SMALL SCALE FIELD TEST DEMONSTRATING CO_2 SEQUESTRATION IN ARBUCKLE SALINE AQUIFER AND BY CO_2-EOR AT WELLINGTON FIELD SUMNER COUNTY, KANSAS DE-FE0006821

W. Lynn Watney, & Jason Rush (Joint PIs)

Jennifer Raney (Asst. Project Manager)

Kansas Geological Survey

Lawrence, KS 66047

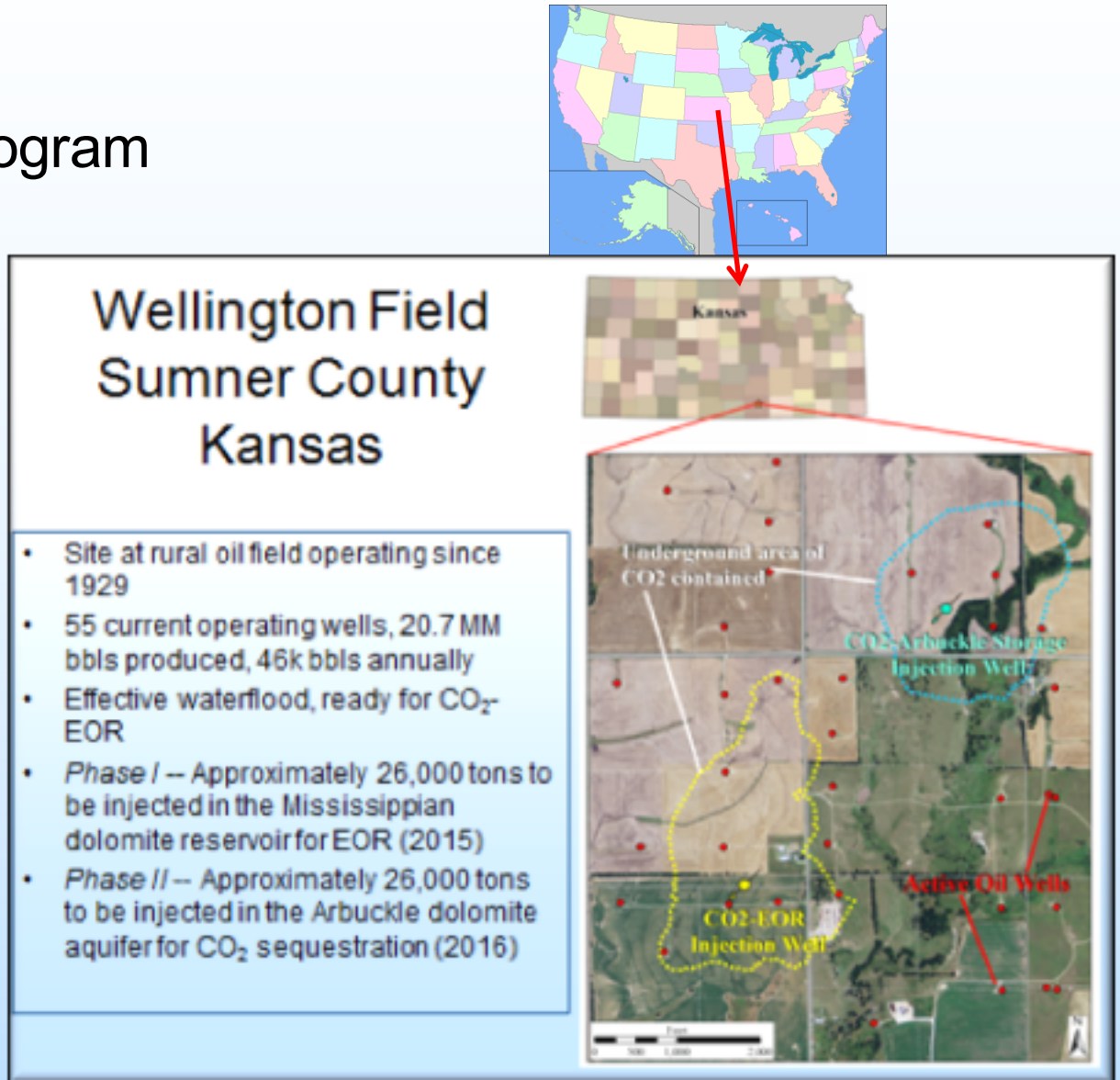
U.S. Department of Energy
National Energy Technology Laboratory
Carbon Storage R&D Project Review Meeting
Developing the Technologies and
Infrastructure for CCS
August 18-20, 2015

Brighton 3 & 4
10:05 AM
THURSDAY, AUGUST 20, 2015

KANSAS GEOLOGICAL SURVEY
The University of Kansas

Presentation Outline

1. Project Overview
2. Benefits to the Program
3. Technical Status
4. Accomplishments
5 Summary
6 Synergistic Activities



Project Team

DOE-NETL Contract #FE0006821

KANSAS GEOLOGICAL SURVEY
The University of Kansas

L. Watney (Proj. Manager, Joint PI), J. Rush (Joint PI), J. Raney (Asst. Project Manager), T. Bidgoli, J. Doveton, E. Holubnyak, M. Fazelalavi, R. Miller, D. Newell, John Victorine
(static & dynamic modeling, petrophysics, well test analysis, high-resolution 2D seismic, install/maintain seismometer array, structural & geomechanical analysis, project management)

Brian Dressel, P.M.

BEREXCO

Dana Wreath, Adam Beren ***(field operator and operations, repeat 3D multicomponent seismic)***

BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

Tom Daley, Barry Freifeld ***(CASSM, U-Tube, cross well seismic for Arbuckle Class VI geosequestration)***

THE LINDE GROUP
Linde
PRAXAIR
Making our planet more productive

CO_2 suppliers as of 2014

DEPARTMENT OF GEOLOGY

KANSAS STATE UNIVERSITY

Saugata Datta, Brent Campbell ***(fluids, soil gas, and USDW monitoring)***

IRIS PASSCAL
INSTRUMENT CENTER
Program for Array Seismic Studies of the Continental Lithosphere

George Tsoflias, Brandon Graham, Alex Nolte (KU Geology) ***seismometer array***

TBirdie Consulting, Inc
4705 McCormick Street • Lawrence • KS 66047 • 785 843 1085 • 785 865 0678 (fax) • tbirdie@sunflower.com

T. Birdie ***(aquifer and geomechanical modeling, EPA Class VI permit & reporting, closure)***

KU THE UNIVERSITY OF KANSAS Department of Geology

Mike Taylor, Leigh Sterns, Drew Schwab ***(cGPS, InSAR)***

Schlumberger

Petrel, TechLog

CMG COMPUTER MODELLING GROUP LTD.

Core Lab
RESERVOIR OPTIMIZATION

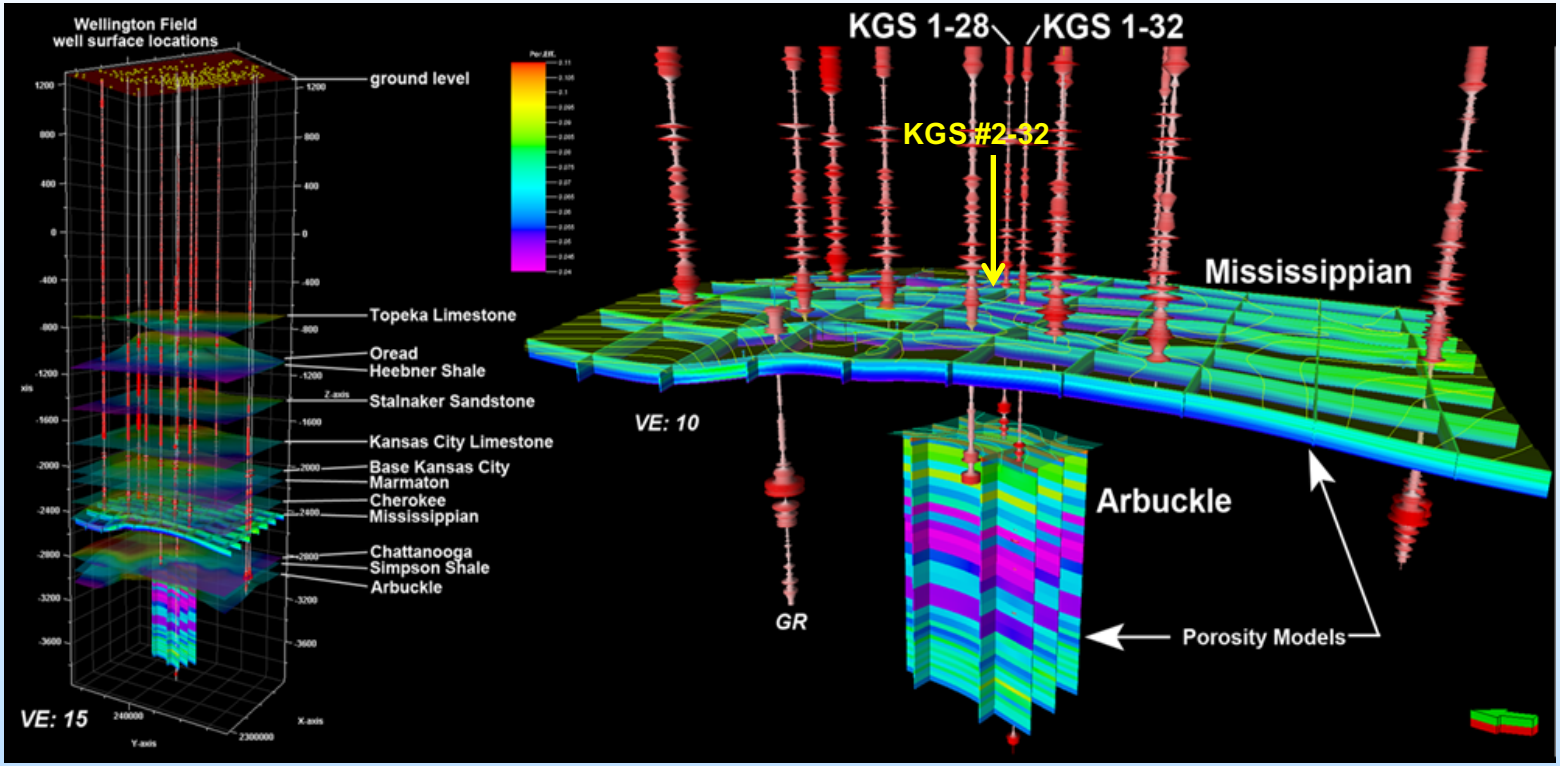
HALLIBURTON

Weatherford

Project established November 2011

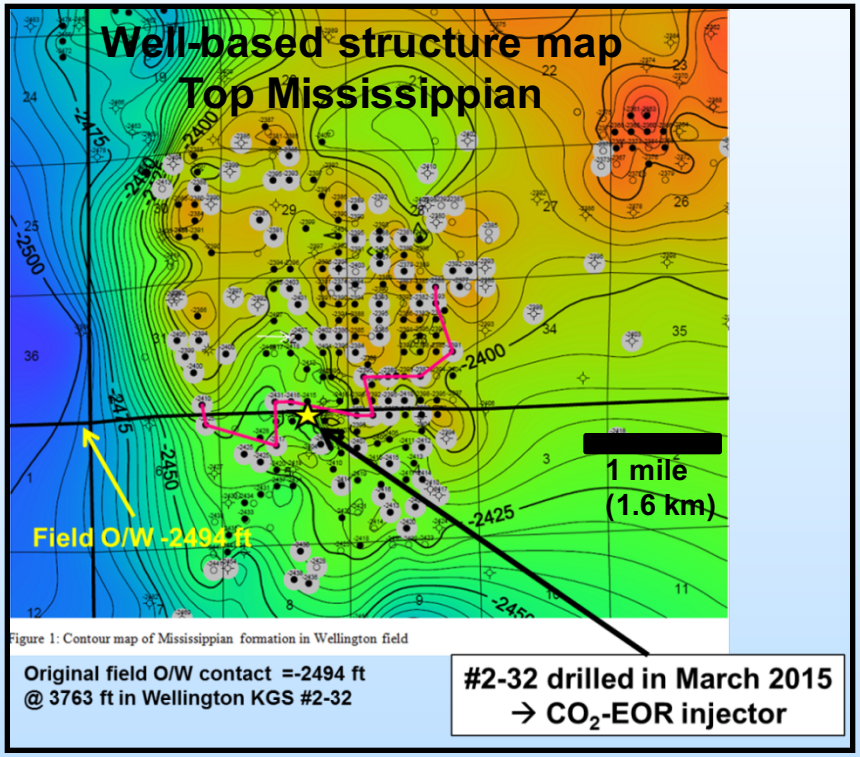
Benefits to the Program

- **Program goals being addressed –**
  - **Demonstrate that 99 percent permanence of injected CO_2**
    - ~26,300 tonnes of CO_2 in each –
      - ❑ *Late Mississippian siliceous dolomite reservoir deposited on a marine shelf to shelf edge ramp (**Class II UIC permit**)*
      - ❑ Underlying *Lower Ordovician Arbuckle Group dolomitic saline aquifer deposited on marine shelf (**Class VI UIC permit**)*
  - **Demonstrate reliable and cost effective MVA (*monitoring, verification, and accounting*) tools and techniques**
  - **Develop best practices for effective and safe CO_2-EOR and CO_2 disposal in a saline aquifer**



Technical Status

- **Milestone 1: Refined static and dynamic models of the Mississippian oil reservoir**
  - *Task 3* -- **Obtained Class II to inject CO_2 in Mississippian oil reservoir in February 2015**
  - Task 9 – **Drilled, cored, logged, and tested Berexco Wellington KGS #2-32 in late March and April 2015**
  - Task 10 – **Complete #2-32 for CO_2-EOR injection, re-pressurizing reservoir prior to CO_2 injection and begin injection of 26,300 tonnes of CO_2 by October 1, 2015**



Readiness to test monitoring technologies in BP2
→ field deployment began in August 2014

1) Shallow water well monitoring
2) 18- seismometer array for passive seismic monitoring
3) cGPS and InSAR surface monitoring of CO_2 injection
4) Monitoring wells in underpressured Mississippian reservoir overlying the caprock
5) High resolution 2D seismic survey to verify any leakage through the caprock (late August 2015)
6) Engineering analysis of CO_2 injection performance

Small Scale CO_2-EOR in Mississippian

→CO_2 injection into a biosiliceous dolomite reservoir

Berexco LLC
Wellington KGS #2-32
2680'FSL & 709'FEL,
Sec 32, T 31S, R 1W
Sumner County, Kansas

BEREXCO

Fossil Drilling

DEVILBISS CORING SERVICE, INC.
"QUALITY SERVICE SINCE 1992"

MUDCO

HALLIBURTON

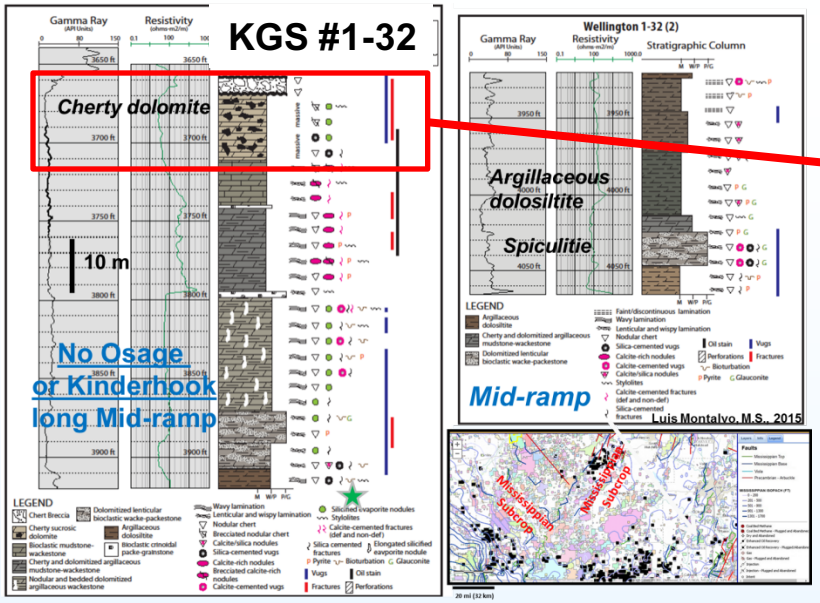
Core Lab

TRILOBITE TESTING, INC.

