Potential Challenges of HyBlend Storage in a Methane Reservoir Located in Southwestern United States

AES-IDS-501. Microbiology of Mineral and Energy Resource Recovery

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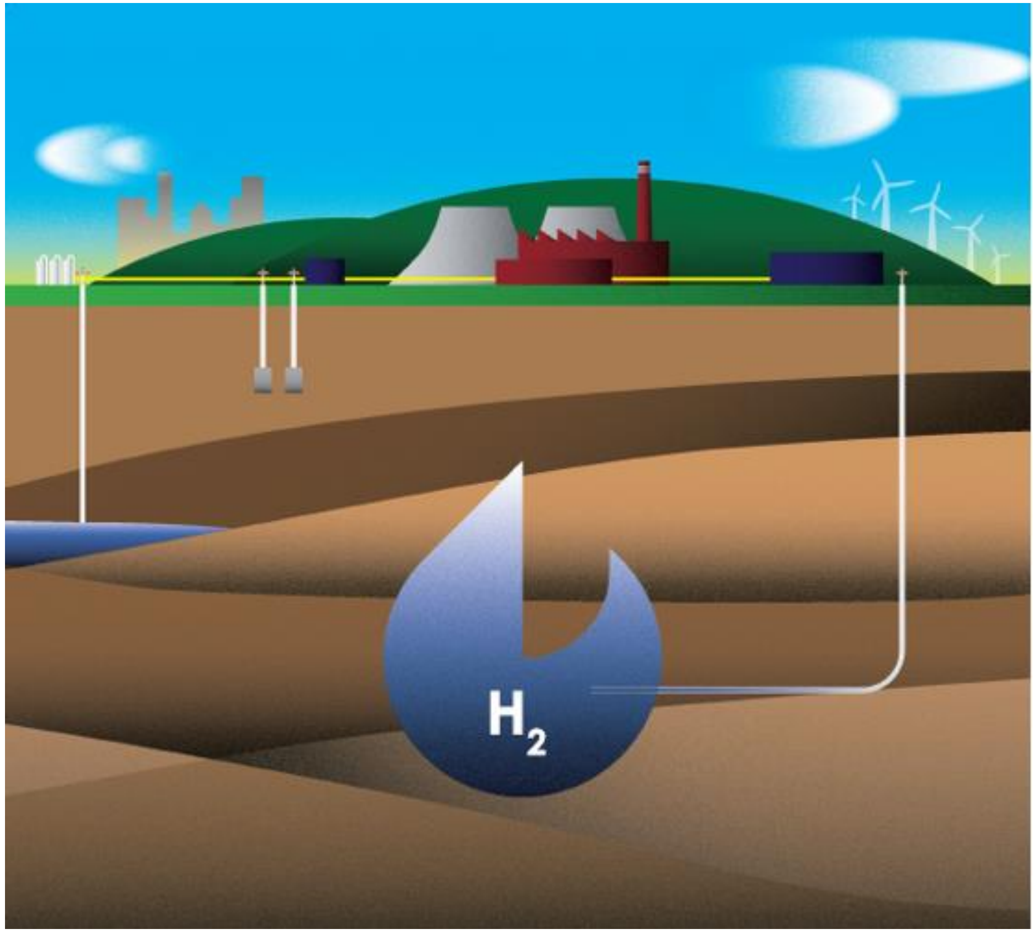

