Modeling CO₂ Sequestration in a Saline Aquifer and Depleted Oil Reservoir to Evaluate Regional CO₂ Sequestration Potential of Ozark Plateau Aquifer System, South-Central Kansas





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Outline of Presentation

- Project Overview and Objectives
- Tasks Completed and In Progress Initial Results
 - Regional Study 17+ county study area, southern Kansas
 - Wellington Field Study Sumner County, Kansas
 - Initial Simulation Studies
- Review of Gantt Chart
 - Tasks and Subtasks scheduled for completion in 2010
 - 2010 Tasks Scheduled to be Completed in 2011
- Budget
 - Planned vs. Actual

Overview

Evaluate CO₂ Sequestration Potential in KS

- Deep Saline Arbuckle Aquifer in south-central KS
- Select depleted mature oil fields

Start Date - Dec 2009







50 miles



Contours = thickness of Arbuckle Group (100 ft C.I.) Regional s<u>tudy → ~20,000 sq. miles</u>

Project Objectives

Build 3 geomodels

- Wellington field (Sumner County)
 - Depleted Mississippian oil field
 - Underlying Arbuckle saline aquifer
- Regional Arbuckle saline aquifer 17+ counties (south-central KS)
- Conduct simulation studies to estimate CO₂ sequestration capacity
- Arbuckle saline aquifer 17+ county area
 - Identify potential sequestration sites
 - Estimate sequestration capacity of Arbuckle saline aquifer in KS
- Risk analysis related to CO₂ sequestration
- Technology transfer

Ozark Plateau Aquifer System

Arbuckle Saline Aquifer with Primary, Secondary, and Tertiary Caprocks





Total Permian evaporite thickness ranges from 400 to 2000' in south-central KS. These evaporites serve as ideal cap rocks being located between shallow freshwater aquifers and hydrocarbon bearing strata and deeper Arbuckle saline aquifer.

Regional Study – Tasks Completed and In Progress Arbuckle Mapping and Areas of Interest

Structure top of Arbuckle Group, regional study area



Regional Study – Tasks Completed and In Progress Arbuckle and Potential Fields Mapping

3rd Order Structural Residual - Top Arbuckle







Regional Study – Tasks Completed and In Progress

Arbuckle Saline Aquifer Hydraulically Connected to Outcrop



Arbuckle exposure at base of Missouri River, north-central Missouri – Elevation 450 ft

& ~200 mi NE.

Assume hydrostatic gradient = 0.435 psi/ft

Difference between estimated hydraulic head at base of Arbuckle DST interval and DST SIP



Arbuckle Saline Aquifer Open or Closed System?

- Arbuckle aquifer is hydraulically connected to outcrop in Missouri
 - North-central edge of Ozark Uplift (~200 mi. NE)
- Arbuckle is the preferred disposal zone for produced oil field brine in Kansas
 - No loss of injectivity reported due to increased backpressure after 75+ years of injection
- Majority of Arbuckle hydrocarbon reservoirs produce under strong bottom water drives
- Arbuckle serves as preferred disposal zone for Class 1 hazardous liquid waste
 - Routine measurements at observations wells show minimal to no increase in reservoir pressure after decades of injection

Regional Study – Tasks Completed and In Progress Re-processed Gravity & Magnetics + Remote Sensing Analysis on Interactive Web-based Project Map

Modeling Carbon Dioxide Sequestration Potential in Kansas

Kansas Geological Survey



Regional scale lineaments + Structure contour top Mississippian

50 mi

http://maps.kgs.ku.edu/co2/?pass=project

Wellington Field Study – Tasks Completed and In Progress Landsat Lineaments and Magnetic Tilt Angle near Wellington Field



Wellington Field Study – Tasks Completed and In Progress 3D seismic P-Wave Processing, Initial Interpretations, & Borehole Site Selection Mississippian Time Structure





Wellington Field Study – Tasks Completed and In Progress Porosity Fence Diagram Mississippian Oil Reservoir





Initial Simulation Studies – Tasks Completed and In Progress 9 Township Model – centered around Oxy-Chem #10





Grids: 330' by 330'

Injection pressure < fracture pressure (3000 psi)

Injection from 2010 to 2060. Run till 2200.



