



LIFE Frac In: Enabling in situ soil remediation on low-permeability sites through hydraulic and pneumatic fracturing

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Project layout



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LIFE Frac-in

- LIFE: EU's financial instrument
 - Supporting environmental, nature conservation and climate action projects throughout the EU
 - > 5500 projects
 - 7 billion euro
- 2022 – 2025
- Partners:
 - Dekonta a.s.
 - ABO nv



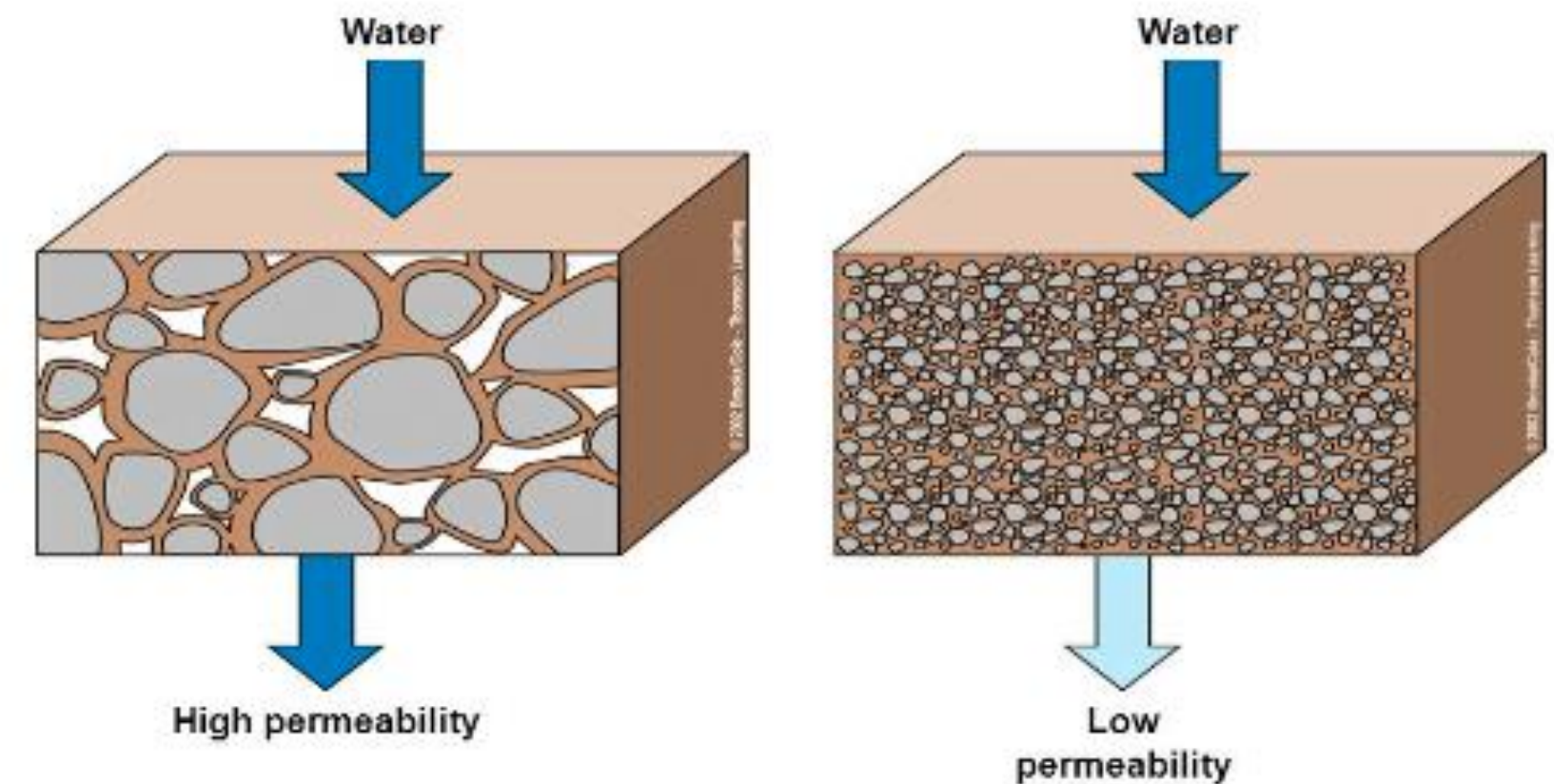
Background

- Shift from EX-SITU to IN-SITU
- Injection
 - Remediation agents (ISCR, ISCO, adsorption, ...)
 - Direct contact with contaminant needed
- Poor applicability in low permeable soils