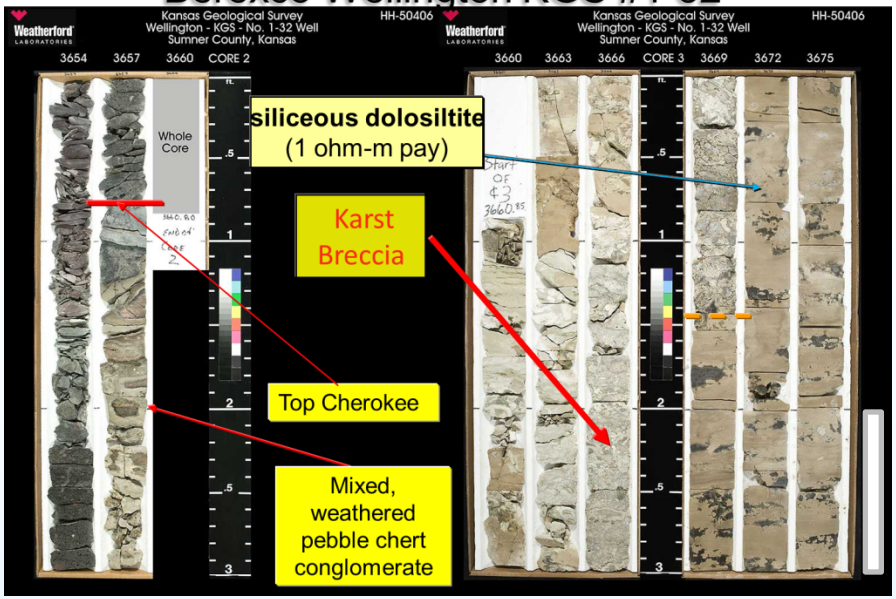
92 ft core cut in KGS #2-32 with 1528 ft previously acquired in KGS #1-32

Drilled in March 2015

No Osage or Kinderhook Mississippian → mid ramp

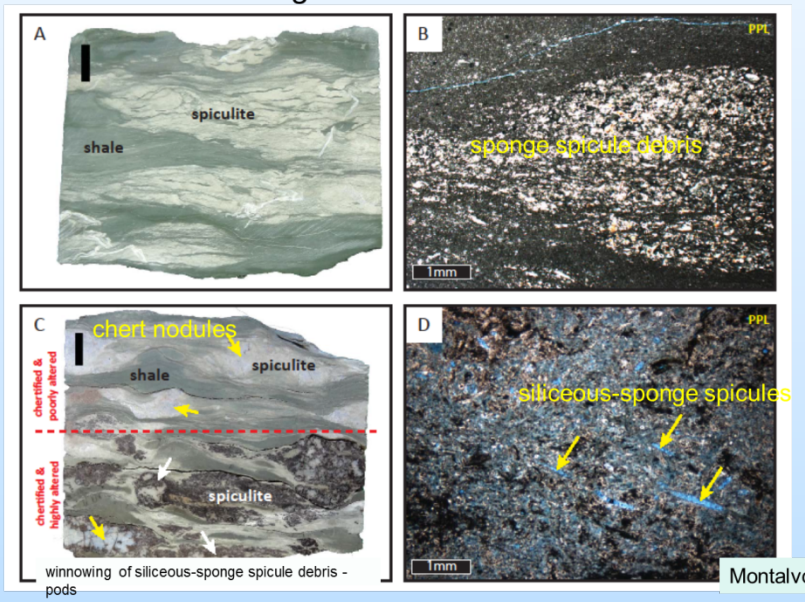


Mississippian pay zone in Berexco Wellington KGS #1-32



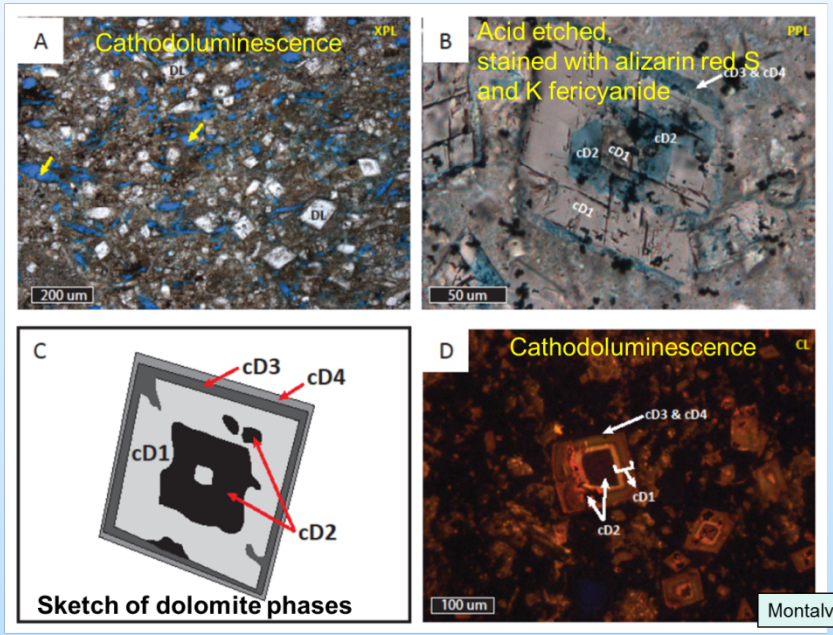
Lenticular Spiculite Wacke/Packestone

Extensive Micro-Porosity Through Dissolution and Etching of the Silica Matrix



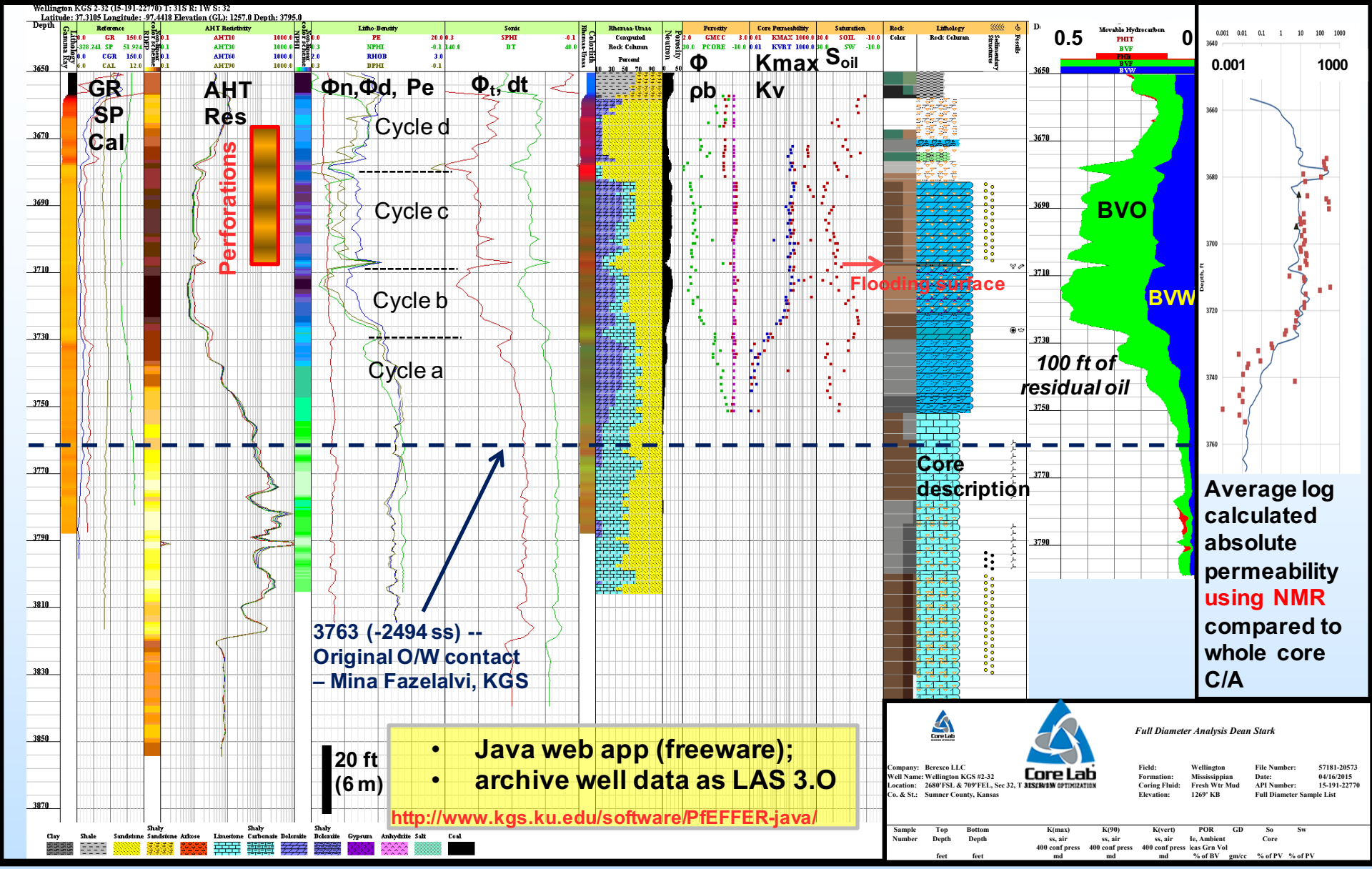
Montalvo (2015)

Rhombic Dolomite Euheral (idiotopic) Different Phases, Feroan and Non-Feroan



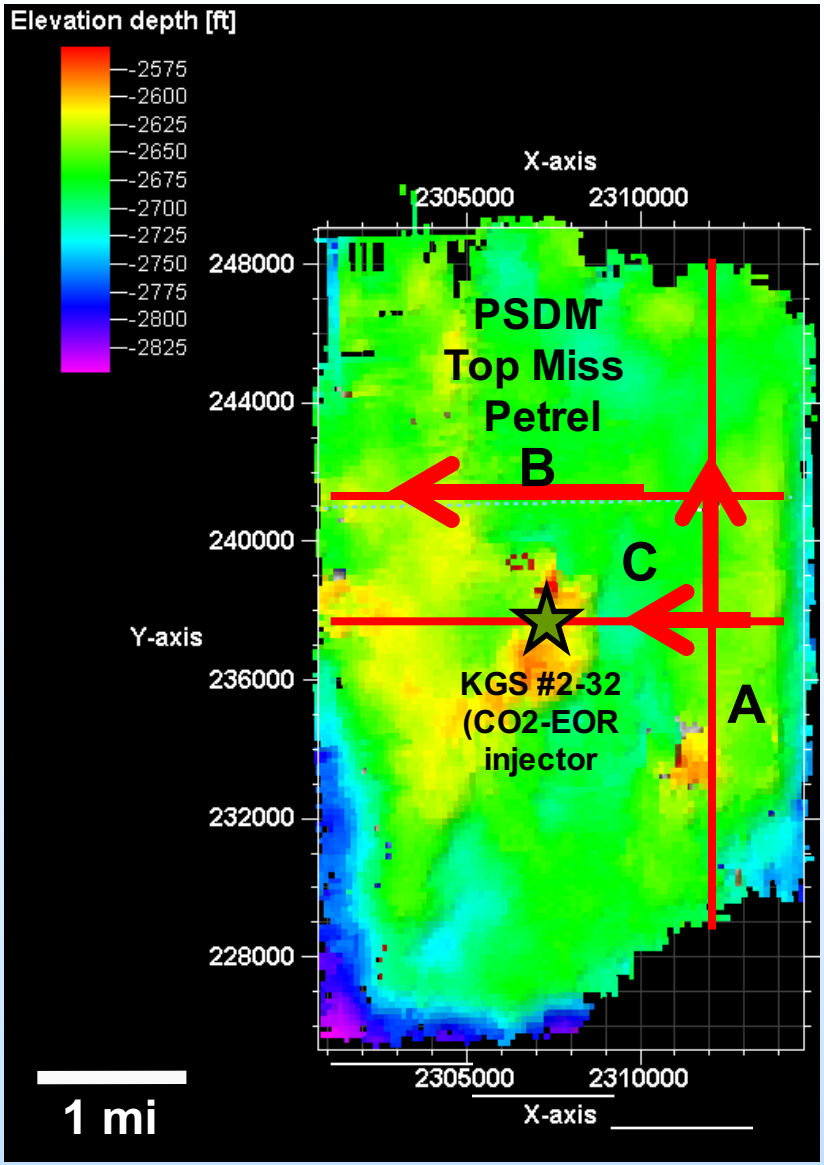
Montalvo (2015)

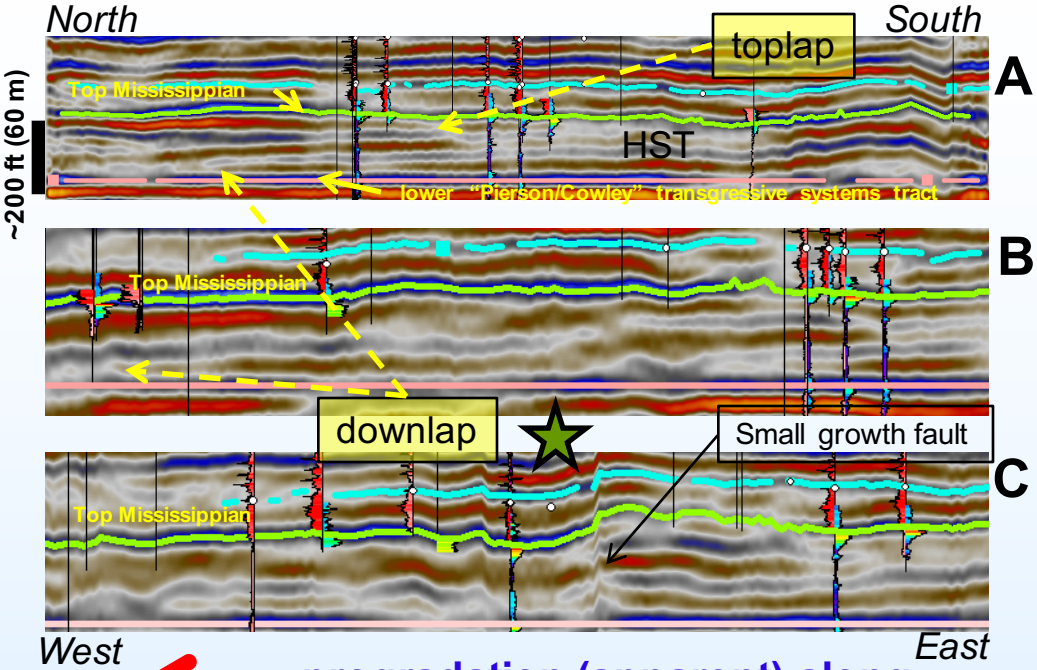
KGS #2-32 Mississippian reservoir interval, composition plot, core analysis, and moveable oil



Mississippian Seismic Stratigraphy using PSDM

→ complex progradational wedges in HST containing high-frequency cycles





progradation (apparent) along high stand systems tract (HST)

