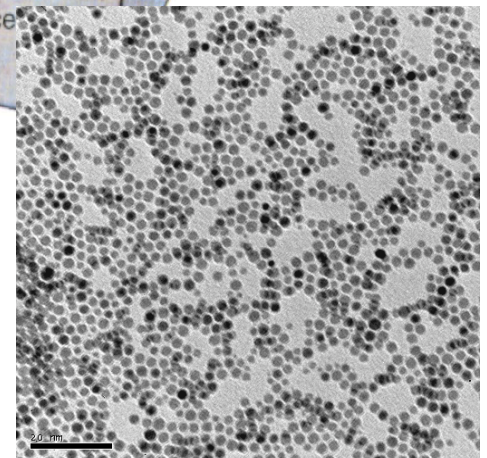
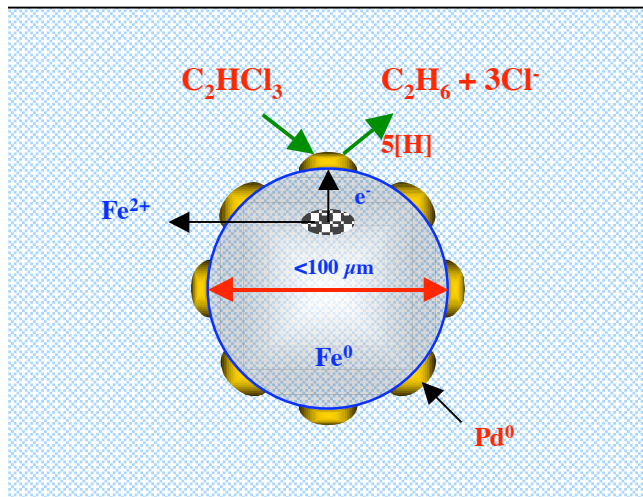
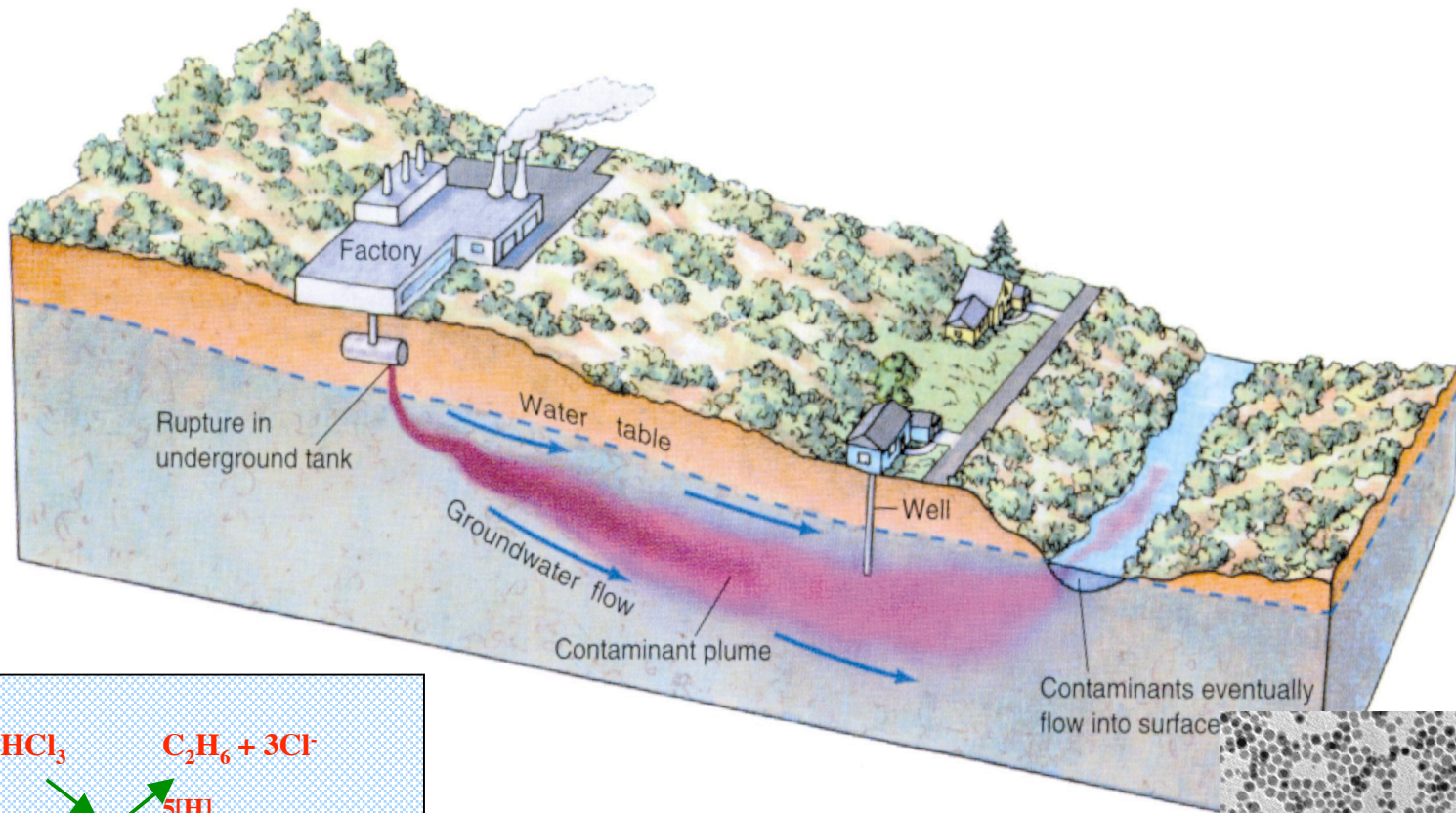