Aim

- Enabling IN SITU soil remediation with Injection in low permeability soils
 - Both chemical and biological reagents
 - Clay to loamy soils
 - Heterogeneous soils
- Mechanism
 - Soil fracturing => creating artificial porosity
 - Suspension injection => maintaining porosity



Artificial porosity





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Frac-In technology





FRAC-IN Concept



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Frac-In Pilot Tests



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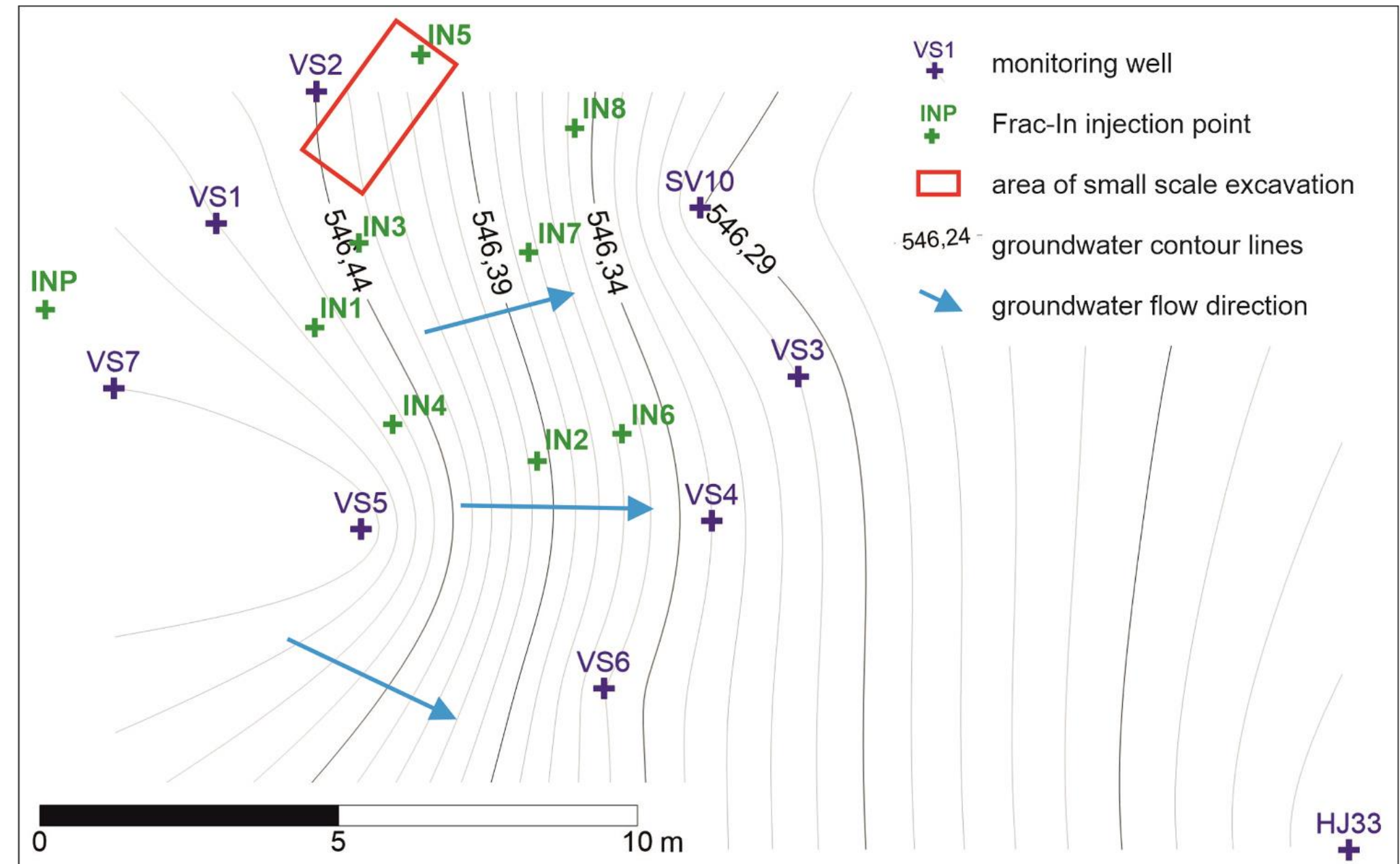
Research sites

