Monitoring and Numerical Modeling of Shallow CO_2 Injection, Greene County, Missouri

DE-FE0001790

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U.S. Department of Energy

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Carbon Storage R&D Project Review Meeting
Developing the Technologies and Building the Infrastructure for CO_2 Storage

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Presentation Outline

I. Benefits

II. Project Overview

III. Technical Status

   A. Background
   B. Results

IV. Accomplishments

V. Summary

Benefit to the Program

- Program goals.
  - Prediction of CO_2 storage capacity.

- Project benefits.
  - Workforce/Student Training:

    Support of 3 student GAs in use of multiphase flow and geochemical models simulating CO_2 injection.

  - Support of Missouri DGLS Sequestration Program.

Project Overview:
Goals and Objectives

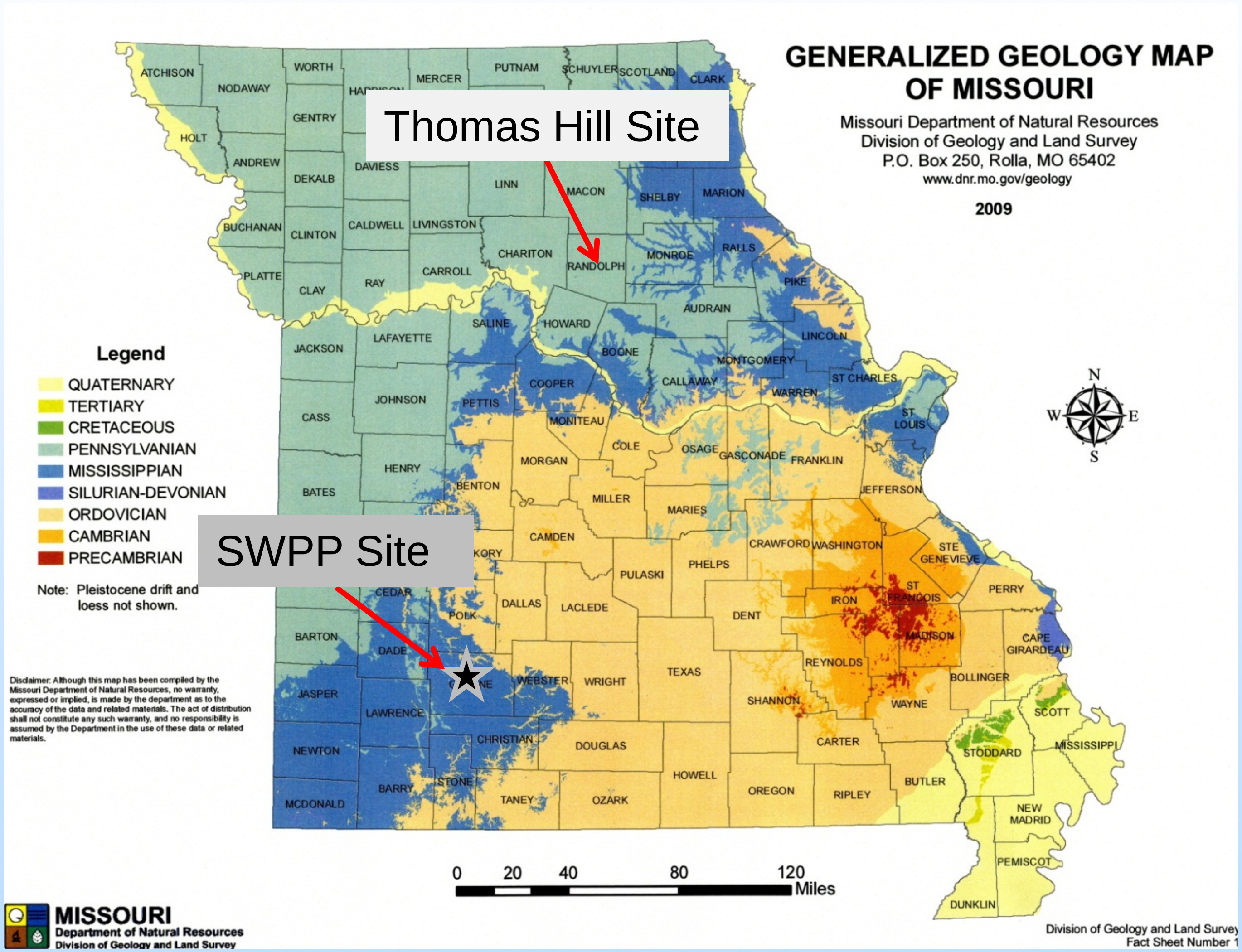
Project Goals and Objectives.