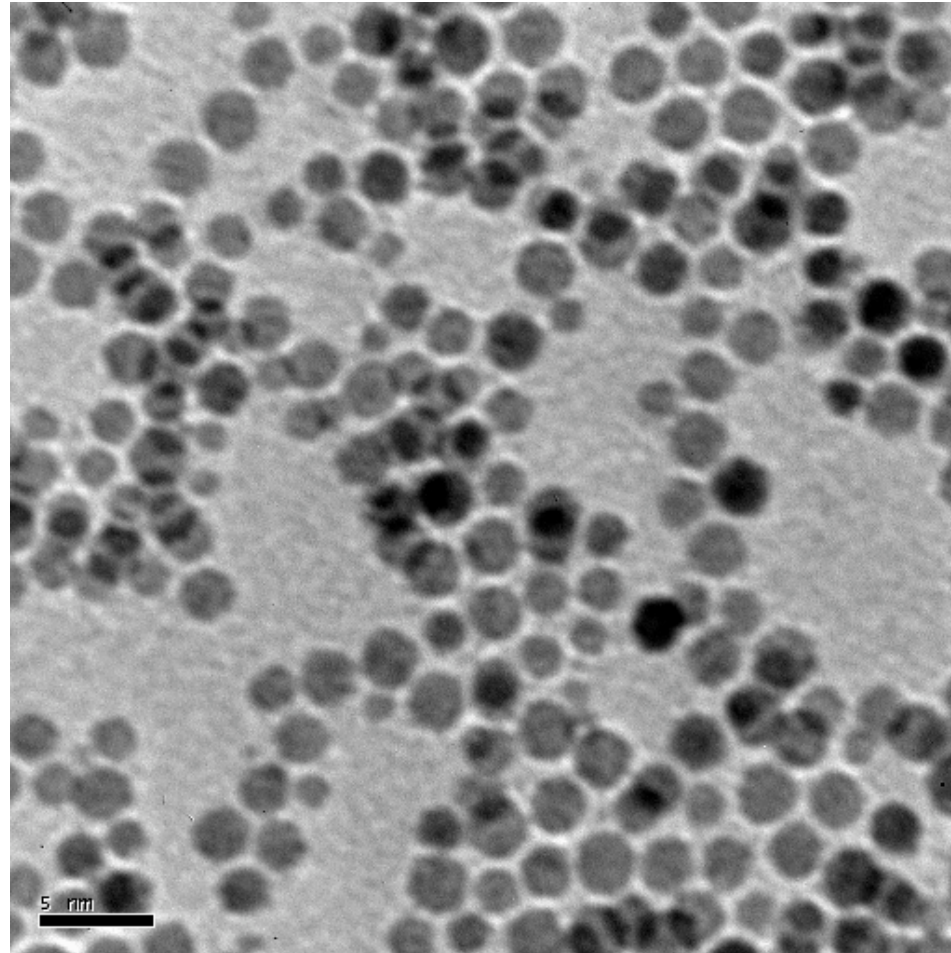
*Environmental
Technologies at the
Nanoscale*

**Nano Iron Particles for
Remediation**

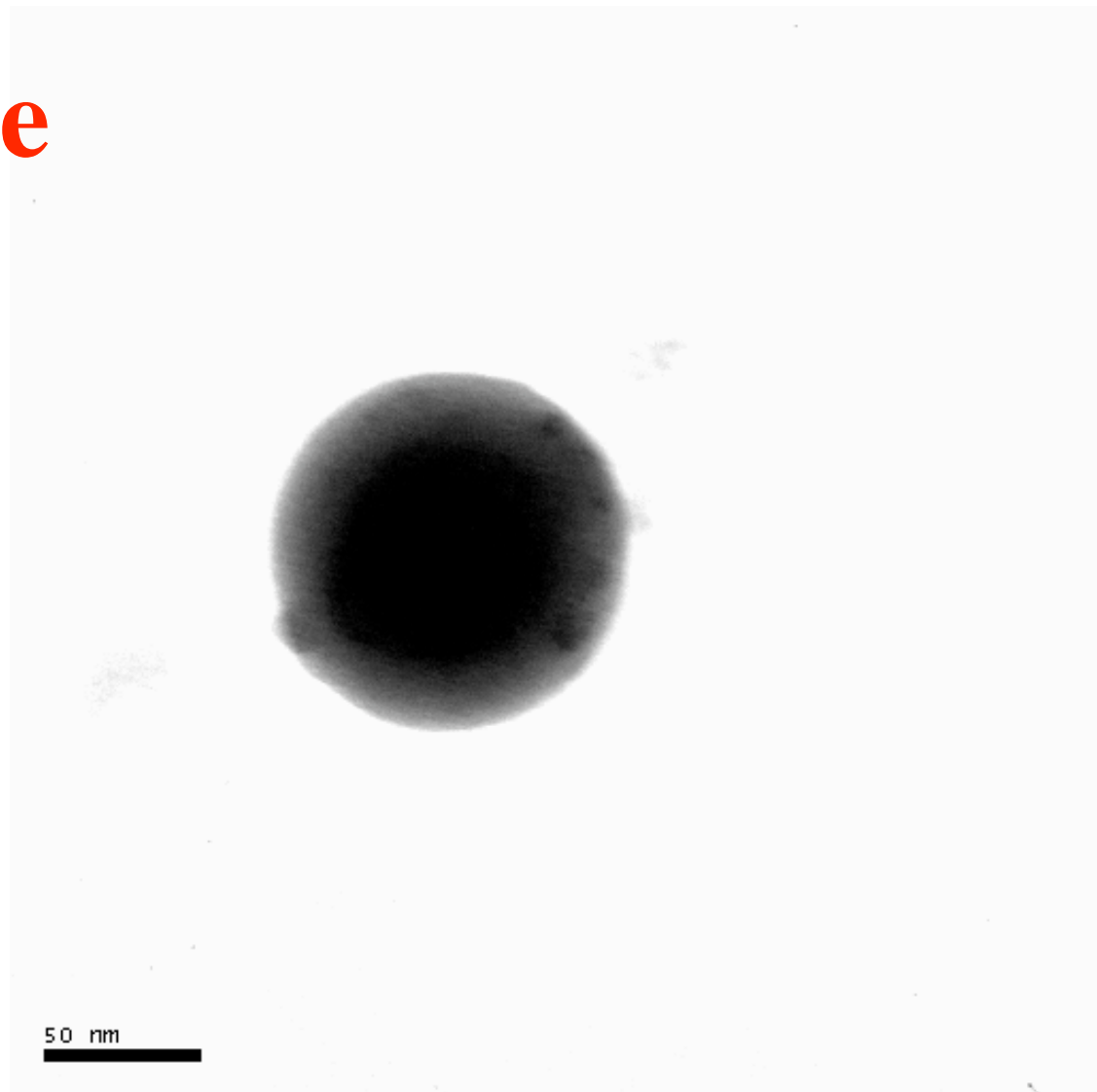
Nanoparticles as Superreactants



Nano Iron Particles (TEM)



Nano Fe



Properties of Nano Fe

Nominal Reaction Rate (□)

0.1-100 mg TCE/g nanoFe/hour (>1,000 X better)