- Types of **contaminations**
 - Mineral oil
 - BTEX, chlorinated ethenes
 - Phthalates, ...
- Types of **geology** (2 sites in CZ, 5 sites in BE)
 - Clay
 - Loam
 - Sandy loam
- **Depth** interval
 - 2m up to 15m



Pilot site western Czechia – old metalwork factory

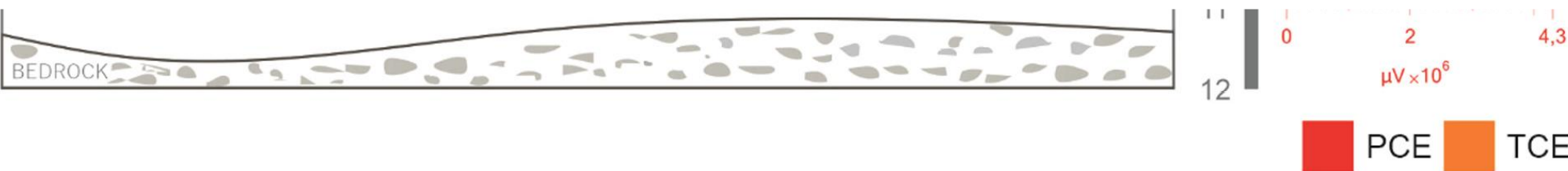
- **Contamination:** chlorinated ethenes
 - PCE DNAPL
- **Geology:** loamy to sandy clay
 - Preferential flow paths
 - Permeability 10^{-5} to 10^{-6} m/s
- **Pilot location**
 - Based on previous MIP survey (EC, XSD)
 - 9 monitoring wells





