil particle size) and <u>flow condition</u>
2) **Chemical factors:** Are asbestos particles attracted to or repulsed from the medium? dictated by <u>surface properties</u> and <u>solution chemistry</u>
3) **Colloid-facilitated transport mechanism:** organic carbon can facilitate/trigger the mobility

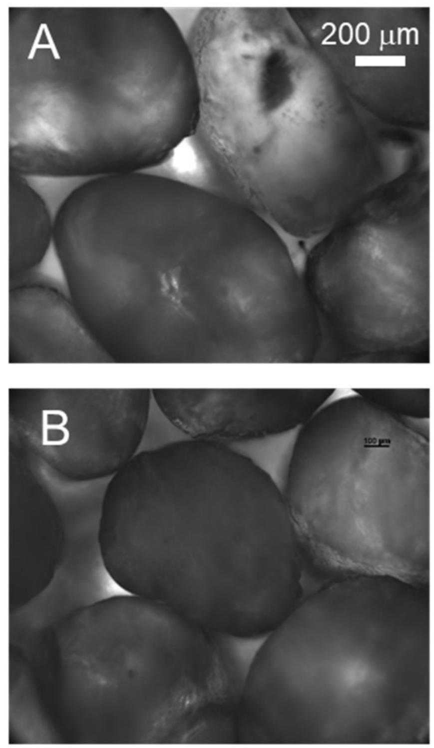


Challenges in laboratory

Main obstacle:
Pore scale visualization of the transport mechanisms is not possible because we cannot see what is happening in soil (black-box).



Translucent Ottawa sand



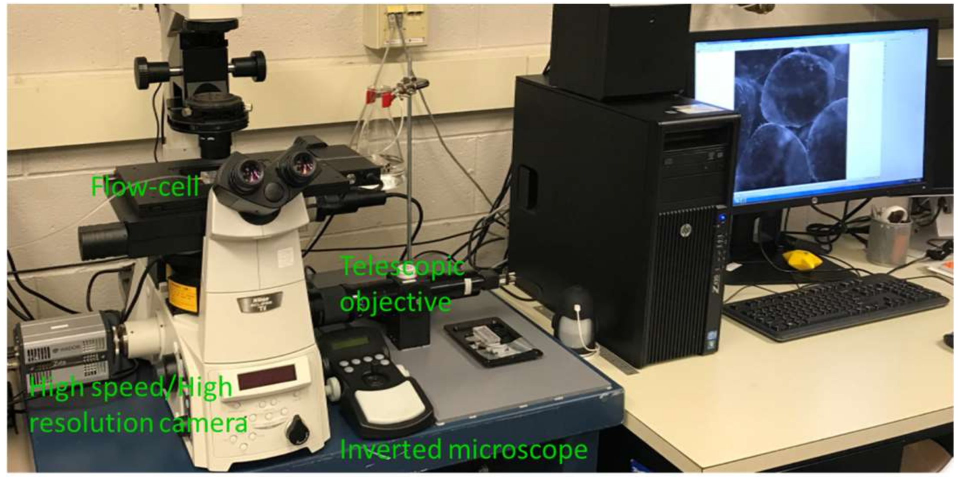
Optical microscope

Limited observation

Novel flowcell & multiscale observation

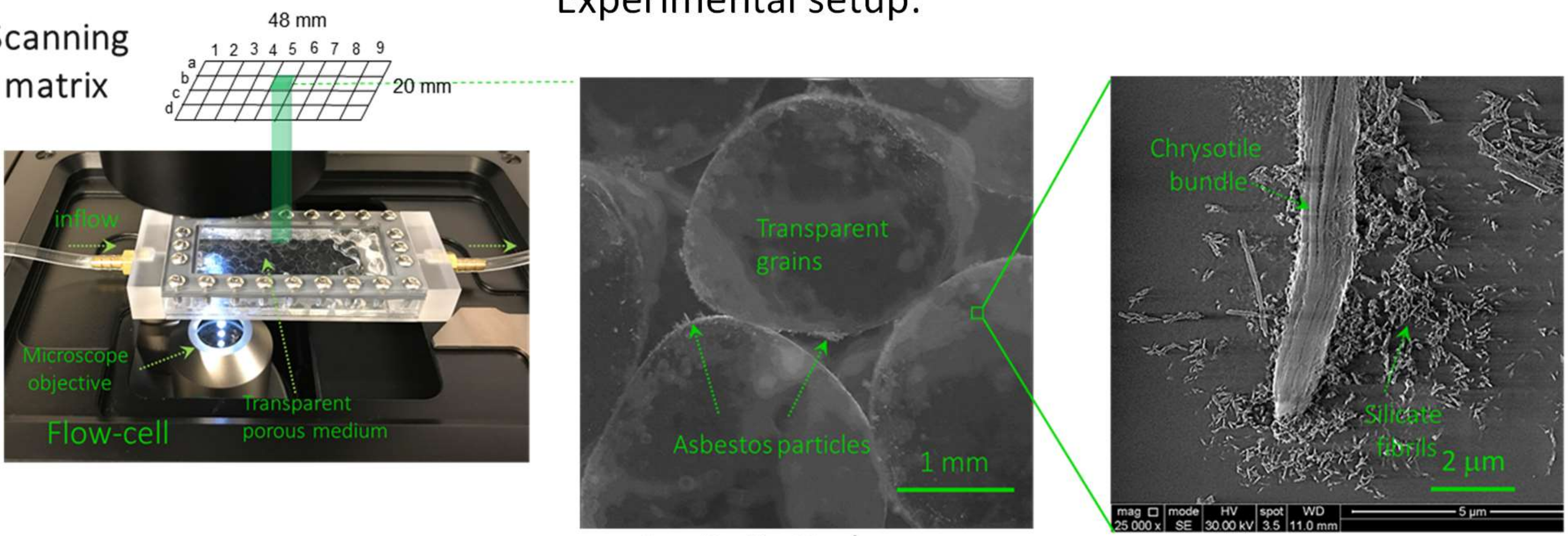
Flowcell setup:

A refractive indexed matched porous medium (transparent) with density, surface charge and cation exchange capacity comparable to soils



Experimental setup:

Scanning matrix



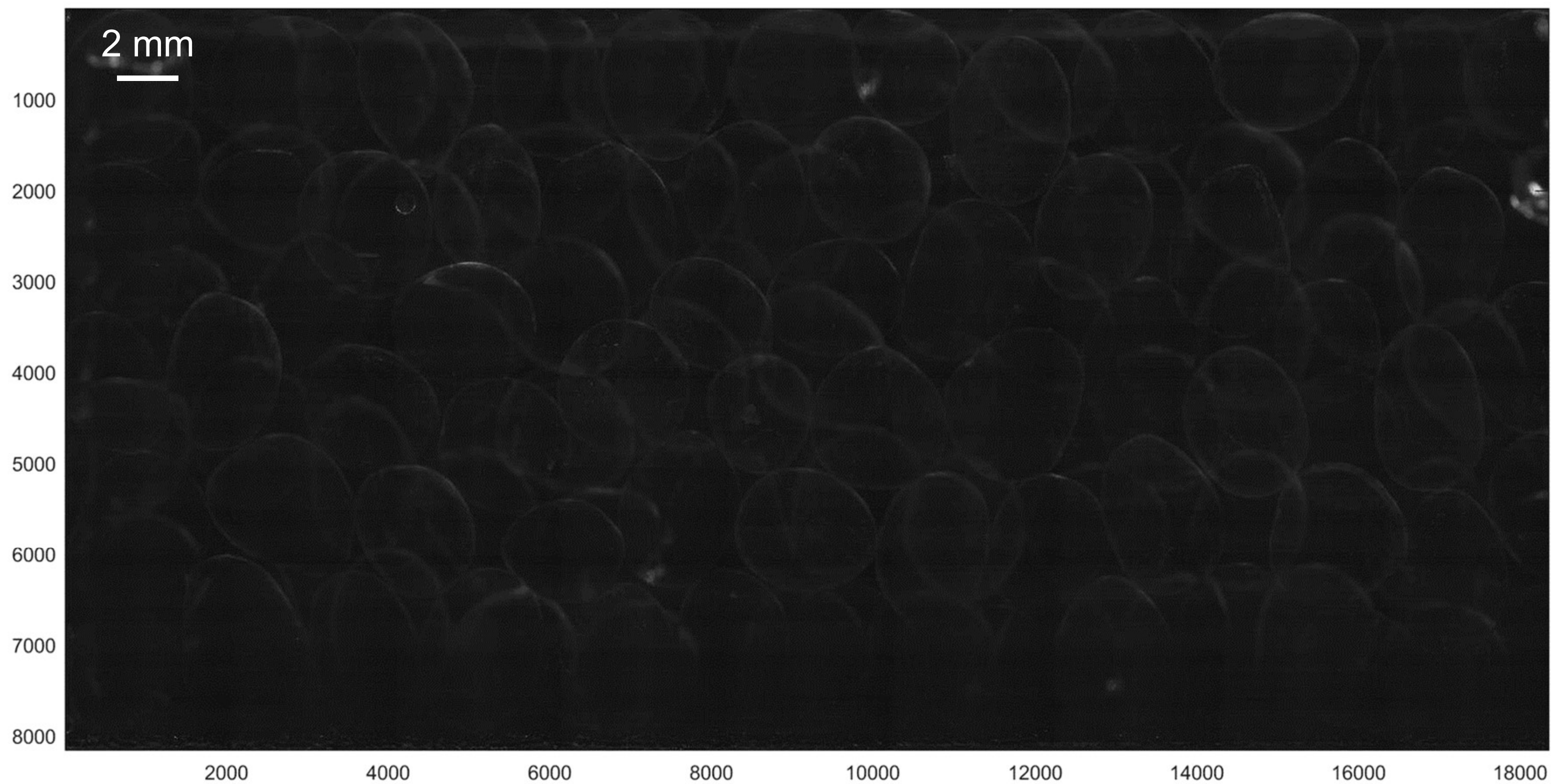
Flowcell with transparent soil

In situ Optical microscopy

SEM & EXDS

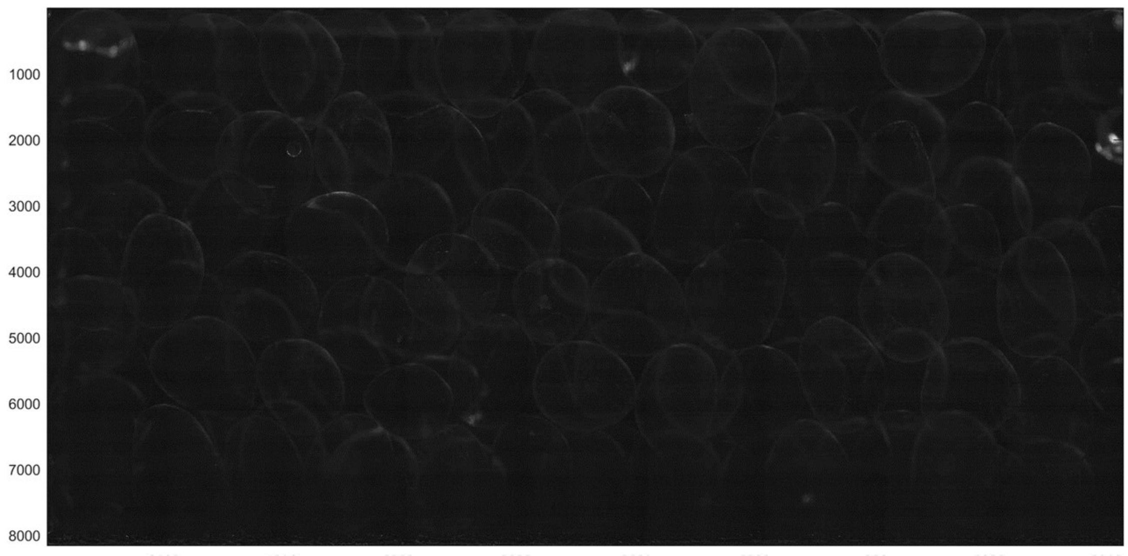
Novel flowcell & multiscale observation

