Biotic and abiotic degradation of 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113): Implications for detoxification of chlorinated ethenes

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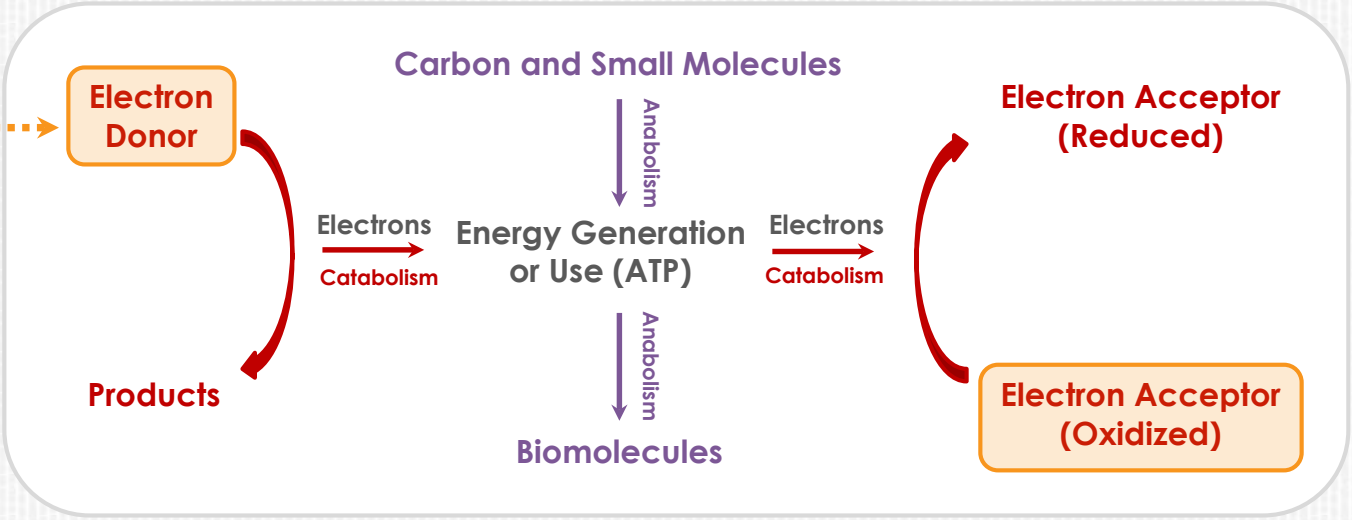
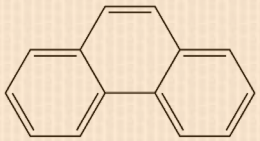
Conventional biodegradation processes



