

Overview:

Biogeochemical Processes and Contaminant Fate in the Groundwater – Surface Water Interface

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Outline

- **Definition of the groundwater-surface water interface (GWSWI)**
- **Physicochemical characteristics of the GWSWI environment**
- **Biogeochemical processes in the GWSWI**
- **Effects of biogeochemical processes on contaminant fate**
- **Conclusions**

What is the GWSWI?

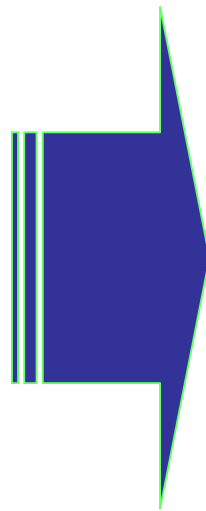
- **Subsurface zone in which the water shares characteristics of both the groundwater and the surface water.**
- **These characteristics might be :**
 - **Redox**
 - **Water Chemistry**
 - **Biological Populations (microbes, benthic organisms)**
 - **Contaminant Profile**

Characteristics of the GWSWI

-Zone of Gradients and Transitions

– Gradients

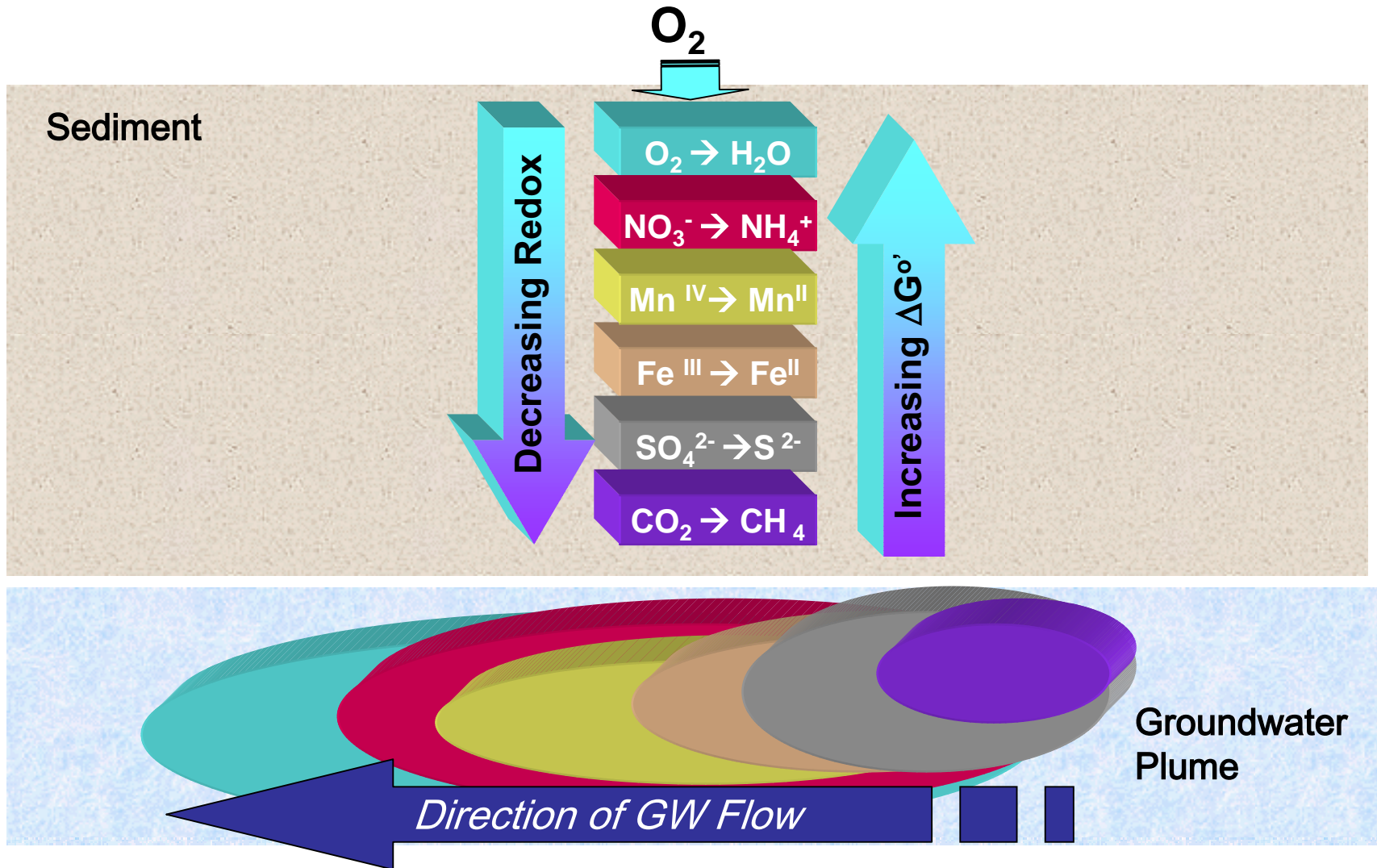
- Oxygen / redox
- Organic content
- Contaminant concentration / form



