Photo by Stephen Groves, Associated Press

USEA

United States Energy Association

CONSENSUS Webinar

Carbon Management and Energy Transition Projects – an Economic Opportunity for Kansas

Tuesday, November 9, 2021

11:00 am - 12:00 pm ET

KGS/KU CCUS Team

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Alex Nolte
Alexis Ahlert

KU KANSAS GEOLOGICAL SURVEY | KU DEPARTMENT OF GEOLOGY College of Liberal Arts & Sciences | BEREXCO | BATTELLE | PREMIER OILFIELD GROUP | AHS | HALLIBURTON | Baker Hughes | PARAGON GEOPHYSICAL SERVICES, INC. | STERLING SEISMIC & RESERVOIR SERVICES | IRIS IDS | U.S. DEPARTMENT OF ENERGY | NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

El Dorado Oil field

- Oil sips were reported by State Geologist, Benjamin F. Mudge before 1860
- After Civil War, in 1892 – first well Norman 1 was drilled in Wilson County, searching for gas
- Largest oil producer/supplier among single fields during WWI
- Influenced aviation industry in Wichita, KS
- Stampelton #1 well – first well which was drilled using geological characterization technics
- Oil was discovered on October 6, 1915 at depth 2,497 ft
- Operators: Standard Oil, Gulf Oil, Gypsy Oil, and other “majors” of the time

