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Pressure Management and Plume Control at the Devine Test Site, South Texas by Means of Brine Extraction

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Abstract

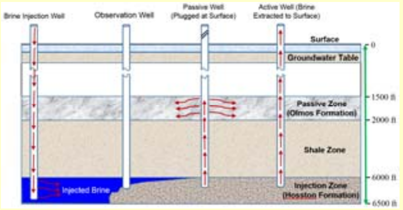
A critical issue for saline CO_2 storage is build-up of pressure caused by CO_2 injection. The magnitude of the pressure build-up depends on many factors, including the injection rate, static properties of the target formation, nature of the in-situ and injected fluids, and the formation boundary conditions. Maximum pressure increase is localized at the injection well; however, a pressure front diffuses into the formation, increasing pressure regionally far from the injection well. Within the context of CO_2 geological storage, excessive pressure buildup is undesirable because it increases risks of CO_2 plume leak into unwanted zones, reduces the storage capacity of the formation and can limit the life of a storage project.

In this study, we design a brine extraction field pilot project for pressure management and plume control at Hosston Formation in Devine Test Site in Texas. We investigated the possibility of using seismic and tracer data to monitor pressure front and injected fluids plume. Seismic surveys provide the volumetric coverage needed to understand the 3D subsurface fluid and pressure front movement; however, the limit of seismic detectability may be influenced by Hosston formation initial pore pressure. The range of minimum pore pressure increase needed to produce detectable P-wave and S-wave seismic velocities is investigated. Simulation study of active pressure management system (APMS) and passive pressure management system (PPMS) at the Devine Test Site is performed using CMG-STARS to demonstrate the possibility of the pressure build up control in the storage formation. The estimation of pore pressure increase from flow simulations will help us to understand if the pressure changes during brine injection and extraction can be detected using seismic response.

Introduction

Extraction of native brine during GCS operations as a pressure management approach can increase storage capacity and effectively diminish the risk of environmental impacts. Minimizing the volume of extracted brine, while maximizing CO_2 storage and meeting other constraints required for safe and efficient GCS operations, is an essential objective of the pressure management with brine extraction schemes. There are two different methods for pressure management using brine extraction as following:

- **Active Pressure Management System (APMS)**
  Brine will be actively extracted to the surface. However, treatment and disposal of extracted brine can be challenging and costly.
- **Passive Pressure Management System (PPMS)**
  Brine will naturally flow from the storage reservoir to other overlaying geological formations by designing the wells with screens in both geologic units.



Model Description

The focus of simulation study in this work is on designing a brine extraction strategy to manage the reservoir pressure build up and to control the injected fluid plume (using tracers in injected fluid). All the simulations are single phase flow of brine at reservoir salinity and the simulations are performed using CMG-STARS simulator. The model consists of three main layers vertically with the Hosston Formation as the most bottom one which is 10 m thick and is subdivided into 5 layers each of 2 m thickness. Three wells (injection, extraction, and observation) are completed at Hosston Formation of 6,500 ft depth and distance between wells is about 45 m.

Model	3-Dimensional Cartesian
No. of Grids	200×200×7
Δx, Δy, Δz	6.5, 6.5, 6.5 ft
Average Porosity	0.25
Average Permeability	1.32 md, 13.2 md,132 md
Depth of Injection	6000 ft
Thickness of Injection Layer (Hosston Formation)	33 ft (10 m)
Water saturation	100 %
K_v/K_h (Crossflow)	0.1
Injection Rate (constant rate)	5000 bbl/day
Production Rate (constant rate)	2500 bbl/day
Well Configuration (3 Wells)	1 Injection, 1 Extraction, 1 Observation
Well Distance	45 m
Formation Salinity	50000 ppm
Initial Reservoir Pressure	3400 psi
Average Reservoir Temperature	65 C (150 F)
Waterflood:	Days injected:
Tracer Conc.: 1 %wt	90 Days

- **No Extraction from Hosston Formation**

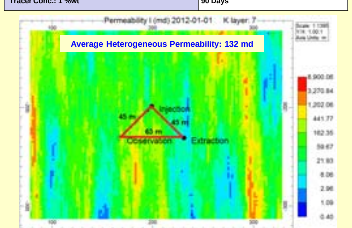
  Brine was injected at constant rate for 90 days and the extraction well was shut in. The purpose was to investigate the pressure increase in Hosston Formation due to brine injection for different heterogeneous cases.

- **Active Extraction from Hosston Formation (Constant Rate Extraction)**

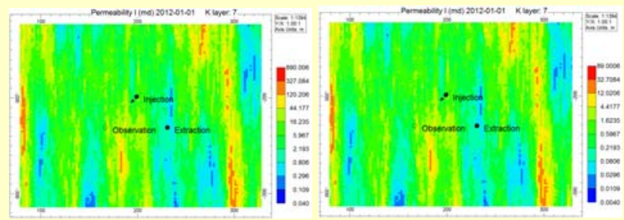
  Brine was injected at constant rate for 90 days and the extraction well was producing at constant rate. The rate of injection was different for various heterogeneous permeability cases which will be explained later.