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Background & Introduction

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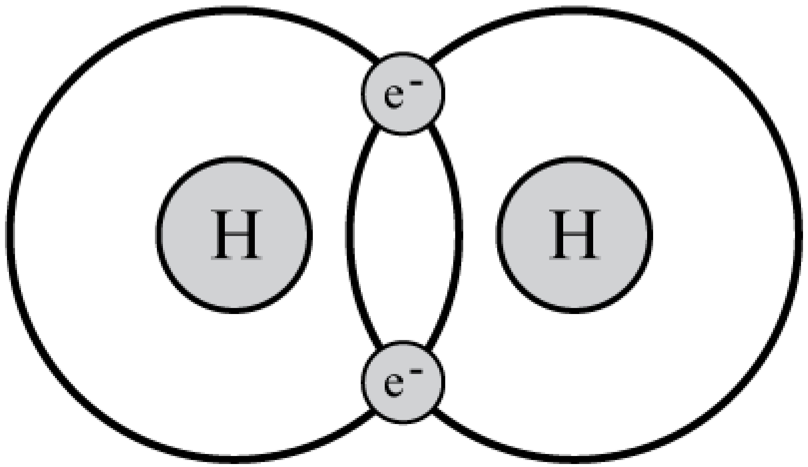
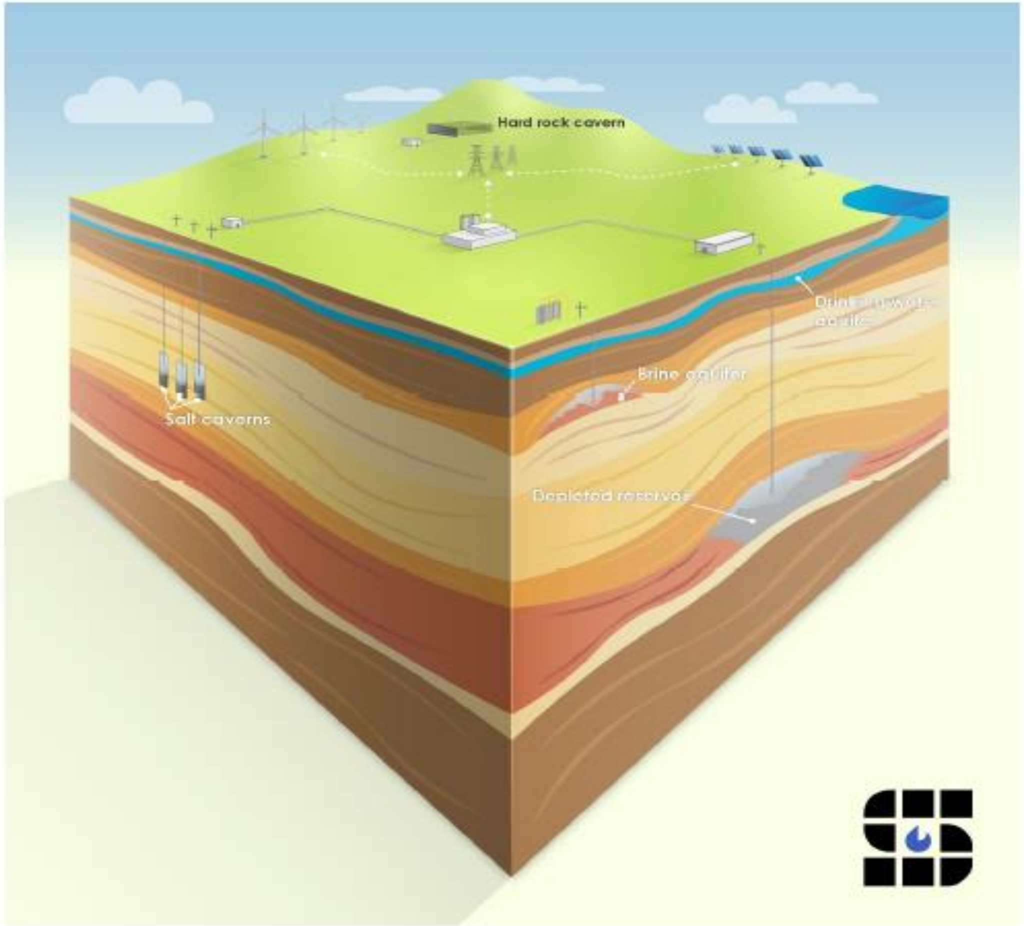


- Hydrogen energy is a **flexible** energy carrier with zero emissions.
- Hydrogen can be produced from a variety of domestic resources (renewable and non-renewable).
- Large-scale hydrogen storage allows for supply/demand decoupling.