@ 22°C

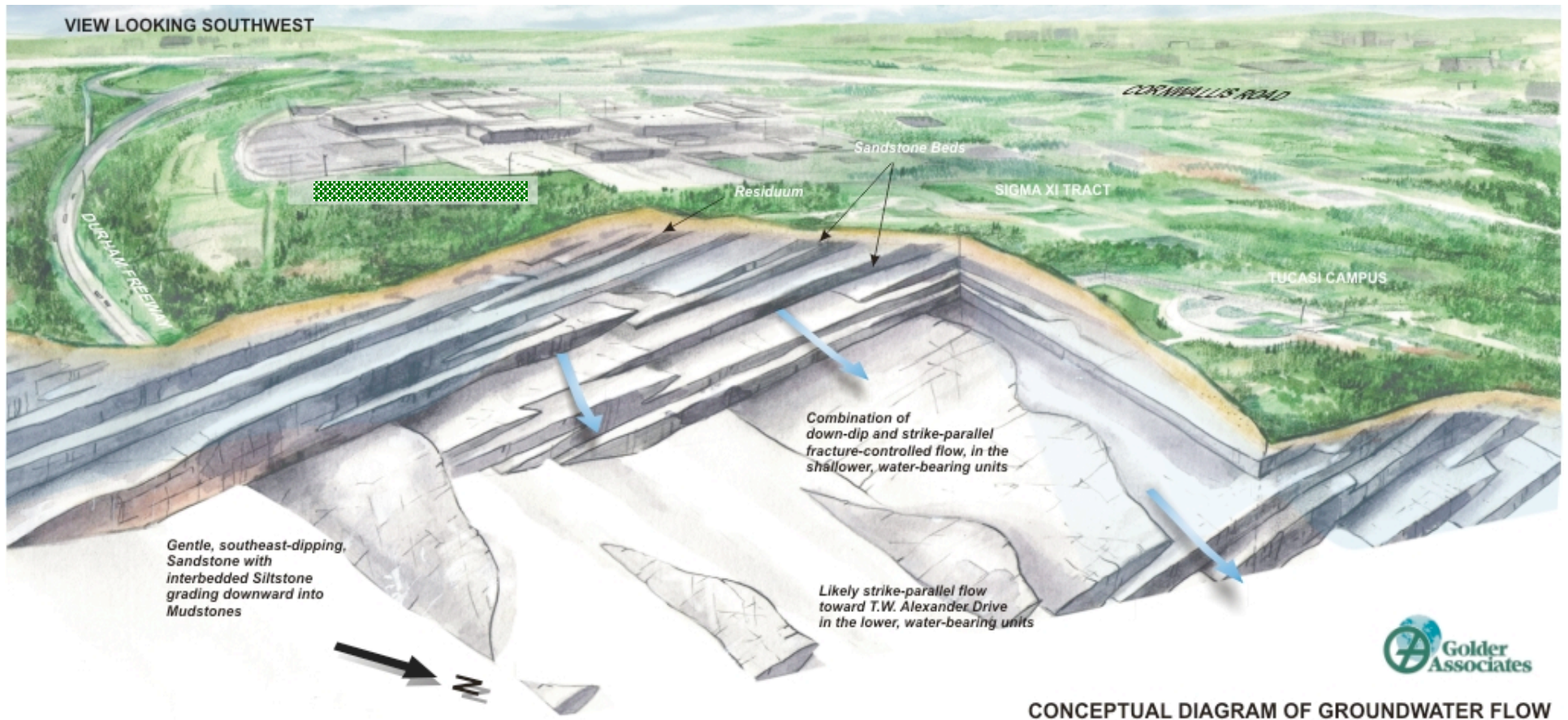
@ 1-100 mg/L TCE @ pH=7

Contaminant Transformation

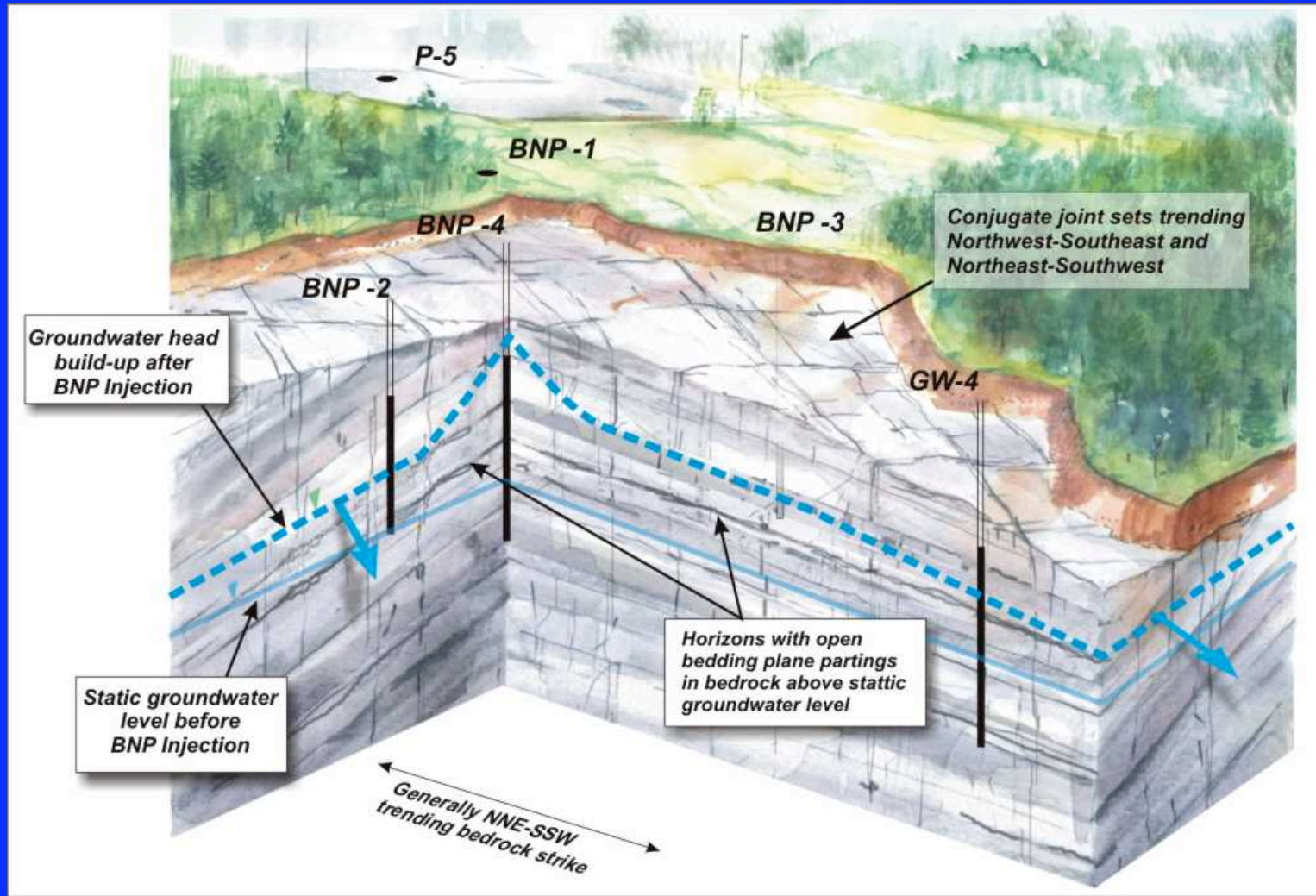
Chlorinated Methanes	Cr(VI)
Chlorinated Ethenes	Pb(II)
Chlorinated Ethanes	Ni(II)
Chlorinated Benzenes	Cd(II)
PCBs	Perchlorate
Lindane (HCHs)	As