Capacity & Injectivity



Initial Simulation Studies – Tasks Completed and In Progress 2D Model around Oxy-Chem #10 – 20 Layer Model Inputs

Approximately 300 core analysis archived from Arbuckle reservoirs – Byrnes et al 2003



Oxy-Chem #10				Sumner CO			
Flow units	Layers	Avg Depth	Pr - Hyd Head	Frac Pr	ppm	Phi	K, md
1	1	2658.5	1245	3009	100079	0.12	100
2	2	2732	1277	3065	105363	0.05	0.001
2	3	2765.5	1292	3090	107863	0.05	0.001
2	4	2799	1307	3115	110422	0.05	0.001
3	5	2834.5	1322	3141	113201	0.12	20
3	6	2871	1338	3169	116130	0.12	20
3	7	2907.5	1354	3196	119135	0.12	20
4	8	2944.5	1370	3224	122261	0.06	0.001
4	9	2981.5	1386	3252	125469	0.06	0.001
4	10	3019	1402	3280	128806	0.06	0.001
5	11	3058.5	1419	3309	132418	0.09	10
5	12	3099.5	1437	3340	136273	0.09	10
5	13	3140.5	1455	3371	140241	0.09	10
5	14	3181.5	1473	3402	144324	0.09	10
5	15	3222.5	1491	3432	148526	0.09	10
5	16	3263.5	1509	3463	152851	0.09	10
5	17	3304	1526	3494	157246	0.09	10
5	18	3344.5	1544	3524	161768	0.09	10
5	19	3385.5	1562	3555	166478	0.09	10
5	20	3426.5	1580	3585	171325	0.09	10

Salinity vs. Depth



Initial Simulation Studies – Tasks Completed and In Progress 2D Model around Oxy-Chem #10 – 20 Layer Model Results



Initial Simulation Studies – Tasks Completed and In Progress 2D Model around Oxy-Chem #10 – 20 Layer Model Results Pressure Leakage (brine) through Cap Rock



Jan 1, 2010 - Sg



Gantt Chart Review 2010 Tasks - Completed, In Progress, & Scheduled for 2011

		Year 1	Year 2	Year 3
Regional geomodel development of Arbuckle saline aquifer		•		
Collect, process, interpret 3D seismic data - Wellington field		ioi		
Collect. process. interpret gravity and magnetic data - Wellingto	n field	<u>č</u>		
Drill, core, log, and test - Well #1 Sched	luled for 2010			
Collect, process, and interpret 2D shear wave survey - Well #1	\$1	<u>S</u>	ial	S
Analyze Mississippian and Arbuckle core	20	ġ		l itie
PVT - oil and water	2	Da	gt et	tia un
Geochemical analysis of Arbuckle water	Ine		J. P	Co
Cap rock diagenesis and microbiology	heo		elle	00 +
Drill, log, and test - Well #2	6		S S S	9 F 17
Complete Wellington geomodels - Arbuckle and Mississippian r	eservoirs		<u>o</u>	Sec
Evaluate CO2 sequestration potential in Arbuckle underlying We	0			
Evaluate CO2 sequestration potential in CO2-EOR in Wellington	field) Ç Ç
Risk assessment - in and around Wellington field				A
Regional CO2 sequestration potential in Arbuckle aguifer - 17+ (counties			1
Technology transfer				

2010 Budget Planned vs. Actual Expenditure

	4th Qtr 2009	1st Qtr 2010	2nd Qtr 2010	3rd Qtr 2010	4th Qtr 2010
	Dec-09	Mar-10	Jun-10	Sep-10	Dec-10
Actual DOE Cost	\$4,019.93	\$84,603.97	\$494,428.37		
Planned DOE Cost	\$1,273.10	\$330,271.41	\$330,271.41	\$1,302,953.72	\$2,065,719.27

Revised Schedule

- Sites selected for test bore holes #1 & 2
- Industry partner (BEREXCO) completing land/lease legal work
- Rig to move to location for drilling test bore hole #1 3rd week of Nov 2010
- Rig reserved for 3 months
 - Will drill test bore hole #2 after completion of #1 back to back
- 2D shear wave survey shot after drilling test bore hole #1
 - Complement multi-component 3D seismic survey (already surveyed)
- Core Analysis mid-2011
- Geochemistry mid-2011
- Revise Geomodel & Simulation later half of 2011



<u>Thank You</u>





http://www.kgs.ku.edu/PRS/Ozark/index.html