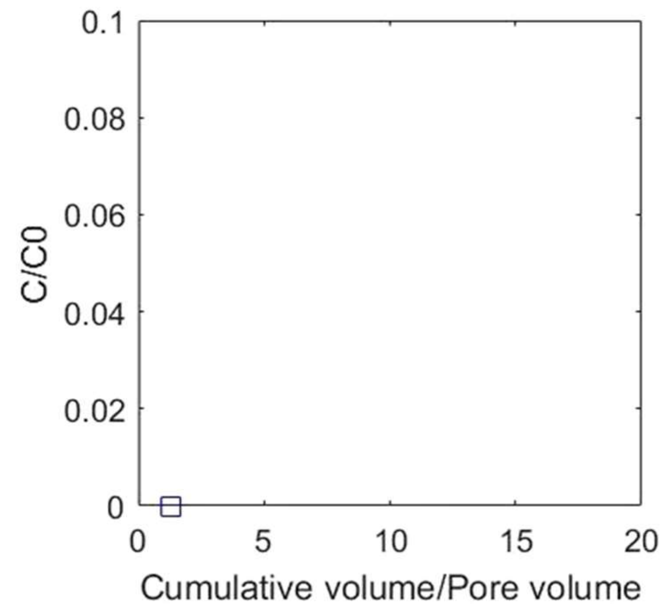
Flowcell with transparent soil (refractive indexed matched)



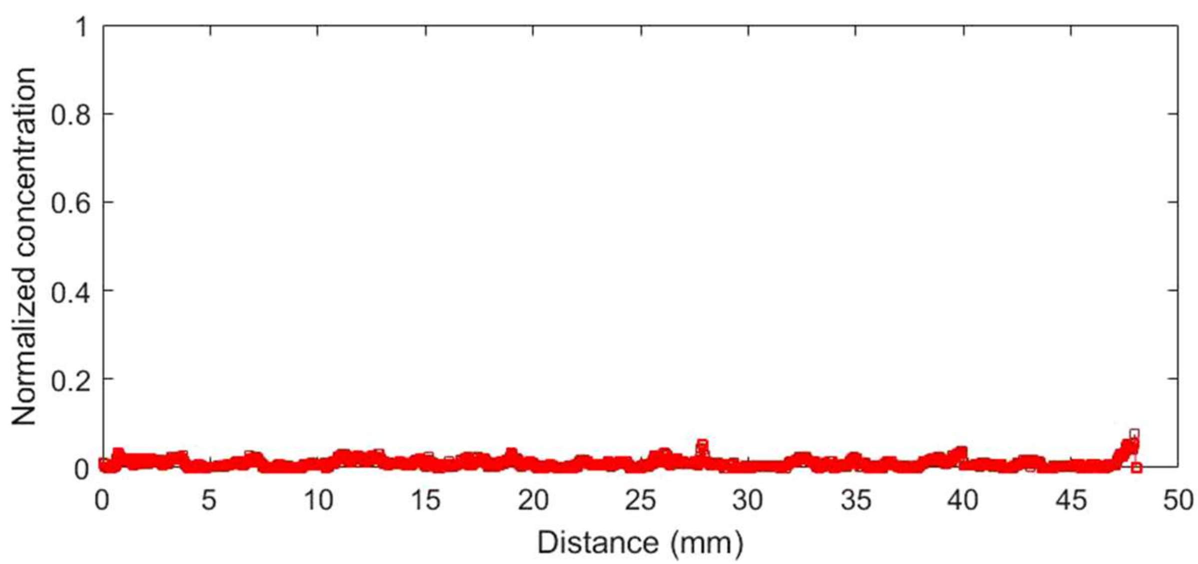
Dimension: 20 mm x 48 mm
Duration: 39 min
water flow velocity: 0.7 cm/min