1. Training graduate students in use of multi-phase flow models related to CO_2 sequestration.

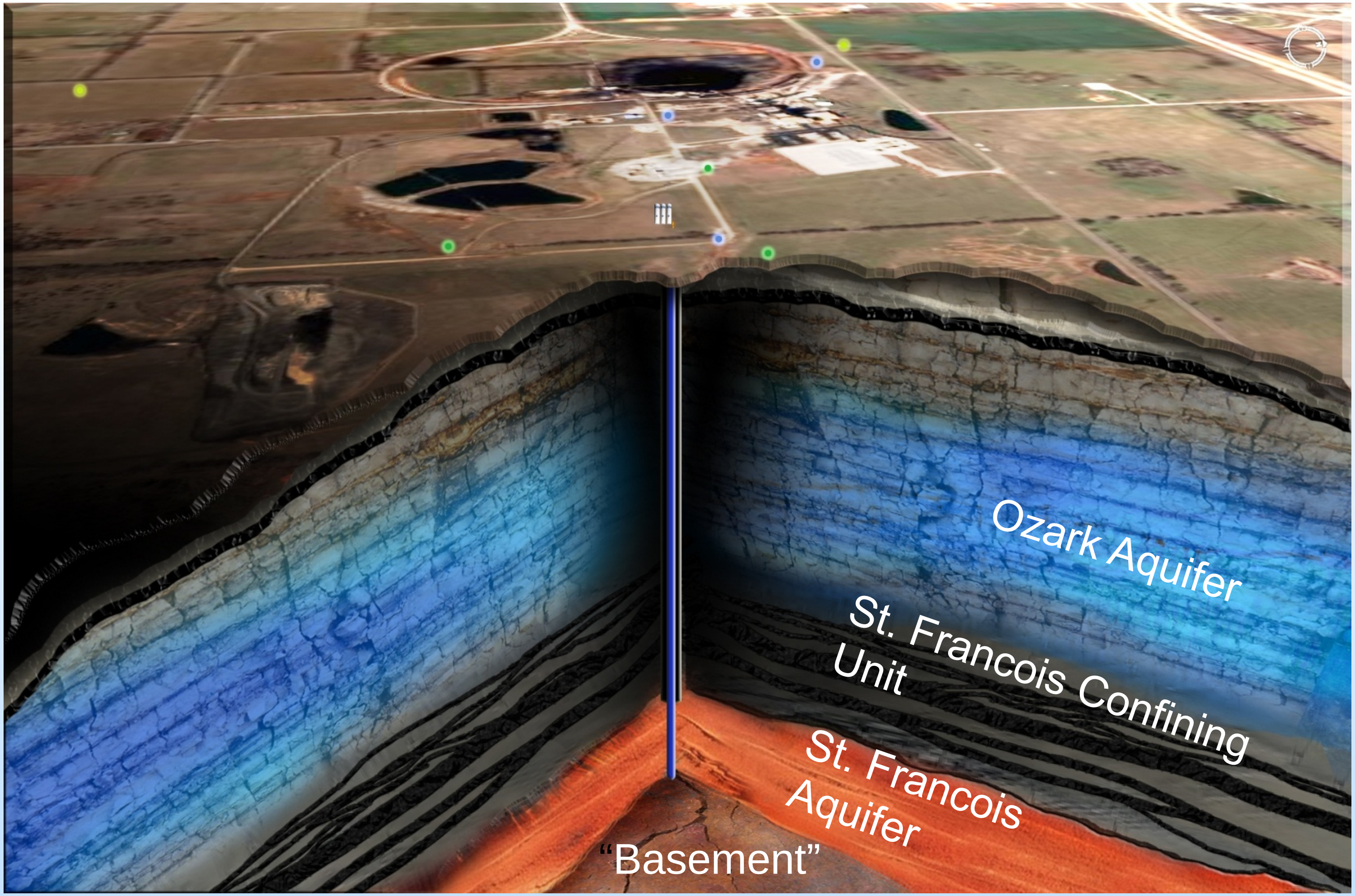
2. Training graduate students in use of geochemical models to assess interaction of CO_2 with pore fluids and potential for precipitation within solid mineral phases.