Background & Introduction

Large-Scale Geological Hydrogen Storage

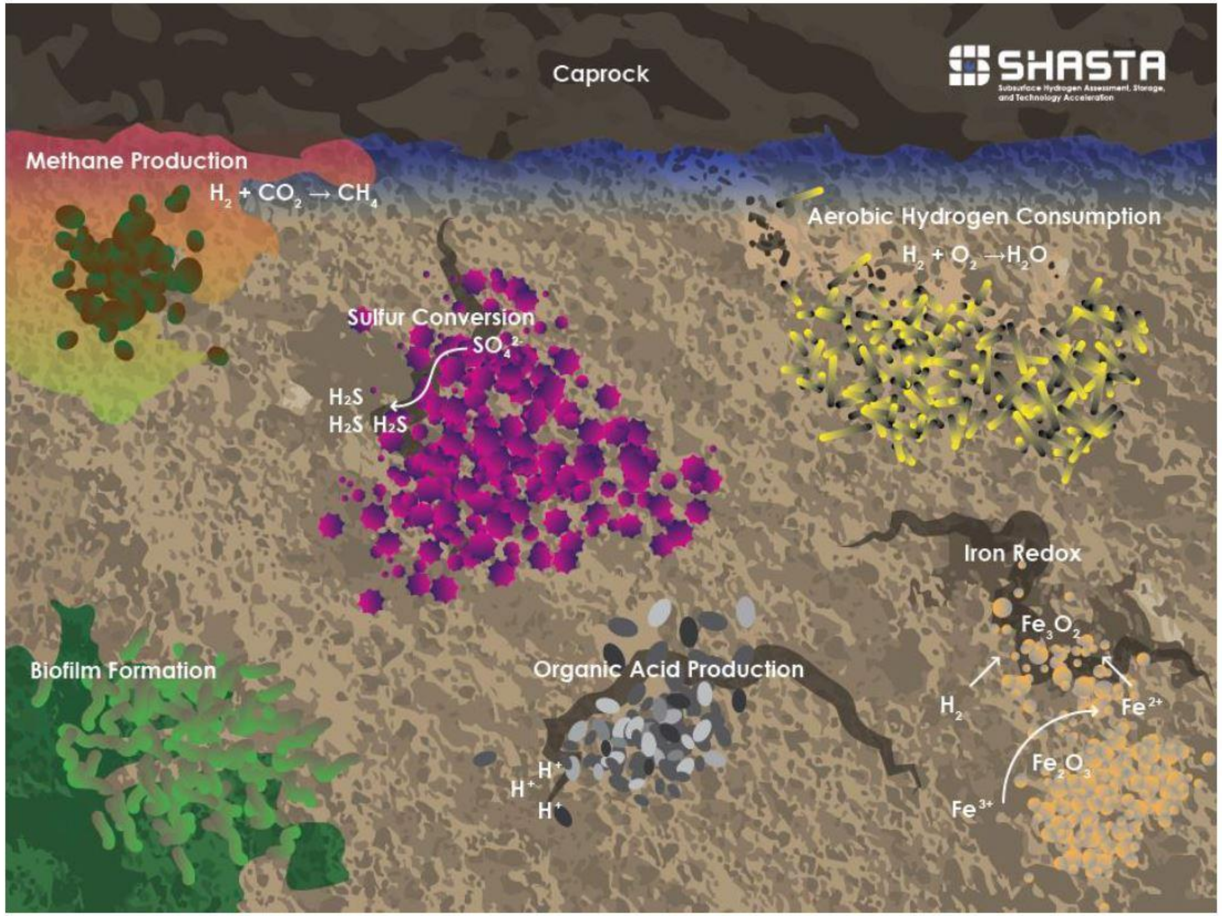


Potential H_2 storage sites:

- Depleted reservoirs
- Brine aquifers
- Salt caverns
- Hard rock caverns

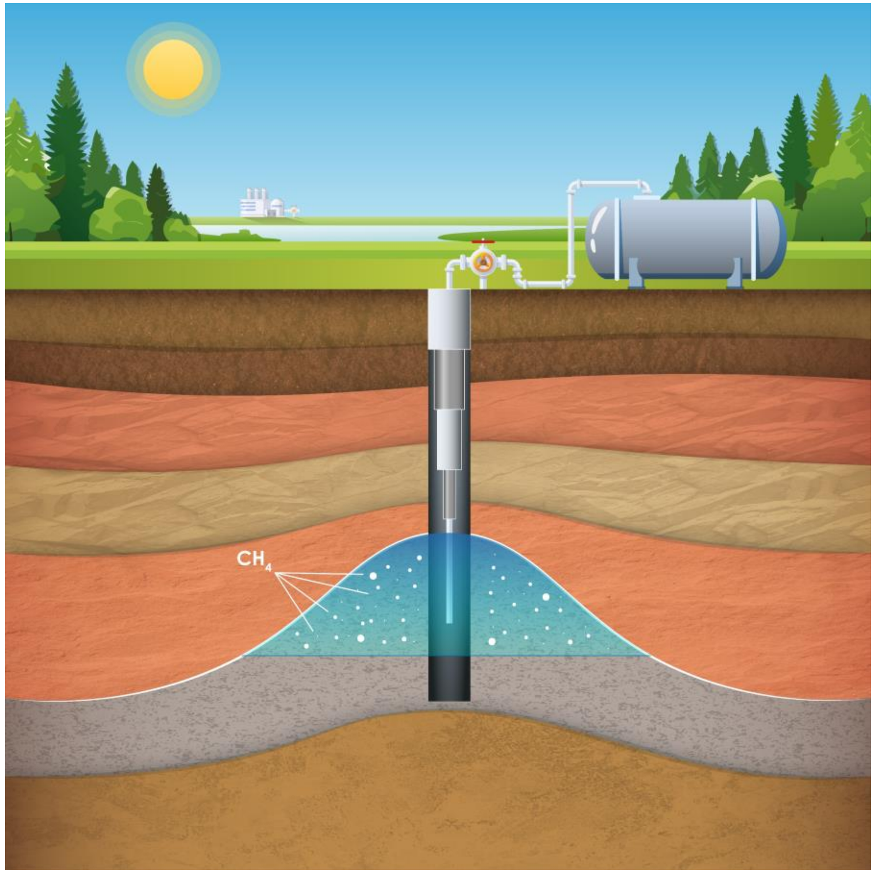
Background & Introduction

Large-Scale Geological Hydrogen Storage Risks Associated with Microbial Activity



Background & Introduction

Large-Scale Geological Hydrogen Storage in Natural Gas Storage Wells



- Natural gas storage has been utilized in North American for over 100 years.
- Many sites are maintained to address seasonal supply/demand variation.
- Existing infrastructure is compatible with storing and transporting a blended mixture of hydrogen and natural gas (hyblend).

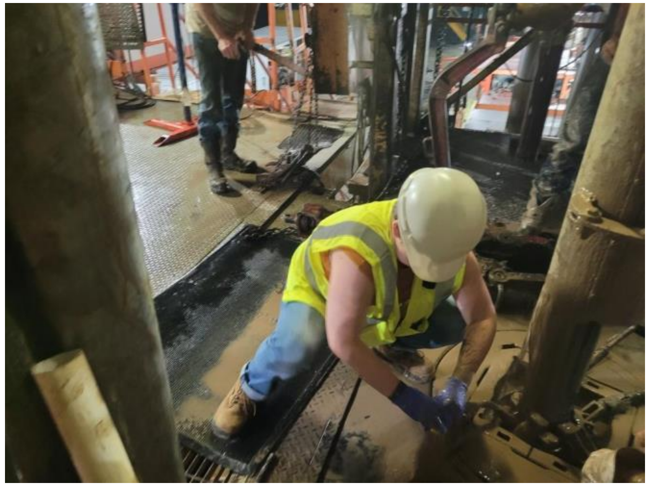
Experimental Design

Two Approaches to Studying Hyblend Storage in Methane Reservoirs

Baseline Characterization

Fluid samples from two field sites were analyzed:

- Ion Chromatography (IC)
- Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES)
- Total Organic Carbon (TOC) Analyzer
- 16S rRNA Gene Amplicon Sequencing
- Metagenomic Sequencing



Short-Term Reactor Simulations

- Reactors were held at reservoir conditions (80 °C and ~1,000 psi) for a natural gas (100% CH_4) and hyblend (80% CH_4/20% H_2) storage environments for both biotic and abiotic (sterilized) measurements
- Timepoints were collected at 1, 3, and 7 days
- Duplicates/Triplicates were collected, when possible

Baseline Characterization

Field Site Gas Headspace, Alkalinity, and Geochemistry

Site 1

- Gas headspace of gas headspace content of predominantly methane (98.7%)
- Higher total dissolved solids (TDS) concentration (92,750 mg/L)

Site 2

- Gas headspace had trace amounts of H_2S (11 ppm) as well as a significant amount of oxygen (19.4%)
- Lower TDS concentration compared to 27,505 mg/L at Site 2

- For both sites, the major cations were calcium, potassium, and sodium and the major anion was chloride
  - Site 2 had higher dissolved iron and sulfate concentrations than Site 1
- For both sites, acetate and propionate had the highest organic acid concentrations
  - Site 2 had higher overall organic acid measurements than Site 1 (1,000 mg/L vs. 4,000 mg/L)

Baseline Characterization

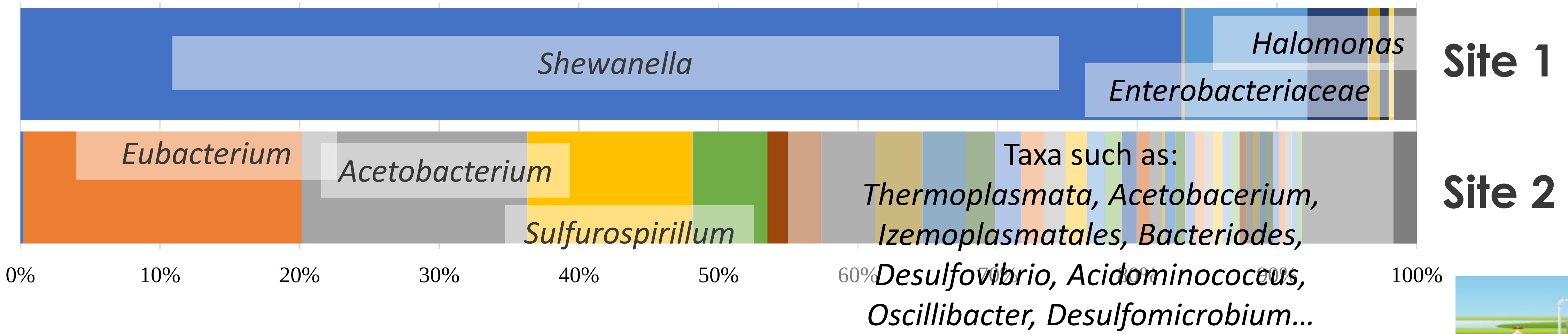
Field Site Microbial Community Composition

Site 1

- Significantly less rich, diverse, and even than Site 2
  - 99 unique ASVs represented
  - Chao1 Index: 104
  - Shannon Diversity: 0.74
  - Pielou's Evenness: of 0.16

Site 2

- Significantly more rich, diverse, and even than Site 1
  - 332 unique ASVs represented
  - Chao1 Index: 355
  - Shannon Diversity: 3.22
  - Pielou's Eveness: 0.55