> 70 compounds tested at Lehigh so far

A Field Demonstration - NC

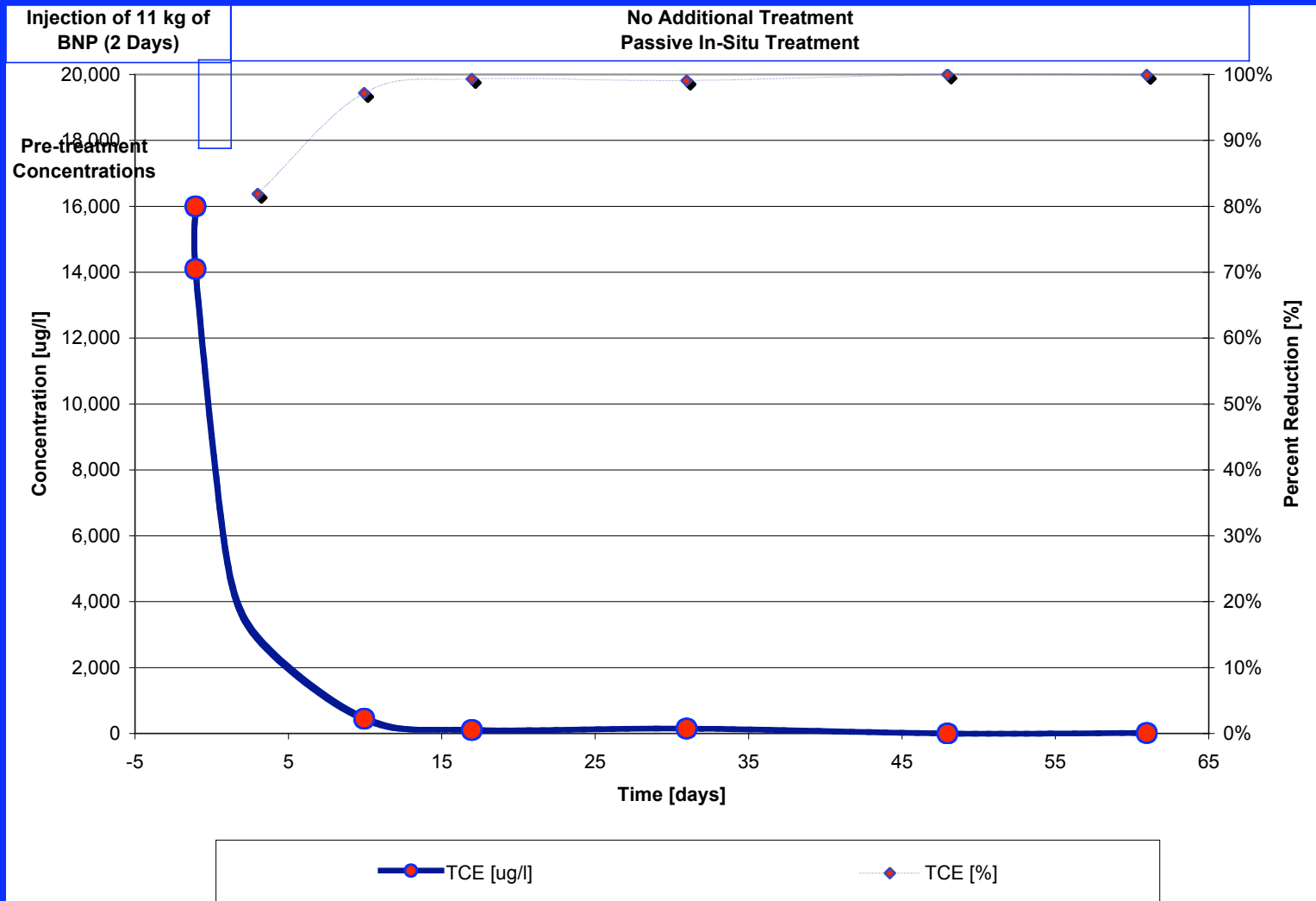


Conceptual Model





Sampling Results (TCE)



Simple Installation Techniques: Braced Excavation, Slurry Wall, Continuous Trenching, Vibrating Beam



A Pilot Study

at

SPOLCHEMIE a.s.