3. Generating a GIS database of pore-fluid chemistry within and above potential CO_2 injection zones in Missouri.

Technical Status:
Background

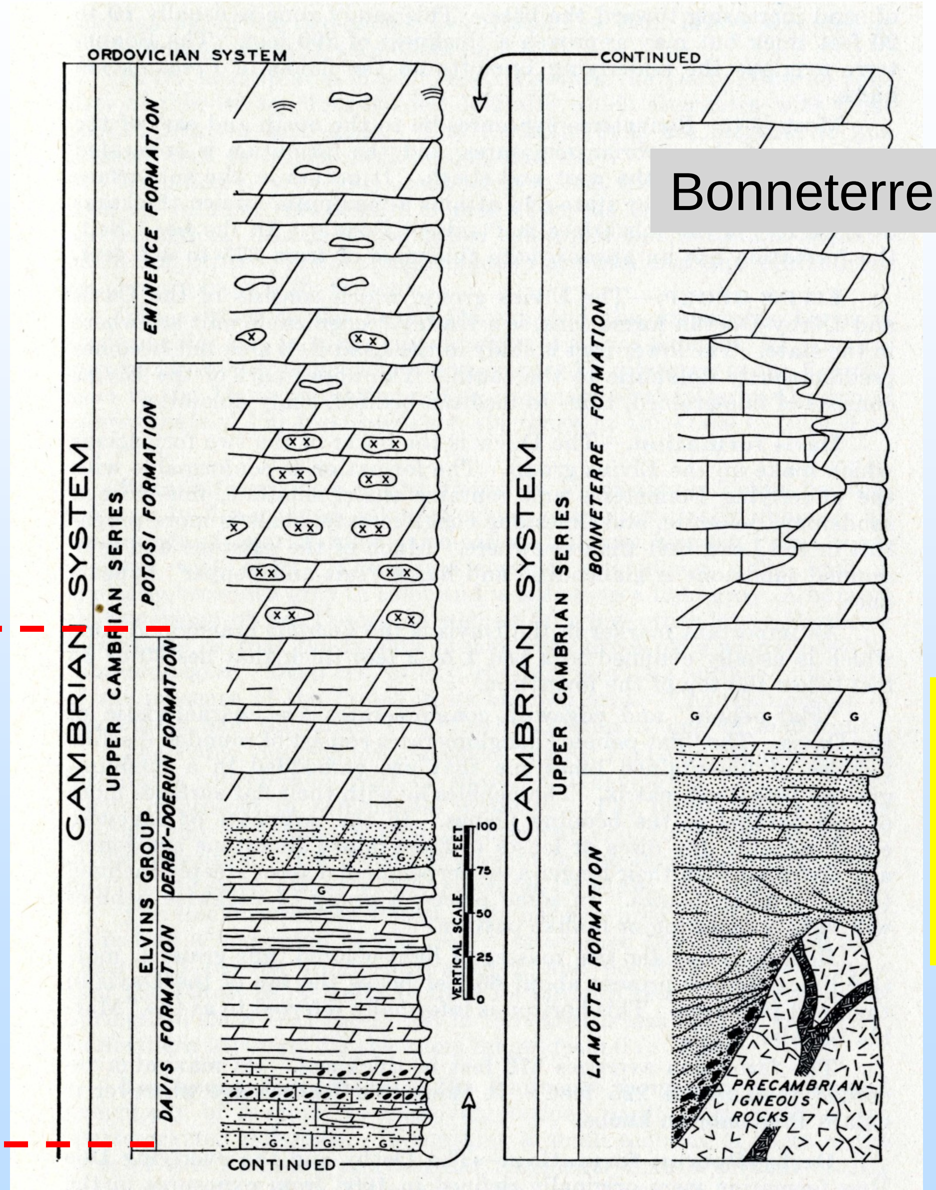


Background



- Main target for CO2 injection throughout Missouri.
- Viability depends on effective caprock and high permeability injection zone.

Background-Stratigraphy



Bonneterre Fm

Base of Ozark Aquifer

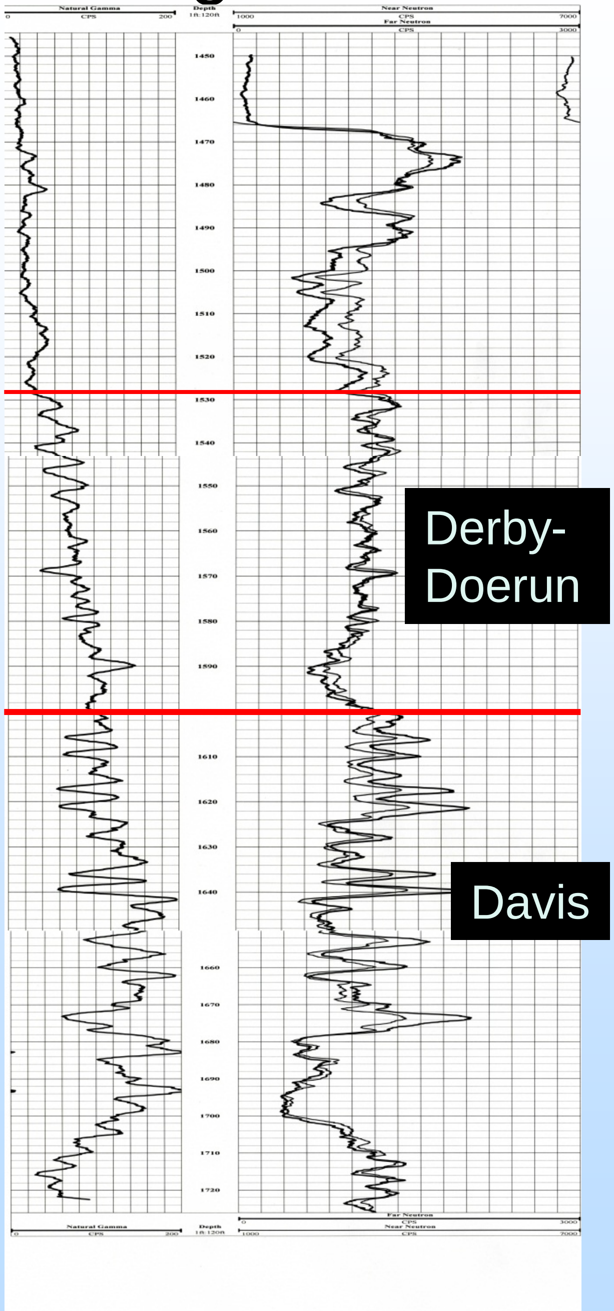
Derby-Doerun Fm.

Caprock

Davis Fm.

Lamotte

Background: Onsite Coring & Testing



St. Francois confining unit is about 50% shale; carbonates are mostly discrete clasts within shale.