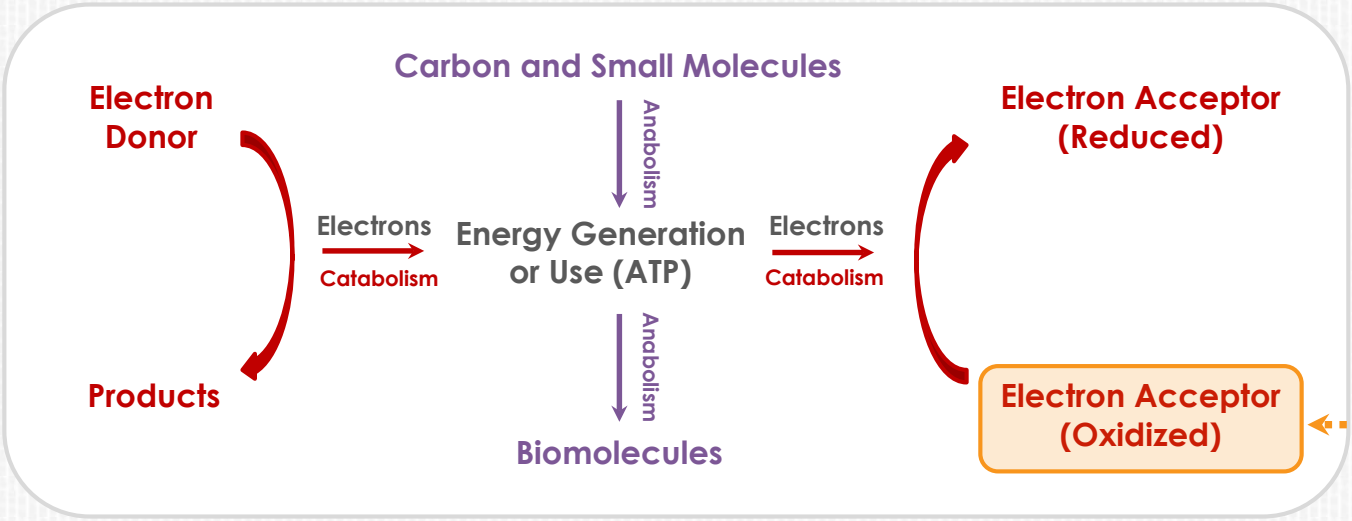
Contaminants



Phenanthrene

		Respiration
O_2 H_2O	*Pseudomonas*	Aerobic
NO_3 N_2	*Azoarcus*	Denitrification
Fe^{3+} Fe^{2+}	*Geobacter*	Ferric reduction
SO_4^{2-} H_2S	*Desulfobacterium*	Sulfate reduction
CO_2 CH_4	*Methanospirillum*	Methanogenesis

Conventional biodegradation processes



Respiration

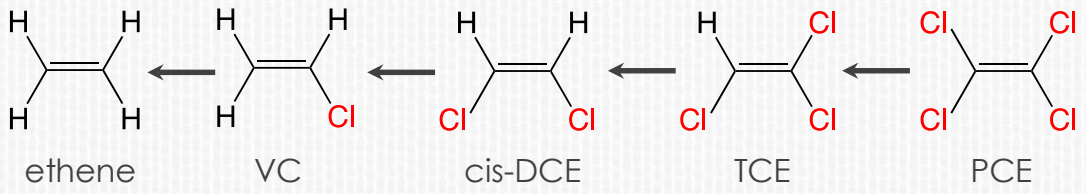
Reductive dehalogenation

ethene PCE

Reductive dehalogenators

Dehalococcoides

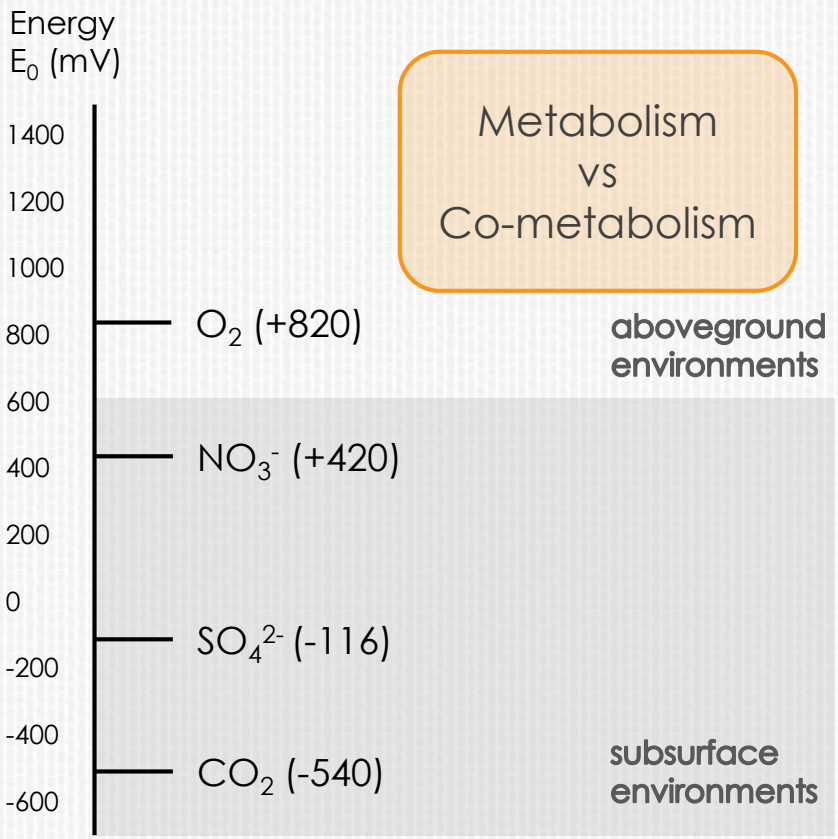
Dehalobacter, Dehalospirillum, Desulfitobacterium Desulfomonile, Geobacter, Dehalococcoides



