

primordial DEEP TECH

taming the biochemistry of
anaerobic life in reservoir
and oil geologies

Advanced
Research
+ Innovation
Agency

ARIA



Renaissance
Philanthropy

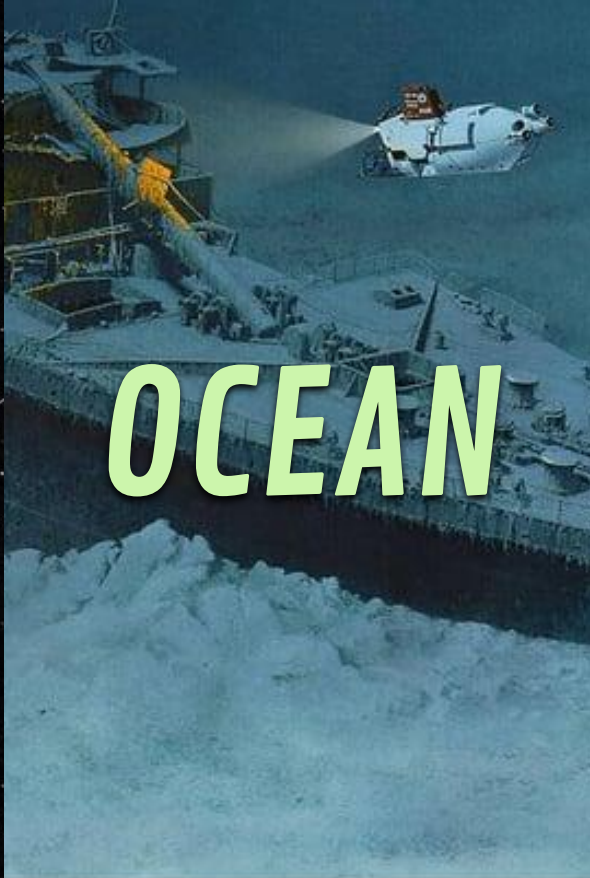
london, uk
8 december 2025
jonathan “jo” melville, ph.d.