– Transitions

- Hydraulic conductivity
- Substrate (adsorption qualities)
- Microbial community
 - Aqueous and surface chemistry
 - Environmental fate of contaminants

Redox Gradients in GW and Sediments



Contaminant Fate and Transport

Dependent upon:

- **Physical-chemical characteristics of the contaminant**
- **Relative kinetics of the process vs. the discharge rate**
- **Depth and differences in surface water and groundwater chemistry**
- **Physiologies and competencies of the microbial population**

Environmental Fates of Contaminants

Transformation:

Chemical changes in contaminant can result in new mobility or toxicity characteristics. Not always desirable.

Ex: PCE → TCE → cDCE → VC → Ethene

Hg_{inorganic} → MethylHg

Nitrobenzene → aniline → covalent bonding to organic matter

Degradation:

Mineralization or transformation of contaminant to an innocuous compound.

Ex: Oxidation of BTEX compounds to CO₂

TCE + CH₄ + O₂ → CO₂

Retardation:

Contaminant transport is retarded through precipitation or sorption reactions within the GWSWI.

Ex: Metal²⁺ + Sulfide²⁻ → Metal-sulfide Precipitate

Abiotic Processes Affecting Contaminant Fate

- **Hydrology** – affects residence time in the different transition zones
- **Precipitation** – immobilization of metals through sulfide precipitation
- **Sorption** – retardation of contaminant mobility through association with organic phases
- **Surface Chemistry** – chemical transformation of contaminants mediated by surface associated reactive minerals

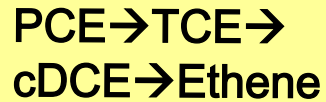
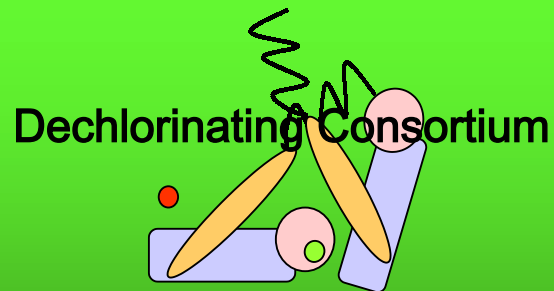
Biotic Processes Affecting Contaminant Fate

- **Direct:** Contaminant transformation is directly linked to physiological processes
 - Reductive Dechlorination of Halogenated solvents
 - Oxidation of BTEX Compounds
 - Co-metabolic Reactions
- **Indirect:** Organism produces an end-product that in turn transforms the contaminant
 - Reduction of nitroaromatics by surface associated reduced iron minerals
 - Precipitation of metallic contaminants by sulfide