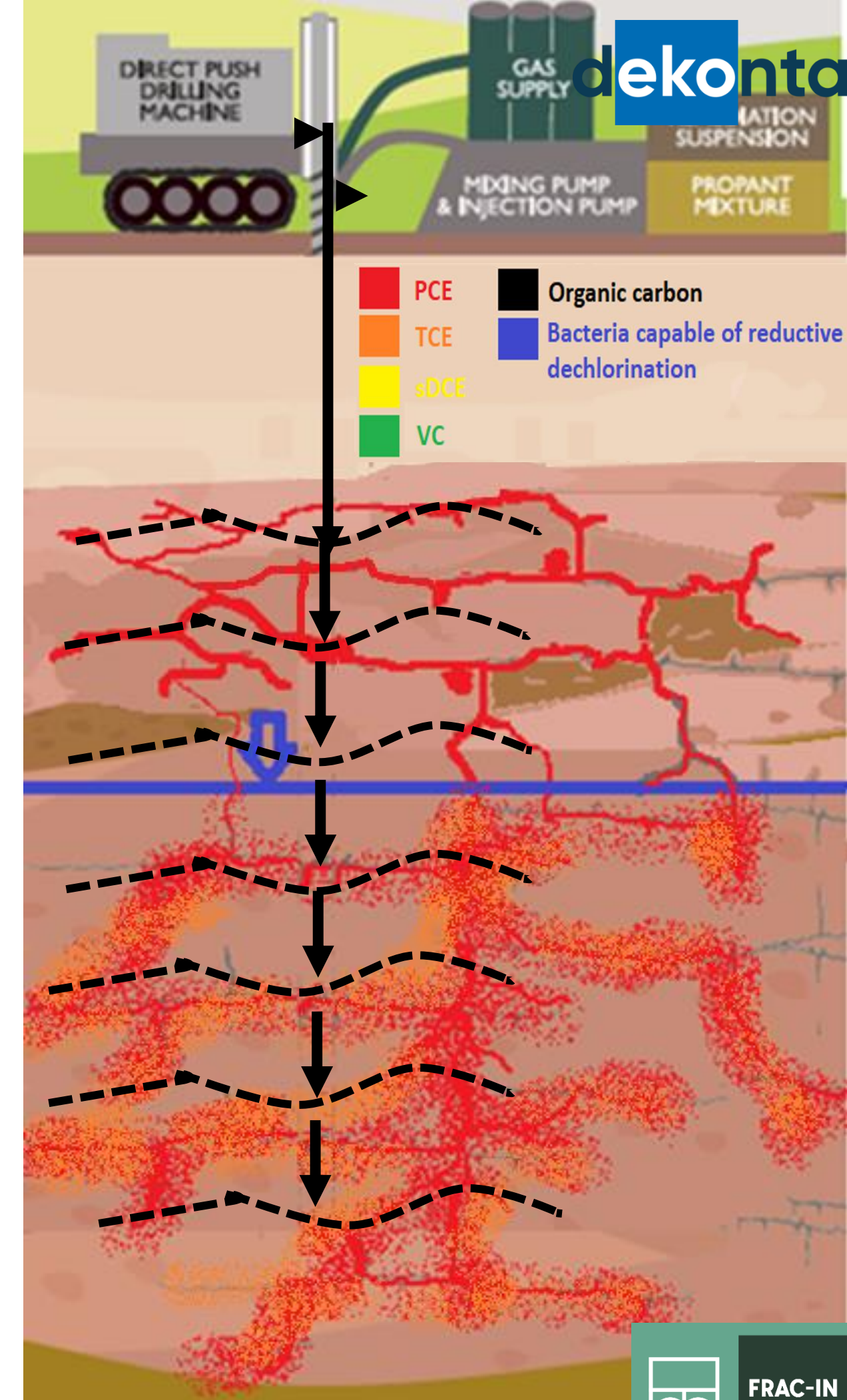
Conceptual site model

- Thin uncontaminated **backfill**
- **Unsaturated zone:**
 - Highly contaminated
 - Fracture network with **PCE** DNAPL
- **Saturated zone:**
 - **PCE** seeping in and dissolving
 - Slow partial dechlorination (**TCE** formation,
 - Transport
 - existing preferential flow paths
 - diffusion



Injections

- **Pneumatic fracturing**
 - Nitrogen gas
 - Widen current fracture system
- **Frac In injections in to both unsaturated and saturated zone**
 - Mixture of sand, milled iron and sulfidized nZVI
 - Dried whey injected afterwards as carbon source for bacteria



Injections

- **Equipment**
 - Connection to injection rods
 - Injection pump
 - Pneumatic system with nitrogen
- **9 injection points, 45 horizons**
 - 5,5 m³ of suspension
 - 1700 Kg of milled Fe and sand
 - 35 Kg of sulfidize nZVI
 - 5,5 m³ of hydraulic/rinse fluid
 - 300 kg of dried whey with pH stabiliser
- **Radius of influence 2 to 6 m**