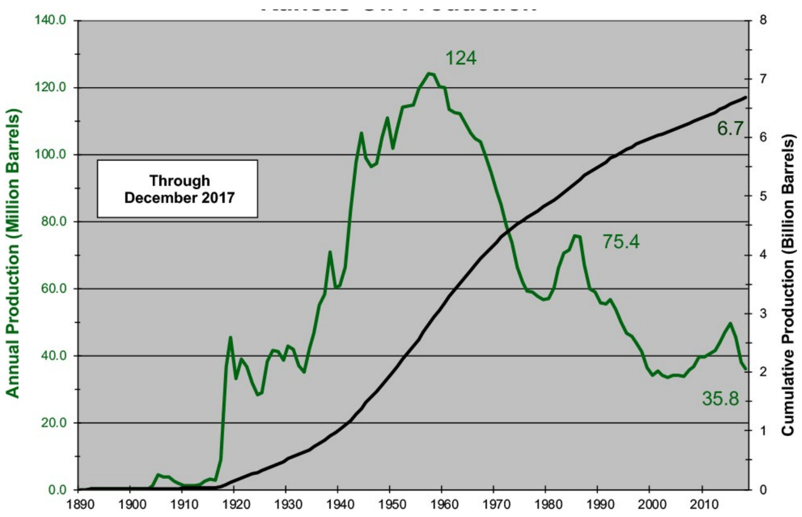
https://www.kshs.org/

http://www.kansastravel.org/kansasoilmuseum.htm

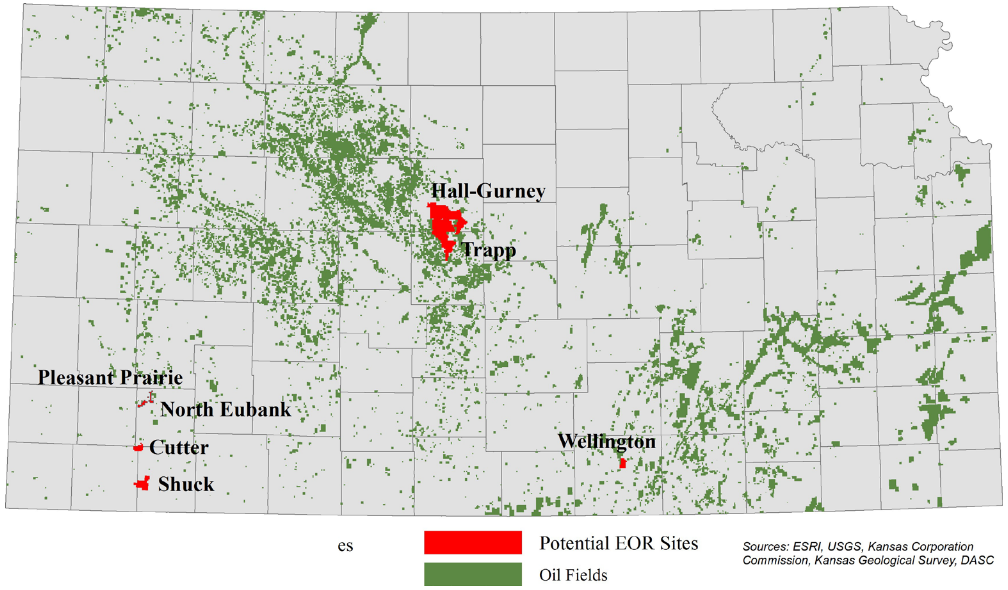
CO_2-EOR Potential in Kansas

- Kansas oil production has been in decline since 1960s
- Uptrends happened due to technological innovation
- A few commercial and pilot CO_2-EOR projects exist
- Several fields are characterized, with geologic and simulation models developed
- KGS is creating a database with waterflood information that will be available soon to CUSP