- **Complex progradation! …albeit slope ~1º**
- **Local <u>antecedent</u> and <u>syndepositional</u> structures impact stratal terminations**
- **Appears to compartmentalize the reservoir suggested by preliminary baseline water chemistry**

actual progradational vector

Jason Rush, KGS

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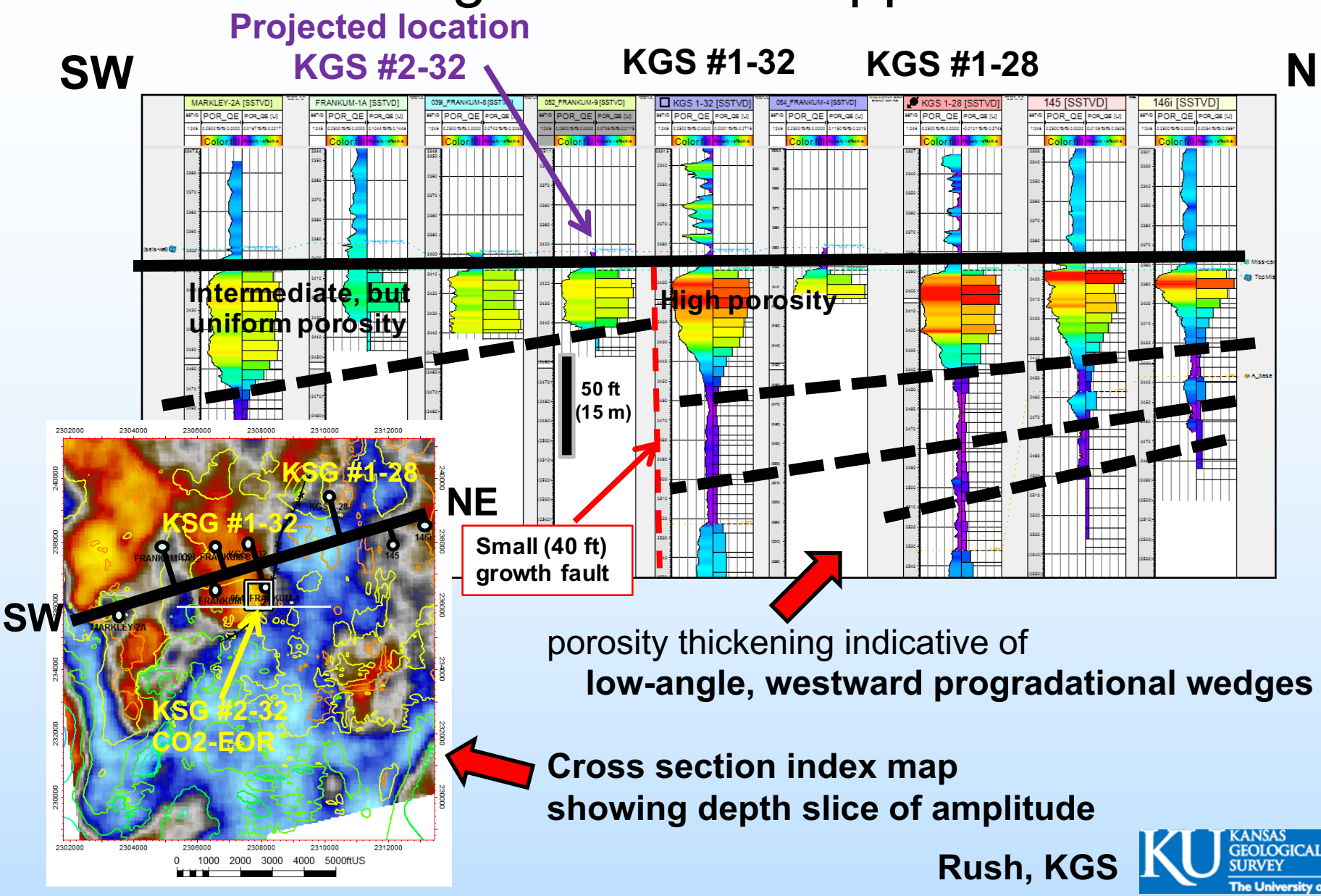
Progradational wedge geometries help to explain lateral changes in Mississippian reservoir



porosity thickening indicative of
low-angle, westward progradational wedges

Cross section index map showing depth slice of amplitude

Rush, KGS

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5 well step-rate test

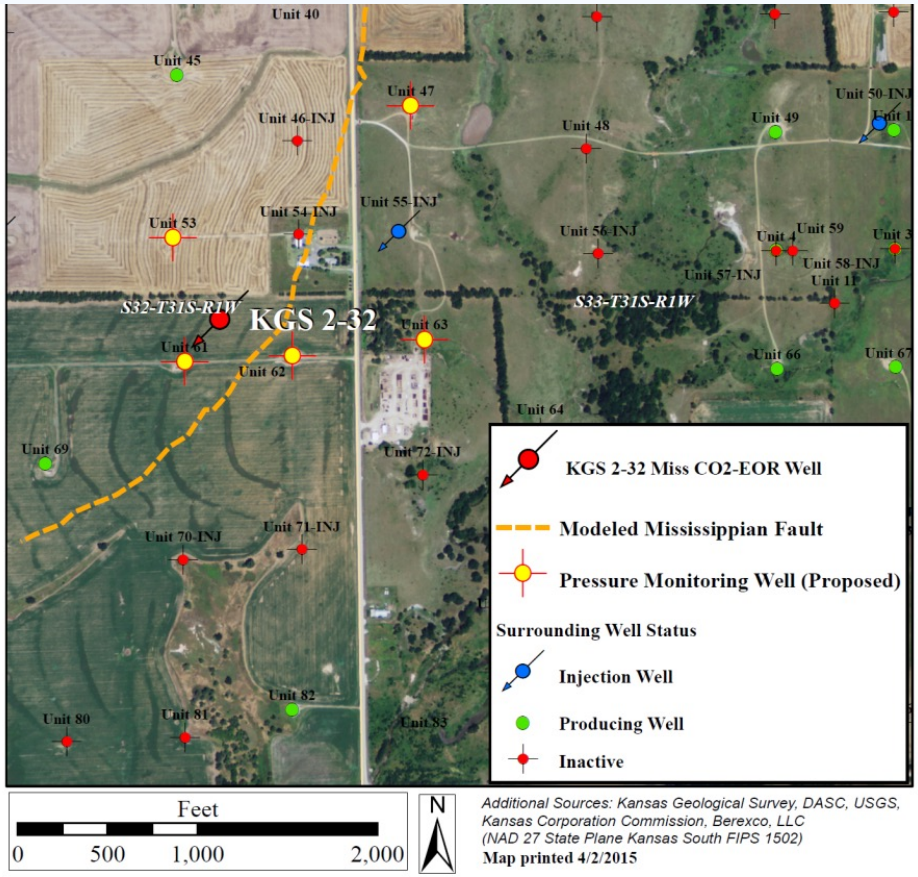
-- *Confirm reservoir pressure*

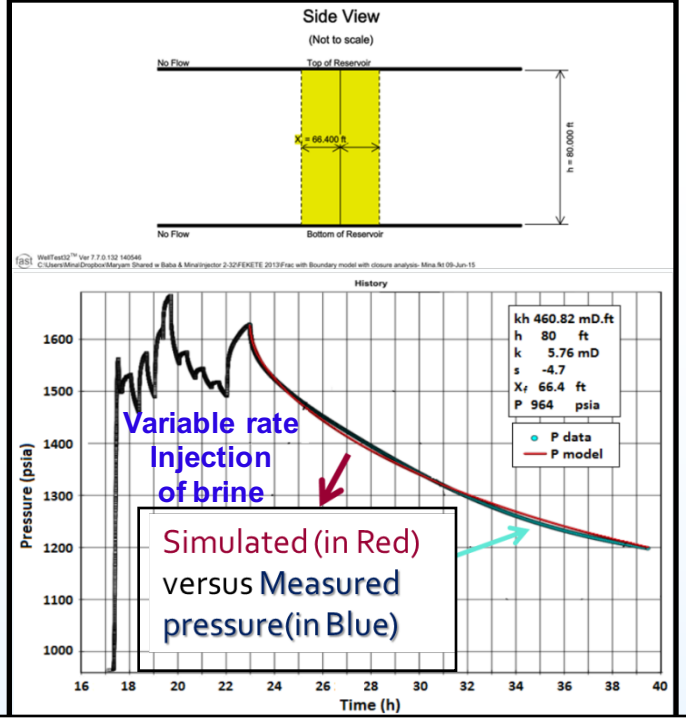
-- *Evaluate*:

a) *connectivity between wells,*

b) fracture vs. matrix flow,

c) fracture closure pressure



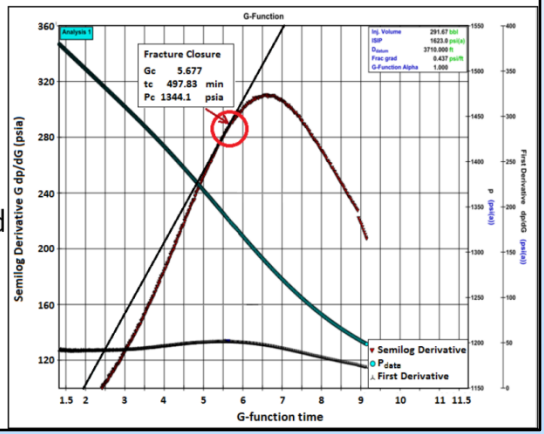


Current reservoir pressure ~900 psi

Fazelalavi KGS

Closure Pressure

- The slope on the G-function derivative defines the closure pressure where the derivative departs from the slope
- Closure pressure is 1334 psi
- Closure pressure gradient is 0.36 psia/ft
- Closure pressure is abnormally Low
- Fracture pressure and closure pressure are reduced due to pressure depletion, water injection and cooling



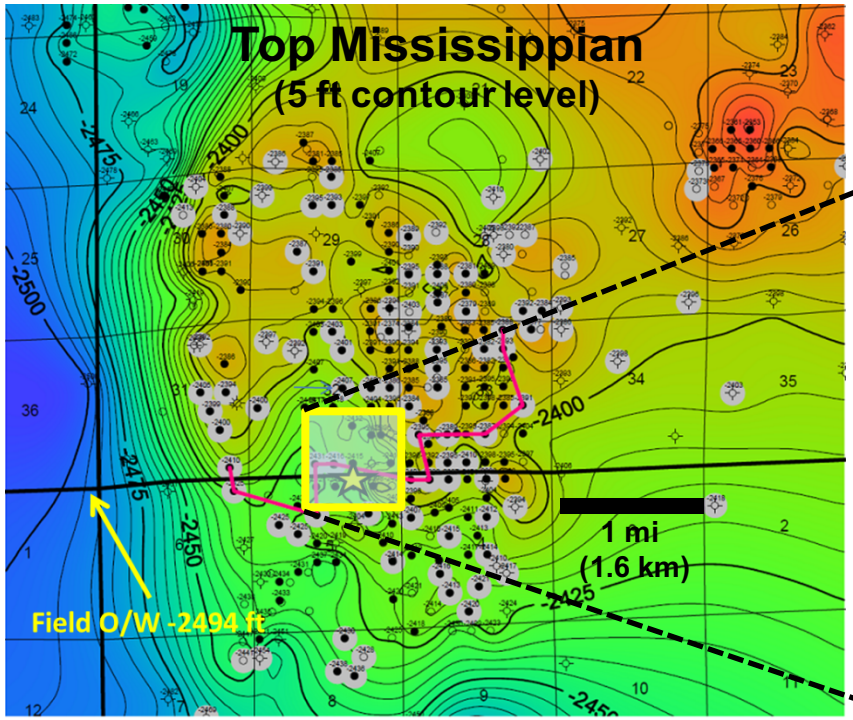
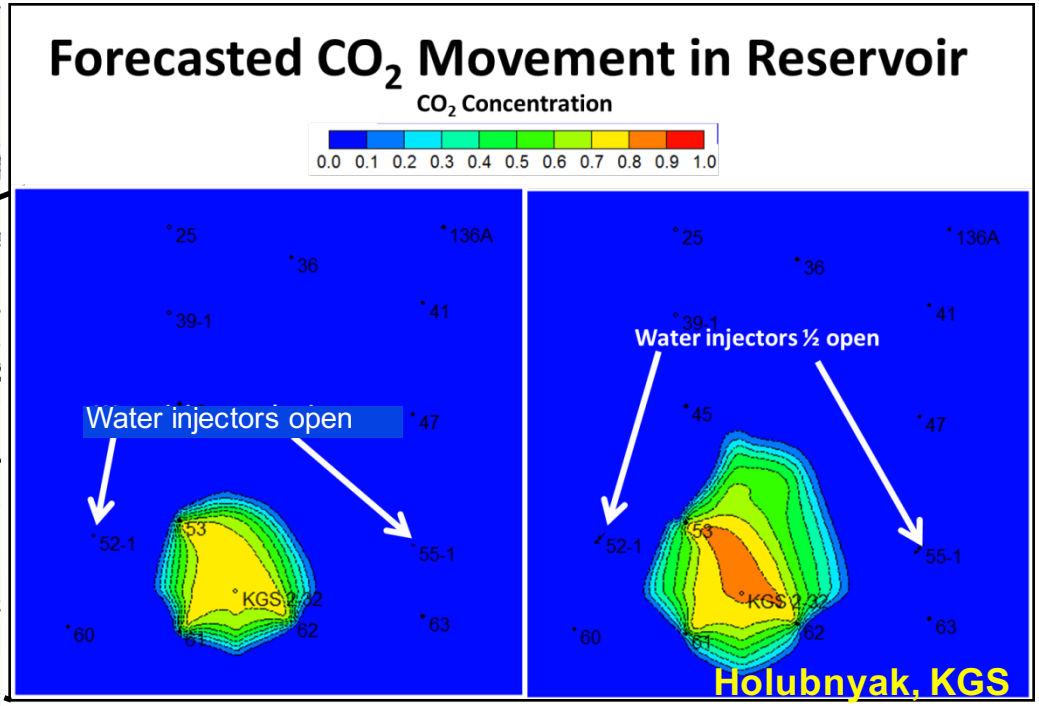
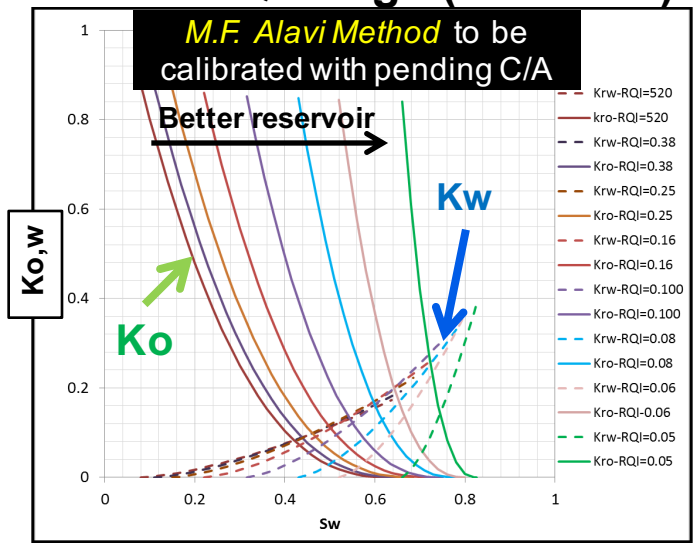
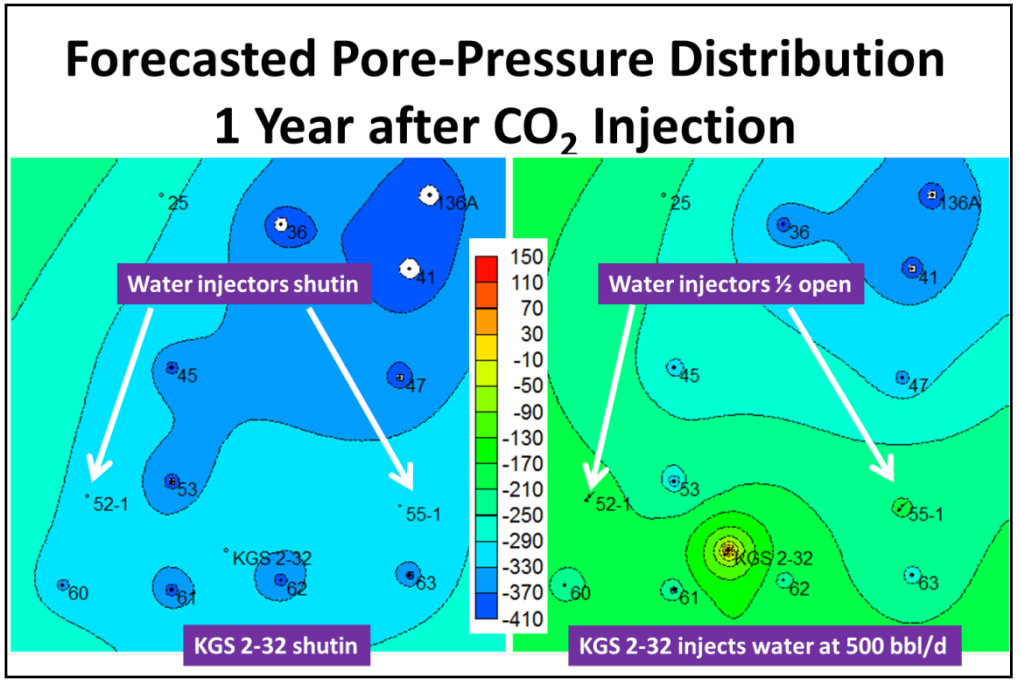