Novel flowcell & multiscale observation





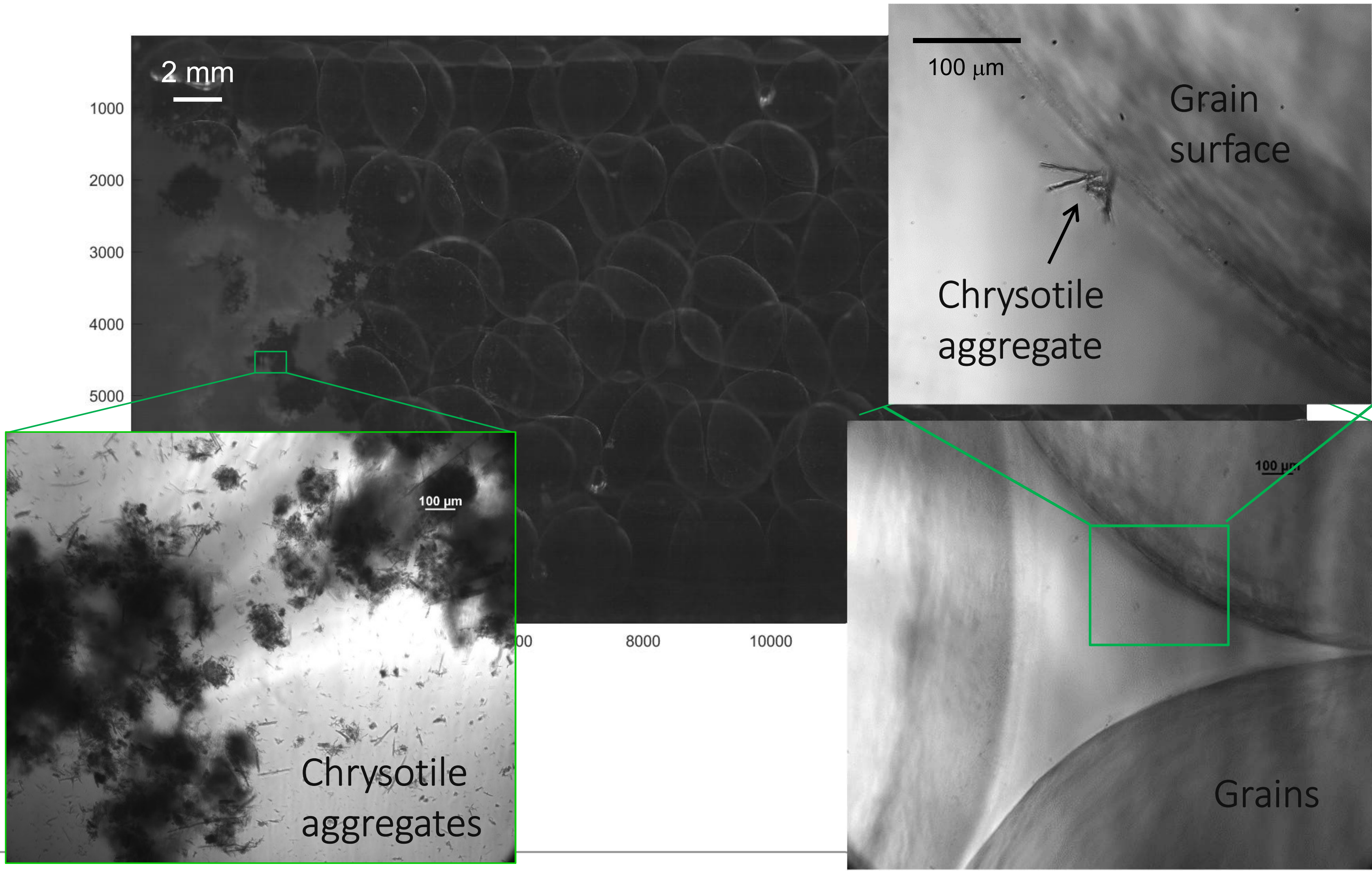
Asbestos Breakthrough curves



Concentration profile curves

Novel flowcell & multiscale visualization

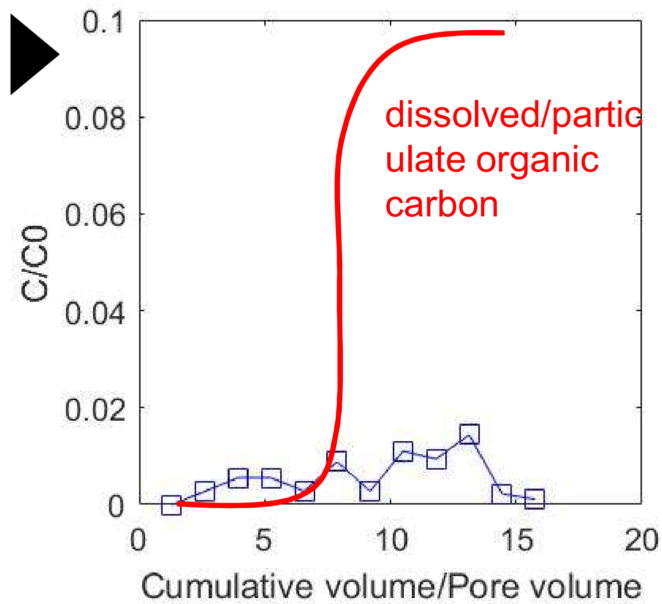
Multiscale observation:

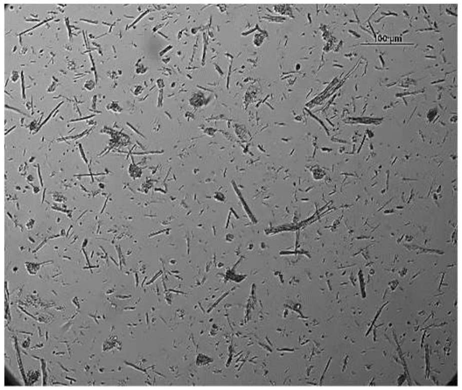


Mobility of asbestos in porous media

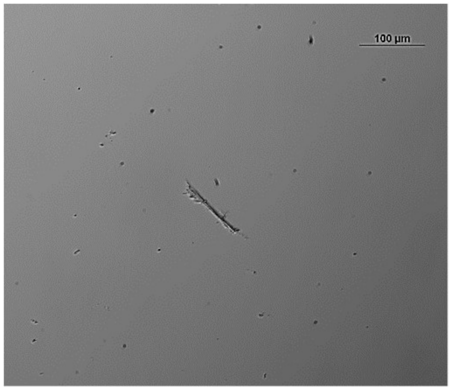
- Similar trends were obtained using sand flowcell
- Compatible with larger scale sand column experiments reported by Mohanty et al., (2016) and Gonneau et al., (2017)
- However, the addition of dissolved/particulate organic carbon resulted in asbestos breakthrough

Asbestos Breakthrough curves





Inflow asbestos concentration (C_0)