Kansas Oil Production is Falling



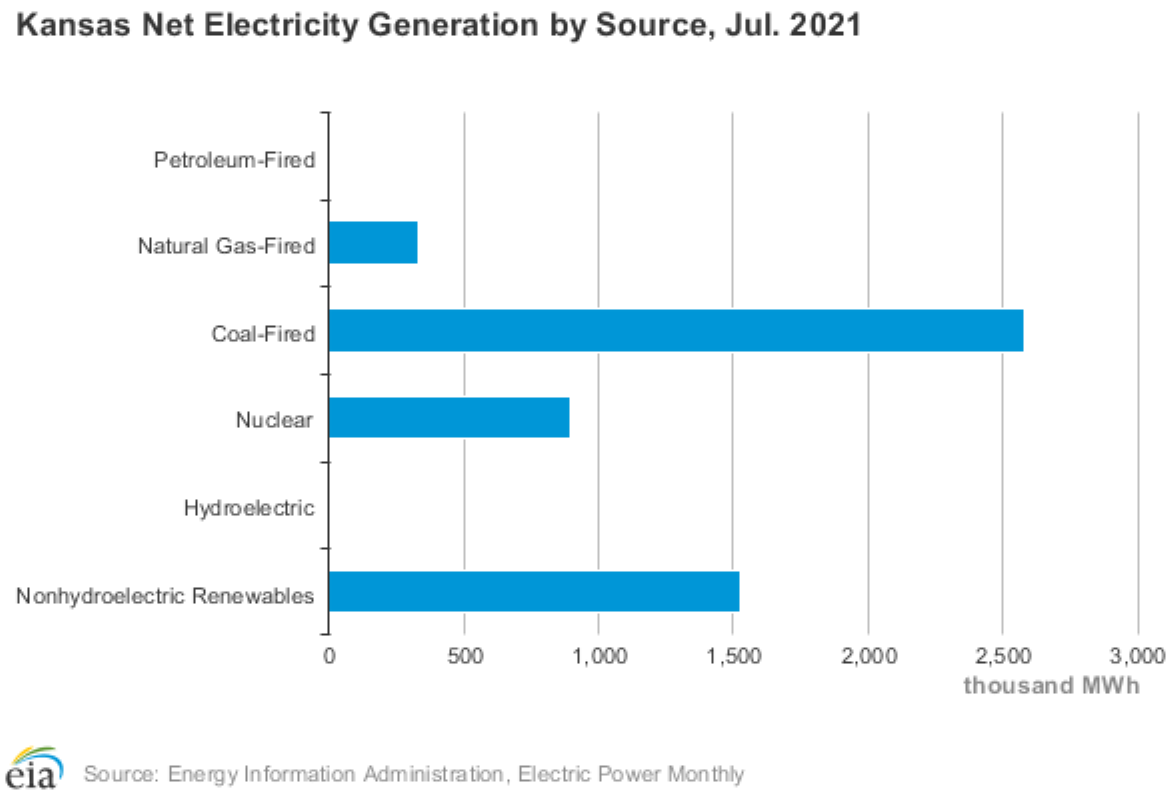
Numerous Potential Sites for EOR

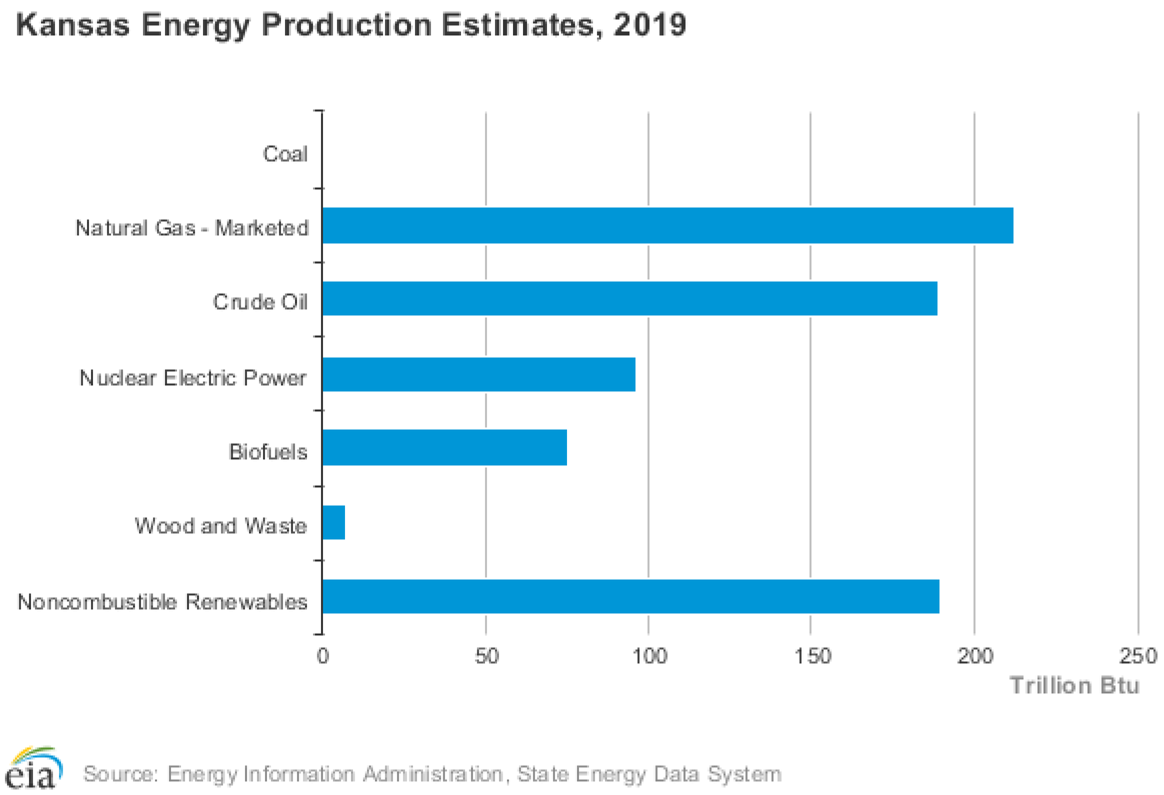


Basin	EOR Potential (mill bbl)	Net CO_2 Demand (MMT)	Direct Jobs Created
Illinois-Indiana	500	160-250	1550-3100
Ohio	500	190-300	1550-3100
Michigan	250	80-130	800-1800
Kansas	750	240-370	2300-4600
	2000	**670-1050**	**3200-12400**

	Injection Rate (Mt/yr)	CO_2 Storage (Mt)	Primary and Secondary (MMBO)	CO_2 EOR (MMBO)	Basis for Estimate
Shuck	0.4	1.5	7.9	3.6	DE-FE000256
Cutter	0.5	1.3	5.4	2.8	DE-FE000256
N Eubank	0.6	1.5	7.4	4.6	DE-FE000256
Pleasant Prairie	0.3	0.5	4.7	2.2	DE-FE000256
Hall-Gurney	1	11.3	62.5	26.8	DE-AC26-00BC15124 and PilotC12 Energy
Trapp	0.5	4.3	31.3	10.3	KGS reports
Wellington	0.6	2.2	16.2	5.3	DE-FE0002056 and Pilot
	3.9	**22.8**	**135.4**	**55.7**	

