Potential Risks Associated with Short-Term Hydrogen Storage in Methane Reservoirs

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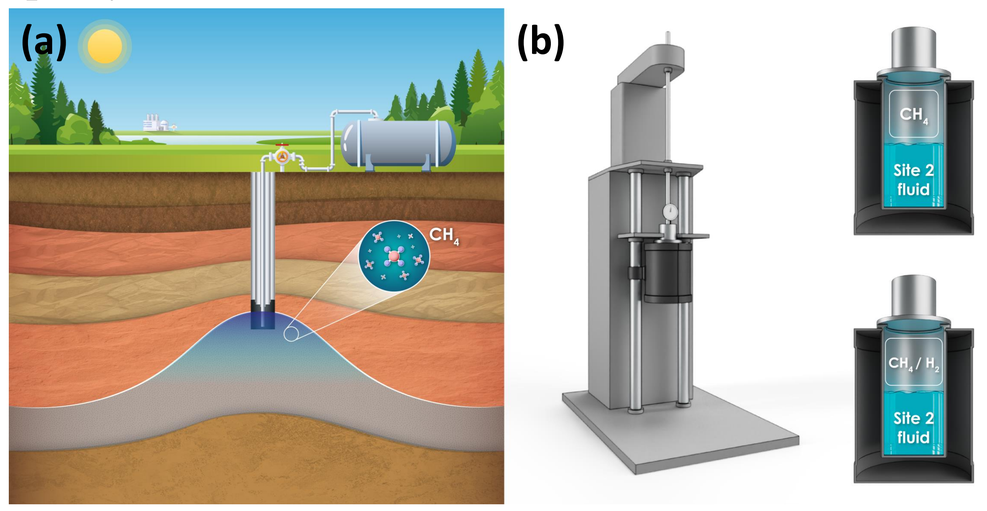
Abstract

Hydrogen (H_2) has been identified as a flexible energy carrier with zero emissions. It is possible to utilize H_2 by storing HyBlend, or H_2 blended with methane (CH_4), in existing natural gas infrastructure. However, the compatibility of adapting the current CH_4 storage strategies to include H_2 injection has not been fully demonstrated. It is essential that we understand the impact of H_2 gas on the naturally occurring microbial community of subsurface storage reservoirs before deploying large-scale H_2-CH_4 storage.

We designed a series of experiments that allowed us to identify potential challenges of HyBlend storage in existing methane reservoirs (Figure 1). First, we characterized two field fluid samples from a CH_4 reservoir located in western United States. Next, we used these samples to complete a series of short-term reactor experiments at reservoir conditions for a natural gas (100% CH_4) and HyBlend (80% CH_4/20% H_2) storage environment.

Figure 1 (Right). Experimental approach included (a) in situ field sampling and (b) reactor simulation experiments.



Results: Baseline Characterization

Table 1. Select fluid sample geochemistry measurements for Sites 1 and 2. All units are mg/L.

	TDS	Cl	Na	Fe	SO_4	Acetate	Propionate
Site 1	93,000	78,000	43,000	90	200	1,300	330
Site 2	28,000	12,000	8,000	100	730	3,800	820

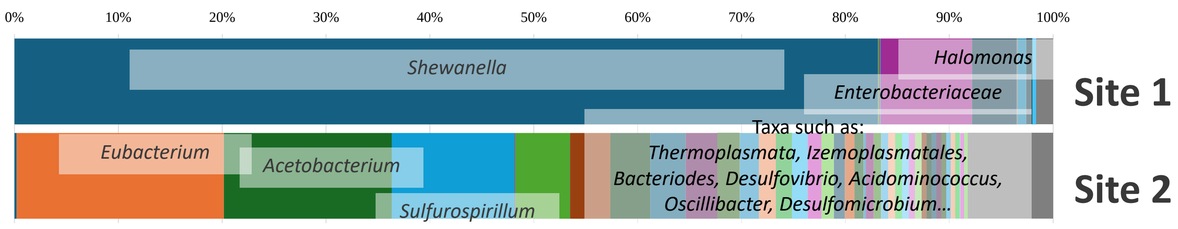


Figure 2. 16S rRNA gene sequencing results for Sites 1 and 2.