there are exactly three unexplored frontiers

SPACE



OCEAN

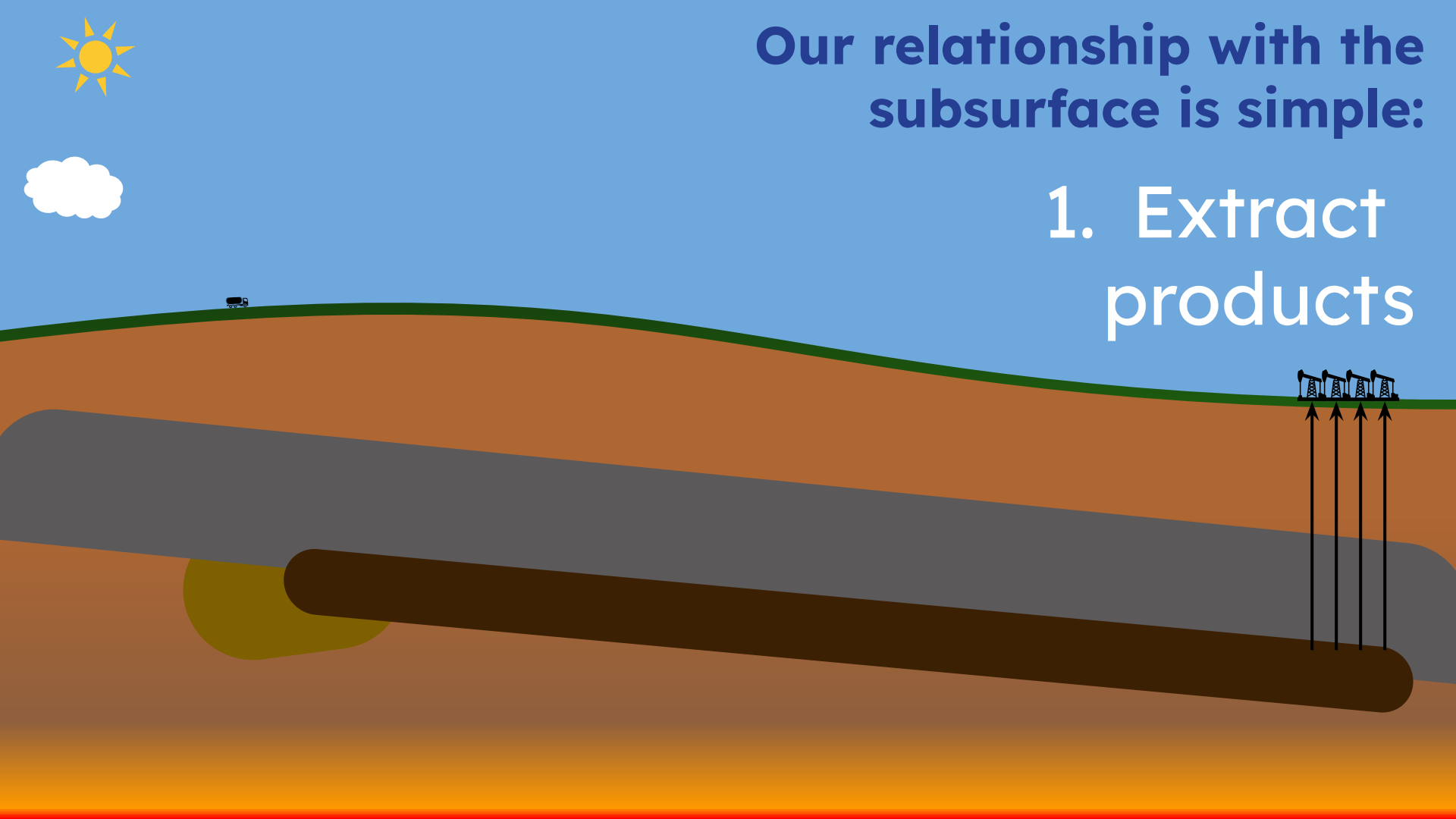


EARTH



Our relationship with the subsurface is simple:

1. Extract products

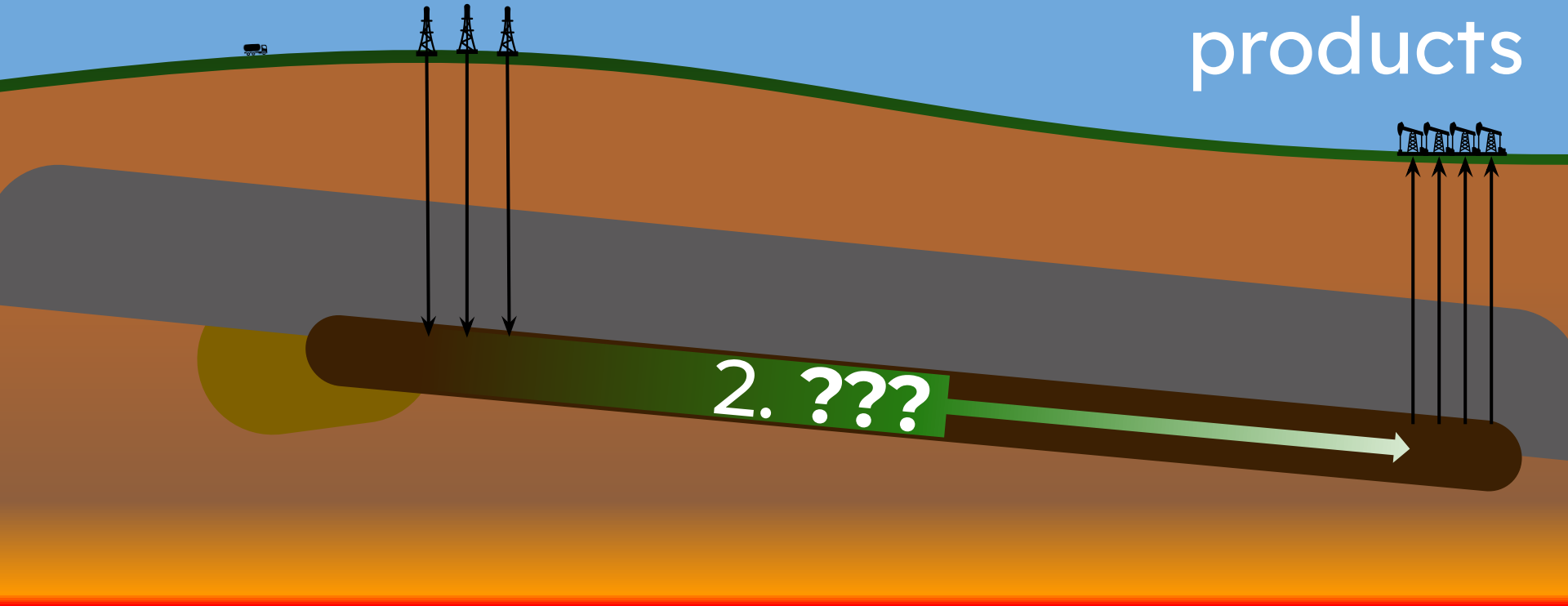




1. Inject
reactants

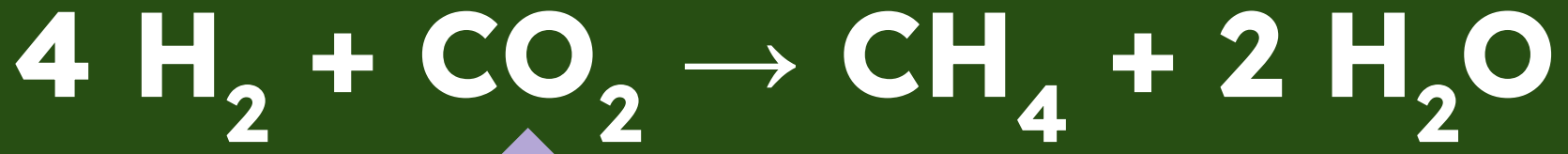
Our relationship with the
subsurface is simple:

3. Extract
products





e^- source



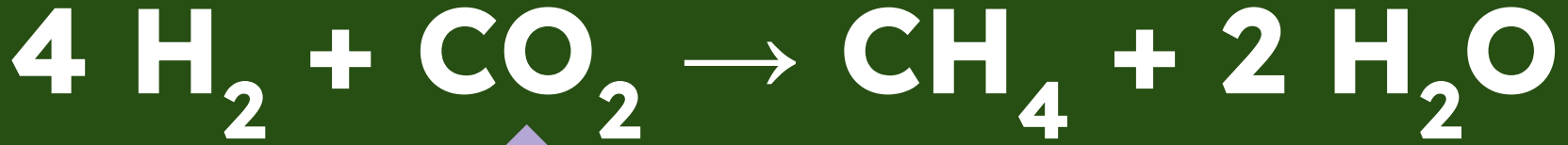
e^- sink



Surface Chemistry:

- oxidizing, aerobic
- e^- sources are limiting

e^- source



e^- sink

Subsurface Chemistry:

- reducing, anaerobic
- e^- sinks are limiting

1. Inject reactants

- ♻️ Waste gases (CO_2 , N_2 , O_2)
- ♻️ Water (H_2O)

3. Extract products

- ♻️ Renewable fuels ($\text{C}_n\text{H}_{2n+2}$)ⁿ⁼¹⁻³
- ♻️ Plastic monomers (C_nH_{2n})ⁿ⁼²⁻⁴
- ♻️ Clean fertilizers (NH_3 , NO_3^-)
- ♻️ Electron carriers (HCOO^-)