Michael Pupeza / Marco Greco

Czech Republic

Golder Associates Inc

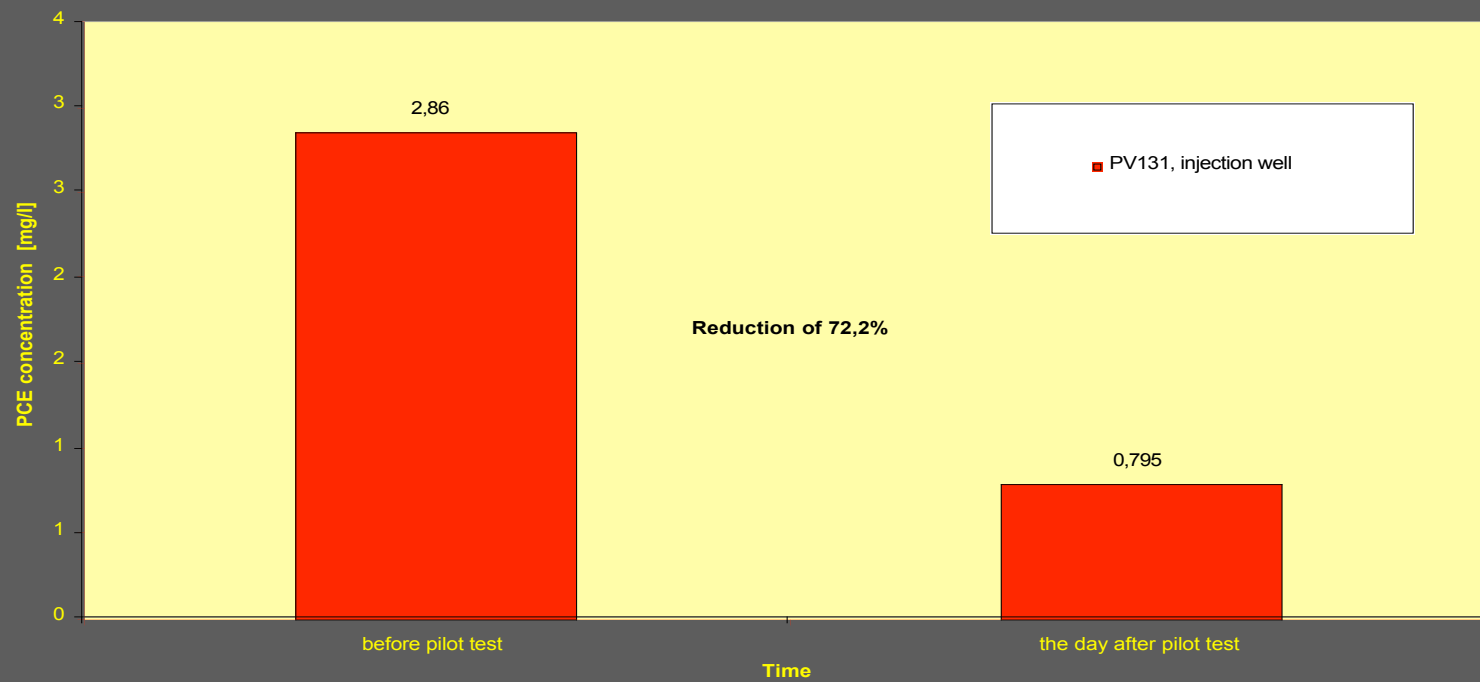
April 2004

The SPOLCHEMIE Test

- Oldest chemical facility in Europe (Solvay-1864)
- Main producer of chlorinated solvents in former Czechoslovakia
- Also producing fertilizers (nitrates, etc.)
- Located on the alluvial terraces of the Elbe River
- Company in course of privatization
- Ongoing production of chlorinated solvents