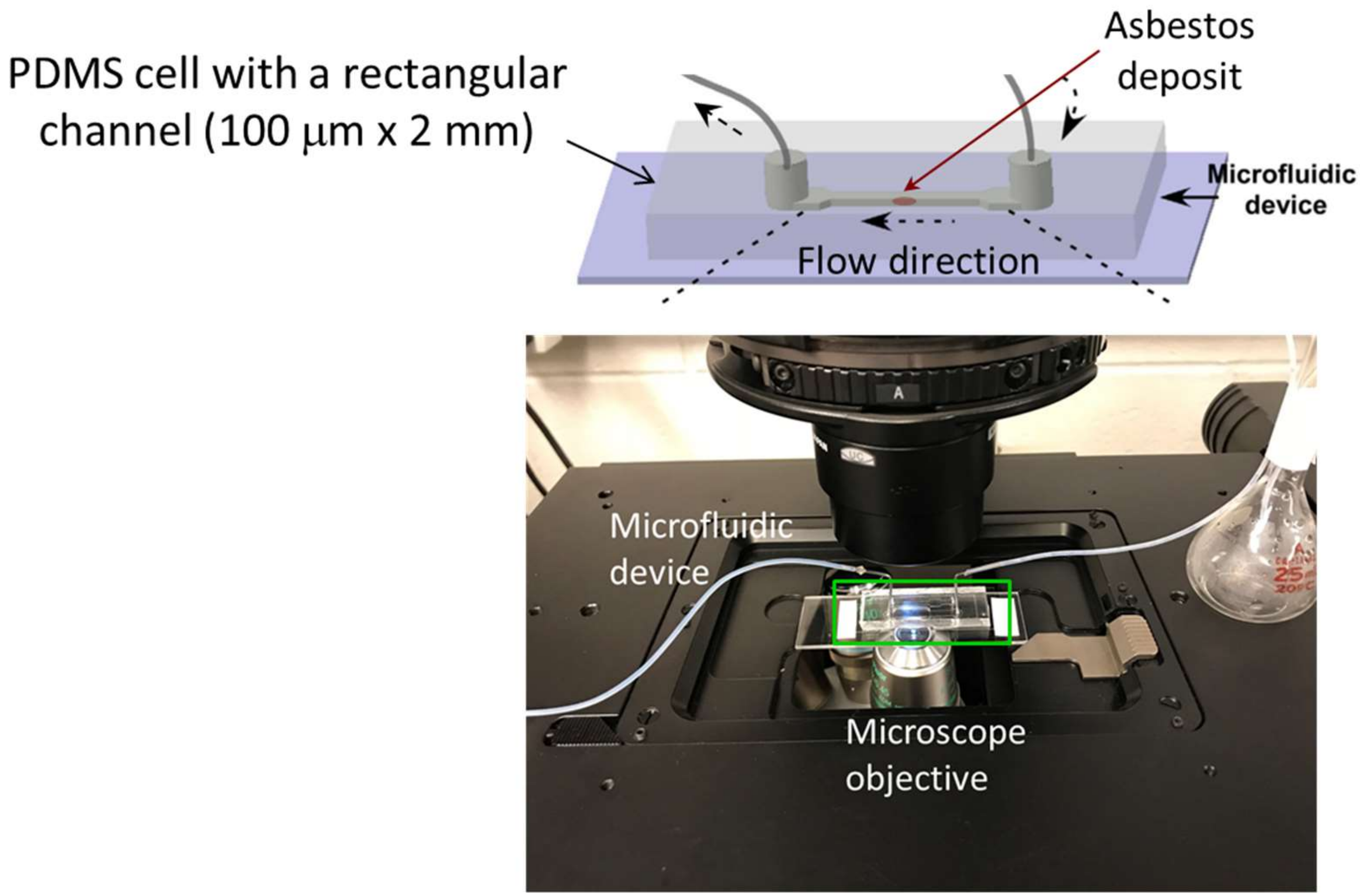


outflow asbestos concentration (C)

Microfluidic device and multiscale observation

Microfluidic cell setup:

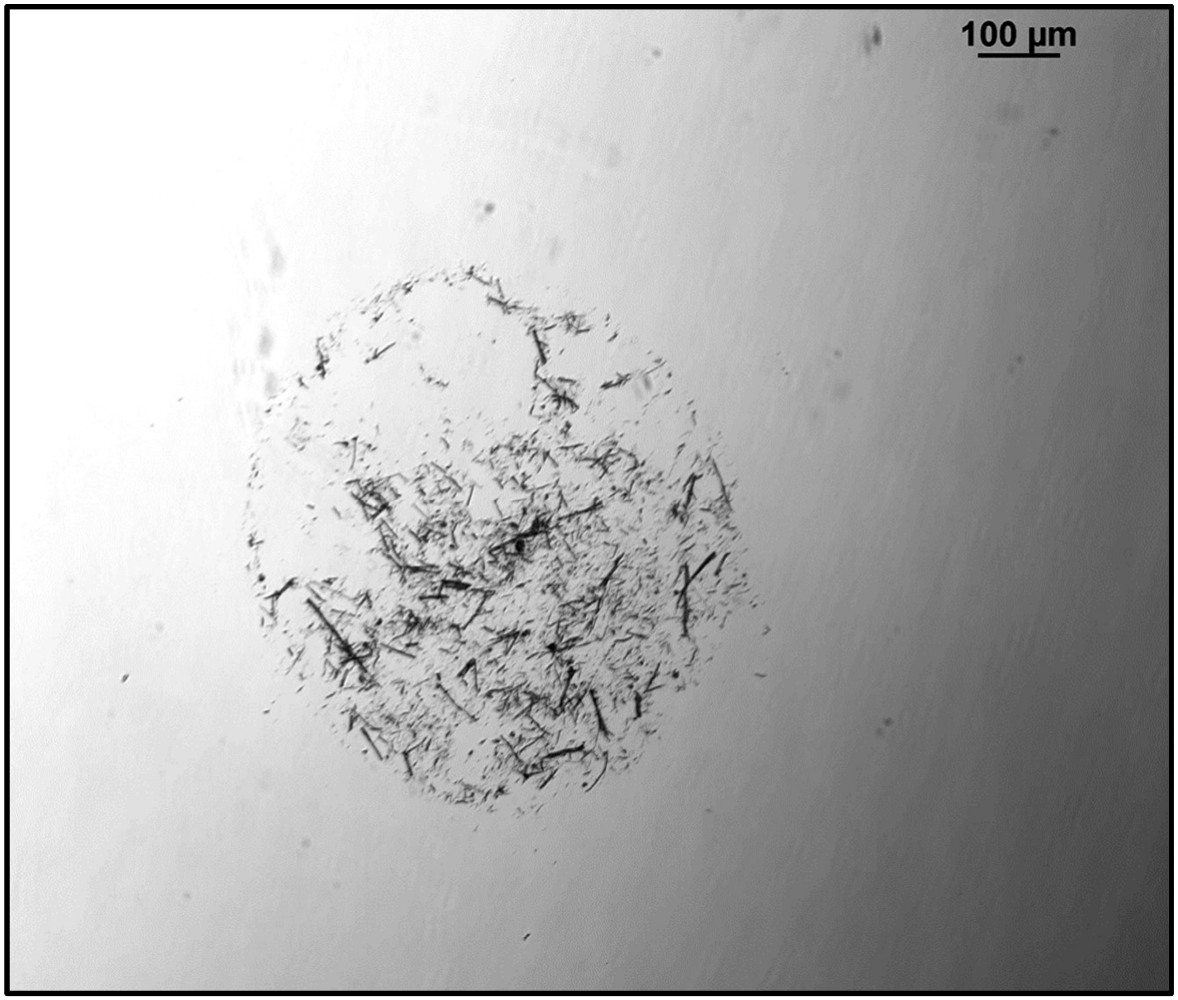
Deposit of chrysotile asbestos on a silica glass coverslip subject to flow to isolate the chemical factors (solution chemistry, colloid-facilitated transport)