Halogenated contaminants e.g. PCE PCB

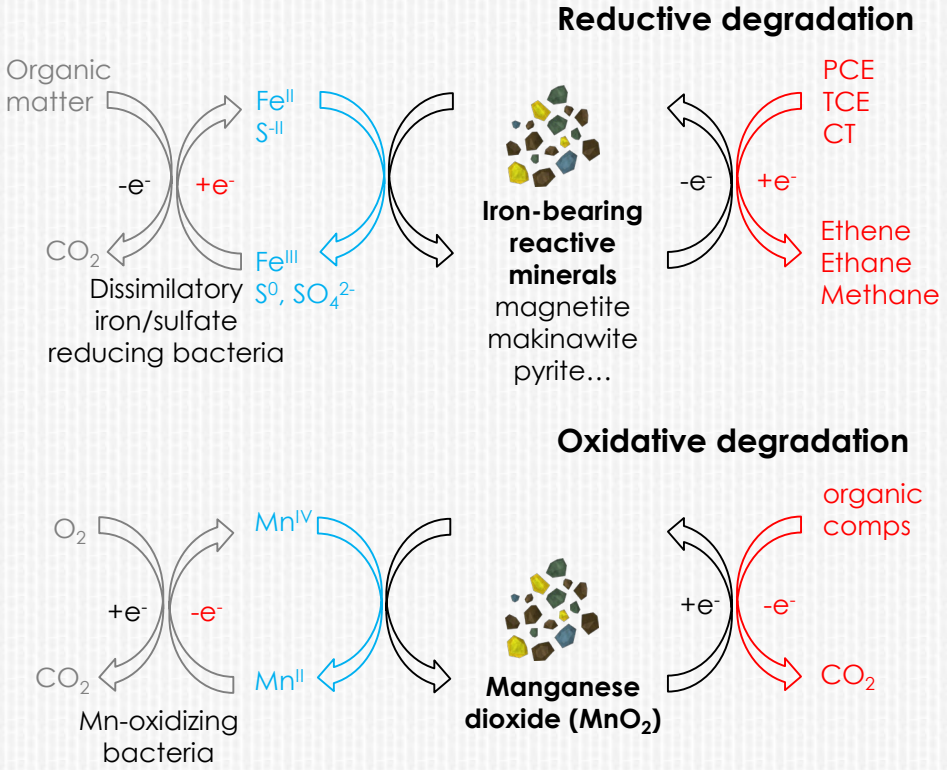
Degradation pathways

Conventional biodegradation

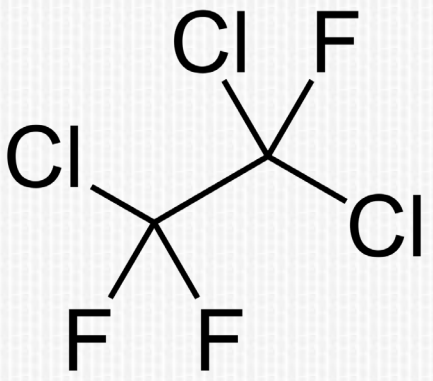


BMAD

Biologically **M**ediated **A**biotic **D**egradation

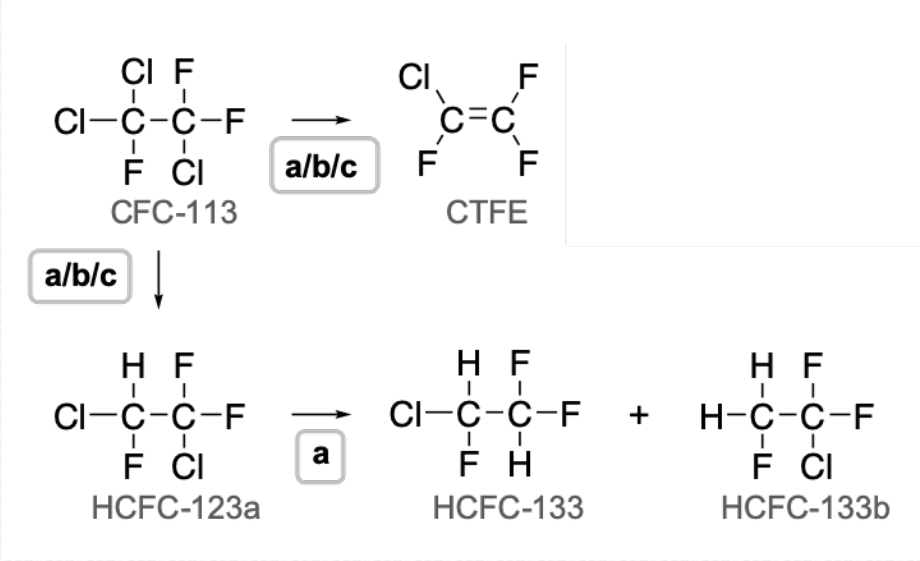


1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)



- A well-known refrigerant
- A versatile solvent, often used in combination with chlorinated solvents such as TCE