Upper Davis: ~2E-6 mD

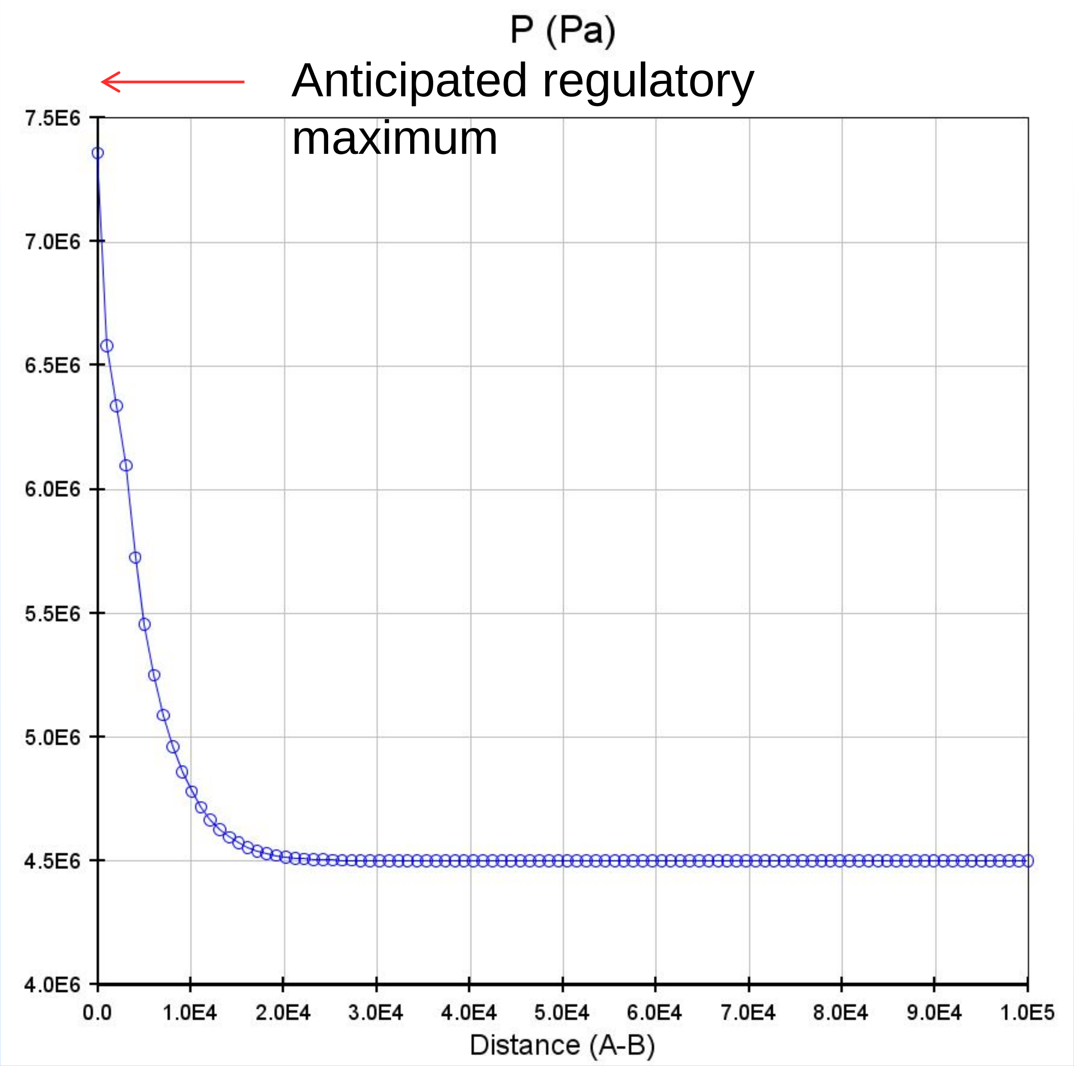
Background: Onsite Coring & Testing

Injection Interval:
~100 mD

"Upper Lamotte"

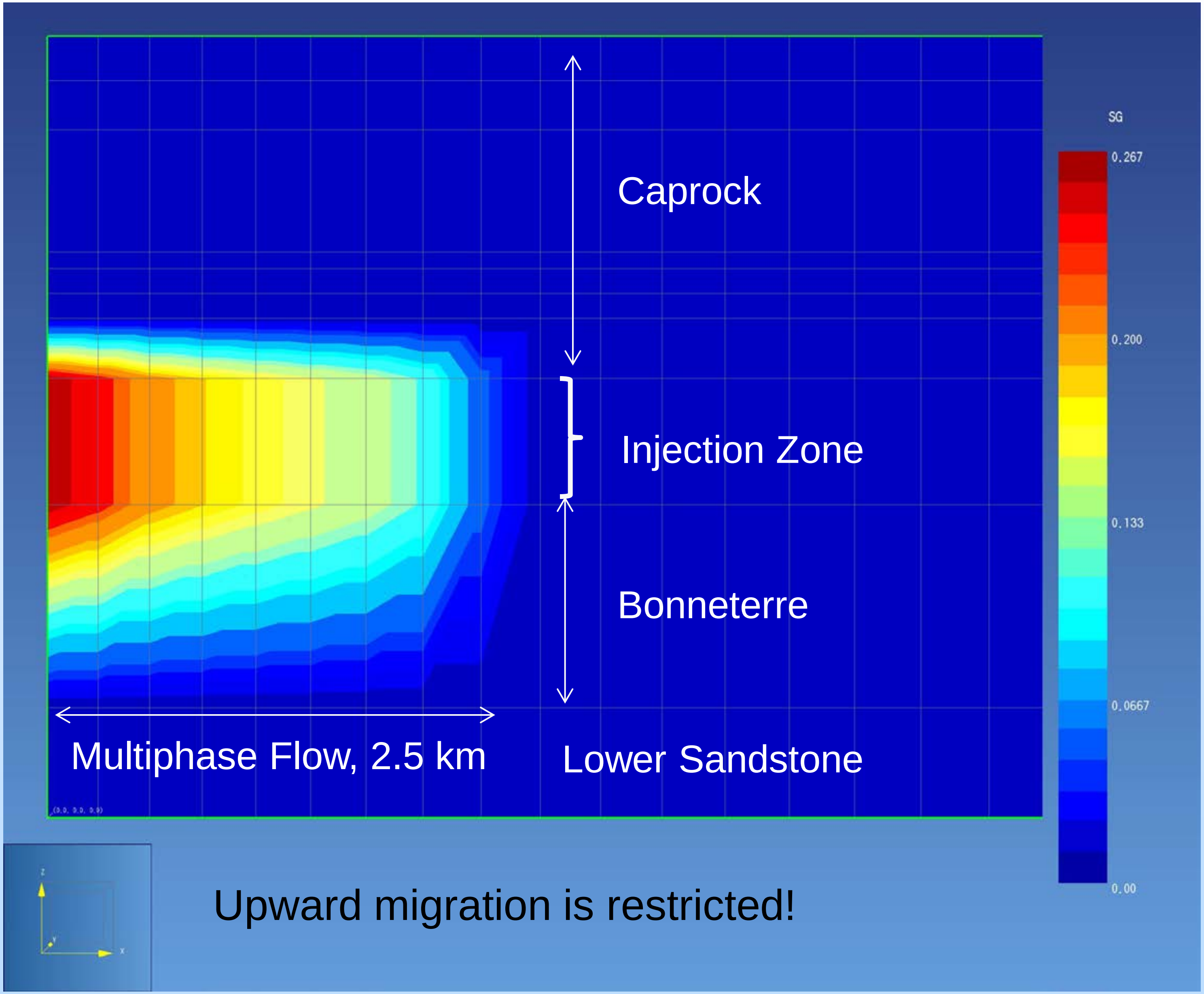
Results: Injection Simulations: 30 years at 410,000 metric tons/year: SWPP Site