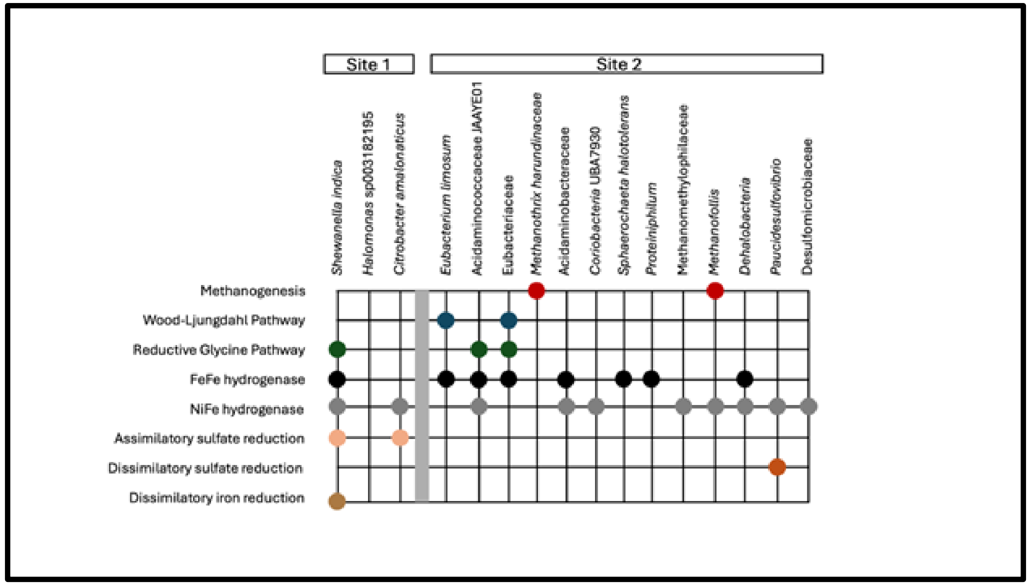


Baseline Characterization

Functional Potential of Field Site Microbial Communities

Site 1

- Obtained 5 MAGs
- Majority of reads mapped to: *Shewanella, Citrobacter, Halomonas*
- Potential hydrogen consuming reactions include assimilatory sulfate reduction, and dissimilatory iron reduction



Site 2

- Obtained 25 MAGs
- Majority of the reads mapped to: *Eubacterium,* Acidaminococcaeceae, Eubacteriaceae, *Proteiniphilum, Pacidesulfovibrio, and Methanothrix*
- Potential hydrogen consuming reactions hydrogenotrophic methanogenesis, acetogenesis, and dissimilatory sulfate reduction

- **Both sites contain microorganisms with the functional capacity to consume hydrogen**

Site 2 Gas Storage Simulation Experiments

Gas Storage Simulation Experimental Design

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Short-Term Reactor Simulations