2. Biogeochemistry!

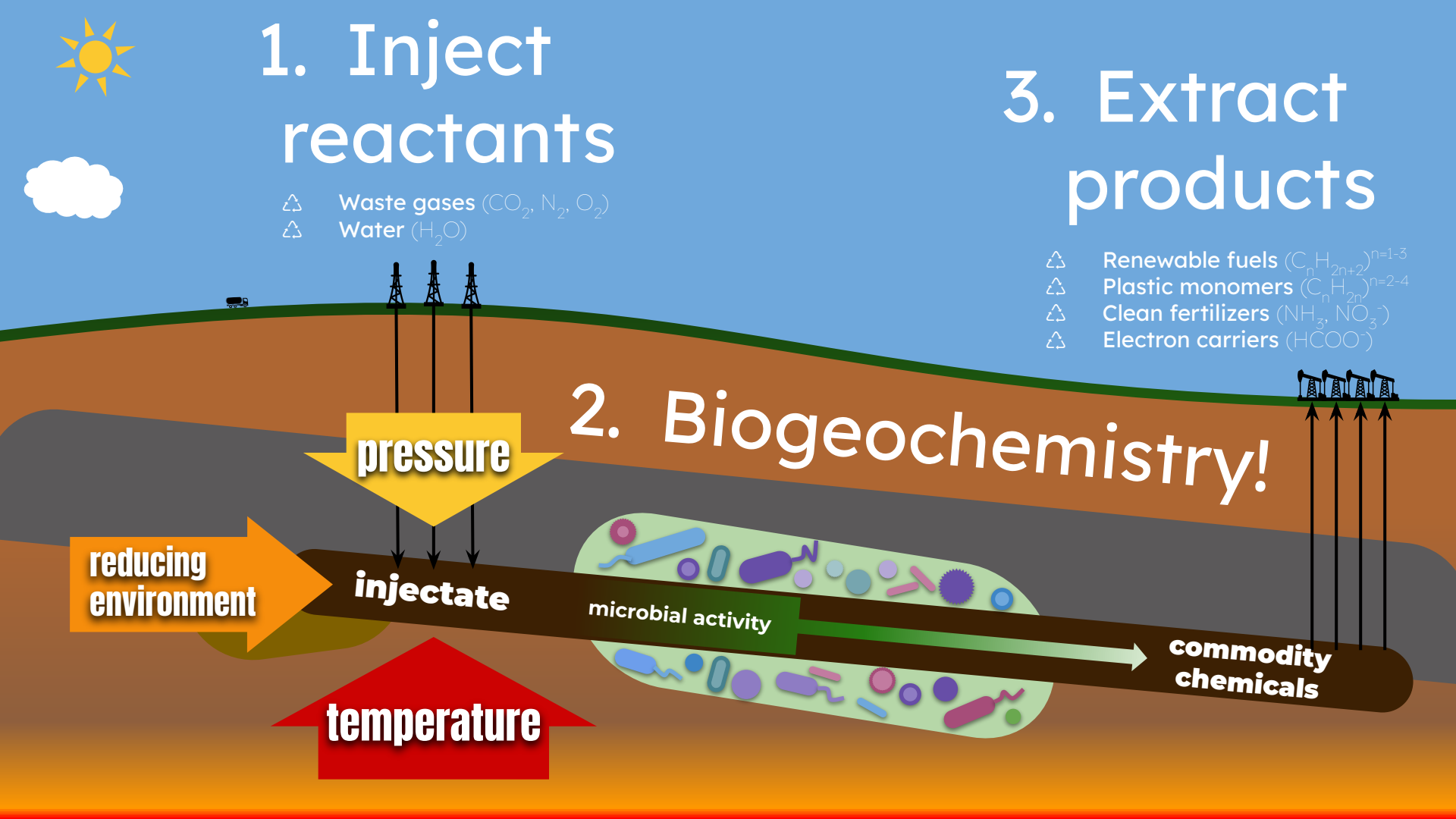
reducing environment

injectate

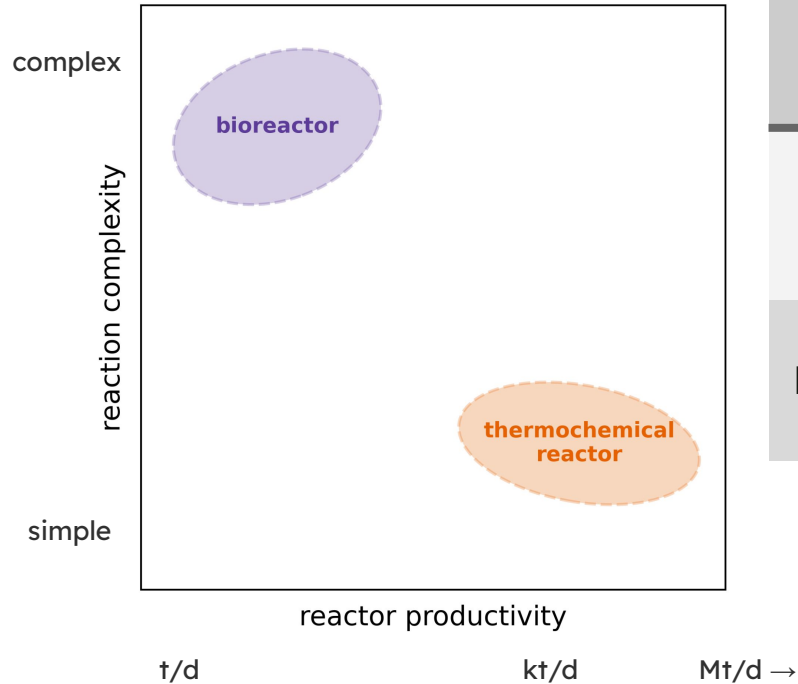
temperature

microbial activity

commodity chemicals

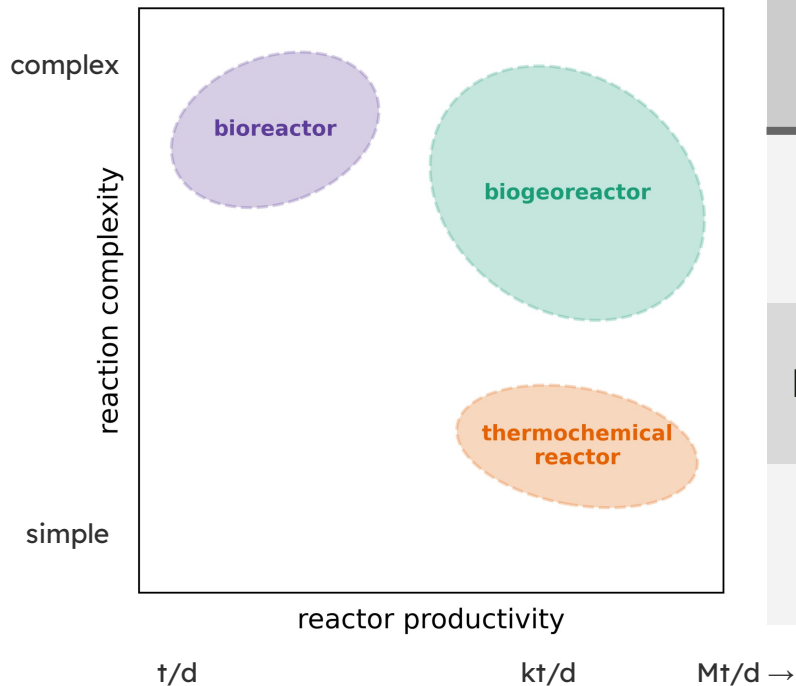