Figure 1: Contour map of Mississippian formation in Wellington field



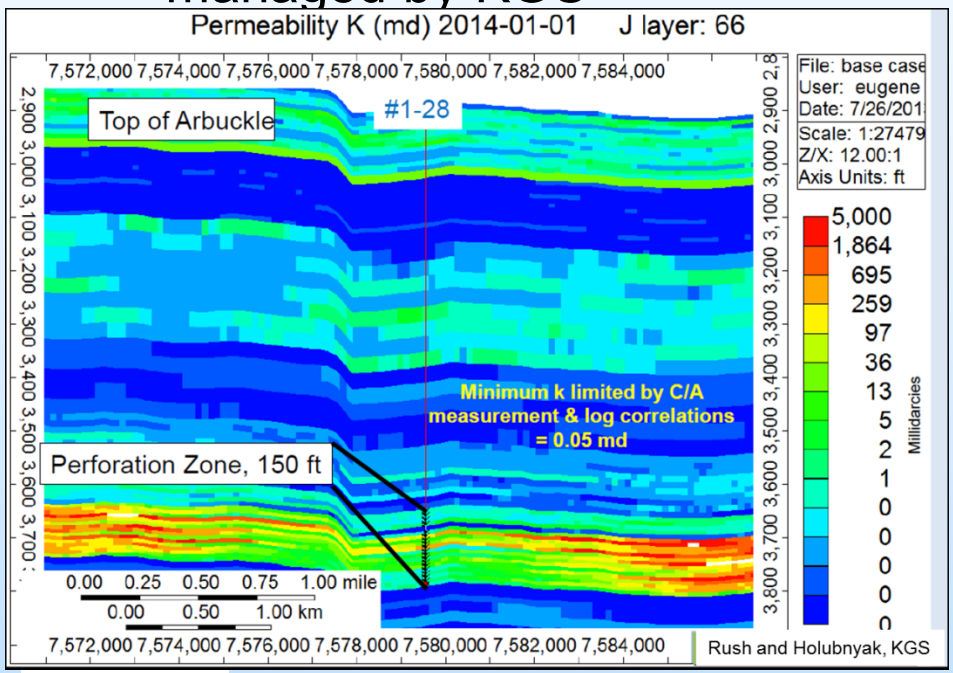
Imbibition Relative Permeability for each RQI range (Oil-Brine)



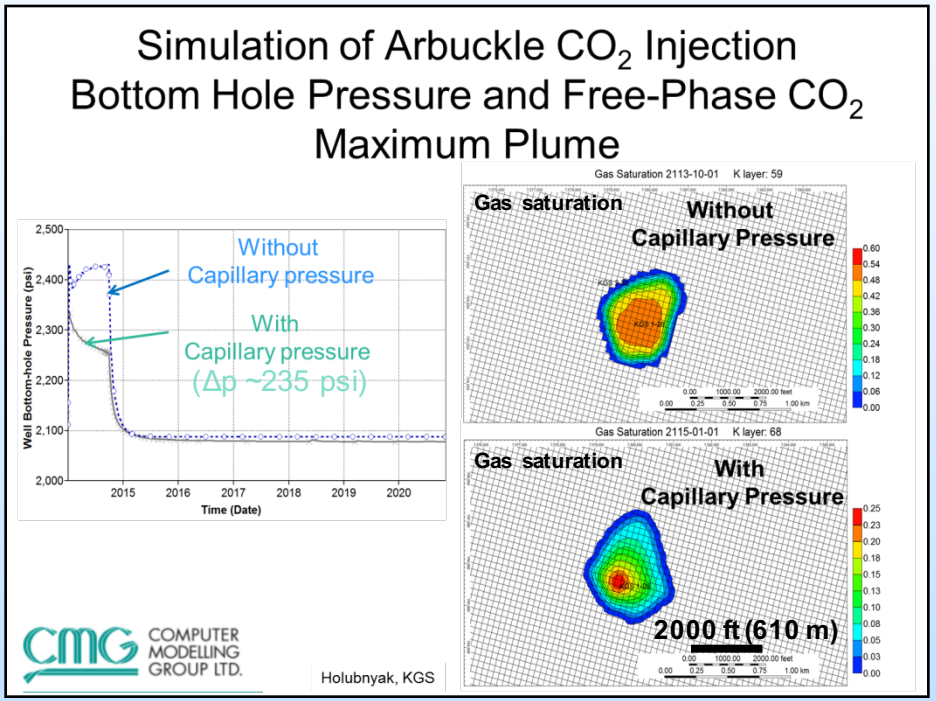


Technical Status

- **Milestone 2 - Submitted Class VI application, June 2014**
  - **Status of application** – a) address remaining requests for information (RAI's), b) resample shallow water wells, c) synchronize and confirm KGS Petrel/CMG and EPA STOMP simulations of the conservative CO_2 plume
  - **Obtain findings** by EPA on Area of Review (*AoR*), financial assurance, post injection site care (*PISC*), obtain draft of Class VI permit for public comment, application filed by Berexco, LLC & managed by KGS



Schlumberger **Petrel**



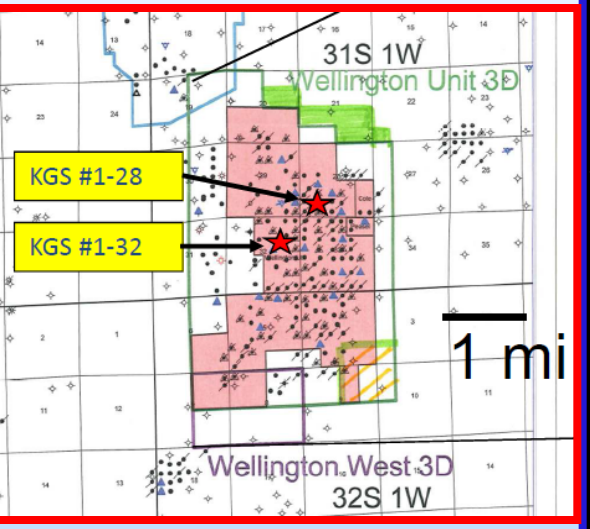
Holubnyak, KGS

Information collected on Arbuckle for saline aquifer

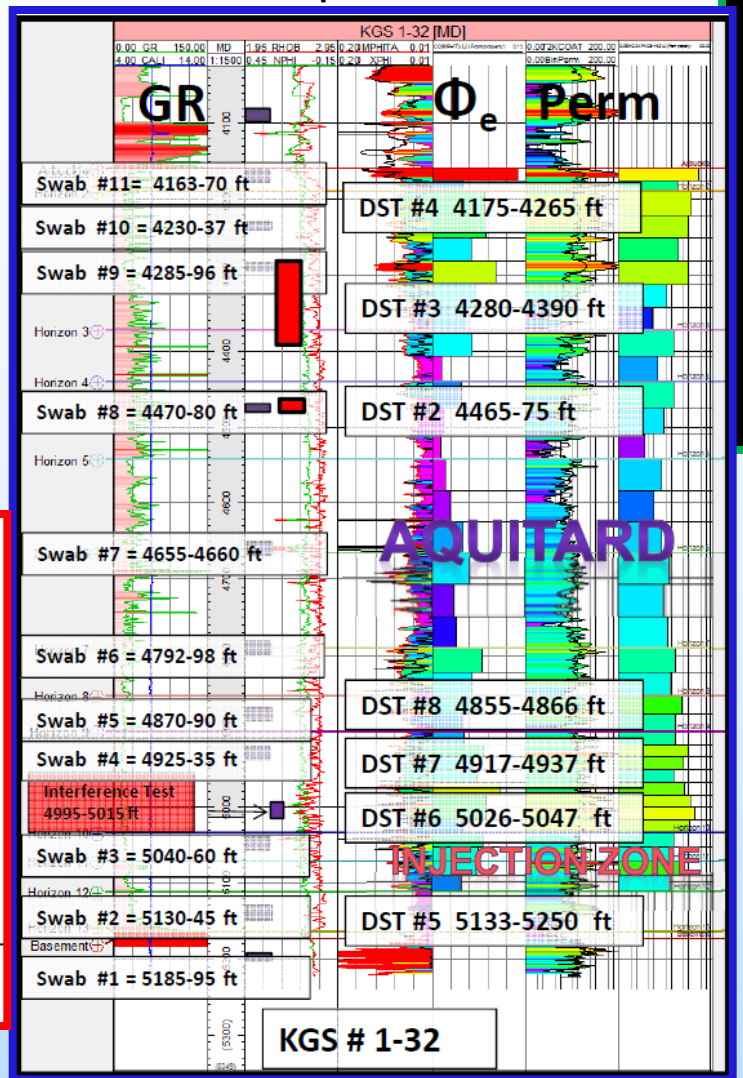
- Multicomponent 3D seismic under DE-FE0002056
- 2 basement tests (#1-32 & #1-28)
- 465 m (1528 ft) core
- Extensive log suite
- Multiple well tests

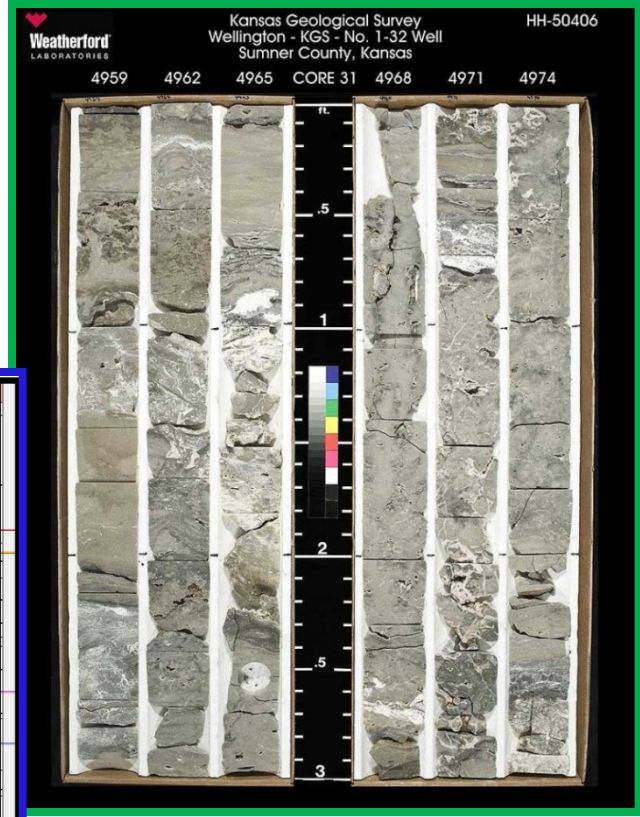
200 ft (60 m)

Multicomponent 3D Seismic Survey



Arbuckle Saline Aquifer Interval KGS #1-32



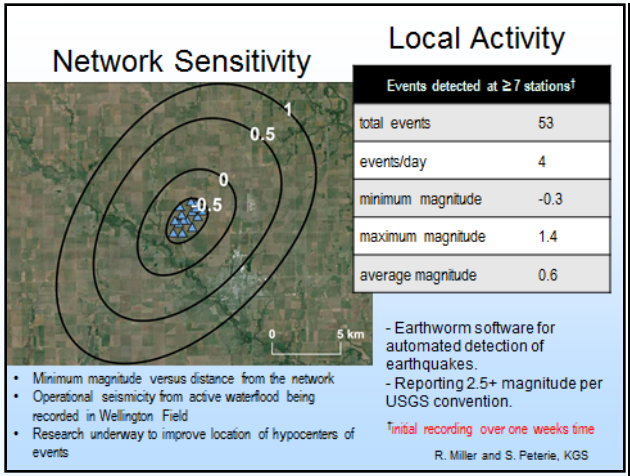


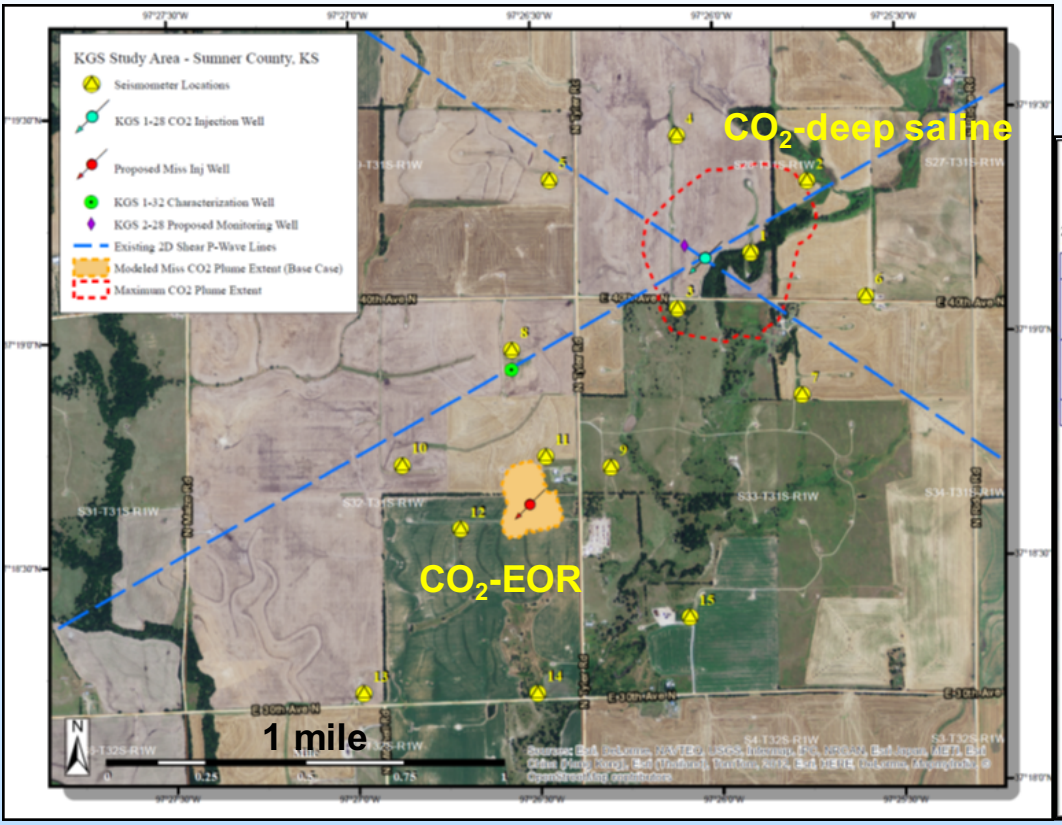
Example of core from CO_2 injection interval in lower Arbuckle; zonal evaporite karst