Kansas Energy Production Profile

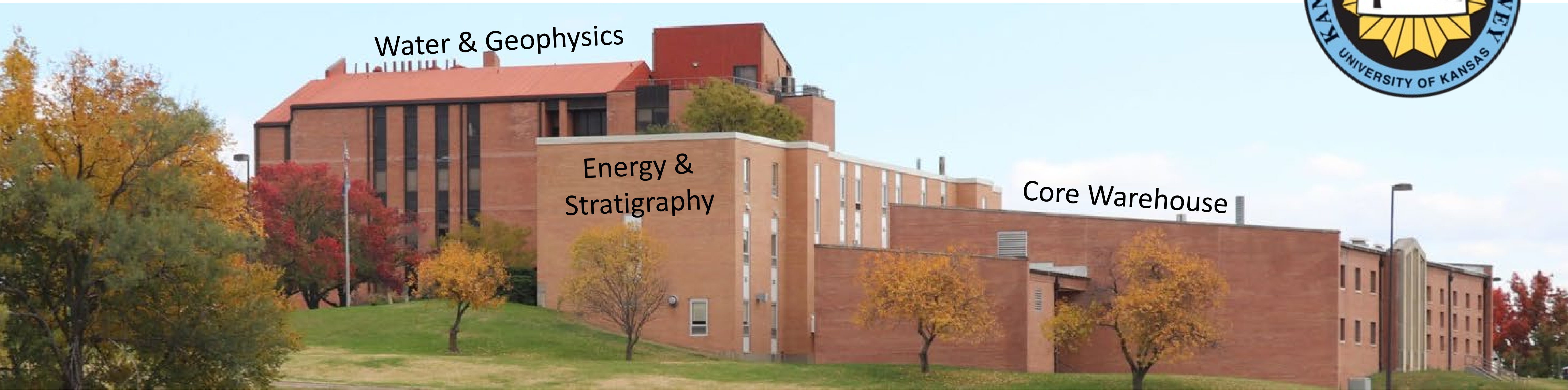




Kansas Geological Survey

- "A Research and public service unit of the University of Kansas"
- 132 years young, ~100 employees of which ~30 are scientists
- Data Resource Library has multiple staff and students who scan and LAS-digitize well logs
- Kansas GIS Clearinghouse & Web Publishing Staff
- Full-time archivist oversees publications, core, cuttings
- We can research anything geological,

  as long as ***it is relevant to Kansas***



Why CCUS in Kansas?

Large point sources of CO_2

Rapid development of renewable energy (#2 in % wind)

How do we avoid junking expensive investments?