Microfluidic device & multiscale observation

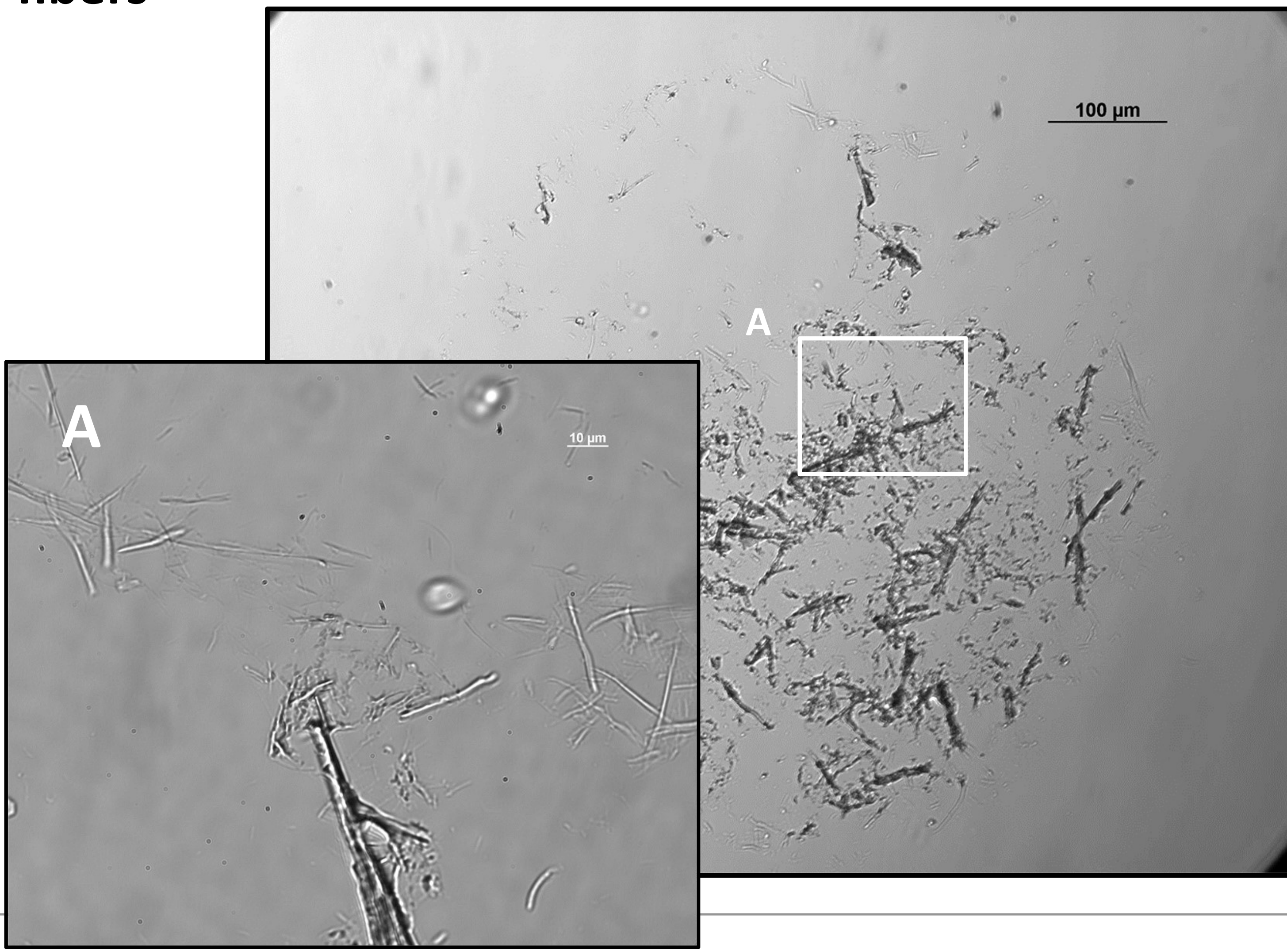
Attachment of asbestos fibers to silica substrate

Flow direction



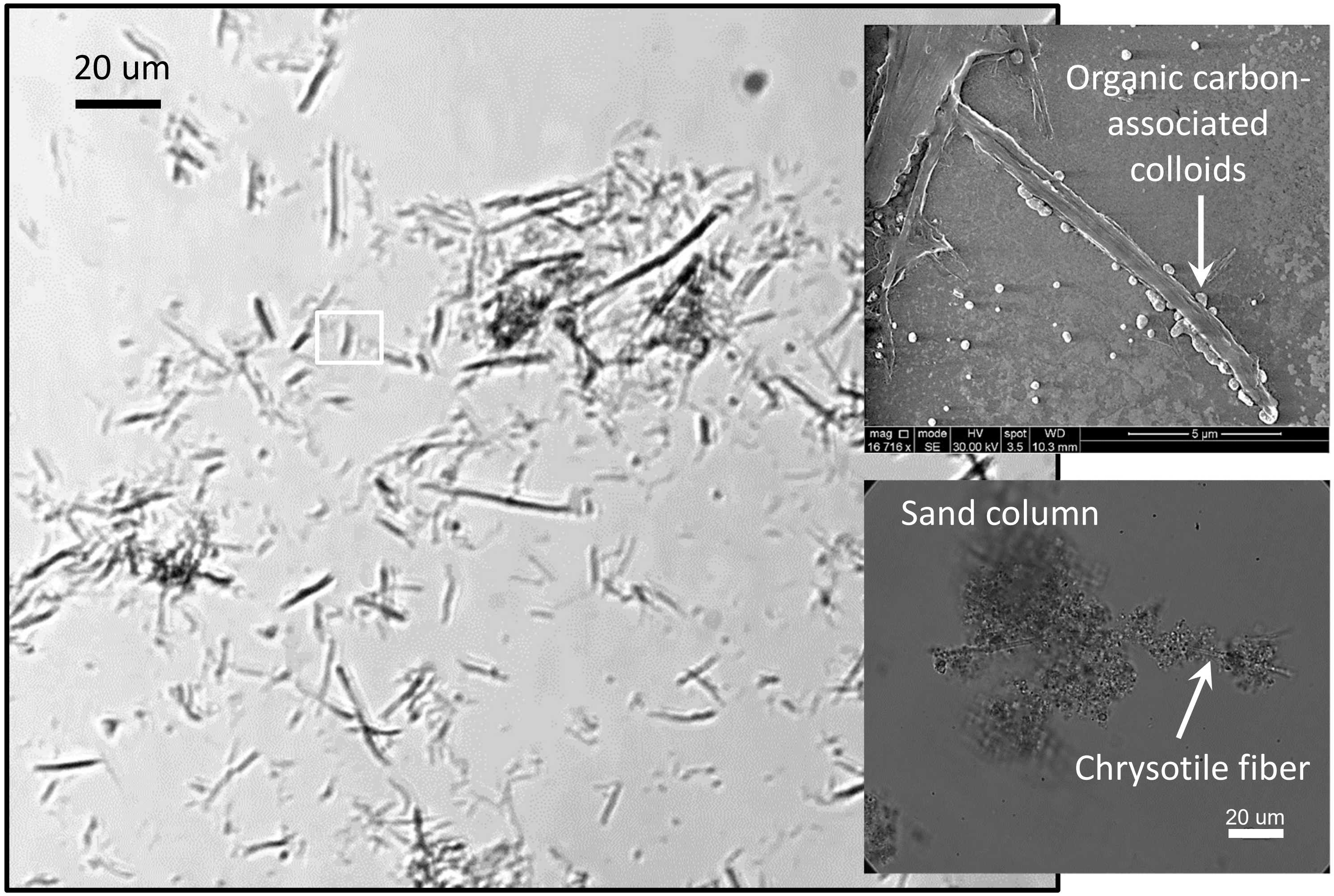
Microfluidic device and multiscale observation