- CFC-113 occurs as (co-)contaminant at many sites

Environmental Fate of CFC-113



a: biological degradation under anoxic conditions (Deipser et al., 1997; Lesage et al., 1990; Lesage et al., 1992; Balsiger et al., 2005)

b: abiotic degradation by zero valent iron (Archbold et al., 2012)

c: abiotic degradation by hematin (Lesage et al., 1992)

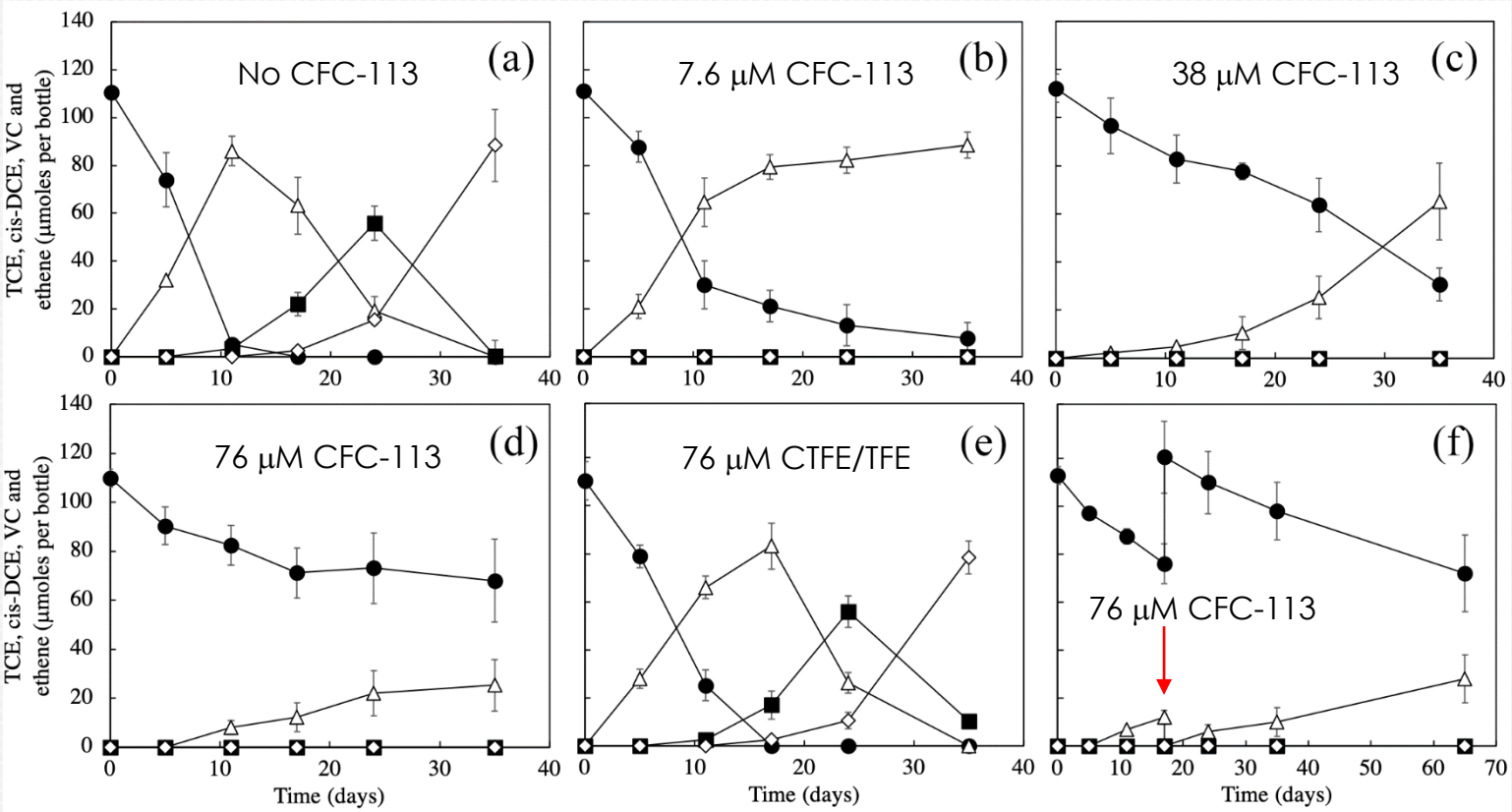
effect of CFC-113 on reductive dehalogenation