Abundant subsurface data

Abundant Reservoirs

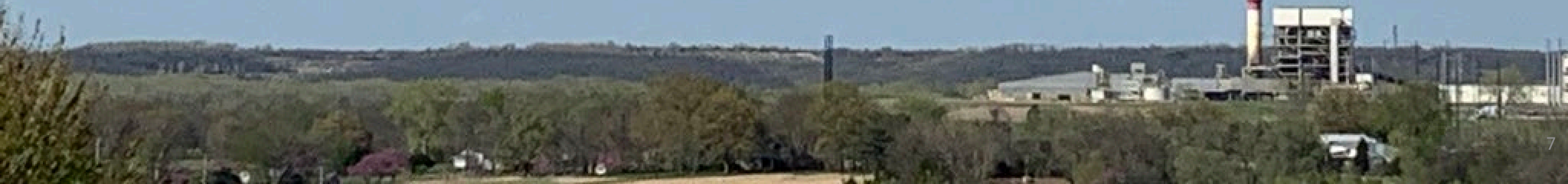
Mature oil and gas industry

EOR Potential

Mature underground injection industry

Saline Storage Potential

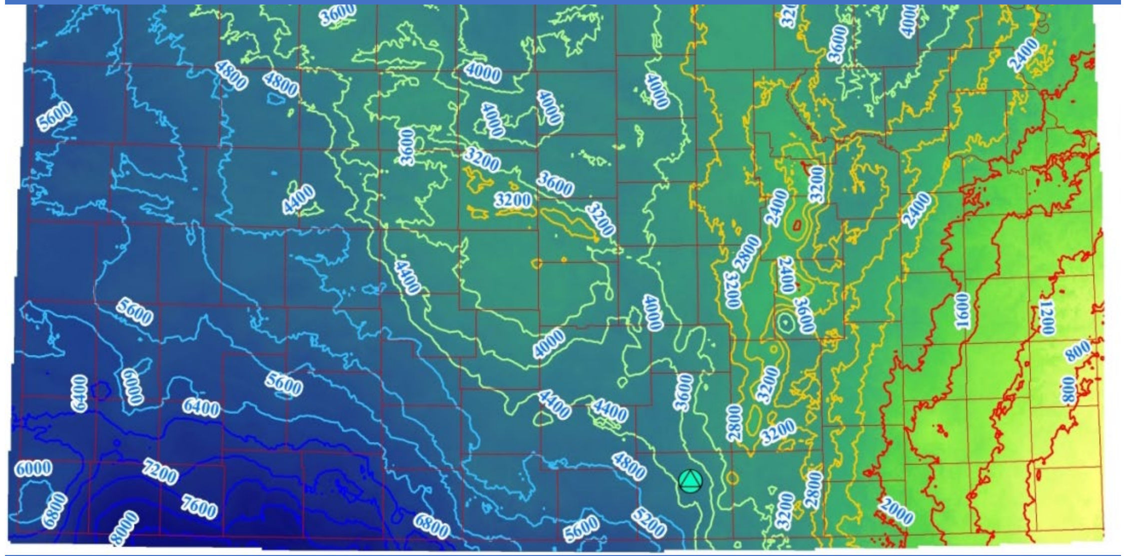
Evergy's Lawrence Energy Center
Often shut down due to low demand for coal-fired power



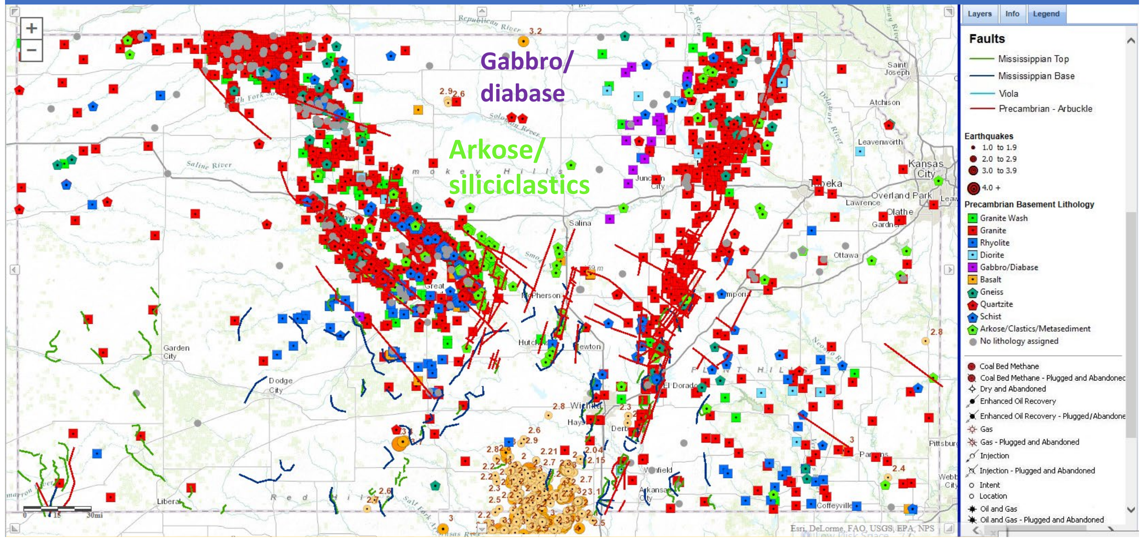
DOE Funded CCUS Research at KGS

Title	Dates	Funding	Status
Pilot CO_2 EOR in the Lansing-Kansas City Formation	2000-2010	$5.4M	Complete
CAP -CO_2 and SWP consortium for CO_2 EOR feasibility study	2009	$2.3M	Complete
Regional Arbuckle Saline Aquifer Characterization Study	2011-2015	$11M	Complete
Volumetric Curve Tool for Modeling Reservoir Compartments	2014-2016	$1.5M	Complete
Small Scale Field Test at Wellington Field	2011-2017	$10.5M	Complete
CarbonSAFE Phase 1	2017-2018	$1.7M	Complete
CarbonSAFE Phase 2	2018-2020	$13M Total $6M spent in KS	Complete
Carbon Utilization and Storage Partnership	2019-2022	$340k	In Progress