Radial Single-Layer Simulation



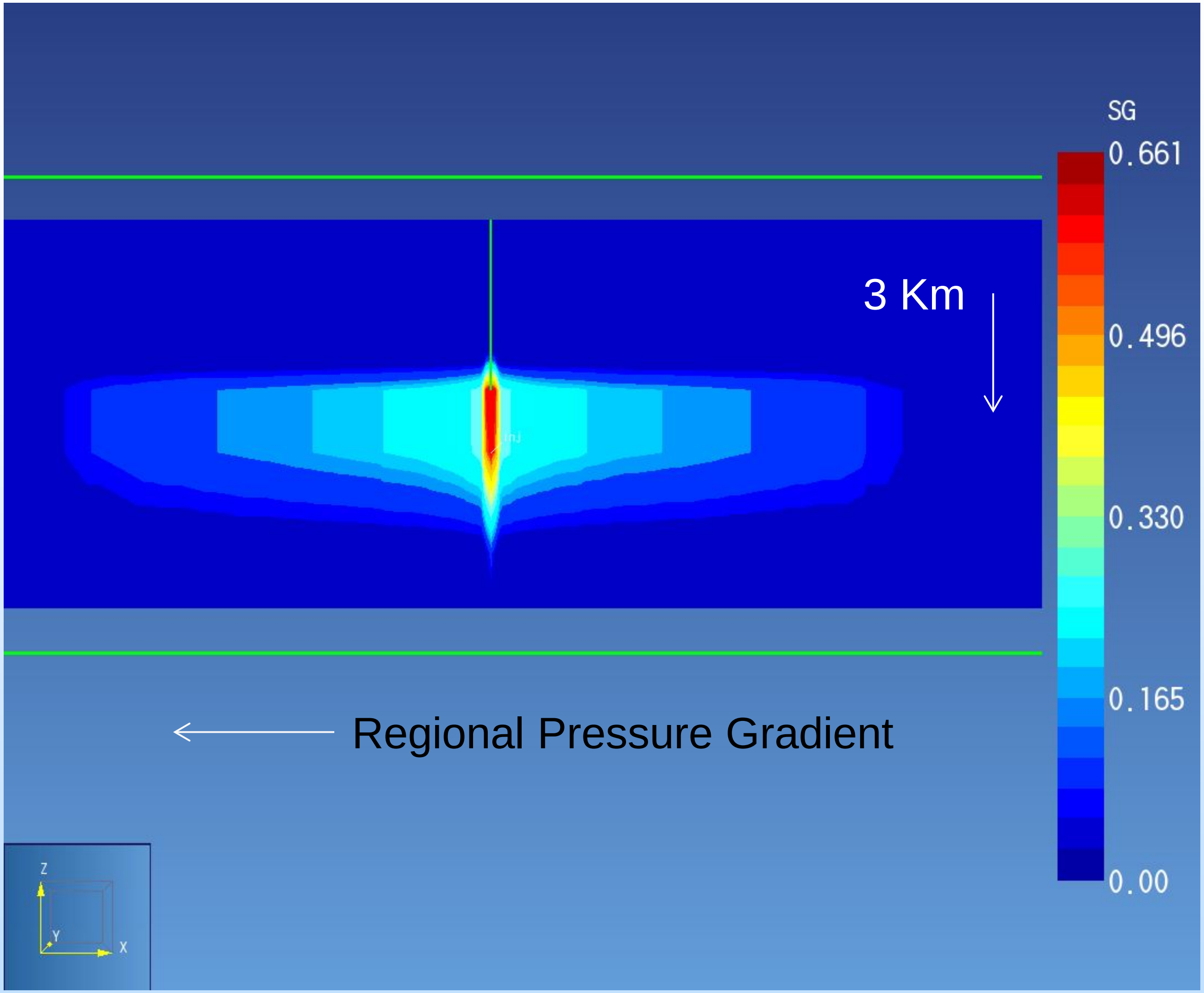
Pressure Within Injection Zone

Results: Injection Simulations: CO_2 Migration after 30 years

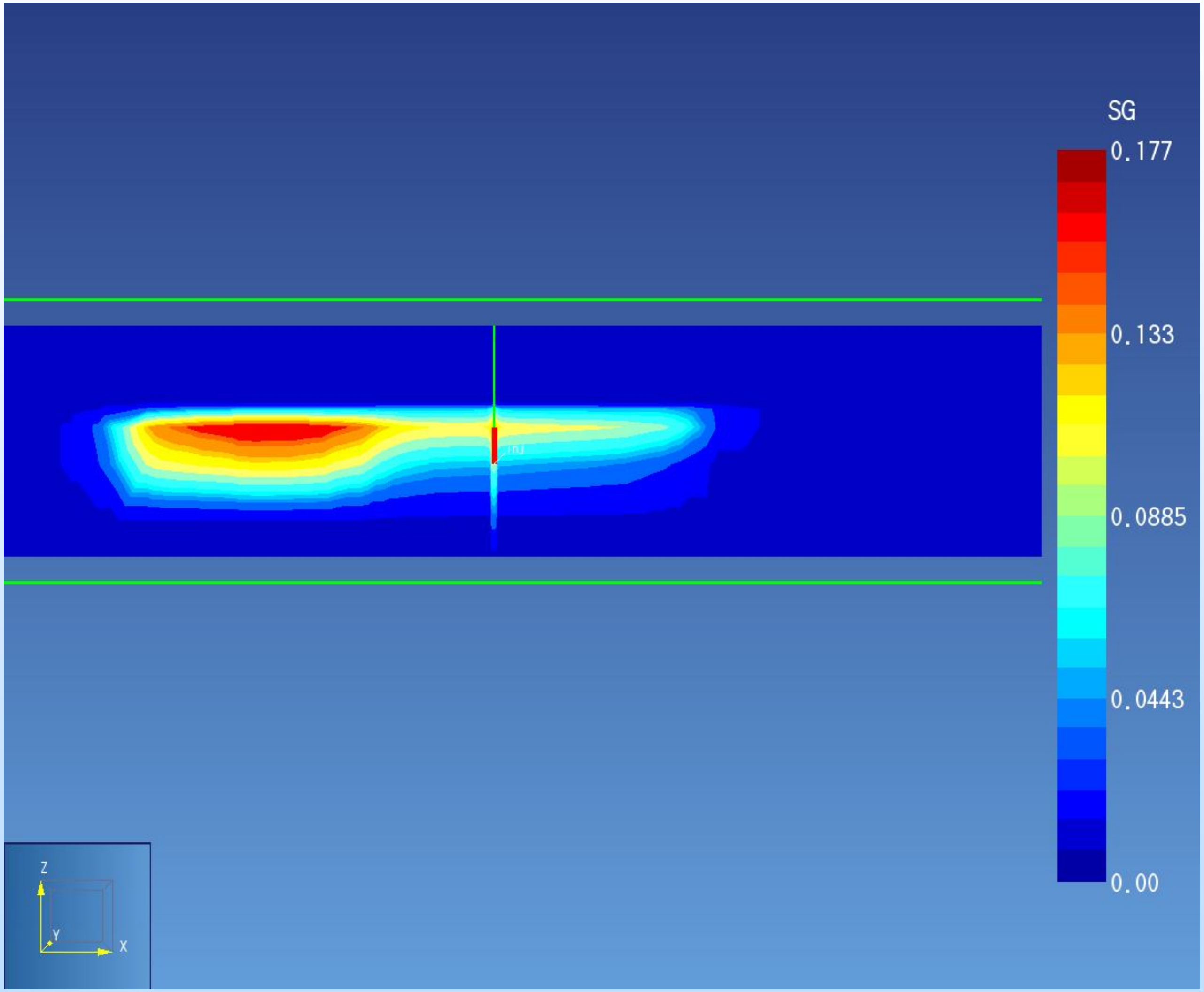


Upward migration is restricted!