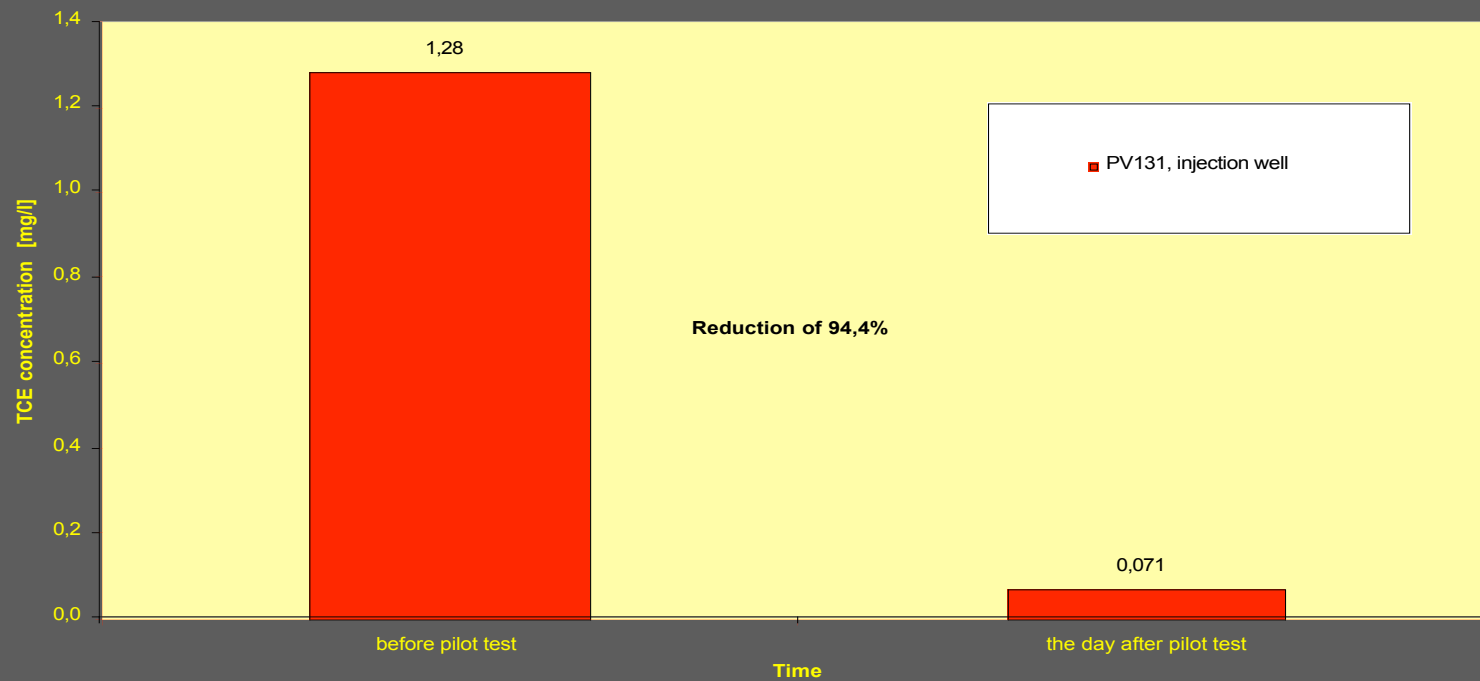
The SPOLCHEMIE Test

PCE decrease in the injection well the day after pilot test



The SPOLCHEMIE Test

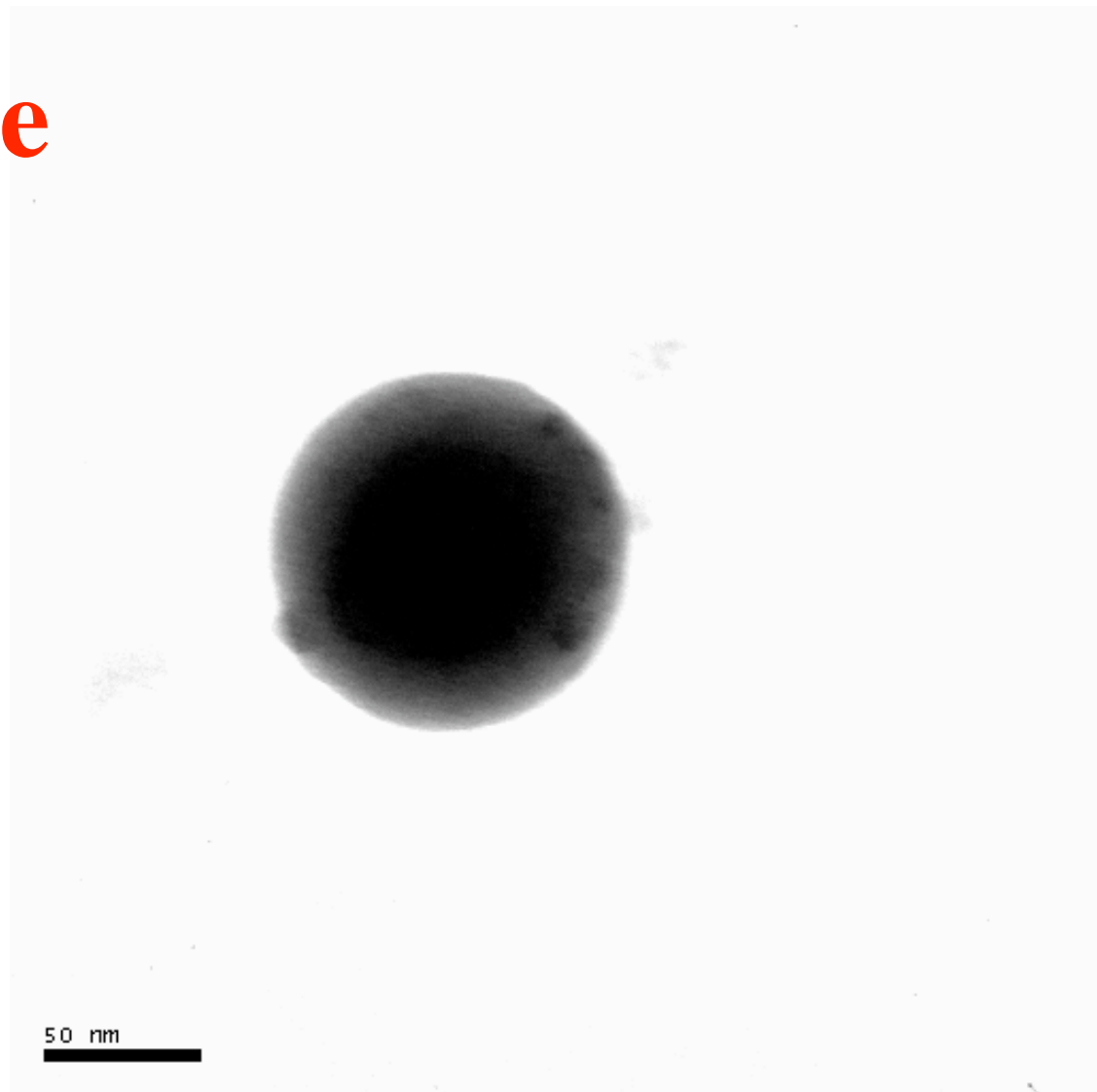
TCE decrease in the injection well the day after pilot test