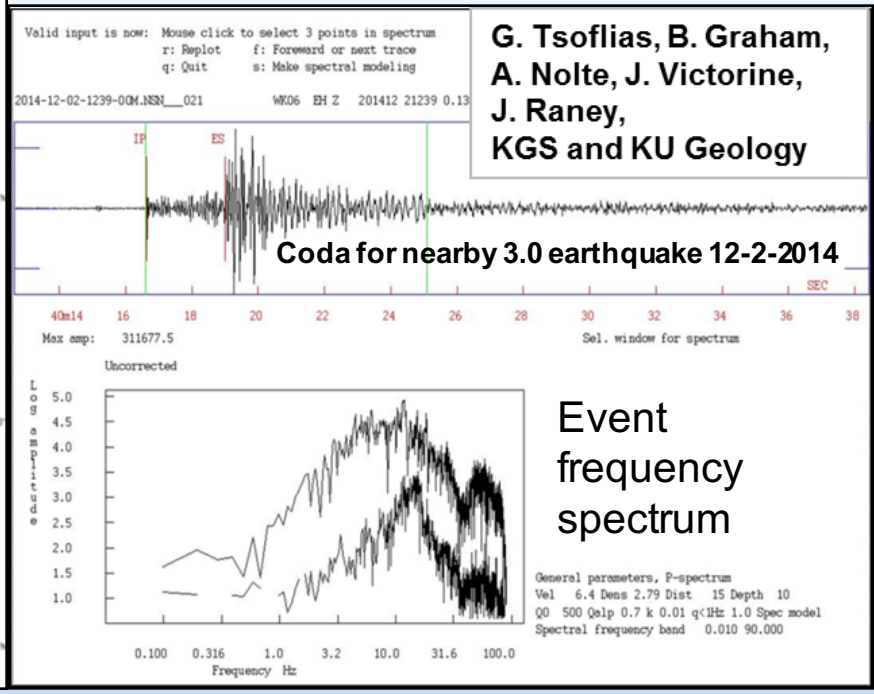
- 11 swabbing intervals and 8 DSTs targeted
- Evaluate both tight and high porosity zones throughout the Arbuckle
- Three distinct hydrostratigraphic units in the Arbuckle (H,O stable isotopes)

• Milestone 3. Pre-injection MVA baseline recording

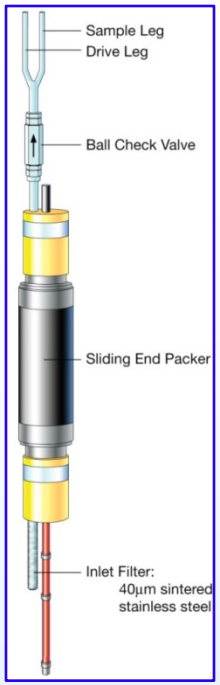
- ❑ Obtaining data from a 18 seismometer array since Fall 2014
- ❑ Collecting data from cGPS and inSAR for processing since August 2014
- ❑ Sampling 3 shallow monitoring wells around KGS #1-28
- ❑ Obtained baseline fluid geochemistry in 10 wells from Mississippian oil reservoir







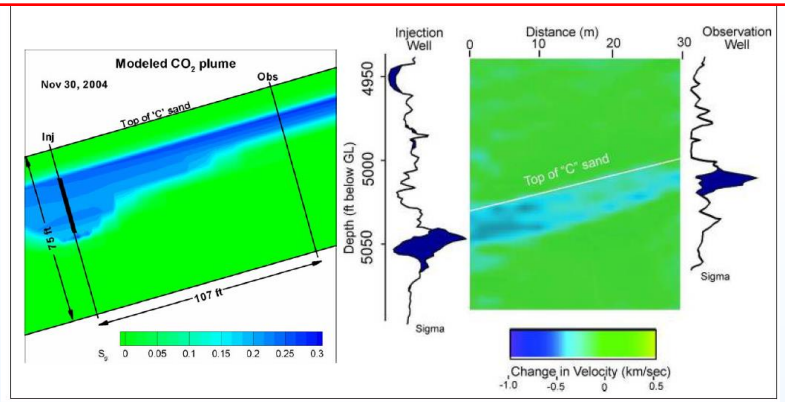
Additional Monitoring Technologies



U-Tube

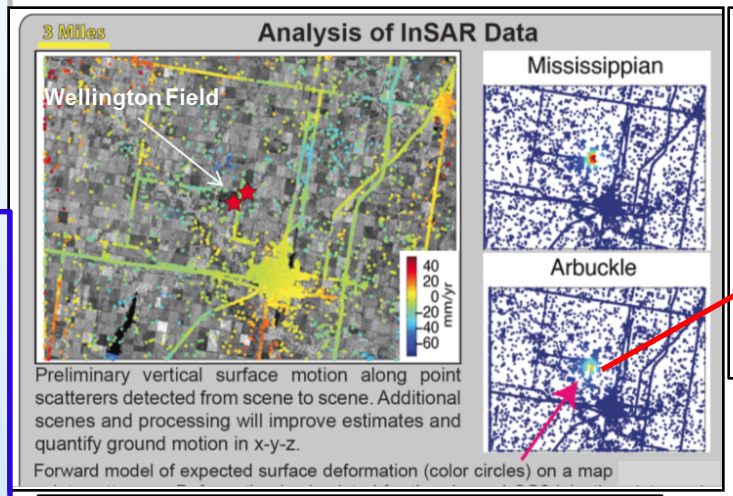
B. Freifeld, LBNL

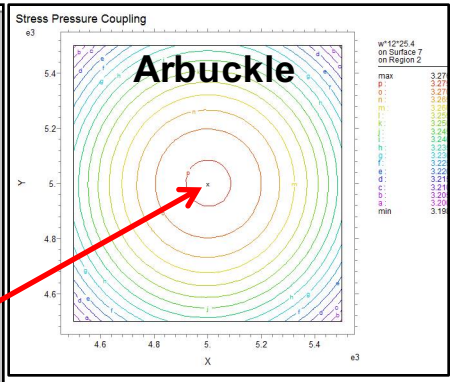
CASSM & Croswell Seismic Tomography



T. Daley, LBNL

Stress Pressure Coupling Simulation





New geomechanical model #2 → predicts approximately 3 mm surface deformation in areal extent shown on map above ~1,000 feet by 1,000 feet – T. Birdie

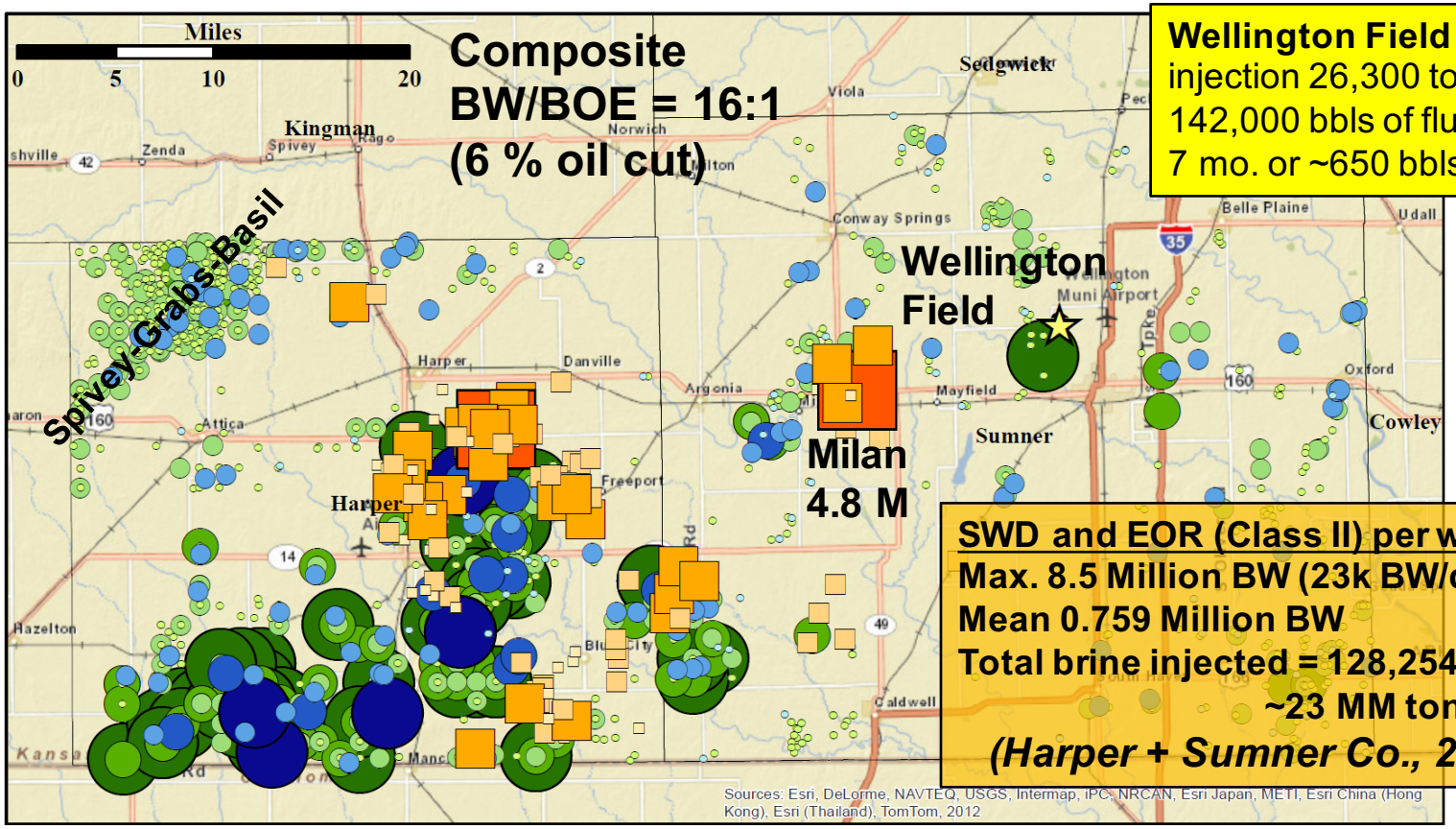
Persistent Point Scatterers being tracked from scene to scene
→ **potential remains to infer Δp from surface motion**

- ❑ **cGPS recording since August 2014**
- ❑ **SAR data being collected ~20 day intervals**
- ❑ **Prospect remains to secure distributed Fiber Optic Arrays for repeat VSP**

  (*R. Trautz, DE-FE-OO12700*)

Induced seismicity west of Wellington Field

Total salt water injected by well (●), BOE produced by oil lease (●) and earthquakes (■) in 2014, Harper and Sumner Counties, Kansas



Wellington Field scheduled injection 26,300 tons = 142,000 bbls of fluid over 7 mo. or ~650 bbls per day

SWD and EOR (Class II) per well in
Max. 8.5 Million BW (23k BW/day)
Mean 0.759 Million BW
Total brine injected = 128,254,699 bbls
~23 MM tonnes CO_2
(Harper + Sumner Co., 2014)

NEIC Earthquakes (2014)
Magnitude
1.9 - 2.5
2.5 - 3.0
3.0 - 4.0
4.0 - 5.0

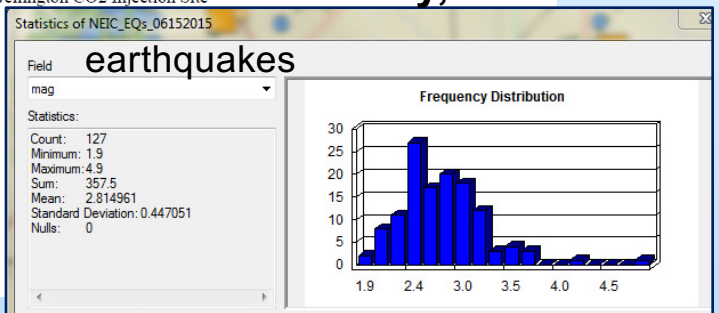
Salt Water Disposal (2014)
Million BBLS
0.1
1.5
5.0
8.5

Total Oil & Gas Production (2014)
Bbls (BOE)
0 - 2,000
10,000
20,000
200,000

★ Wellington CO2 Injection Site

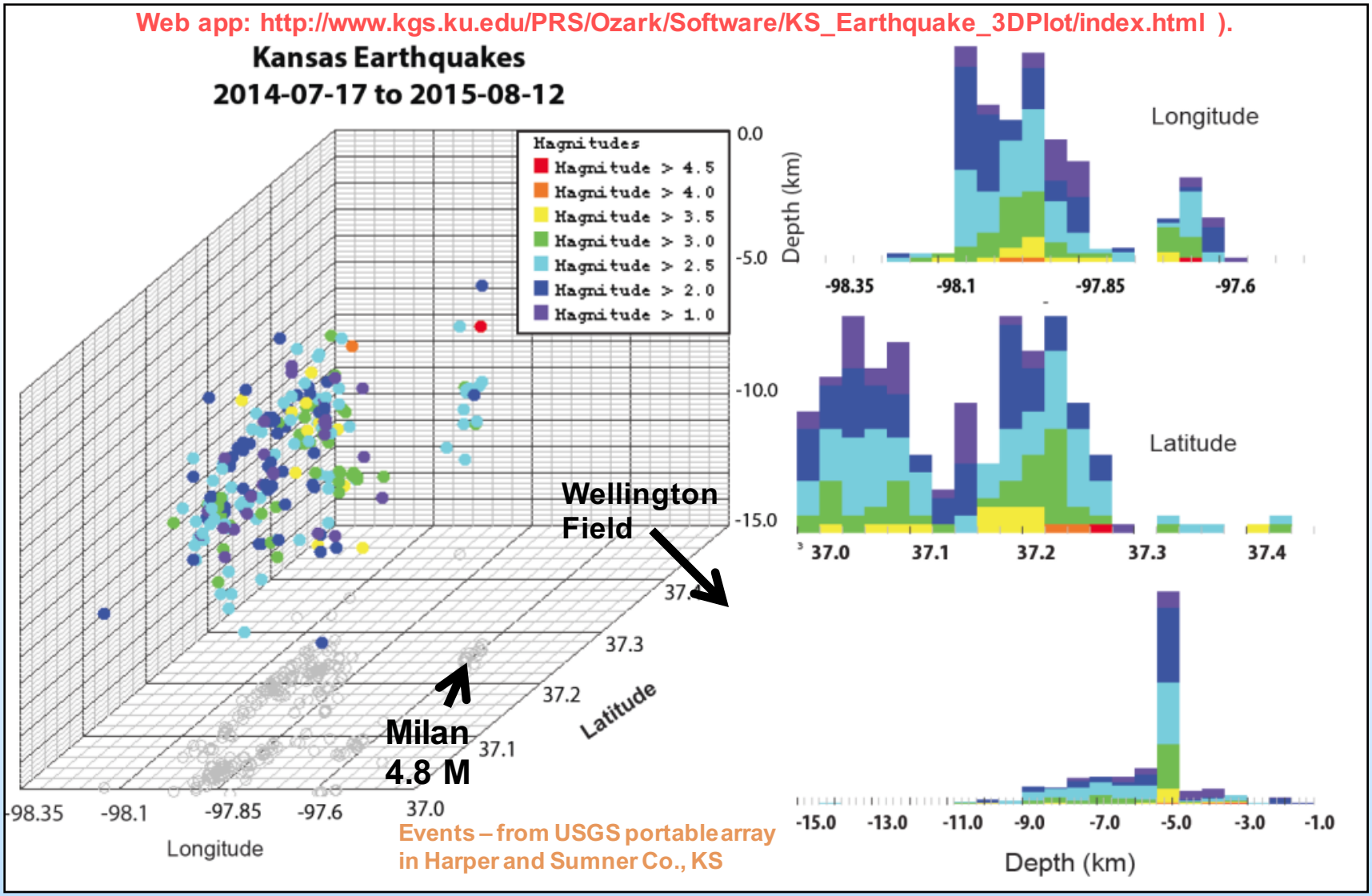
Min 1.9
Max 4.9
Mean 2.8
127 earthquakes in 2014