The tradeoff for industrial biochemistry is slow kinetics



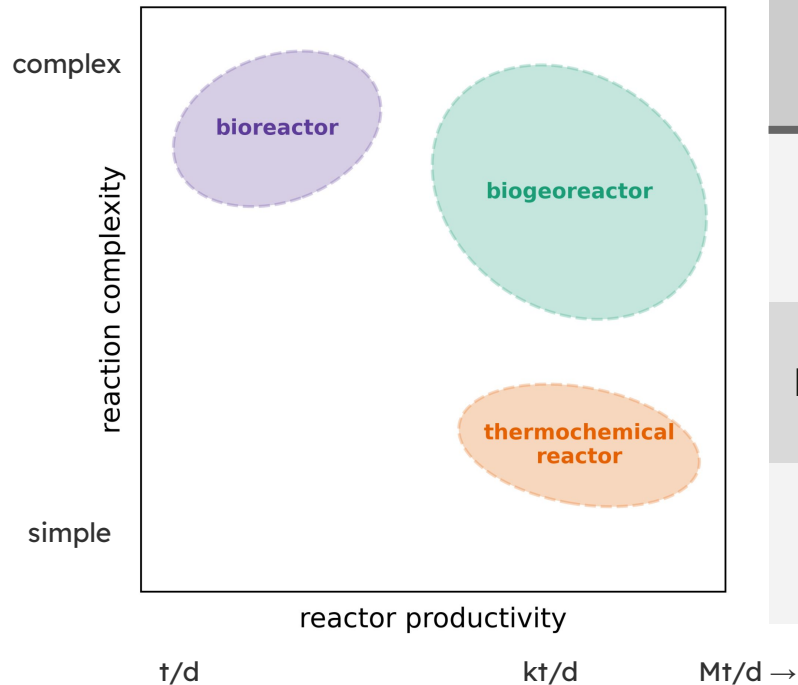
	total productivity ton / yr		unit productivity ton / (m ³ · yr)		size m ³
thermo-chemical reactor	~10 ² ~ 4	≈	~10 ²	×	10 ⁰ ~ 2
bioreactor	~10 ⁻¹ ~ 2	≈	~10 ⁻¹	×	10 ⁰ ~ 3

Biogeoreactors make up for slow kinetics with volume



	total productivity ton / yr		unit productivity ton / (m ³ · yr)		size m ³
thermo-chemical reactor	~10 ² ~ 4	≈	~10 ²	×	10 ⁰ ~ 2
bioreactor	~10 ⁻¹ ~ 2	≈	~10 ⁻¹	×	10 ⁰ ~ 3
biogeoreactor	~10 ² ~ 4	≈	~10 ⁻⁶	×	10 ⁸ ~ 10