(L)	W
X	
200	100
100	100
200	100
200	100
50 x	

SV10

+

N	S (L)	W
OK	100	100
OK	100	50
X	X	X
X	X	X
OK	200	150
OK	100	100
OK	100	100

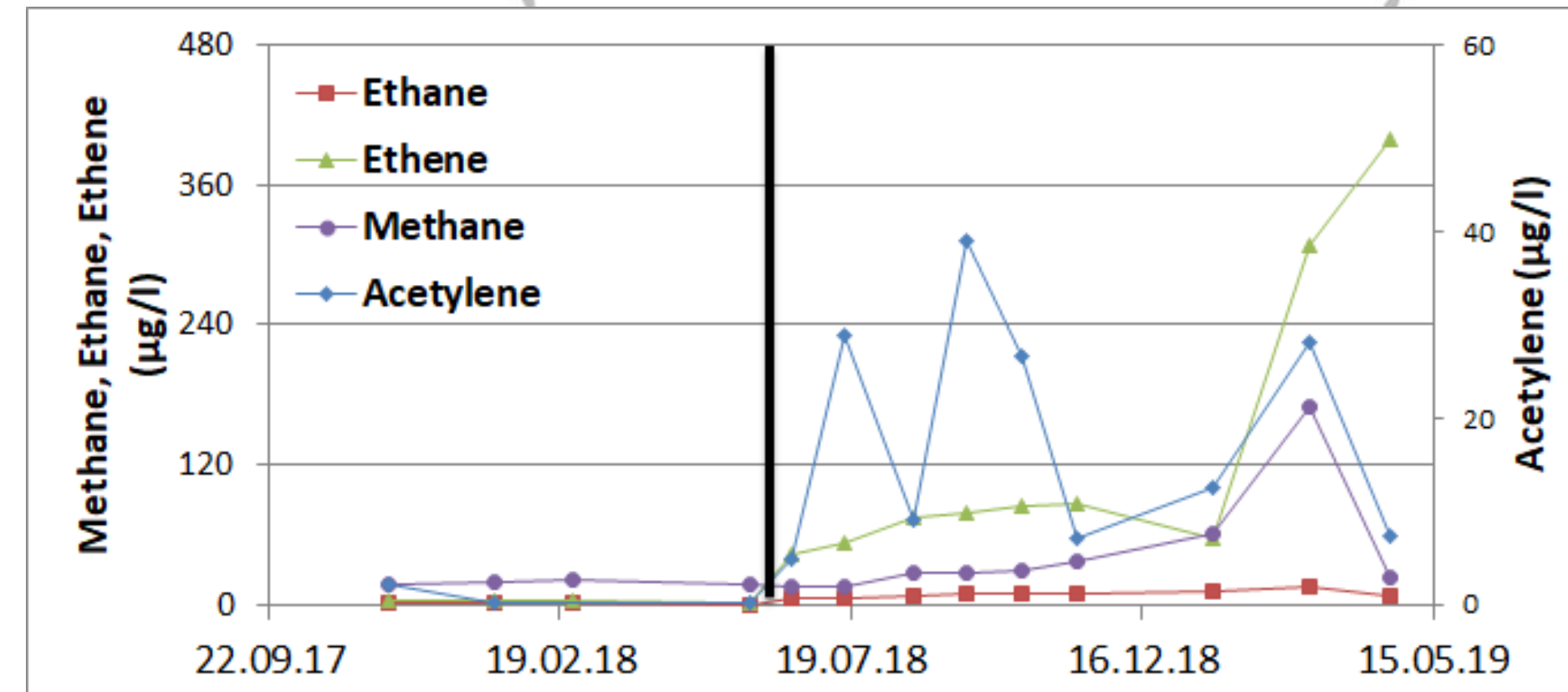
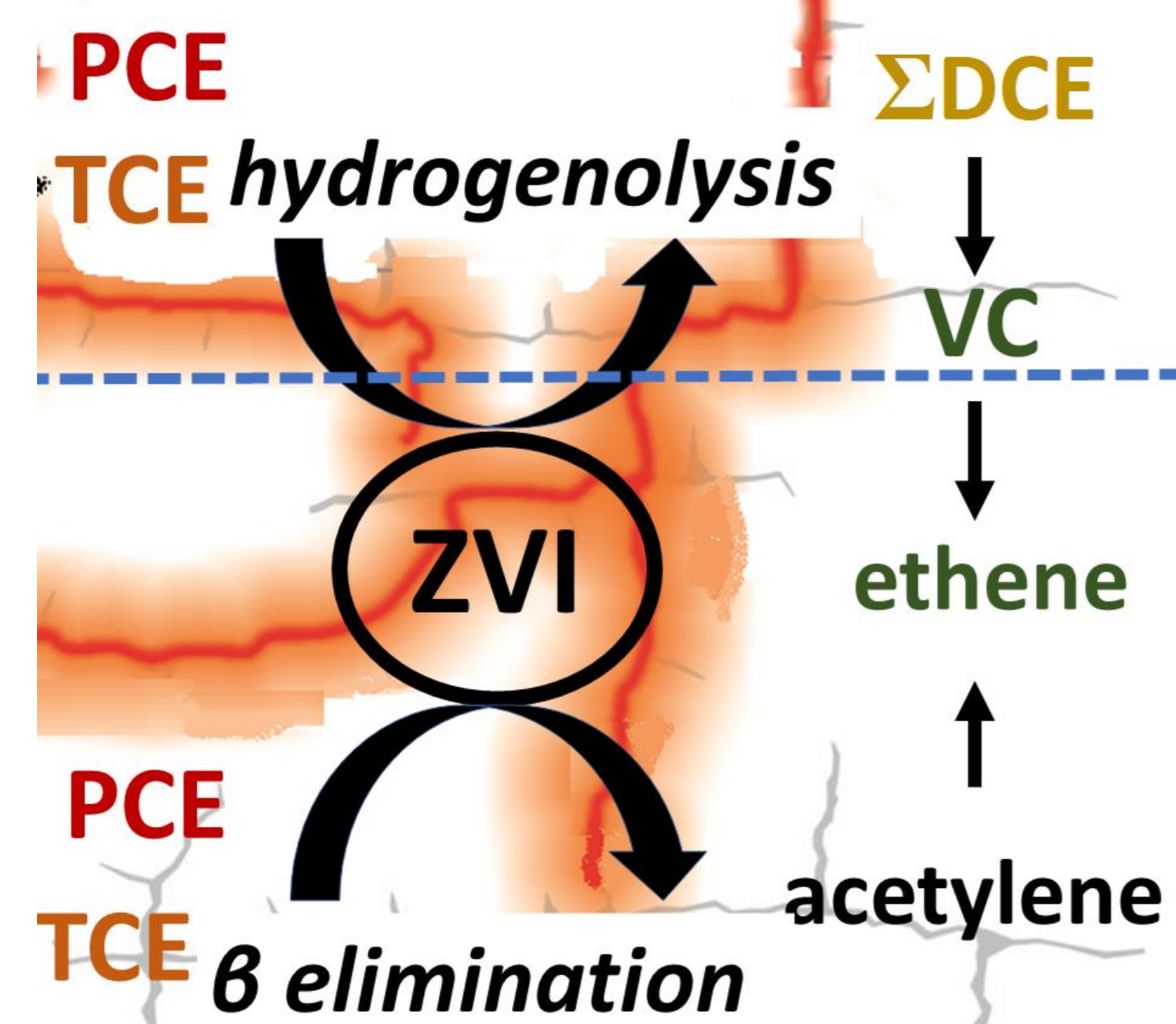
VS3