Results: Compositional Simulations: CO_2 Migration after 30 years



Results: Compositional Simulations: CO_2 Migration after 1000 years



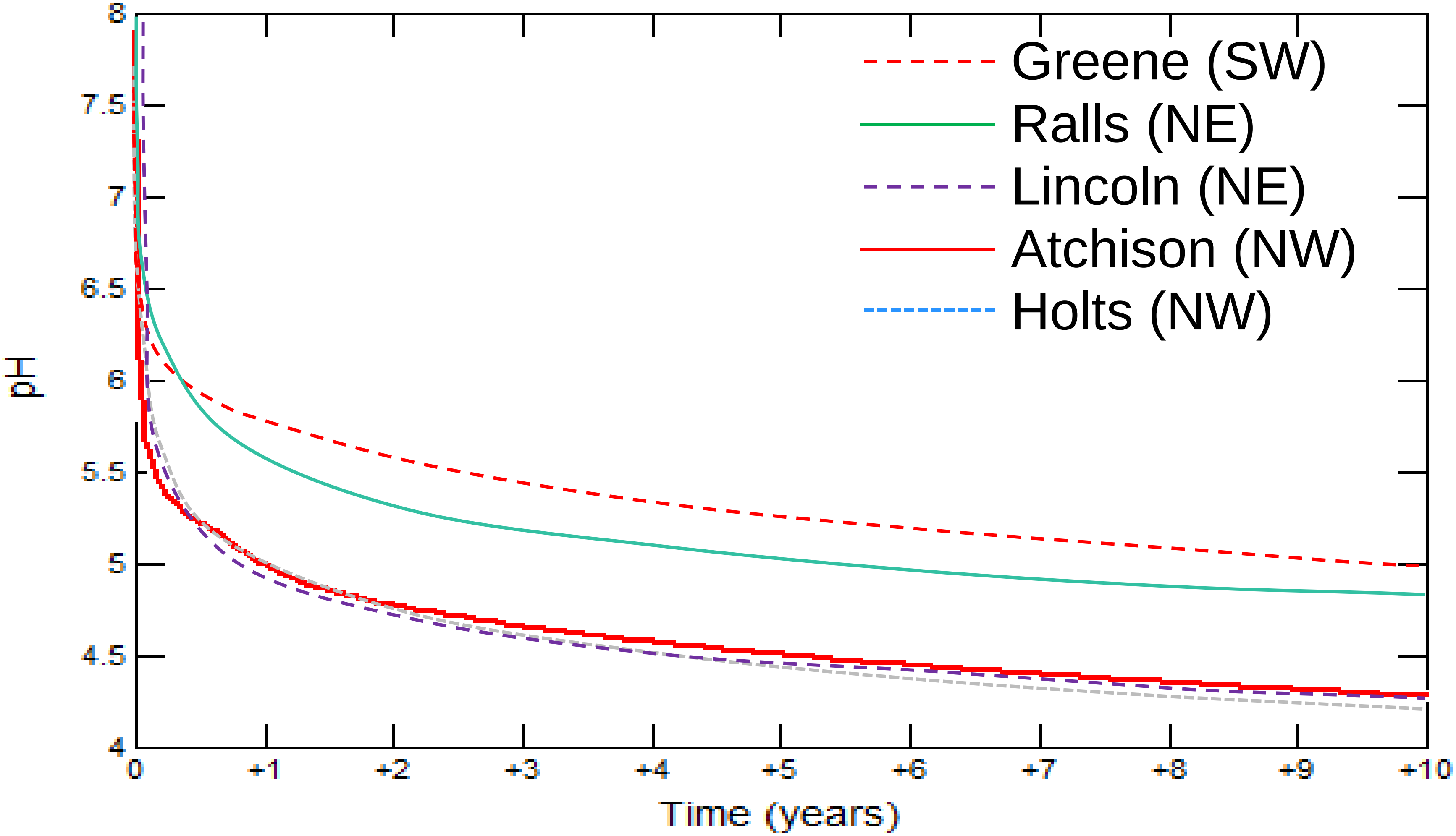
Results: Geochemical Modeling: Need Major minerals.