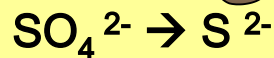
Abiotic / Biotic Processes

- *Fundamentally Linked*

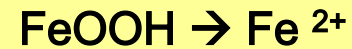
Biotic Processes



Sulfate Reducing
Bacteria



Iron Reducing
Bacteria



Precipitation of Metal
Sulfides

Reactive Surface Assoc. Fe^{2+}
+ Carbon Tet → Chloroform

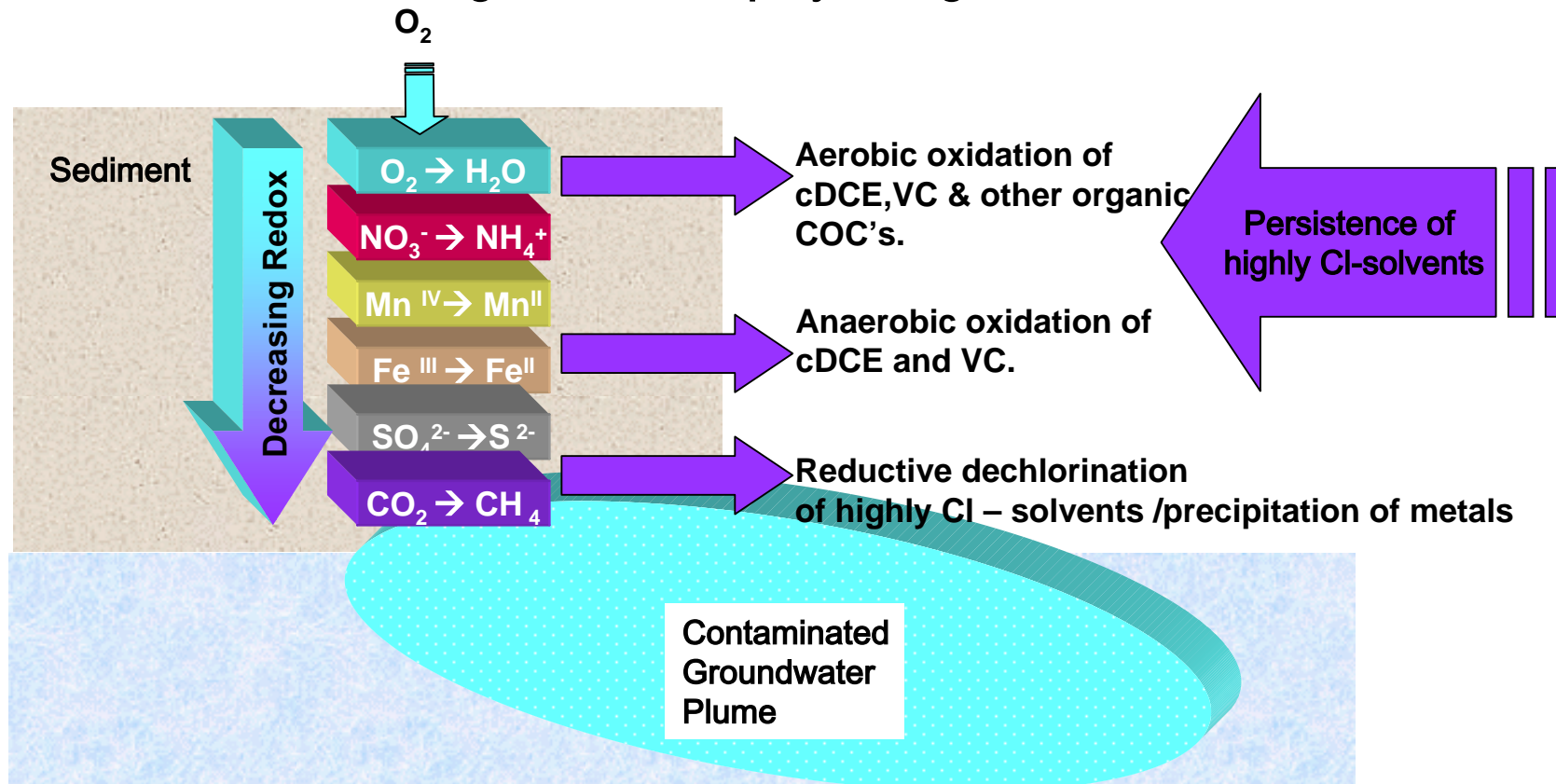
Abiotic Processes

& Effects of hydrology, sorption and residence time...