The biggest bioreactors on the planet are **IN** the planet

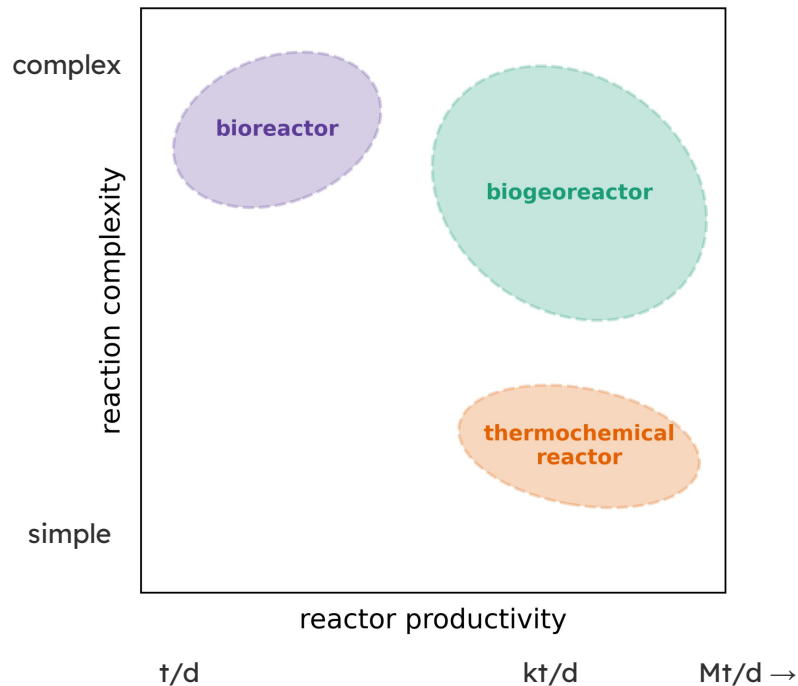


	total productivity ton / yr		unit productivity ton / (m ³ · yr)		size m ³
thermo-chemical reactor	$\sim 10^2 \sim 4$	\approx	$\sim 10^2$	\times	$10^0 \sim 2$
bioreactor	$\sim 10^{-1} \sim 2$	\approx	$\sim 10^{-1}$	\times	$10^0 \sim 3$
biogeo-reactor	$\sim 10^2 \sim 4$	\approx	$\sim 10^{-6}$	\times	$10^8 \sim 10$

$1 \text{ km}^3 = 10^9 \text{ m}^3$

- [1] *Nature* **2021**, 600, 670. [doi:10.1038/s41586-021-04153-3](https://doi.org/10.1038/s41586-021-04153-3); [2] *ChemRxiv* **2020**. [doi:10.26434/chemrxiv.13238996.v1](https://doi.org/10.26434/chemrxiv.13238996.v1)
 [3] *Biofuels Bioprod. Bioref.* **2017**, 11, 798. [doi:10.1002/bbb.1786](https://doi.org/10.1002/bbb.1786)

Our knowledge of biogeochemistry is:



1. Reactive

(minimal predictive power)

2. Fossil-centric

(siloes in legacy oil & gas)

3. Ripe for revolution

(new industries & recent techniques)

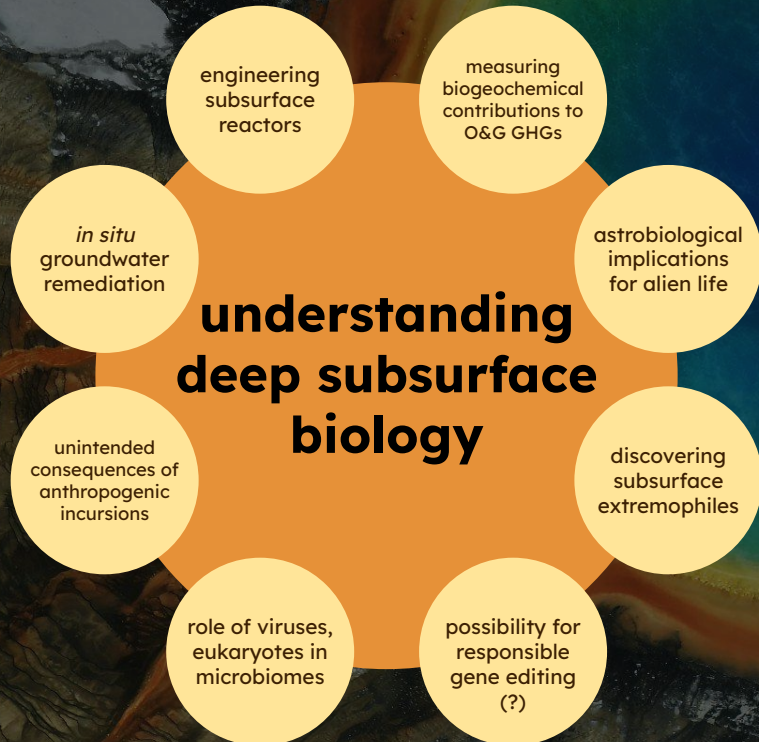
4. Diverse in impact

(chemicals, GHGs, biotech, remediation)

[1] ISME, 2024, 18, wrac091. [doi:10.1093/ismejo/wrac091](https://doi.org/10.1093/ismejo/wrac091)

[2] Antonie Van Leeuwenhoek, 2000, 77, 103. [doi:10.1023/A:1002434330514](https://doi.org/10.1023/A:1002434330514)

we still don't understand the subsurface



Core beliefs

- The subsurface has been the primary source of materials and energy for all modern history
- Our knowledge of the subsurface has always been secondary to our ability to extract from it
- The better we understand our natural world, the more harmoniously we can live with it

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intrigued? learn more at
Faraday, 15:00

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