Mineral sequestration: need (non carbonate) source of divalent cations

Minerals	Chemical composition	% (vol)
Quartz	SiO_2	77.19
K-feldspar	$KAlSi_3O_8$ =(1/2K_2O, 1/2Al_2O_3, 3SiO_2)	0.18
Albite	$NaAlSi_3O_8$	0.04
Kaolinite	$Al_2Si_2O_5(OH)_4$	0.11
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$	0.24
Montmorillonite	$(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2\cdot nH_2O$	0.13
Glauconite	$(K,Na)(Fe,Al,Mg)_2(Si,Al)_4O_{10}(OH)_2$	0.02
Chlorite	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	0.02
Calcite	$CaCO_3$	0
Dolomite	$CaMg(CO_3)_2$	0
Hematite	Fe_2O_3	0.08
Goethite	FeO(OH)	0.05

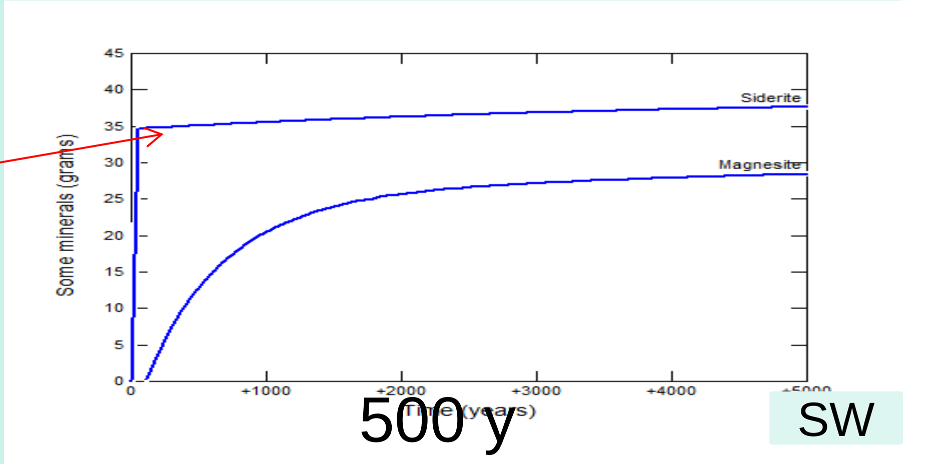
Nondorf, 2010: Ms Thesis

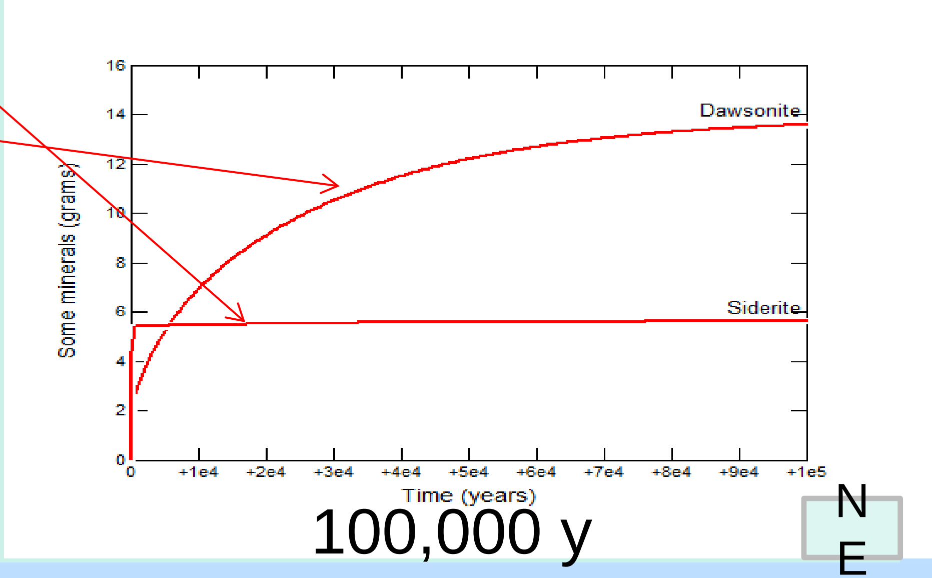
Results: Geochemical Modeling: pH Changes Due to CO_2 Injection



Results: Mineral trapping

- Major minerals precipitating:
- Siderite ($FeCO_3$)
- Magnesite ($MgCO_3$)- SW Mo
- Dawsonite ($NaAlCO_3(OH)_2$)





Results: Long-Term Mineral Trapping

CO2 stored in Minerals (in g/kg of free

Mineral	Greene (SW)	Atchison (NW)	Holts (NW)	Ralls (NE)	Lincoln (NE)
Magnesite	7	0	0	0	0
Siderite	12	2.9	3.1	2.5	3.2
Dawsonite	0	2.0	2.6	3.0	2.3
Total	19	4.9	5.7	5.5	5.5

Accomplishments to Date

1. Completed simulations of injection and post-injection phase for the St. Francois aquifer system in Missouri.

2. Compiled a GIS database of pore-fluid chemistries within and above potential injection zones in Missouri.

3. Completed geochemical reaction modeling CO_2 reactions and mineral trapping at four sites in Missouri.

Summary

Key Findings:

1. Sustained Injection rates (single well) of about 2,800,000 tons/year of CO_2 are possible within Missouri's St. Francois aquifer (deeper supercritical conditions).