Types of GWSWI's - 1

- High Redox Plume → Low Redox Interface

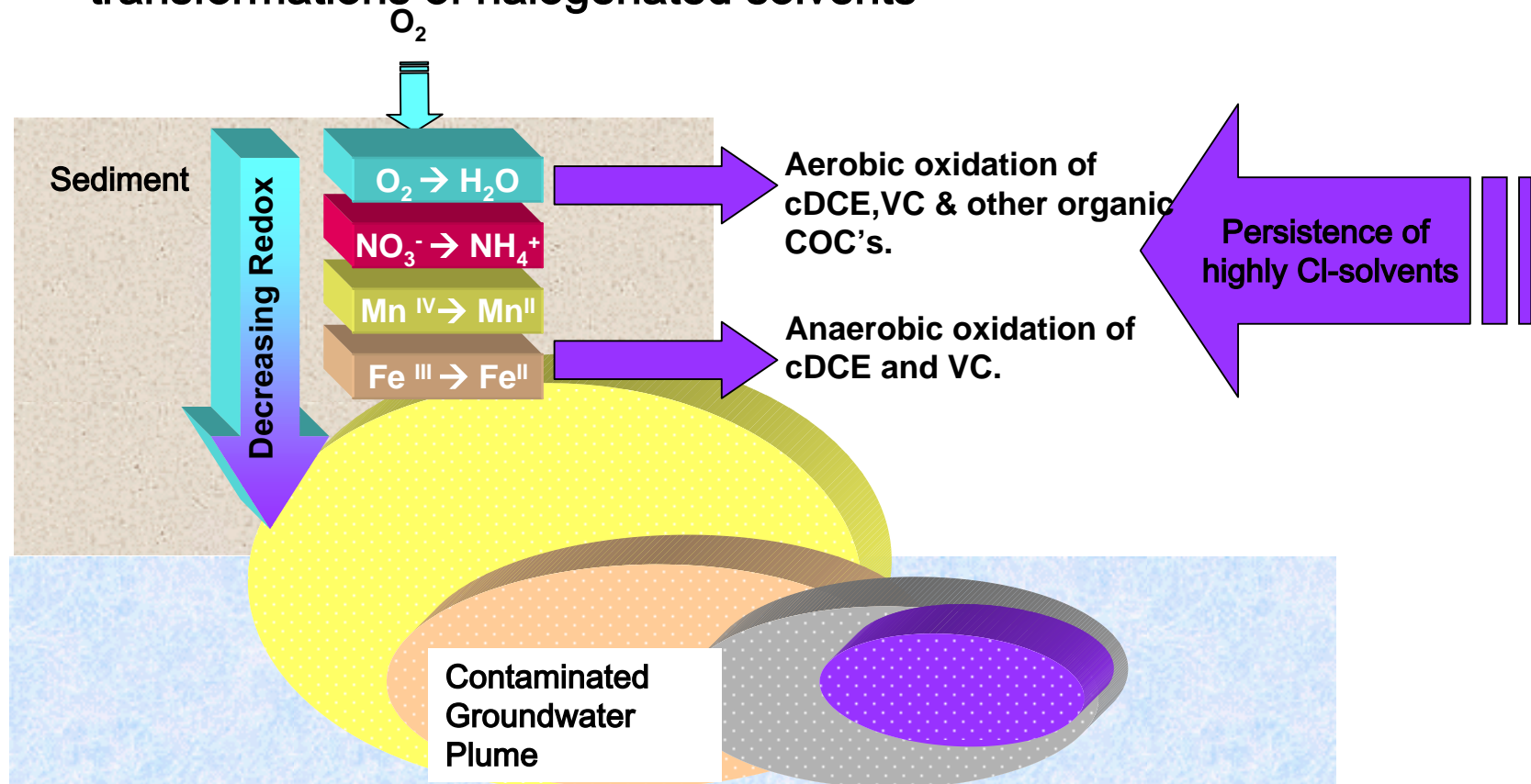
- High redox plume enters low redox GWSWI – zone of accelerated biodegradation for poly-halogenated solvents