Jenn Raney, KGS

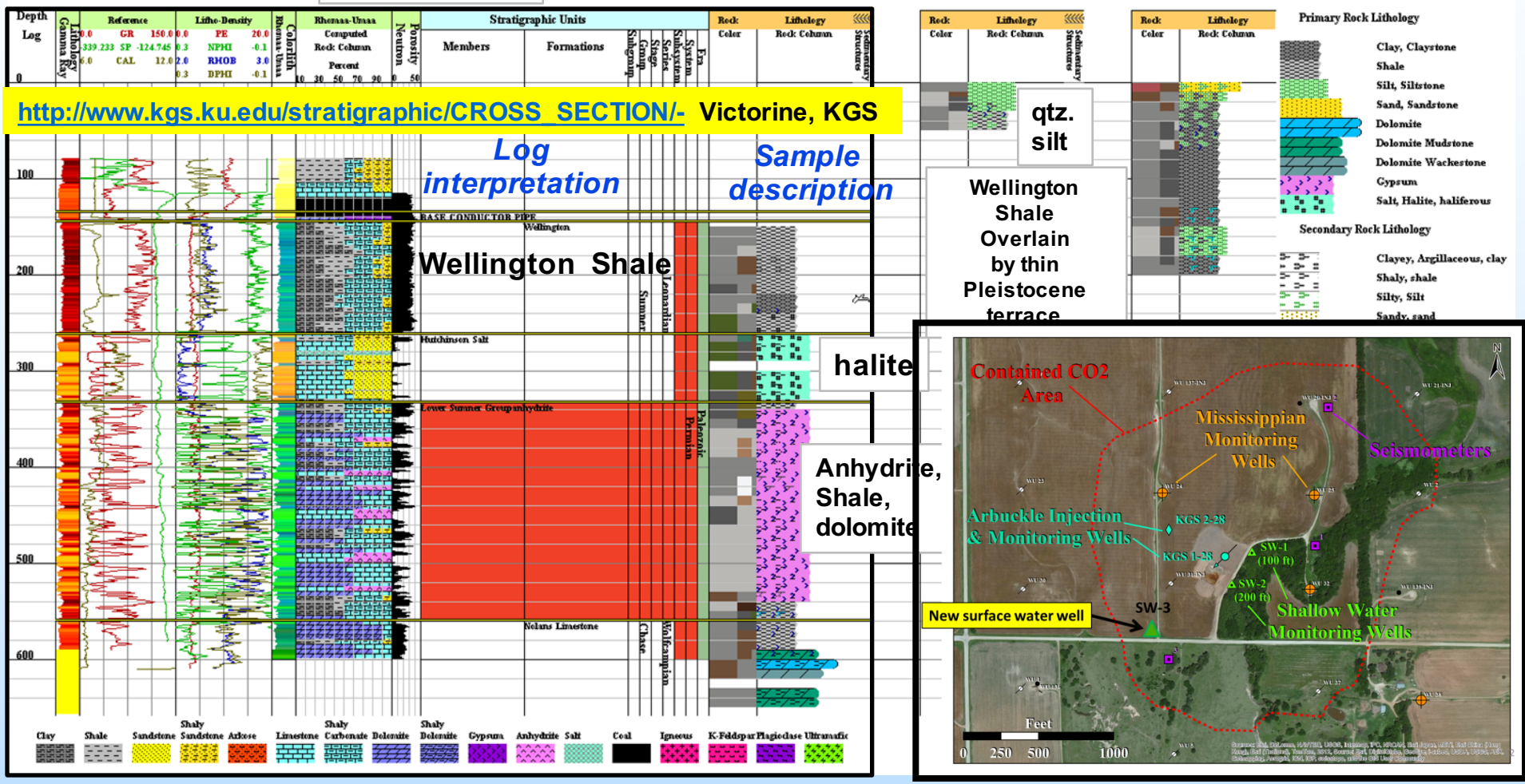


Testing pseudo 3D display web app

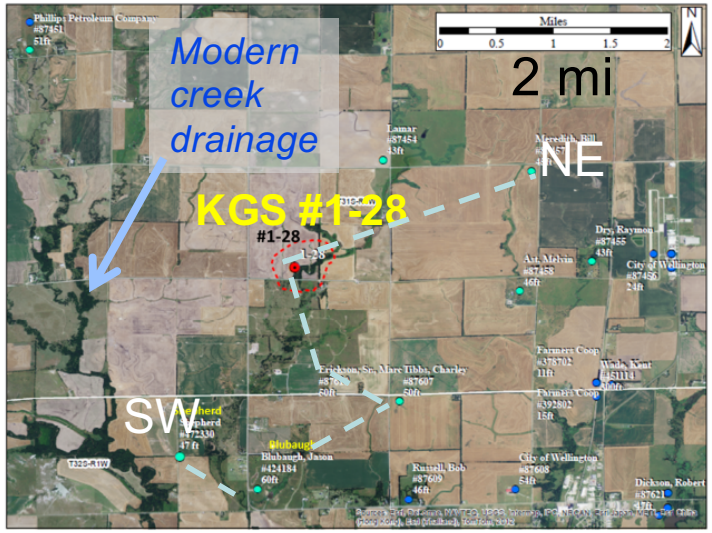
to map solutions of hypocenters of earthquakes in two county area SW of Wellington Field



SW-NE well log and sample cross section extending from new CO_2-EOR injection well to the **shallow monitoring wells**

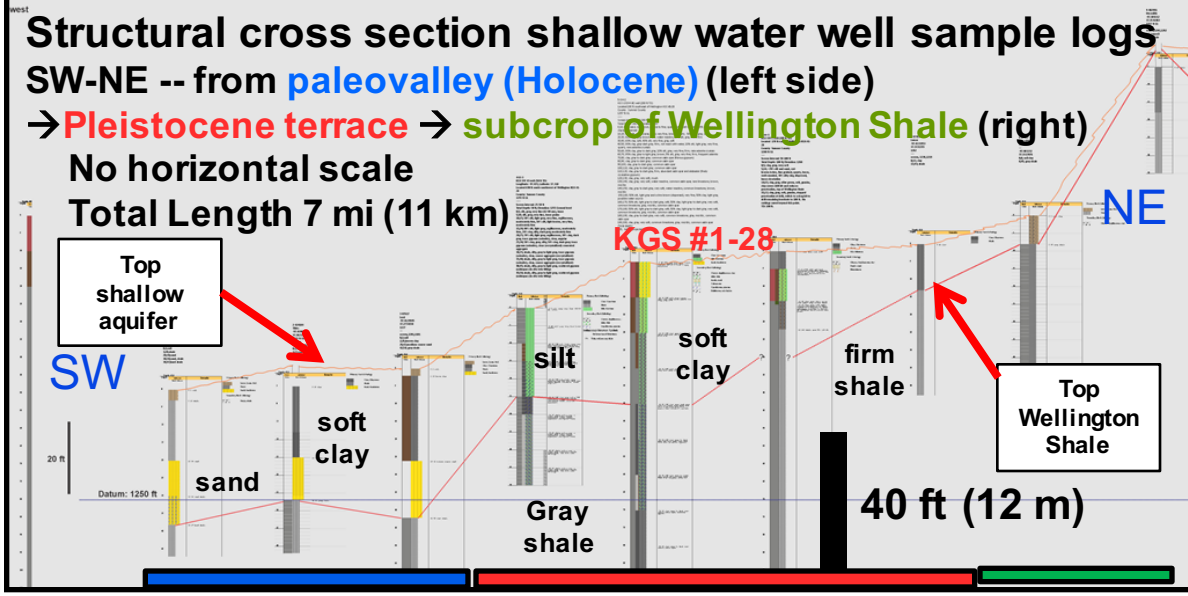


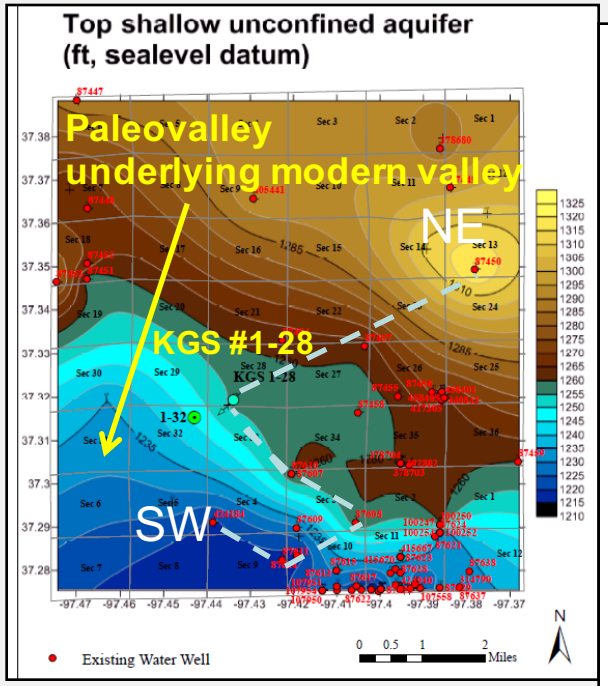
Shallow aquifer distribution and interaction with surface water

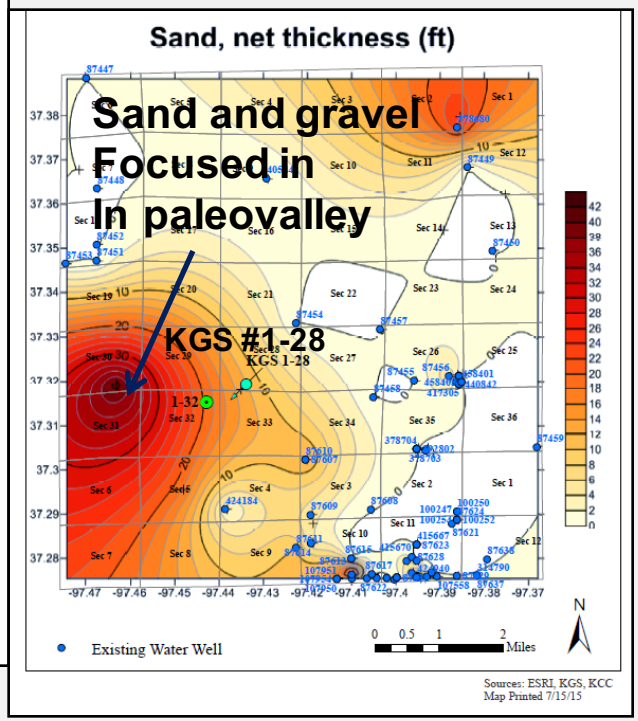


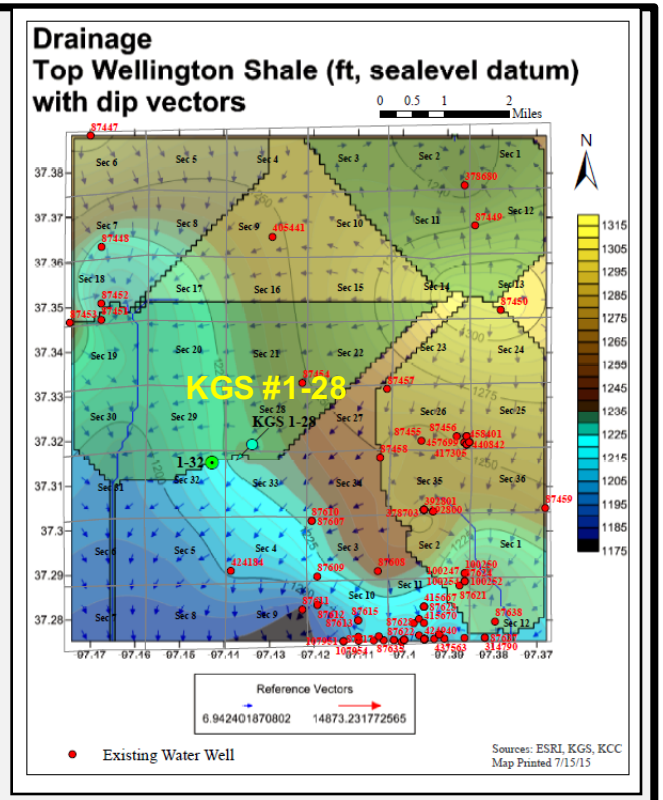
Structural cross section shallow water well sample logs

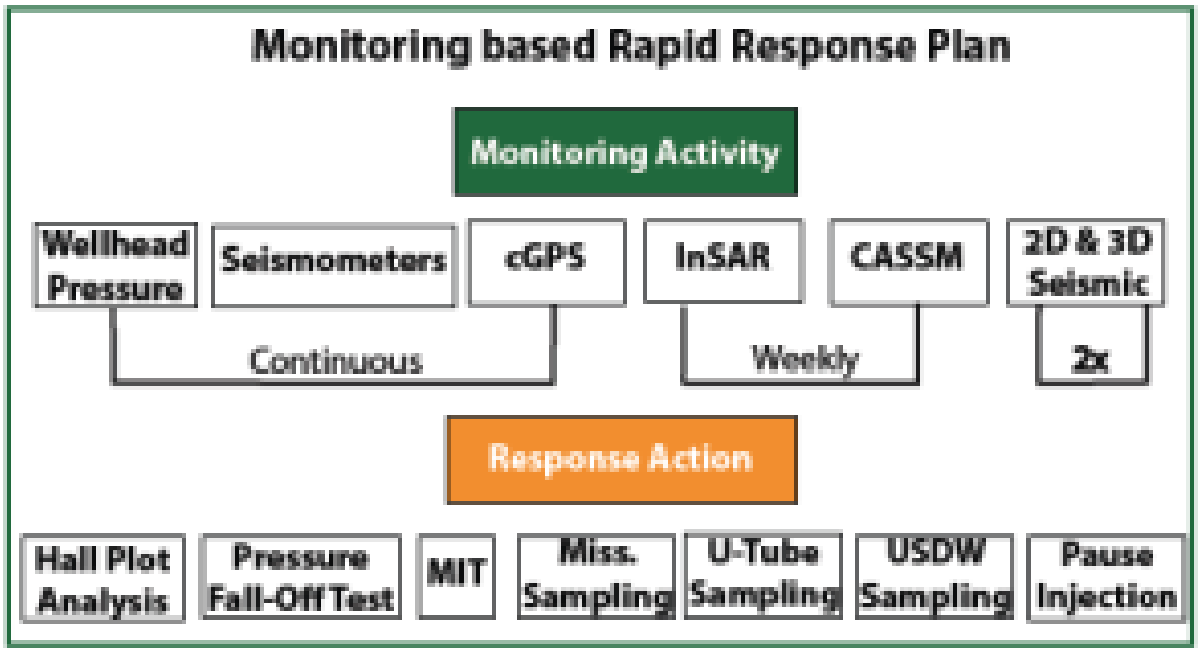
SW-NE -- from paleovalley (Holocene) (left side)
→Pleistocene terrace → subcrop of Wellington Shale (right)
No horizontal scale
Total Length 7 mi (11 km)