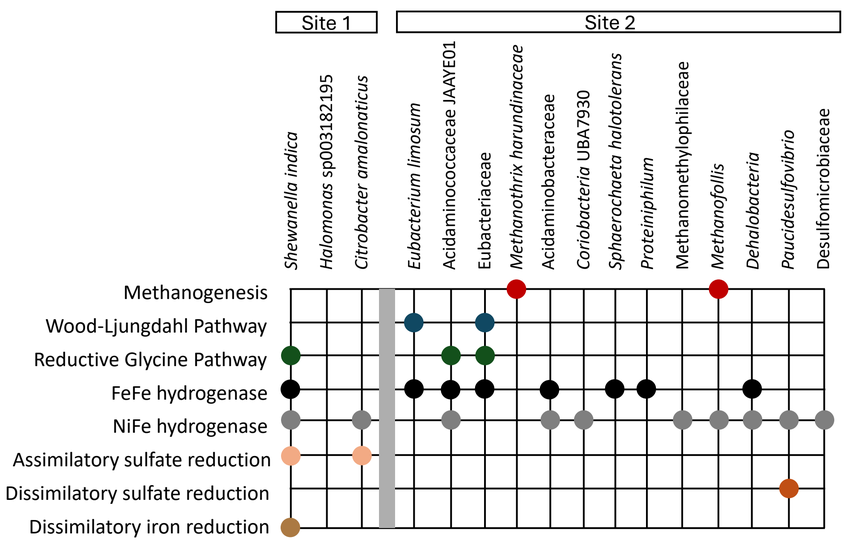


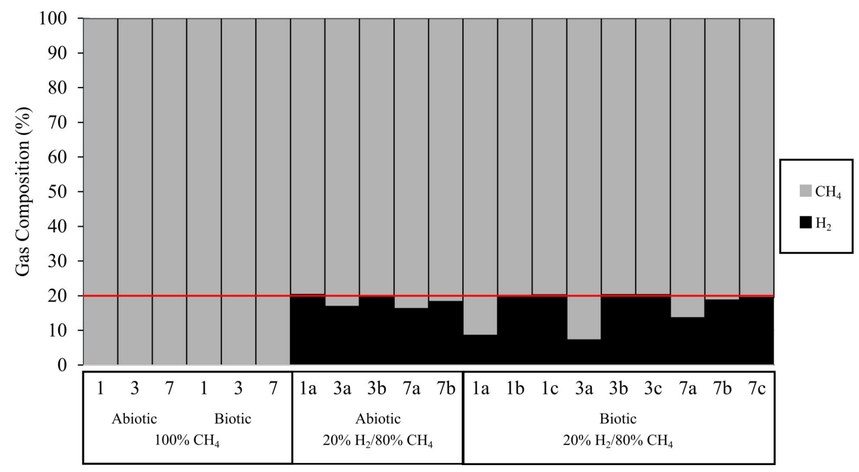
Figure 3 (Left). Overview of potential hydrogen consuming reactions encoded by metagenome-assembled genomes (MAGs) from Sites 1 and 2.

Experimental Design and Results: Short-Term Reactors

Table 2. Experimental matrix for short-term reactor study. 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

Figure 4 (Right). Bar chart showing the headspace gas composition at the conclusion of each reactor experiment. The red bar visually indicates 20%.



Minimal changes were found between the initial Site 2 fluid composition and the reactor timepoints (data not shown due to size).

Conclusions

- 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.
- Minimal changes were observed in the fluid and gas composition of the 80% CH_4/20% H_2 blend reactors, suggesting 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.

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