Attachment of mobile organic particles to immobile asbestos fibers



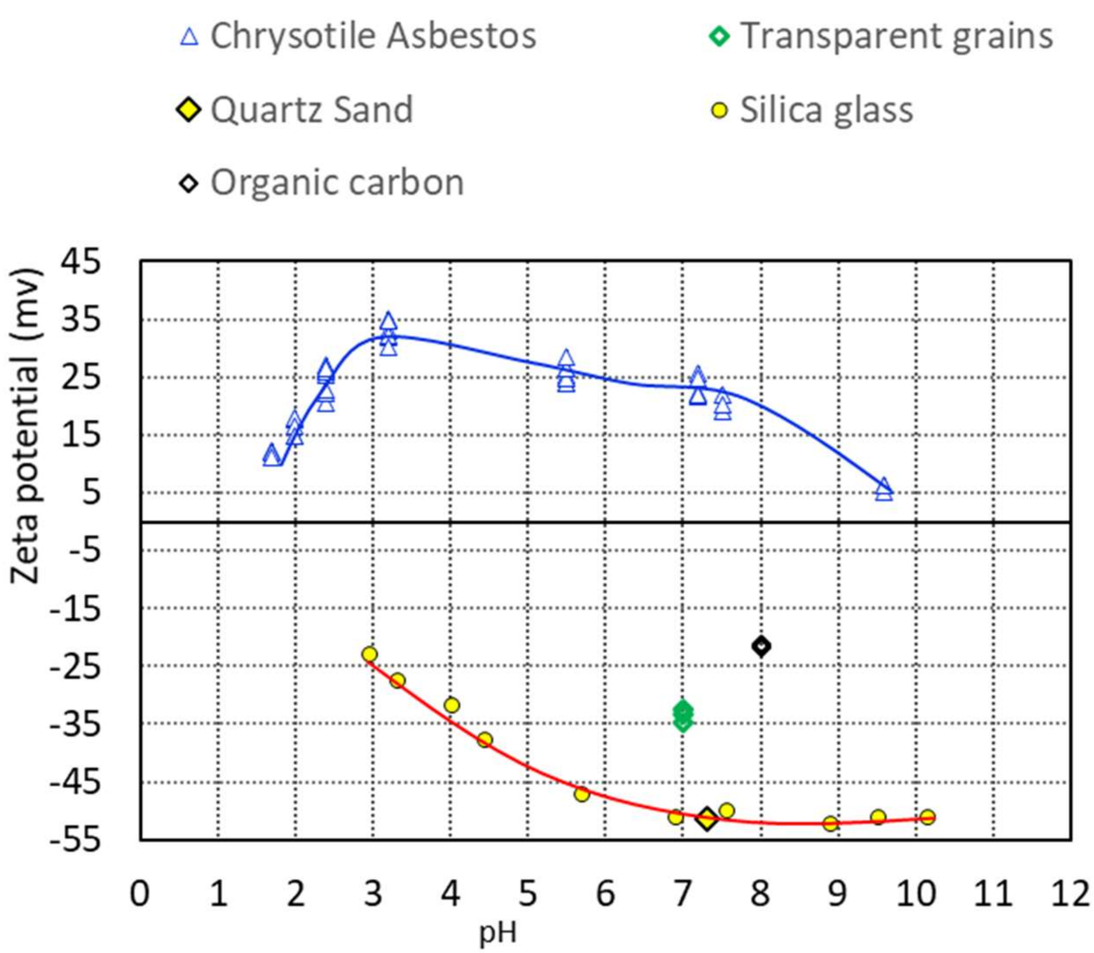
Microfluidic device and multiscale observation

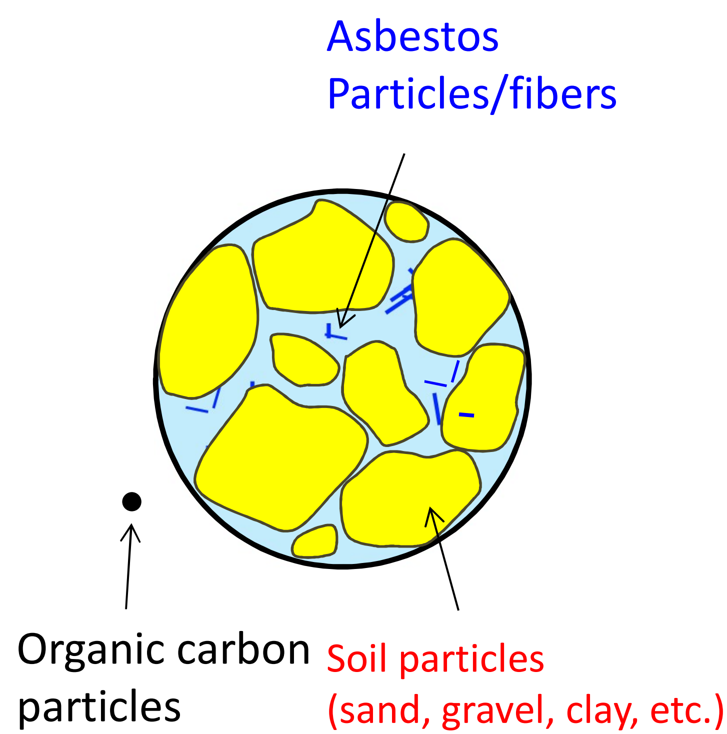
Mobilization of asbestos fibers by attaching to organic particles