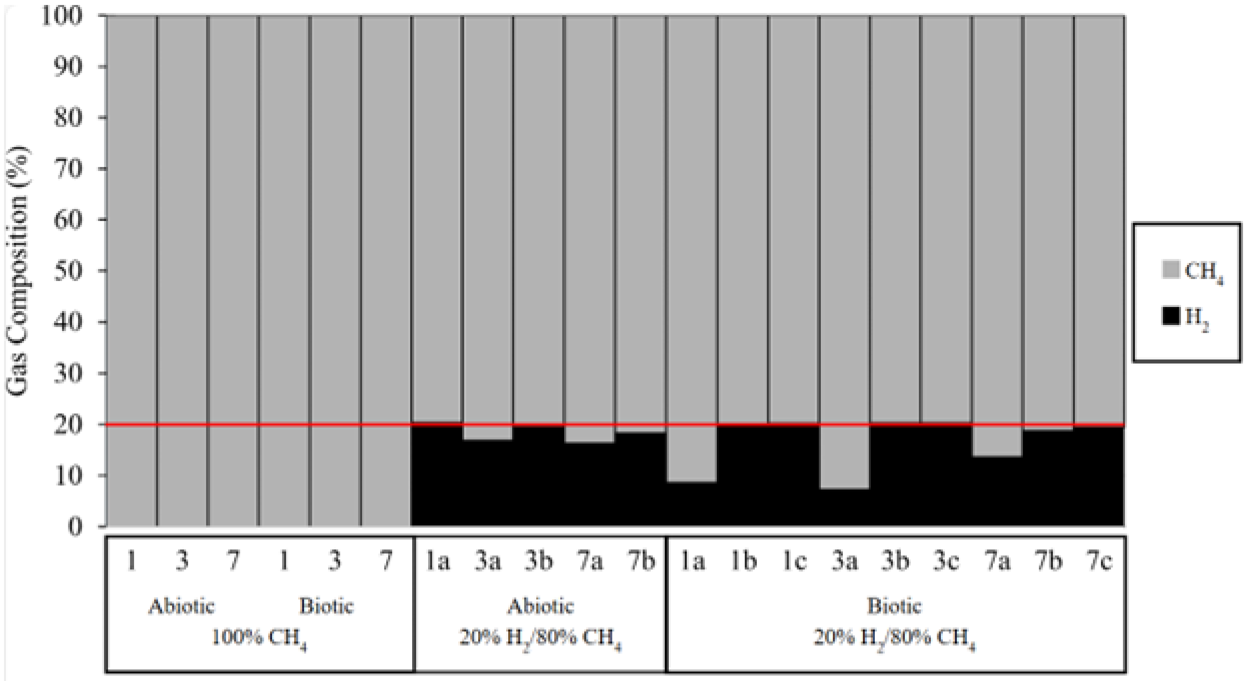
- Reactors utilized fluid from Site 2 and were held at reservoir conditions (80 °C and ~1,000 psi)

	Abiotic Control (100% CH_4)	Biotic Control (100% CH_4)	Abiotic (20% H_2/80% CH_4)	Abiotic (20% H_2/80% CH_4)
1 Day	X	X	X	XXX
3 Days	X	X	XX	XXX
7 Days	X	X	XX	XXX

- Endpoint gas headspace was measured, and fluids were analyzed with: IC, ICP-OES, TOC analyzer, and 16S rRNA Gene Amplicon Sequencing

Site 2 Gas Storage Simulation Experiments

Gas Storage Simulation Experimental Design Results



- Stable pH: Site 2 had a pH of 5.695 and the final reactor pHs ranged from 5.577 to 5.692.
- Reactors pressurized with the 20% H_2/80% CH_4 gas blend demonstrated an average drop in hydrogen of 3.6% across both the abiotic and biotic.
- Minimal changes between reactor geochemistry measurements across treatments.
- Biotic reactors were populated by microbes that are common in subsurface environments and were found in the in situ field site, although composition and abundance of each sample was highly variable.

Conclusions

Baseline:

- Baseline characterization field samples had distinct geochemical and microbiology profiles, even though they were collected from the same geographic region.
- Both reservoirs harbored a diverse microbial population capable of consuming hydrogen through iron reduction, nitrate reduction, sulfur reduction, and acetate production.

Conclusions

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Baseline:

- Baseline characterization field samples had distinct geochemical and microbiology profiles, even though they were collected from the same geographic region.
- Both reservoirs harbored a diverse microbial population capable of consuming hydrogen through iron reduction, nitrate reduction, sulfur reduction, and acetate production.

Gas Storage Reactors:

- Minimal changes were observed in the fluid and gas composition of the 80% CH_4/20% H_2 blend reactors.
  - This suggests that short-term hydrogen storage at adapted underground natural storage locations may be highly successful.
- Both the abiotic and biotic reactors had exhibited some hydrogen loss, averaging a loss of 3.6% H_2 across all reactors.
  - The minor decrease of hydrogen across both abiotic and biotic sites implies that hydrogen injection and storage may inherently have reduced recoverability, perhaps from hydrogen adsorption.

Questions?

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Identifying Potential Geochemical and Microbial Impacts of Hydrogen Storage in a Deep Saline Aquifer

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