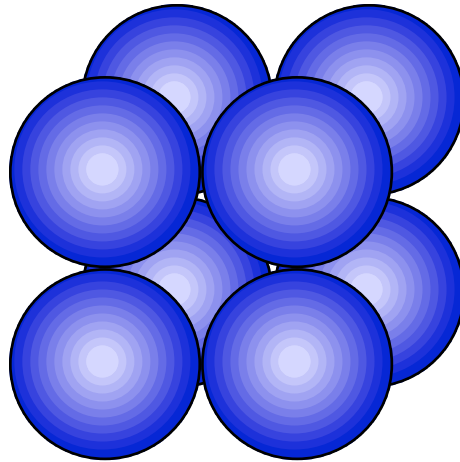
Next Generation

Nano Iron Particles

Nano Fe



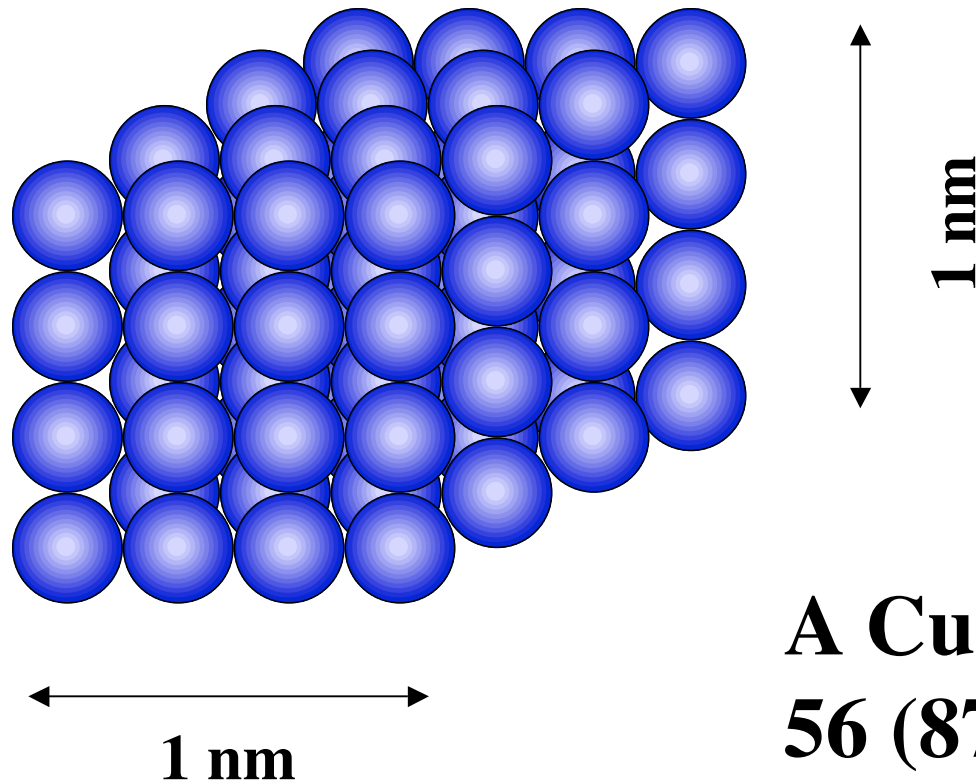
Surface



0.5 nm

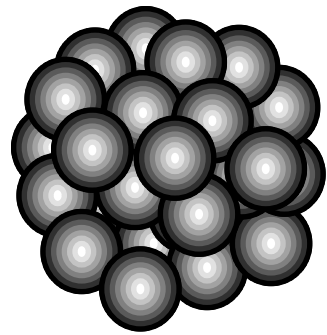
8 Fe atoms - 100% on surface

and Material Use Efficiency



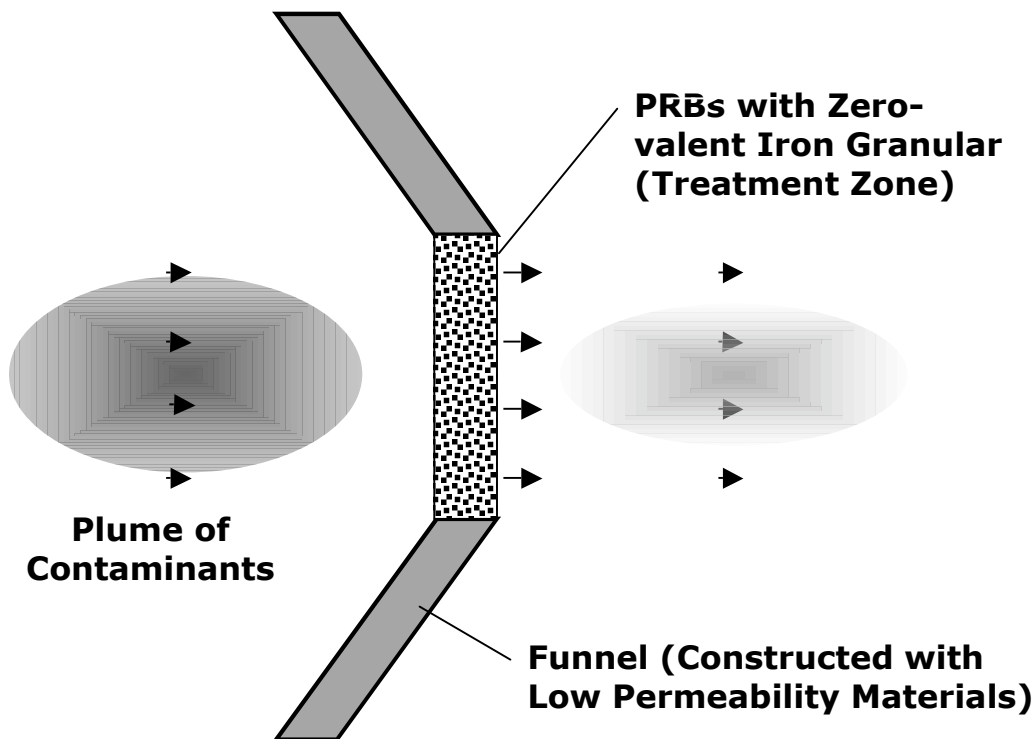
**A Cube of 64 Fe atoms
56 (87.5%) on surface**

Nano Iron



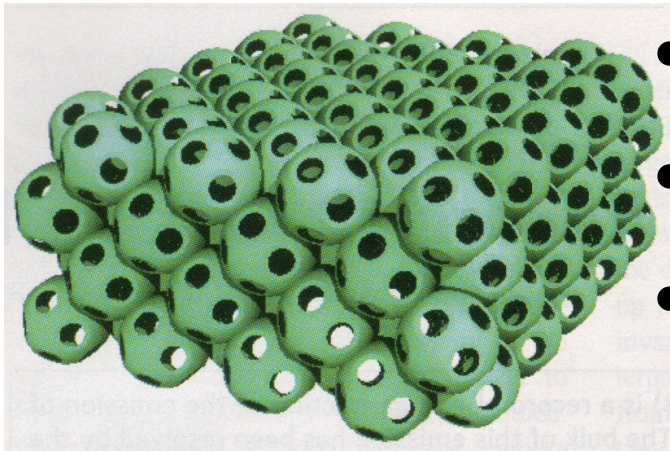
50 nm
~ 4% on Surface

Permeable Reactive Barriers (PRBs)