- Injection Control Plan
- Wellington Seismic Action Plan
- Monitoring-based Rapid Response Plan
- Emergency Remedial Response Plan

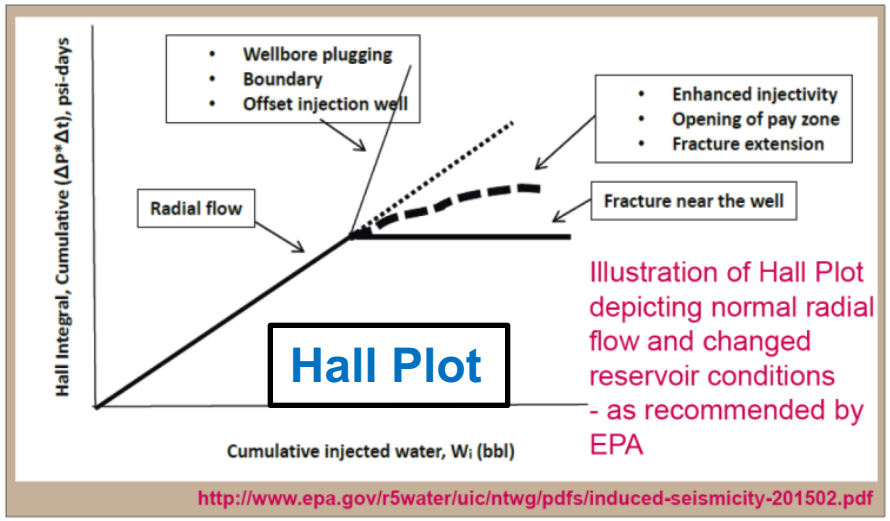


Illustration of Hall Plot depicting normal radial flow and changed reservoir conditions - as recommended by EPA

http://www.epa.gov/r5water/uic/ntwg/pdfs/induced-seismicity-201502.pdf

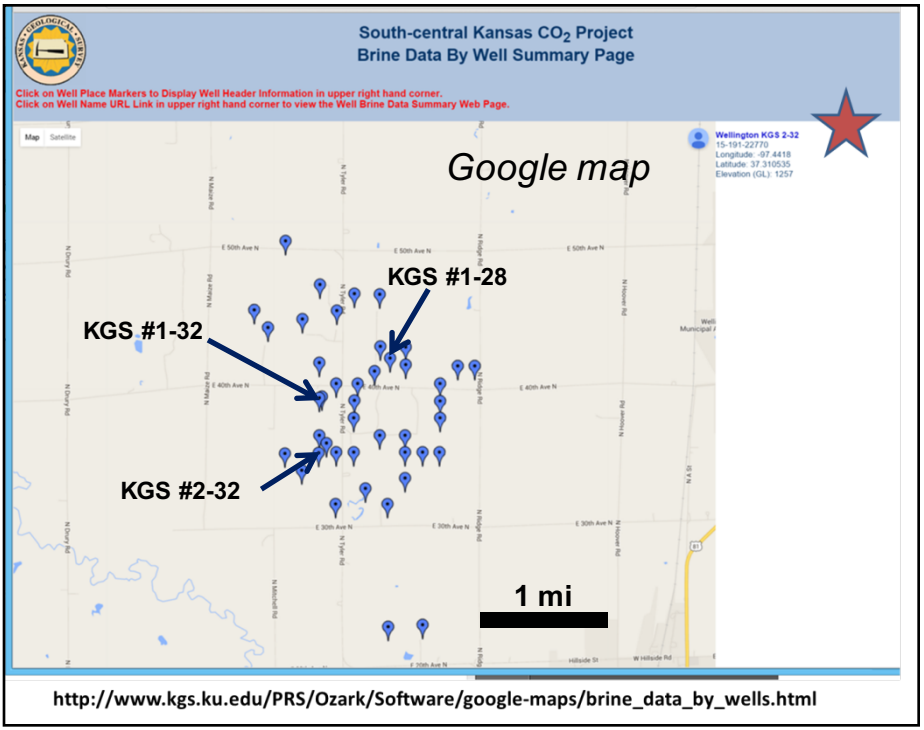
Under review by EPA

Operational plan for safe and efficient CO2 injection to
Draft emergency and remdial response plan for Class VI permit

The success of the Monitoring and Rapid Response Plan to provide early warning is based on prioritizing the monitoring technologies by establishing:

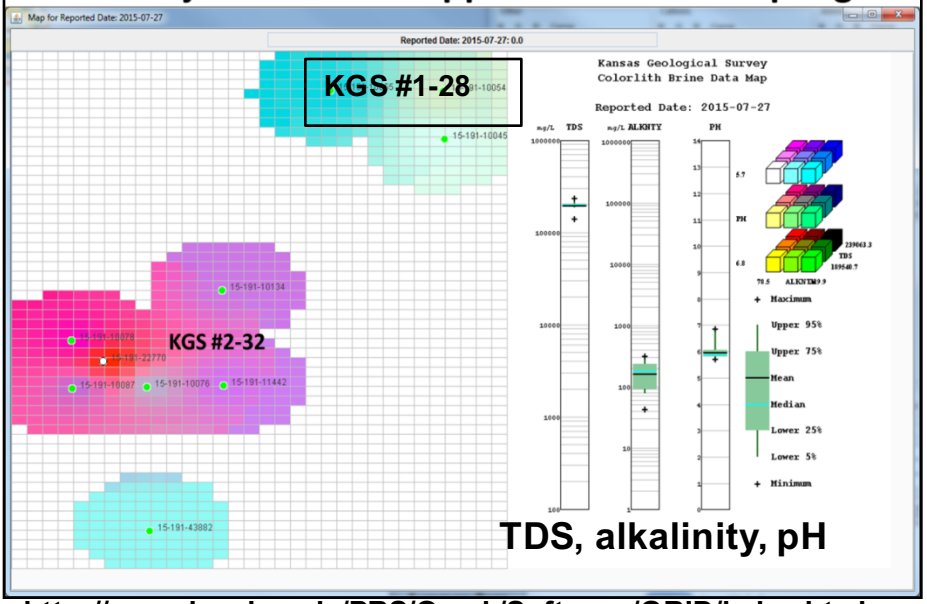
1) reliability of the data and approaches used to analyze the data,
2) frequency that the data is acquired during injection
3) sensitivity and precision of the monitoring method and its ability to detect small changes in CO2 plume behavior;
4) location and therefore resolution from which the data is collected,
5) spatial resolution and coverage of the CO2 plume; and
6) ability to detect movement out of the injection zone both above and below the injection zone.

Baseline water sampling at surface and in the **Mississippian oil reservoir**



http://www.kgs.ku.edu/PRS/Ozark/Software/google-maps/brine_data_by_wells.html

Pre-injection Mississippian baseline sampling



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

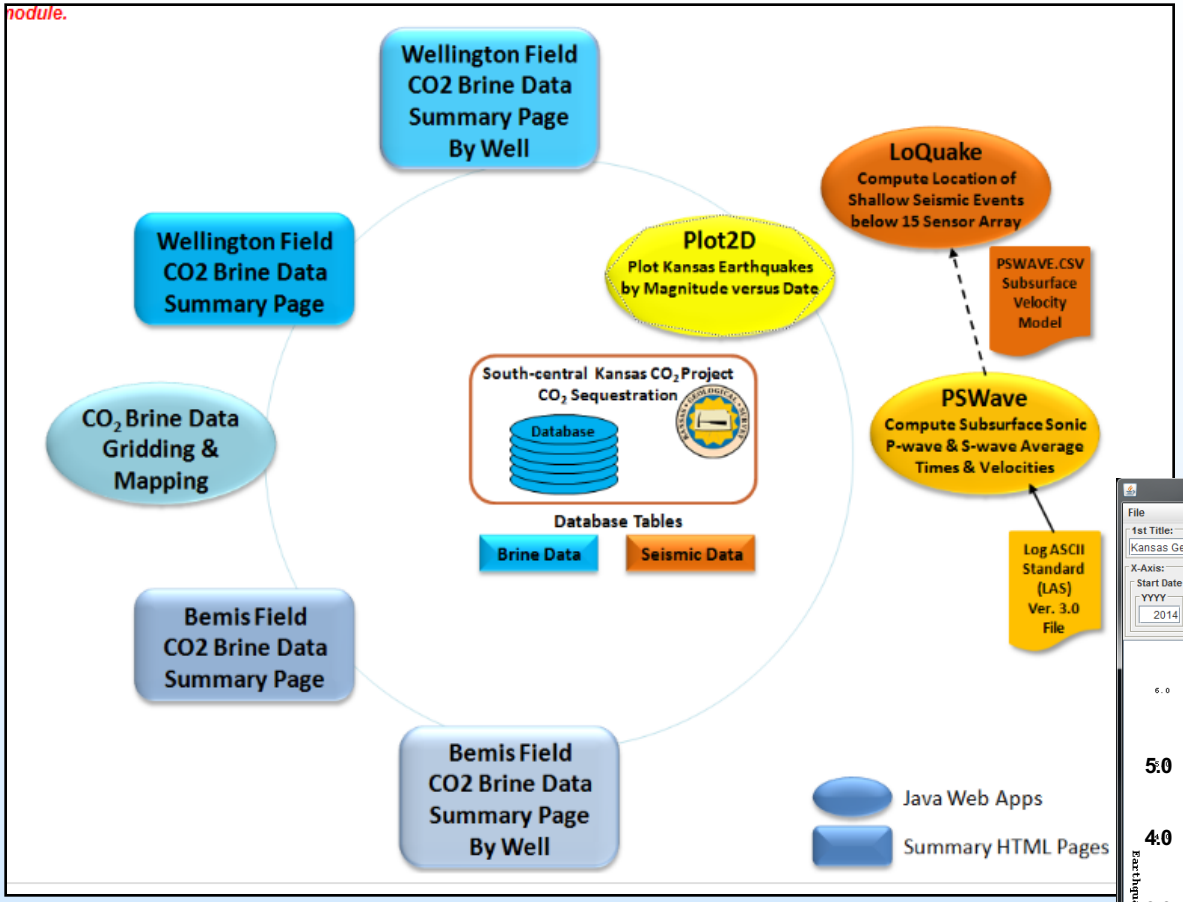
South-central Kansas CO_2 Project
Brine Data Types Database Table Contents

Cations			Anions			Other Data		
ID	Mnemonic	Description	ID	Mnemonic	Description	ID	Mnemonic	Description
0	Si	Silicon	50	H	Hydride	110	CO2	aqueous CO2
1	NH4	Ammonium	51	F	Fluoride	111	H2S	aqueous H2S
2	H3O	Hydronium	52	Cl	Chloride	112	O2	aqueous O2
3	Li	Lithium	53	Br	Bromide	200	SPGR	Specific Gravity
4	Na	Sodium	54	I	Iodide	201	SIGMA	Specific Conductivity
5	K	Potassium	55	OH	Hydroxide	202	SIGMA2	Specific Conductivity 2
6	Rb	Rubidium	56	BO3	Borate	203	PH	PH
7	Cs	Cesium	57	CO3	Carbonate	204	degF	Temperature (degrees F)
8	Be	Beryllium	58	HCO3	Bicarbonate	205	degC	Temperature (degrees C)
9	Mg	Magnesium	59	OCl	Hypochlorite	206	DEGi	Initial Temperature
10	Ca	Calcium	60	ClO2	Chlorite	207	DEGf	Final Temperature
11	Sr	Strontium	61	ClO3	Chlorate	208	DEGa	Average Temperature
12	Ba	Barium	62	ClO4	Perchlorate	209	PSI	Pressure (psi)
13	Al	Aluminum	63	CN	Cyanide	210	PSIi	Initial Pressure (psi)
14	Sn	Tin	64	NCO	Cyanate	211	PSIf	Final Pressure (psi)
15	Sn2	Tin(II)	65	OCN	Isocyanate	212	OHM	Resistivity (Rw)
16	Sn4	Tin(IV)	66	SCN	Thiocyanate	213	OHM75	Resistivity at 75 deg F
17	Pb	Lead	67	N	Nitride	214	OHME	Estimated Rw
18	Pb2	Lead(II)	68	N3	Azide	215	TDS	Total Solids
19	Pb4	Lead(IV)	69	NO2	Nitrite	216	TDSe	Estimated Total Dissolved Solids
20	Sb	Antimony	70	NO3	Nitrate	217	TDSc	Total Solids Computed
21	Sb3	Antimony(III)	71	NH2	Amide	218	NTU	Trubidity
22	Sb5	Antimony(V)	72	MnO4	Permanganate	219	mV	Redox Potential
23	Bi	Bismuth	73	P	Phosphide	220	SALNTY	Salinity
24	Bi3	Bismuth(III)	74	PO3	Phosphite	221	HARDNESS	Total Hardness
25	Bi5	Bismuth(V)	75	PO4	Phosphate	222	RATIO	Anion/Cation Ratio
26	Cr	Chromium	76	HPO4	Hydrogen phosphate	223	FLUID	Sample Volume
27	Cr2	Chromium(II)	77	H2PO4	Dihydrogen phosphate	224	GMCC	Fluid Density
28	Cr3	Chromium(III)	78	As	Arsinide	225	ALK	Alkalinity-Spectrometer
29	Mn	Manganese	79	AsO4	Arsenate	226	ALK2	Alkalinity-Test Kits
30	Mn2	Manganese(II)	80	AsO3	Arsenite	300	FORM	Formation
31	Mn3	Manganese(III)	81	Se	Selenide	301	AGE	Formation Age
32	Fe	Iron	82	S	Sulfide	302	TOP	Top Depth
33	Fe2	Iron(II)	83	HS	Hydrogen Sulfide	303	BASE	Base Depth
34	Fe3	Iron(III)	84	SO3	Sulfite	400	deg-Multi	Temperature Multi-meter
35	Co	Cobalt	85	HSO3	Hydrogen Sulfite	401	deg-Cond	Temperature Cond-meter
36	Co2	Cobalt(II)	86	S2O3	Thiosulfate	501	NH4-2	Ammonium-SPEC
37	Co3	Cobalt(III)	87	SO4	Sulfate	533	Fe2-2	Iron-SPEC
38	Ni	Nickel	88	HSO4	Bisulfate	569	NO2-2	Nitrite-SPEC
39	Ni2	Nickel(II)	89	O	Oxide	570	NO3-2	Nitrate-SPEC
40	Ni3	Nickel(III)	90	IO3	Iodate	587	SO4-2	Sulfate-SPEC
41	Cu	Copper(I)	91	BrO3	Bromate	630	Mn2-3	Manganese-KIT
42	Cu2	Copper(II)	92	OBr	Hypobromite	633	Fe2-3	Iron-KIT
43	Ag	Silver	93	CrO4	Chromate	652	Cl-3	Chloride-KIT
44	Au	Gold(I)	94	Cr2O7	Dichromate	675	PO4-3	Phosphate-KIT
45	Au2	Gold(II)	95	CH3COO	Acetat			
46	Zn	Zinc	96	HCOO	format			
47	Cd	Cadmium	97	O2	Peroxi			
48	Hg2	Mercury(I)	98	C2O4	Oxalat			
49	Hg	Mercury(II)						
100	Mo	Molybdenum						
101	Te	Tellurium						
102	Ti	Titanium						
103	Tl	Thallium						
104	U	Uranium						
105	V	Vanadium						
106	W	Tungsten						
107	Y	Yttrium						

