Water Alternating Gas Cycling to Optimize CO_2 Mineralization for Geological Carbon Storage: Cascadia Project

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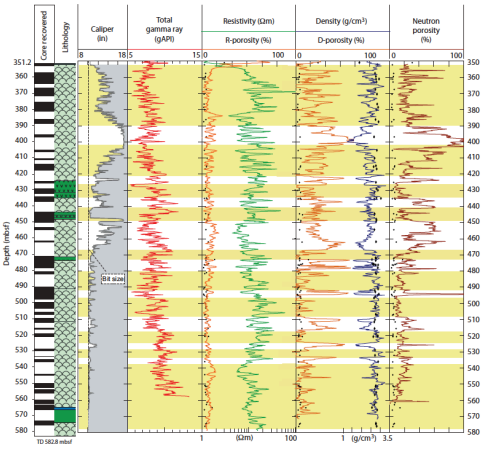
INTRODUCTION

Sub-ocean basalt rock formations provide enormous storage capacity for secure and safe storage of CO_2 in mineralized form. Two recently completed field injection projects, CarbFix in Iceland, and Wallula in Washington State, have both shown a rapid mineralization of CO_2 into stable carbonate in basalt formations. CarbFix injected fully dissolved CO_2 in fresh water (25:1 water ratio by volume) and documented >95% carbon mineralization in basalt within 2 years. Similarly, Wallula injected pure liquid CO_2 into basalt and documented carbon mineralization within 2 years.

As tested in the CarbFix project, various injection strategies involving co- or alternating-injection of CO_2 and water into basalt reservoirs may improve the mineralization of thermodynamically stable carbon solid phases. In addition, these strategies may help maximize injection volumes, minimize energy needs for pumping, and improve operational efficiencies.

BASALT PROPERTIES



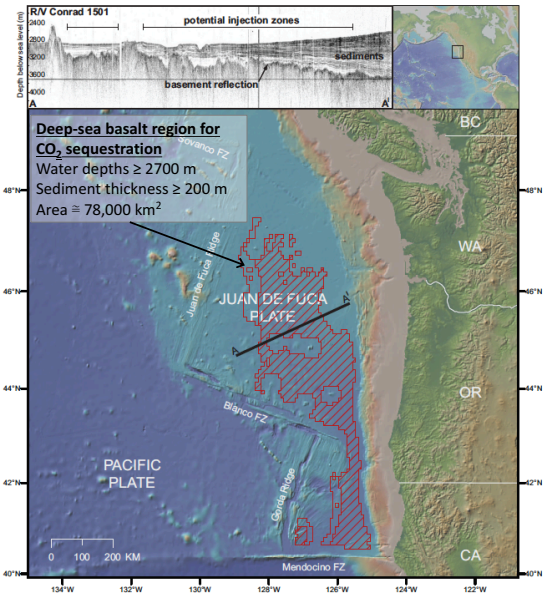
Goldberg et al. (2008)

Basalt Mineral Assemblages used in the Model Layers		
Breccia (1000 mDarcy, 0.15 porosity)		
• Plagioclase	0.4054 vf	2.68 gm/cm³
• Pyroxene	0.2180 vf	3.21 gm/cm³
• Mesostasis	0.1971 vf	2.31 gm/cm³
• Olivine	0.0295 vf	3.32 gm/cm³
Vesicular (100 mDarcy, 0.075 porosity)		
• Plagioclase	0.4412 vf	2.68 gm/cm³
• Pyroxene	0.2372 vf	3.21 gm/cm³
• Mesostasis	0.2145 vf	2.31 gm/cm³
• Olivine	0.0321 vf	3.32 gm/cm³
Massive (0.001 mDarcy, 0.05 porosity)		
• Plagioclase	0.4531 vf	2.68 gm/cm³
• Pyroxene	0.2437 vf	3.21 gm/cm³
• Mesostasis	0.2203 vf	2.31 gm/cm³
• Olivine	0.0329 vf	3.32 gm/cm³

Reaction Network

35 Aqueous Species
11 Solid Species

CASCADIA PROJECT LOCATION

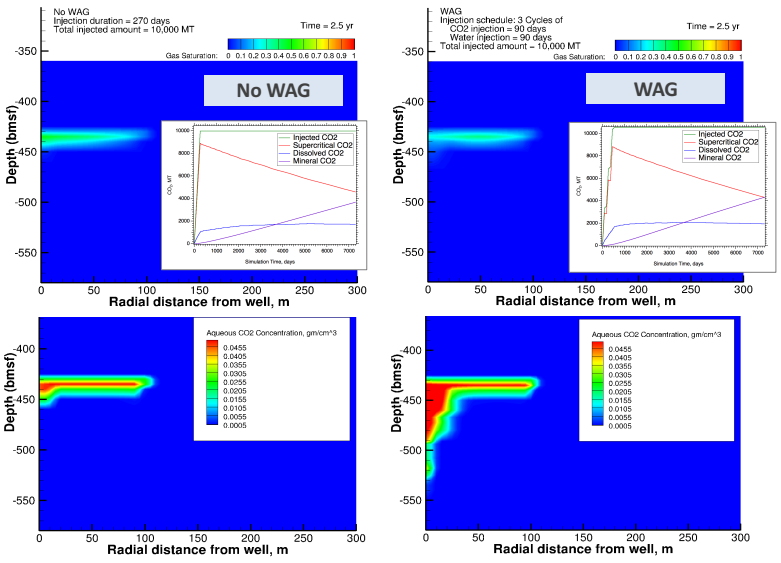


Targeted injection formation for the project is the sub-ocean basalt basement in the Juan de Fuca ridge, a few hundred kilometers west of Vancouver Island, Oregon, and Washington:

- Highly fractured, channelized, and porous (10-15%)
- Sealed by impermeable fine-grained turbidities and hemipelagic clay sediments.
- Comprises both pillow lavas and massive flows containing plagioclase, olivine, and clinopyroxene.

WAG CYCLING SIMULATIONS

- **STOMP-CO_2 w/ ECKEChem**



PRELIMINARY CONCLUSIONS

- WAG cycling may improve mineralization by increasing the amount of CO_2 in the dissolved phase and also allowing larger surface area contact with the formation matrix.
- Optimization of WAG cycling using reservoir simulators is important for developing a site specific injection strategy.
- More accurate assessment for this project will depend on the updated reaction network and kinetics as well as the site specific subsurface characterization data.

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