&

natural attenuation pathways of CFC-113

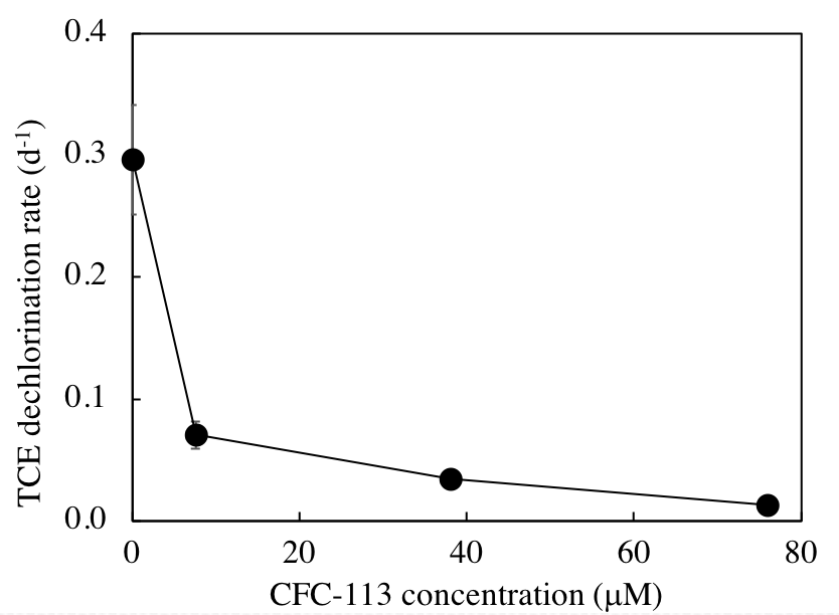
Effects of CFC-113 on Reductive Dechlorination

100 mL DCB-1 medium in 160 ml serum bottle with SDC-9™
5 mM lactate and 10 µL of TCE

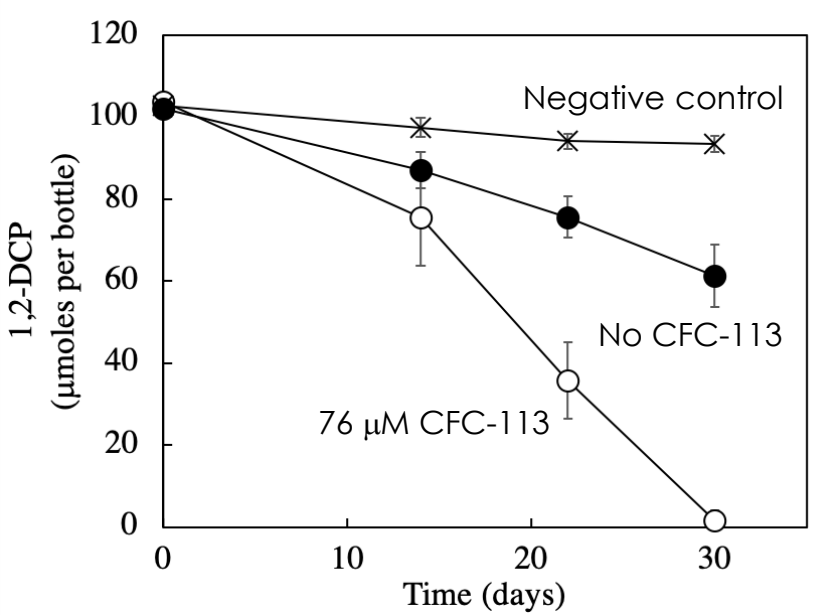


Closed circle, TCE; open triangle, cis-DCE; closed square, VC; open diamonds, ethene.