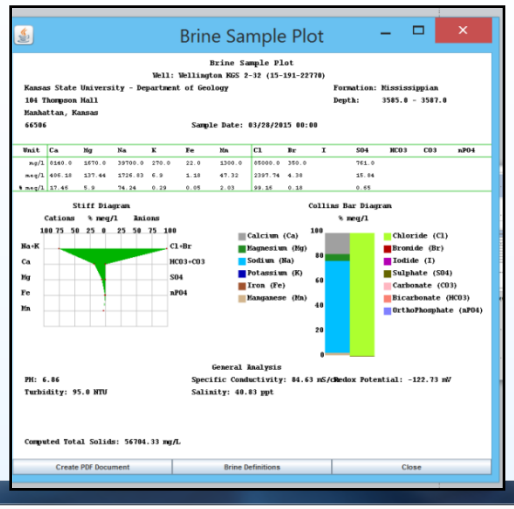
Brent Campbell, Chance Reese, Saugata Datta KSU, John Victorine, J. Raney, John Doveton, KGS

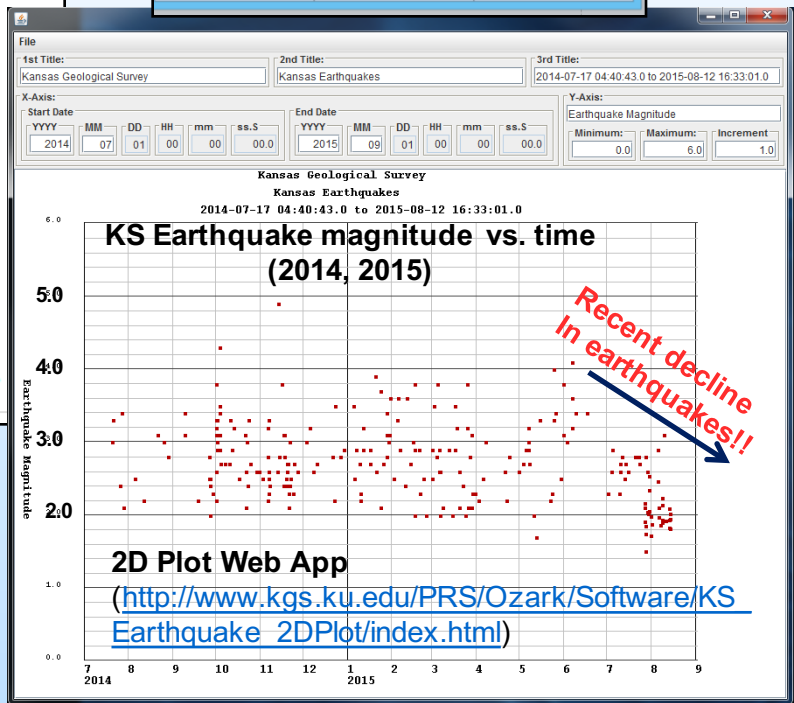
http://chasm.kgs.ku.edu/ords/iqstrat.co2_brine_data_type_pkg.build_web_page

KGS CO_2 online web dashboard provides integrated view of monitoring activity



(http://www.kgs.ku.edu/PRS/Ozark/Summary/CO2_II.html)





Accomplishments to Date in BP2 (September 2014 → current)

- **Class VI permit review –**
  - AoR through simulation
  - USDW evaluation
  - Financial assurance
  - PISC
  - Only RAIs, no NODs
  - Obtain Class II UIC permit, drill KGS #2-32, 92 ft of core with whole core routine and special analyses, comprehensive wireline log, test including 5-well interference test, complete and undergoing repressurization
- **MVA pre-injection baseline monitoring --**
  - 18-seismometers network
  - Geochemistry of brines in 10 Mississippian wells for Class II and VI monitoring
  - InSAR consistent point scatterers and geomechanical model to simulate surface deformation

Future Plans and Expectations

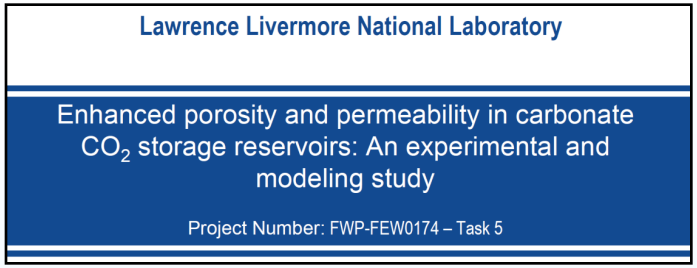
- **Complete repressurization of the Mississippian reservoir for CO2-EOR injection and inject CO_2 -- September 2015**
  - Meeting with public in Wellington town hall meeting following commencement of Mississippian injection.
- **Obtain draft Class VI permit -- October 2015**
  - 6 mo. fabrication lead time CASSM, U-Tube, and Fiber Optic Array (pending decision); 2 months equip, test, and prepare #1-28 for injection
- **Obtain Class VI permit -- January 2016**
- **Drill, complete, test #2-28 Arbuckle monitoring well -- March 2016**
- **Inject CO2 into Arbuckle -- April 2016**
  - **Employ Operational Plan for Safe and Effective CO2 Injection**
  - **Complete CO2 injection -- September 30, 2016**
  - **Requested 1 yr. PISC**
  - **Validation of models and predictions**
  - **A final report in 2017!**

Summary

- Use of Wellington Field as a calibration site and field demonstration
- Test best practice, cost-effective monitoring to aid in applying next-generation CO_2-EOR methods, refine model predictions, and optimize CO_2 utilization and storage
- Coupling the oil field and underlying saline aquifer to increase long-term safe & dependable CO_2 storage

Synergistic Activities

- Collaboration with Susan Carroll, PI, LLNL

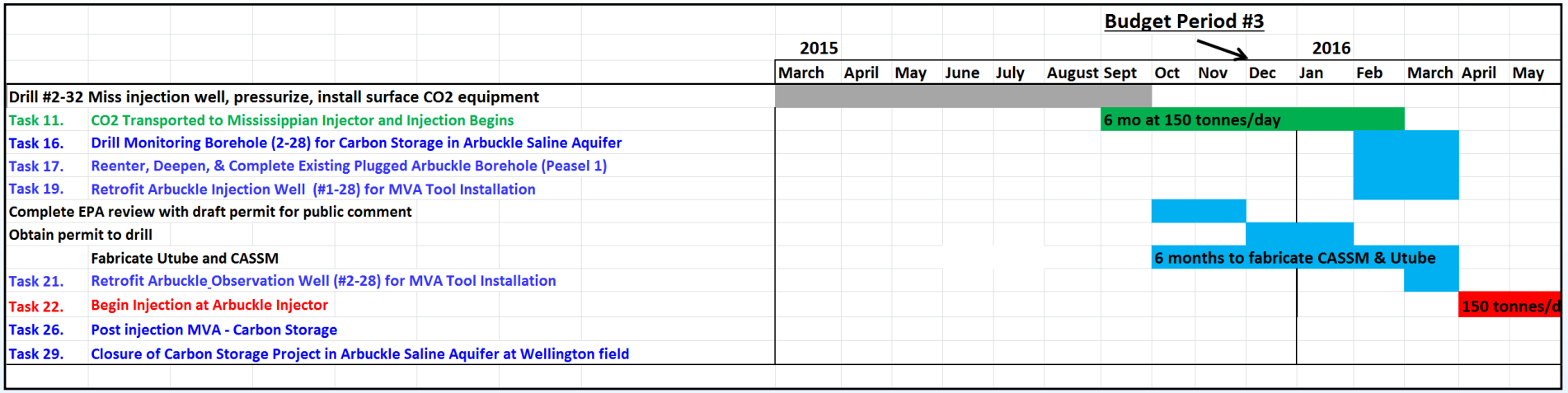


  - task addition → *Experimental calibration of NMR well logs to determine pore connectivity in the injection zone at the Wellington CO_2 storage demonstration site, Kansas*
- Data rich
  - Carbonate and caprock cores, modern wireline logs, tests
  - Water and oil samples
  - Multicomponent 3D → Bob Hardage at BEG, new processing techniques
  - Earthquake catalog being built from operating IRIS/KGS 18-seismometer array
  - Monitoring and risk analysis from operational plan for safe and effective injection and adaptation by EPA for this project
  - Test NRAP tools
- Extensive Web (Java) application tools and development, petrophysical application focus, data archiving
  - Need more users

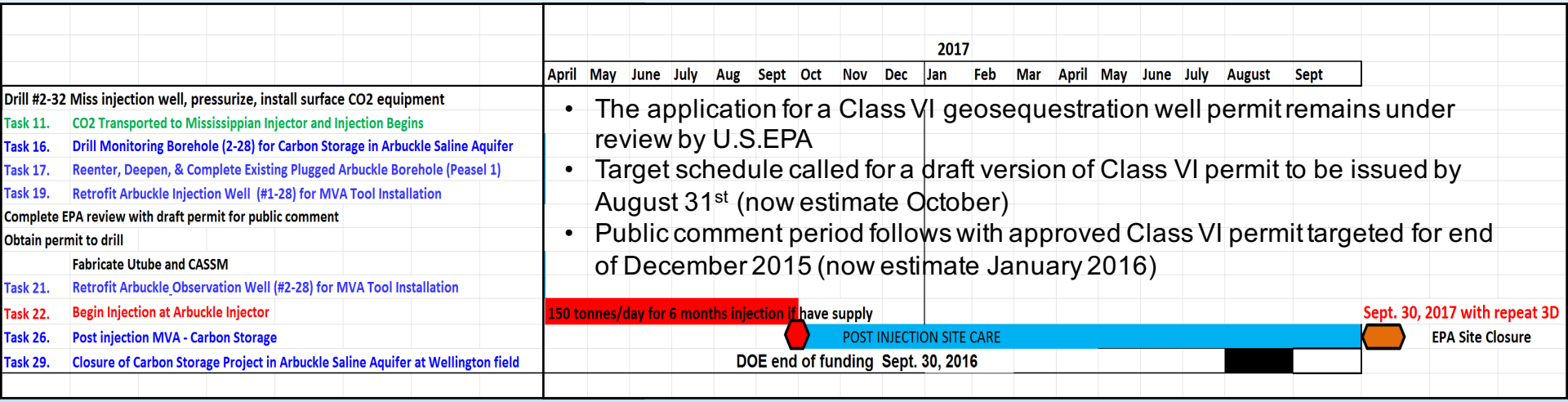
Appendix

Schedule – Wellington Small Scale Injection DE-FE0006821

Mississippian CO_2-EOR



Arbuckle CO_2 Class VI



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Holubnyak, Yevhen, Watney, W., Rush, J., and Fazelalavi, F., 2014, Reservoir Engineering Aspects of Pilot Scale CO2 EOR Project in Upper Mississippian Formation at Wellington Field in Southern Kansas, Energy Procedia 00 (2013) 000–000, 9 p.

Watney, W.L., 2014, “Carbon Storage and Utilization in Kansas – Are We Ready?” at Annual Oil and Gas Seminar, Kansas NextStep, Hays, Kansas.

Watney, W.L., Rush, J., and Raney, J., 2014, SMALL SCALE FIELD TEST DEMONSTRATING CO2 SEQUESTRATION IN ARBUCKLE SALINE AQUIFER AND BY CO2-EOR AT WELLINGTON FIELD SUMNER COUNTY, KANSAS DE-FE0006821Present update of project at DOE review meeting in Pittsburgh, Carbon Storage R&D Project Review Meeting Developing the Technologies and Infrastructure for CCS

Bibliography

Watney, L., April 14, 2015, A Maturing Mississippian Lime Play in the Midcontinent – A Perspective on What We Know and Need to Know, KU Interdisciplinary Carbonate Consortium.

Watney, L., May 5, 2015, CO2-EOR in the Wellington Field, Sumner County, South Central Kansas -- Southwest Kansas CO2-EOR Initiative CO2 utilization in oil fields and storage in Arbuckle saline aquifer in southern: Kansas, Implementing CO2 Utilization and Storage (CCUS) in Kansas, KU TORP Improved Oil Recovery Conference, Wichita.

Watney, L., June 18 2015, invited presentation to Kansas Society of Professional Engineers, “Local Earthquake Activity, Wichita.

Watney, L., et al., August 2015, Workshop – Annual meeting of the Kansas Independent Oil and Gas Association, Wichita

Kansas Geological Survey and KU TORP Present Carbon Dioxide EOR Applications for Kansas Operators

presented by

Kansas Geological Survey and Departments of Geology at The University of Kansas and Kansas State University

Wellington Field Operator

BEREXCO

KU KANSAS GEOLOGICAL SURVEY The University of Kansas

NETL

KIOGA Annual Meeting

Sunday August 2, 2015

10:00 am to 3:00 pm

Hyatt-Regency, Wichita, KS (downtown)

KSCO2

Final Agenda

- **1. Highlight the work being conducted related to CO2-EOR in the state (Lynn 10:00-10:20 am)**
  - Regional and statewide CO2-EOR and storage assessments
  - Southwest Kansas CO2-EOR Initiative
  - Summary of Hall-Gurney CO2, pilot and commercial scale CO2-EOR
  - A new Kansas CO2-EOR Initiative
    - Proof of concept needed with a successful CO2-EOR injection at Wellington
    - Prospectus for Governor's Conference
  - **2. Introduction to Wellington CO2-EOR small-scale test (Lynn 10:20-10:45)**
    - Support of DOE-NETL, Contract DE-FE0006821
    - Participation in Wellington CO2-EOR Project by *Kansas Independent Oil and Gas Industry and those serving the industry*
      - *Berexco, LLC – operator of the field and field-based activities, Linde, Praxair – CO2 supply, Fossil Drilling, MudCo, Devilbiss Coring Services, Halliburton, Core Lab, Trilobite Testing, Schlumberger, CMG, Continental Analytical Services, Inc.*
      - *Other collaborators – LLNL, LBNL, IRIS-PASSCAL, Tbirdie Consulting, Inc., KGS, KU Geology, KSU Geology*
- **3. Characterization of carbonate reservoirs by "exotic" logs (NMR, microresistivity imaging, geochemical log, etc.) --John Doveton (10:45-11:30)**
- ***11:30 – 12:00 -- Examine 98 feet of Mississippian core from the KGS #2-32***
  (http://chasm.kgs.ku.edu/ords/qualified.well_page.DisplayWell?f_kid=1044998939)
- ***LUNCH 12:00-12:30 p.m. -- Continue examination Mississippian core from the KGS #2-32***
- **4. Site characterization – Lynn , Mina Fazelalavi and John Victorine (12:30-1:00)**
  - Summary of stratigraphy, sedimentology, and diagenesis of the Mississippian reservoir –Drilling, coring, logging, and testing the Mississippian at Berexco Wellington KGS #1-32, KGS #1-28, #2-32
    - Core analysis and well testing - routine and special; ties to well logs and use in the geocellular model (*FZI* indices, flow units)
    - Well completion – acidizing
- **5. Petrel geocellular model and seismic inversion – Jason Rush (1:00-1:20)**
- **6. Reservoir characterization and well testing - Mina Fazelalavi (1:20-1:40)**
  - Capillary pressure and relative permeability
  - Pulse/interference test in KGS #2-32
- **7. Compositional simulation of CO2-EOR pilot -- Eugene Holubnyak (1:40-2:00)**
- **8. Monitoring performance of CO2 injection – 2:00-2:20**
  - **Fluid monitoring – baseline and during CO2 injection – Lynn, Saugata Datta & Brent Campbell (KSU), John Victorine, Jenn Raney, Tiraz Birdie (Tbirdie) and Lynn**
  - **Microseismic monitoring – Lynn, George Tsoflias (KU), Alex Nolte (KU, KGS), Brandon Graham (KU, KGS), John Victorine and Jenn Raney (KGS), Lynn**
  - **InSAR-cGPS – Lynn, Mike Taylor (KU), Drew Schwab (KU, KGS), Tandis Bidgoli (KGS)**
- **9. Open discussion of the Wellington CO2-EOR project and implementing CO2-EOR in Kansas – Lynn moderating (2:20-3:00)**