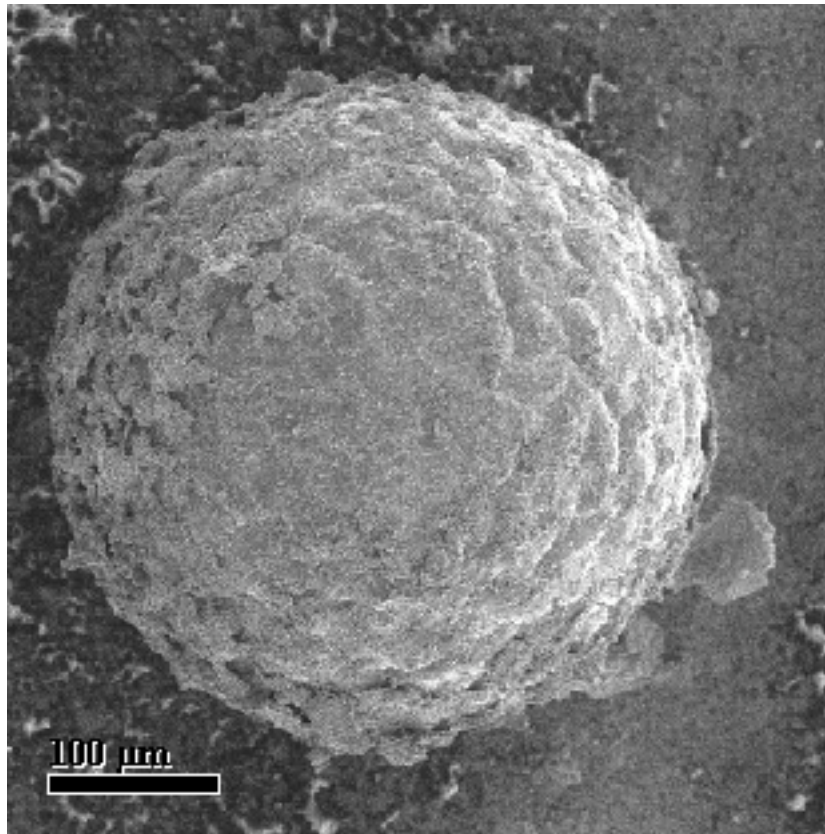
1 mm
< 0.0001%
on Surface

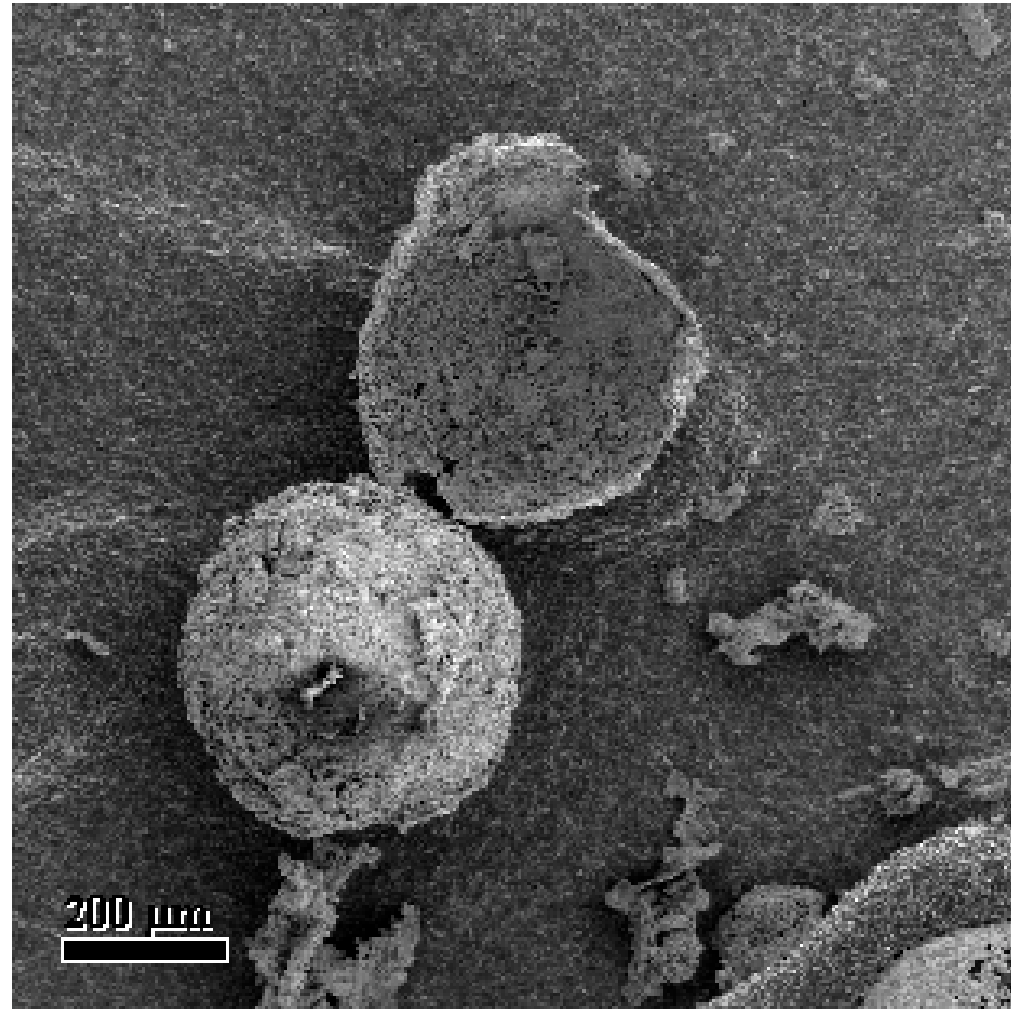
Next Small Thing - Porous Nanoparticles

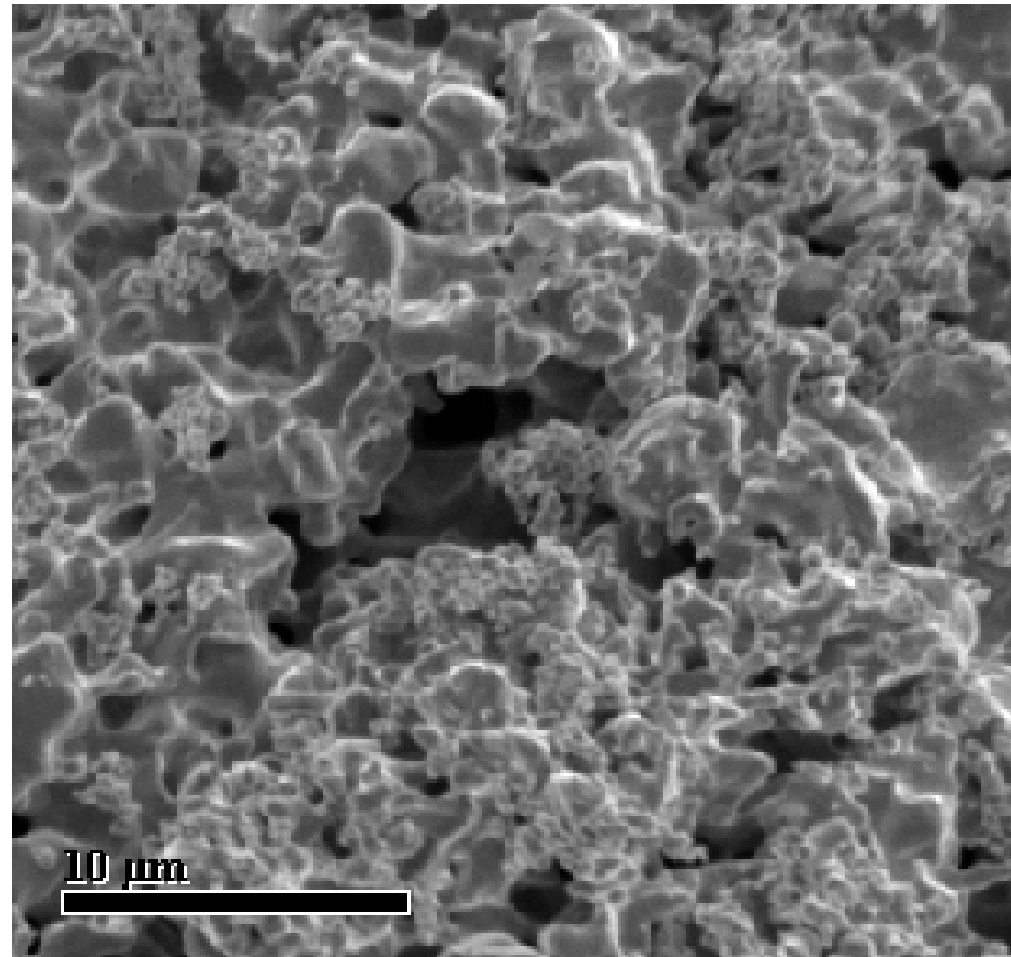


- Large surface area
- Better hydraulics
- High mobility

Template-directed Synthesis (Hollow and Porous Iron)







Specific Surface Area

	Size	BET area (m²/g)
Solid sphere	0.4 mm	1.9
Porous sphere (synthesized)	0.4 mm	2100

COSTS

Iron Filings	Nano Iron	Porous Iron
\$0.5/kg	~\$50/kg	~\$100/kg
<10 m ² /kg	~25,000 m ² /kg	~200,000 m ² /kg
<20 m²/dollar	~500 m²/dollar	~2,000 m²/dollar

“There's Plenty of Room at the Bottom”

Richard Feynman

December 1959

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