Effects of CFC-113 on Reductive Dechlorination

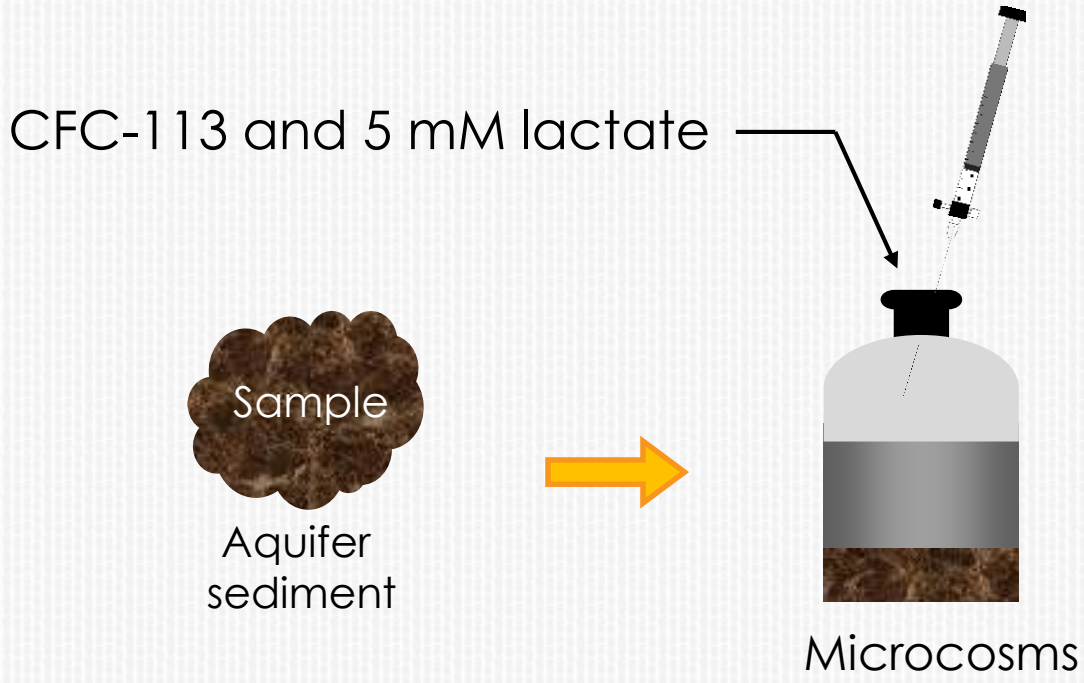


Effects of CFC-113 on TCE dechlorination rate by SDC-9™



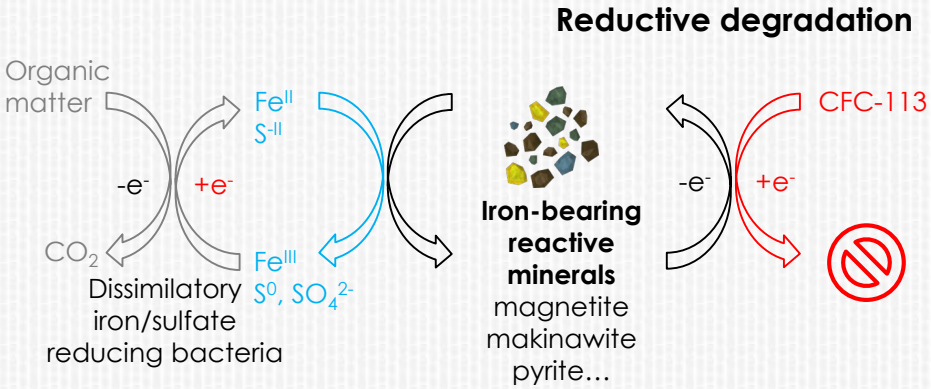
Effects of CFC-113 on 1,2-DCP dechlorination by *Dehalogenimonas lykanthroporepellens* strain BL-DC-9