Colloid-facilitated transport mechanism

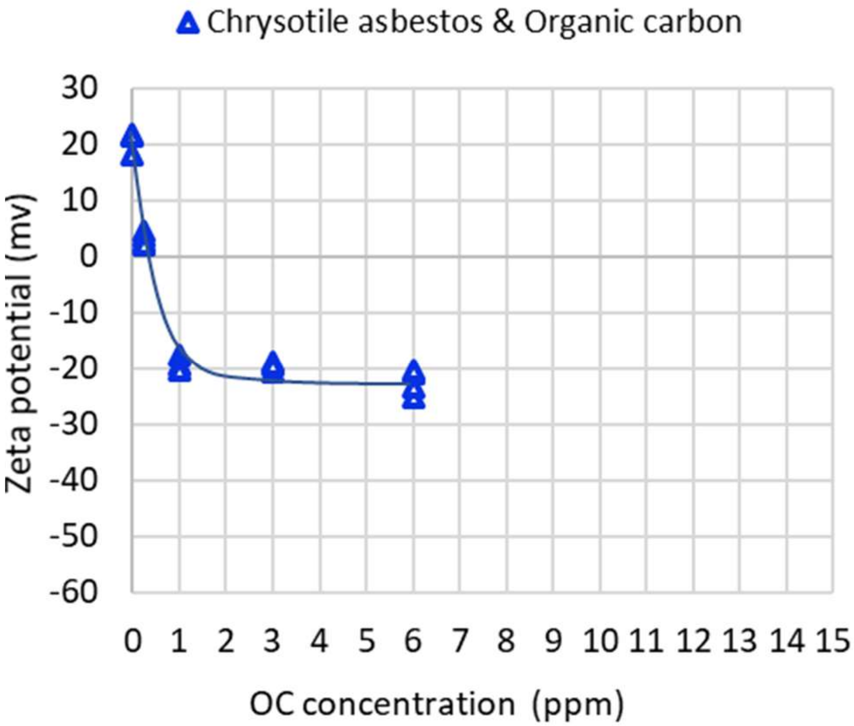
Surface charge properties

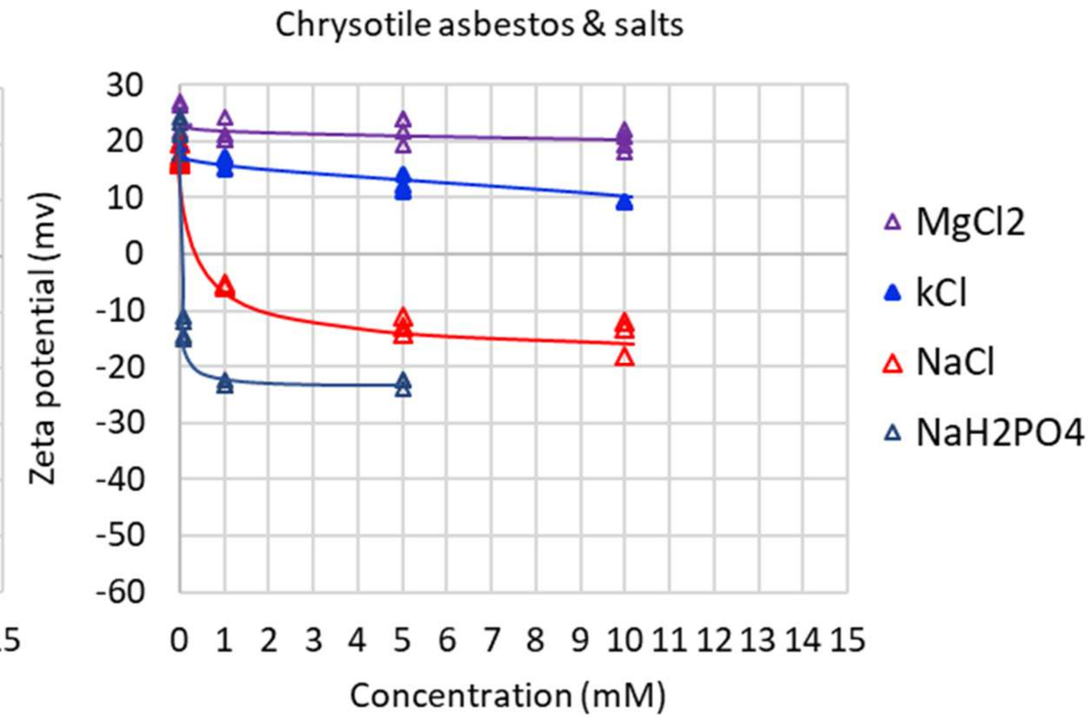




Colloid-facilitated transport mechanism

Surface charge properties

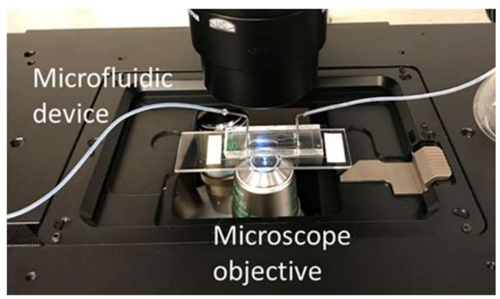




Addition of small quantity of dissolved organic carbon will reverse the surface charge of asbestos particles

Conclusions and outlook:

- Pore-scale visualization of transport mechanism in colloid and contaminant transport in porous media
- Effect of dissolved/particulate organic carbon as a colloid-facilitated transport mechanism that triggers the mobility of asbestos particles
- This technique provides implications towards a *body-on-a-chip* concept to study the mobility of asbestos particles in the human body



body-on-a-chip

Thank you for your attention!