- **Passive Extraction from Hosston Formation to Olmos Formation (No Brine Extraction to Surface)**

  Brine was injected at constant rate for 90 days and the extraction well was shut in. A towel will directly divert brine from Hosston Formation (6,500 ft depth) to Olmos Formation (1,500 ft depth) and monitor the pressure control in Hosston Formation.

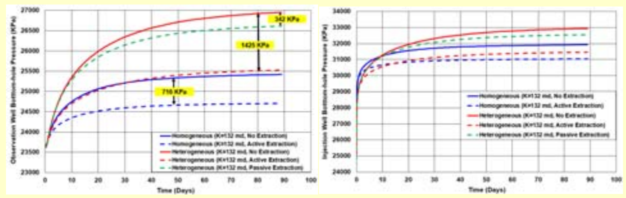


Heterogeneous Permeability Distributions

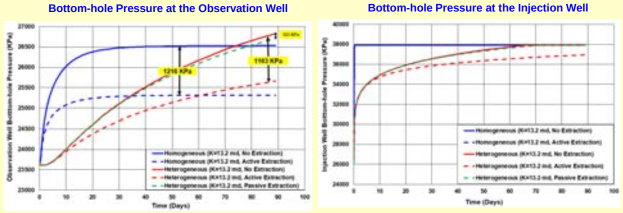


Pressure Control for Different Extraction Scenarios

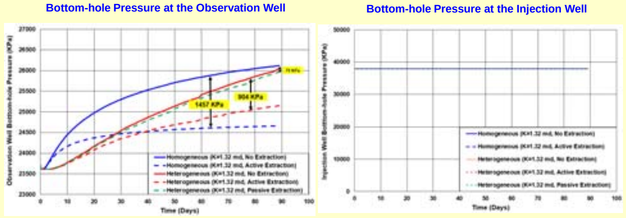
Average Heterogeneous Permeability: 132 md



Average Heterogeneous Permeability: 13.2 md

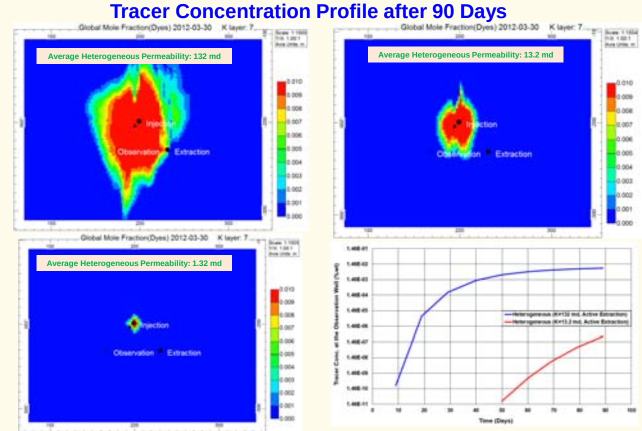


Average Heterogeneous Permeability: 1.32 md



Tracer Injection

Tracer Concentration Profile after 90 Days



	Average Permeability = 1.32 md		Average Permeability = 13.2 md		Average Permeability = 132 md	
	Homogeneous	Heterogeneous	Homogeneous	Heterogeneous	Homogeneous	Heterogeneous
No Extraction (Injection Rate, bbl/day)	698	698	1000	1000	5032	5032
Active Extraction (Extraction Rate, bbl/day)	95	346	503	503	2516	2516
Pressure Increase (No Extraction, KPa)	2497	2434	2920	3215	1805	3339
Pressure Increase (Active Extraction, KPa)	1040	1530	1704	2052	1089	1914
Pressure Control by Active Extraction, KPa	1457	904	1216	1163	716	1425
Pressure Increase (Passive Extraction, KPa)	--------	2355	--------	3092	--------	2997
Pressure Control by Passive Extraction, KPa	--------	79	--------	123	--------	342

Conclusions

- Numerical simulations were performed for different brine extraction scenarios using CMG-STARS to optimize the best pressure control design. Different heterogeneous permeability distributions were assigned to study the impact of brine extraction on pressure control.
- The sensitivity simulations using CMG-CMOST indicated that main brine extraction design variables are permeability, layer thickness, porosity, injection rate, and the rock compressibility.
- The sensitivity simulations illustrated that reservoir permeability, heterogeneity, and thickness are the key pressure control parameters; however, porosity and rock compressibility have negligible effect on pressure control.
- The comparison of active and passive brine extraction scenarios indicates that active extraction can control pressure considerably more favorable than passive extraction. The percentage ratio of pressure control for active extraction compared to no extraction is in the range of 35-45% and for passive extraction it is only about 2-5% for different heterogeneous cases.

Acknowledgements

We gratefully acknowledge the financial support of the DOE-NETL Brine Extraction Storage Test Project (DE-FE0026137) at the Gulf Coast Carbon Center at The University of Texas at Austin.