Microbial Reductive Dechlorination of CFC-113



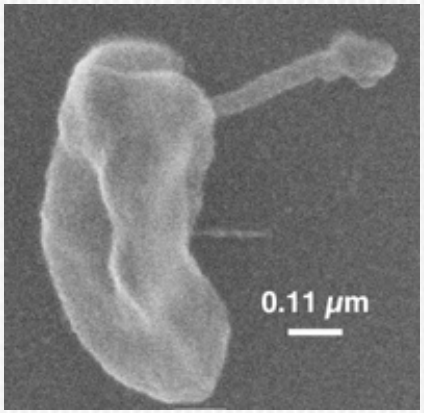
- CFC-113 → CTFE
- Dechlorination activity was NOT sustained in the transfer culture

Abiotic Degradation by Reactive Mineral Phases

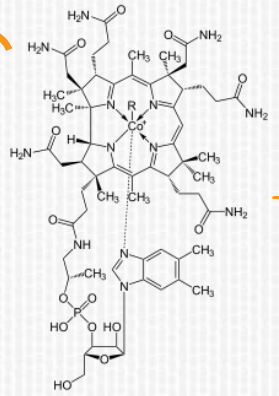


- Positive control with TCE confirmed the reactivity of the mineral phases
- No transformation of CFC-113 was observed

Dehalococcoides are corrinoid-auxotrophs.



Dehalococcoides



corrinoid

Acetogens

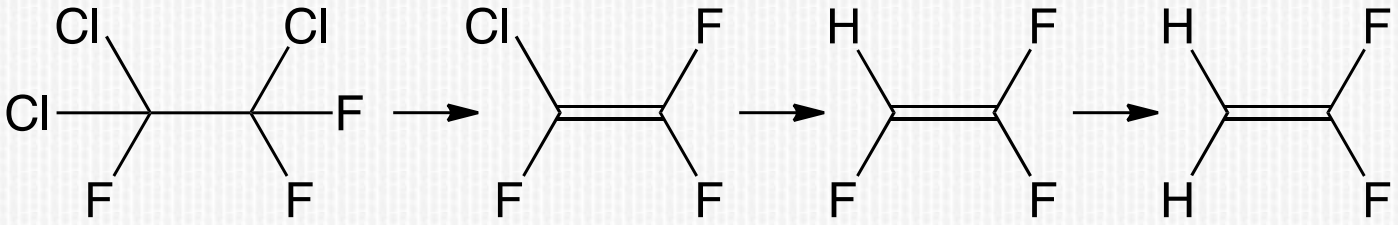
Methanogens

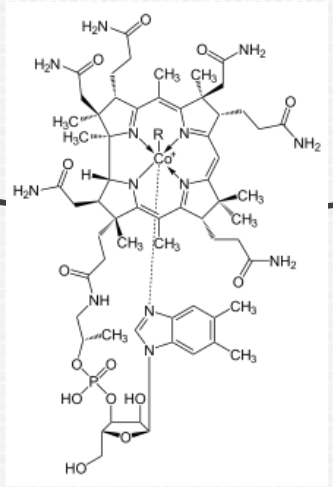
Iron reducers

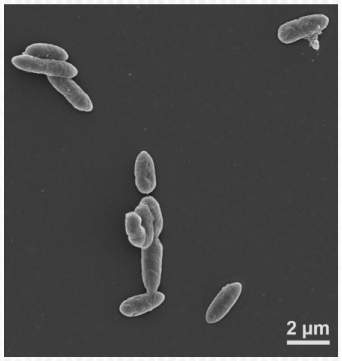
etc.

These *extra cellular* biomolecules are available.
Then, also mediate abiotic degradation?