Types of GWSWI's - 2

- *Low Redox Plume* → *High Redox Interface*

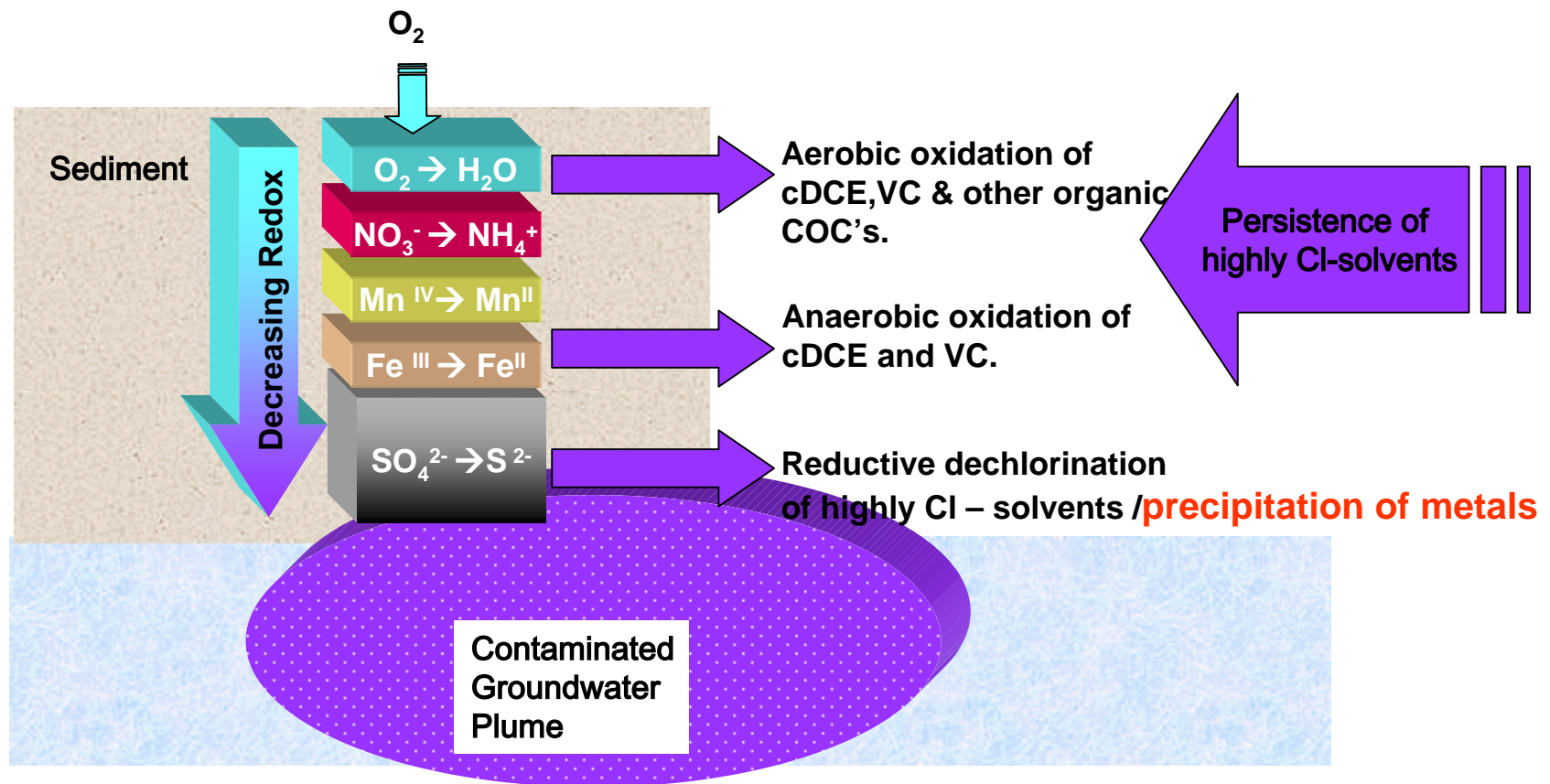
- Low redox plume enters high redox GWSWI – Respiration processes complete degradation of products of anaerobic transformations of halogenated solvents



Types of GWSWI's - 3

- *Low Redox Plume* → *Low Redox (Sulfate Reducing) Interface*

- Low redox plume enters zone of sulfate reduction in GWSWI (low redox) allowing precipitation of metal contaminants



Biogeochemical Processes in the GWSWI

Conclusion - 1

- Abiotic and biotic processes in the GWSWI environment may lead to significant changes in the chemistry, toxicity, and/or mobility of a contaminant.



- Discharge of groundwater from a contaminated plume into surface water *does not necessarily* mean discharge of plume contaminants.

Biogeochemical Processes in the GWSWI

Conclusion - 2

- **Characterization of the GWSWI environment is necessary for accurate determination of risk to human and environmental health and selection of best strategies for management of GW contaminants.**