2. Mineral trapping should be extensive and rapid due to abundant glauconite.

Lessons Learned:

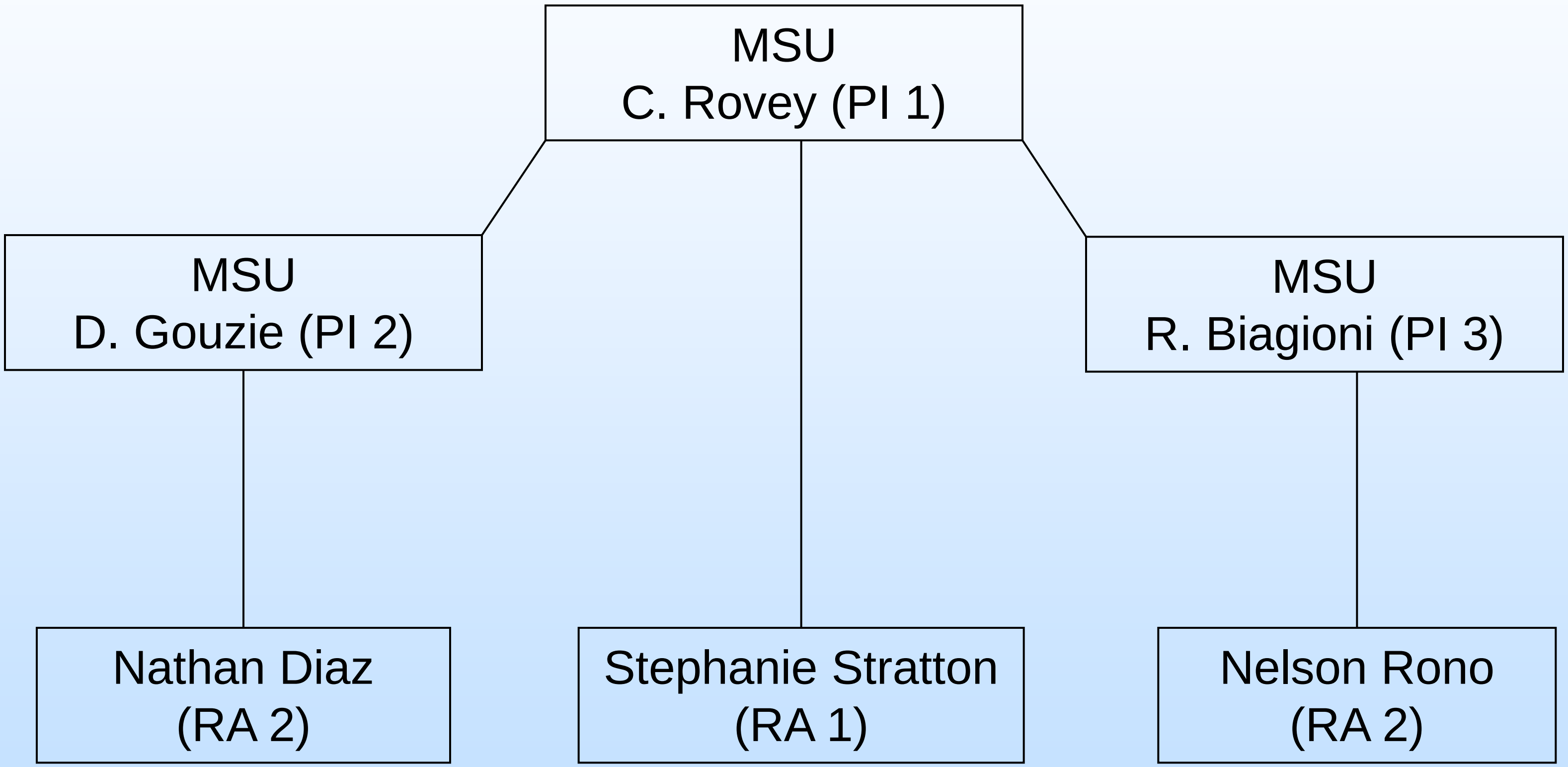
1. Be Flexible: Original work plans never go according to schedule.

Future Plans:

Appendix

Organization Chart

- Project team, organization, and participants.



Gantt Chart

Year	2010		2011				2012			
Quarter	3	4	1	2	3	4	1	2	3	4
Task: Student Training in Numerical Modeling					←	—	—	—	—	→
Subtask: Internship at DGLS									↔	100
Subtask: Analysis of Onsite Hydraulic Data						←	→	100		
Subtask: Simulation of CO_2 Injection						←	—	—	→	100
Subtask: Long-Term Simulation										↔ 0
Task: GIS Data Base of Pore-Fluid Chemistries in Missouri	←	—	—	—	—	—	—	→		
Subtask: Internship at DGLS					↔	100				
Subtask: Select and Sort Wells by Stratigraphic Unit		←	—	—	→	100				
Subtask: Entry Into GIS Database					←	—	→	100		
Subtask: Chemical Facies Maps							←	→	100	
Task: Student Training in Geochemical Modeling	←	—	—	—	—	—	—	→		
Subtask: Internship at DGLS					↔	100				
Subtask: Obtain Pore-Fluid Chemistries		←	—	—	→	100				
Subtask: Simulate CO2 Injection at 4 Potential Missouri sites					←	→	100			

Bibliography

Rono, N., Biagioni, R, Rovey, C. and Gutierrez, M., 2013. Geochemical sequestration reactions within the Lamotte Sandstone at five different locations in Missouri. Environmental Geosciences, v. 20 (3), p. 1-12.