Biologically mediated abiotic degradation of CFC-113





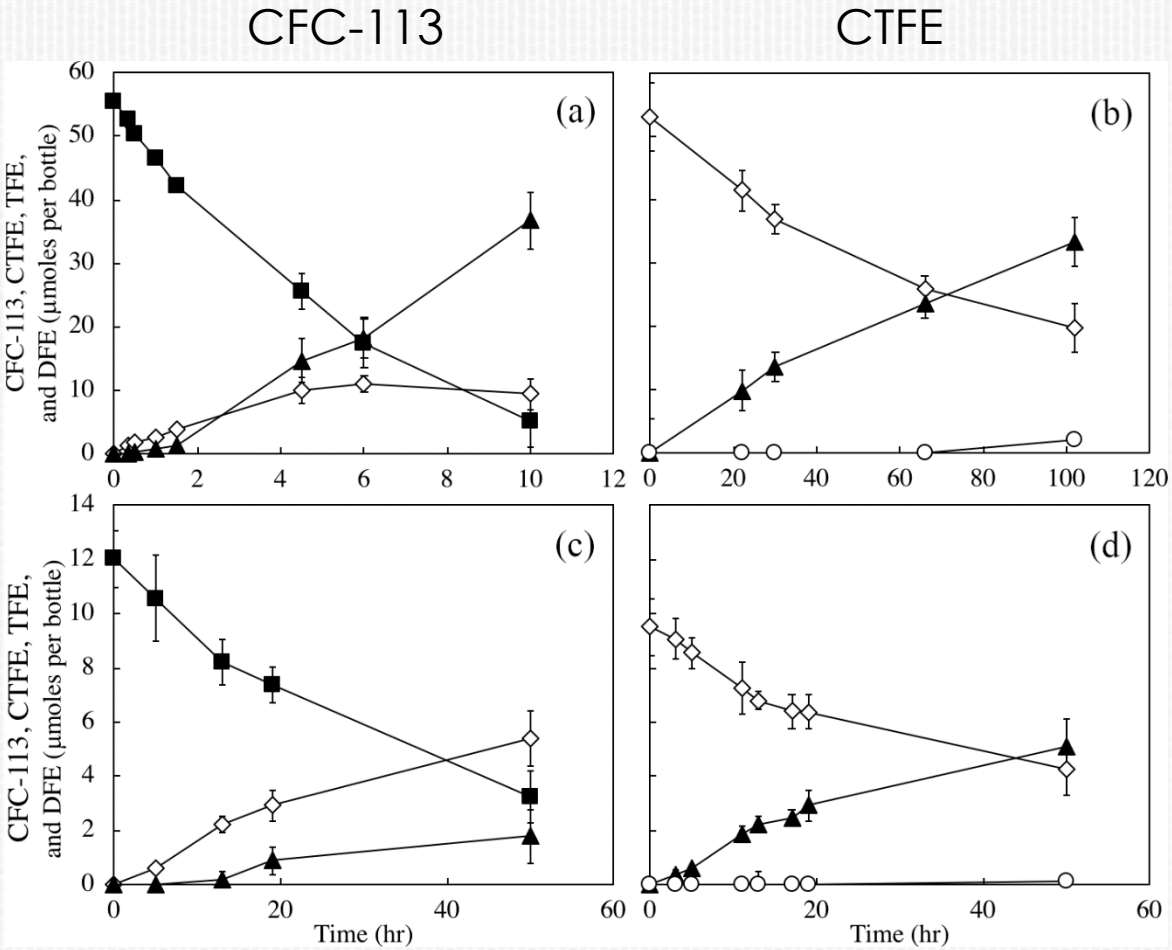


Sporomusa ovata (no dehalogenase)

Biologically mediated abiotic degradation of CFC-113

Vitamin B12/Ti(III)Cit

Sporomusa ovata
with 15 mM betaine



Closed square, CFC-113; open diamond, CTFE; closed triangle, TFE; open circle, DFE

Discussion

- *in situ* bioremediation treatment of chlorinated ethenes can be compromised when CFC-113 exists as a co-contaminant
- analogous inhibitory response of *Dehalococcoides* to perfluorinated compounds has also been reported, but it was reversible
- it still remains unclear whether the observed dechlorination activities of CFC-113 were fortuitous or metabolic processes
- natural CFC-113 attenuation may be more attributed to metallocoenzyme mediated co-metabolic degradation

Acknowledgement