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VS4

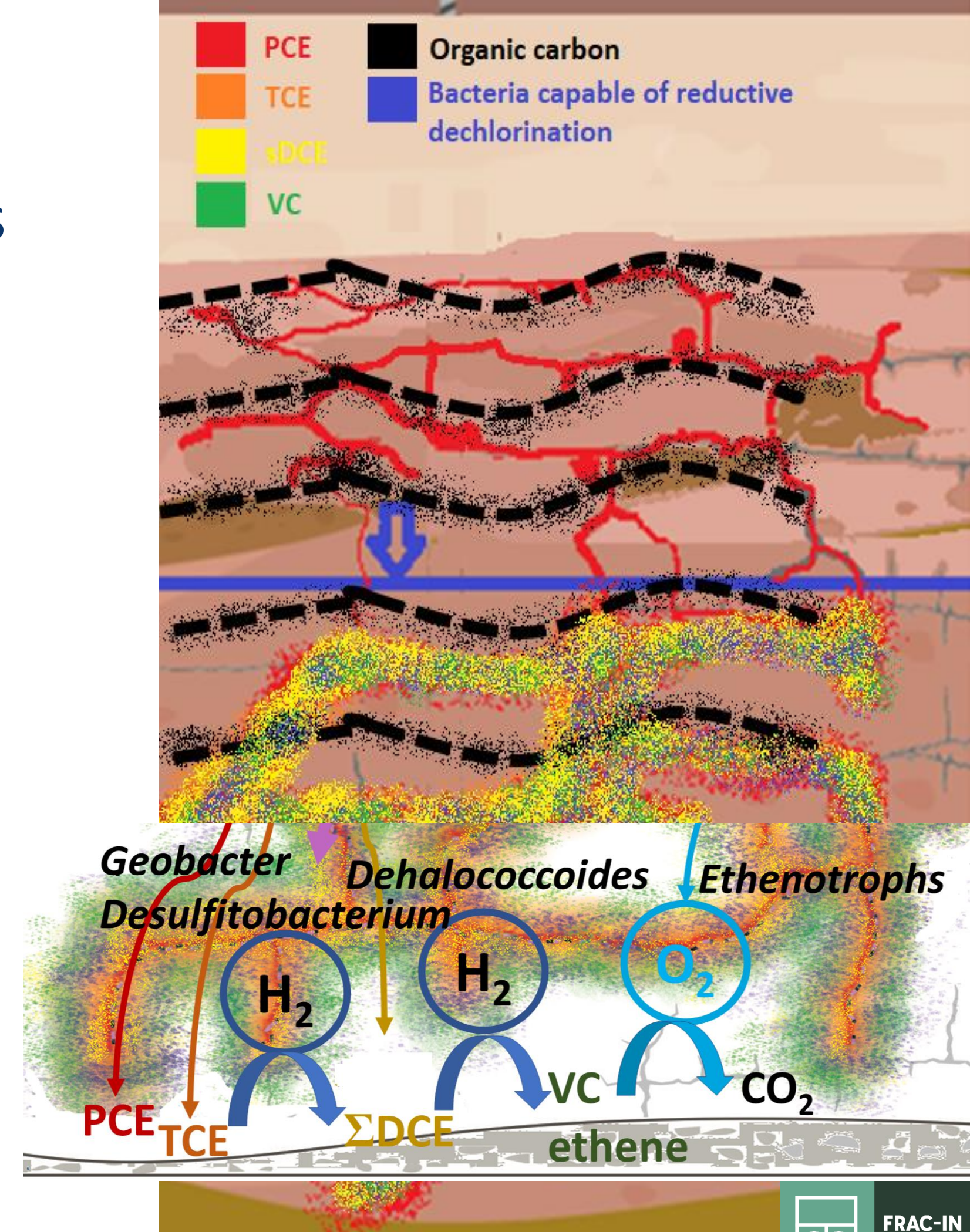
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- Low **bacterial** abundance
- Low **DCE** and **VC** concentrations
- High **organic carbon** concentrations
- **Saturated zone**
 - **PCE** mobilized and partly dechlorinated to **TCE**
- **Existing network of cracks widened**
 - Partly filled with iron
 - Abiotic **PCE** reduction generates acetylene



Pilot results – 30 months after injections

- **Unsaturated zone**
 - Precipitation seeps into treated fractures
 - **PCE** reduced to **DCE** and flushed to groundwater
- **Saturated zone**
 - High abundance of **bacteria** (both anaerobic and aerobic)
 - Lower **PCE** and **TCE** concentrations in groundwater
 - **DCE** concentrations dominate and decrease
 - **VC** is not accumulated (ethenotrophic bacteria)
- **Biotic dechlorination** is dominant



Pilot conclusions

- **Soil permeability** increased
- **Abiotic reduction of chlorinated ethenes** dominated 6 months after injection
- **Biological reduction of chlorinated ethenes** dominated 30 months after injection
 - Dechlorinating bacteria gradually increased
 - DCE accumulated
 - VC did not accumulate due to ethenotrophs
- **Condition of the site** significantly improved

Conclusion

- Development of **operational guidelines**
 - Optimal operating conditions
 - Vertical working ranges
- **Compatibility**
 - Remediation agents
 - Geology types
- **Validation** of FRAC-In technology
 - Provide reference projects
 - Speed up implementation of full-scale application





Thank you for your attention

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