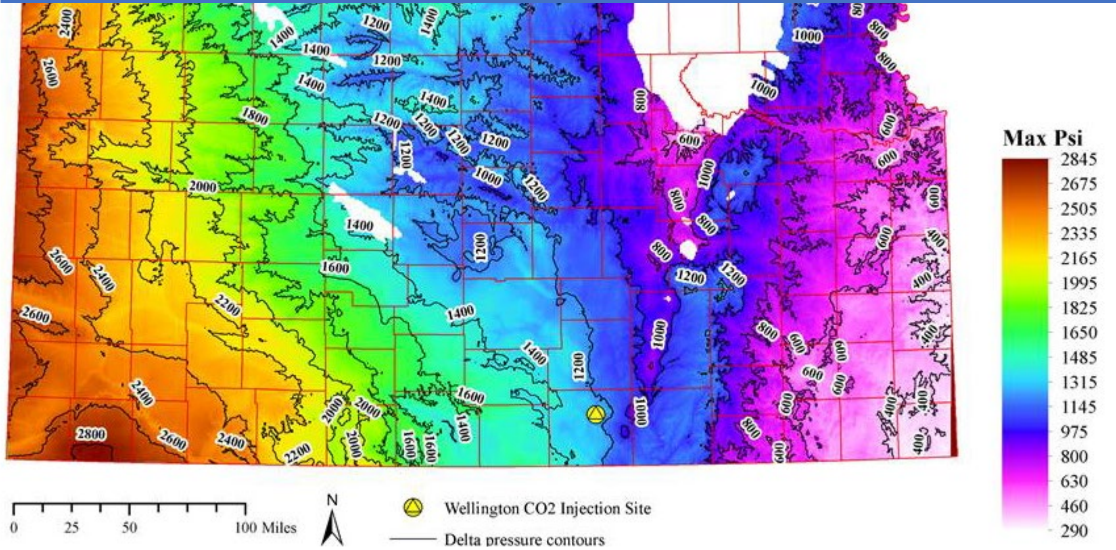
Depth (in feet) Below Ground Surface to Top of Arbuckle



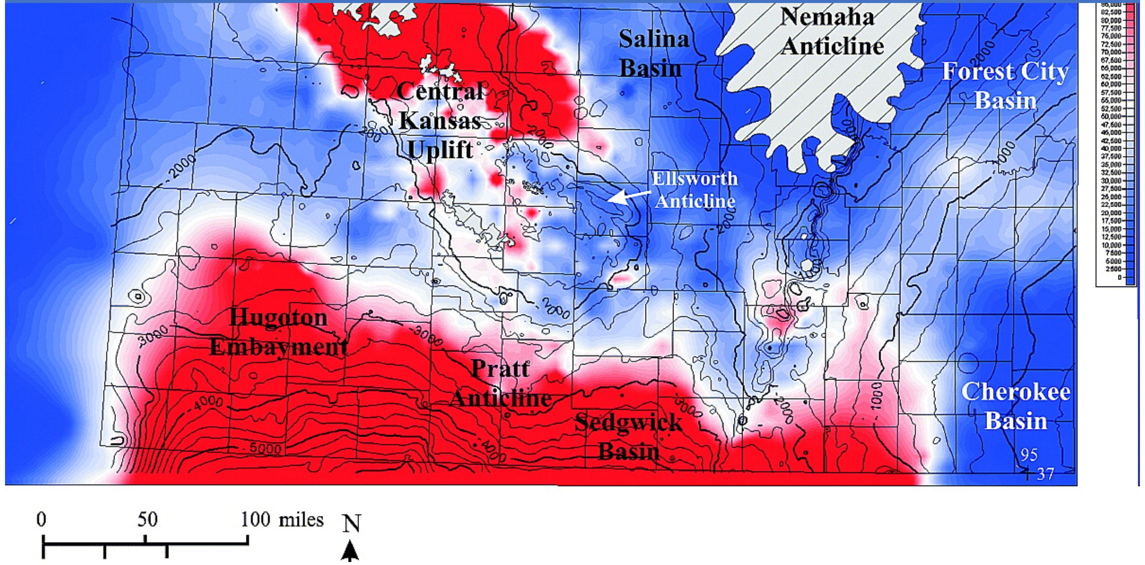
Basement geology and structure (Midcontinent Rift System)



Maximum Allowable Increase in Pore Pressure

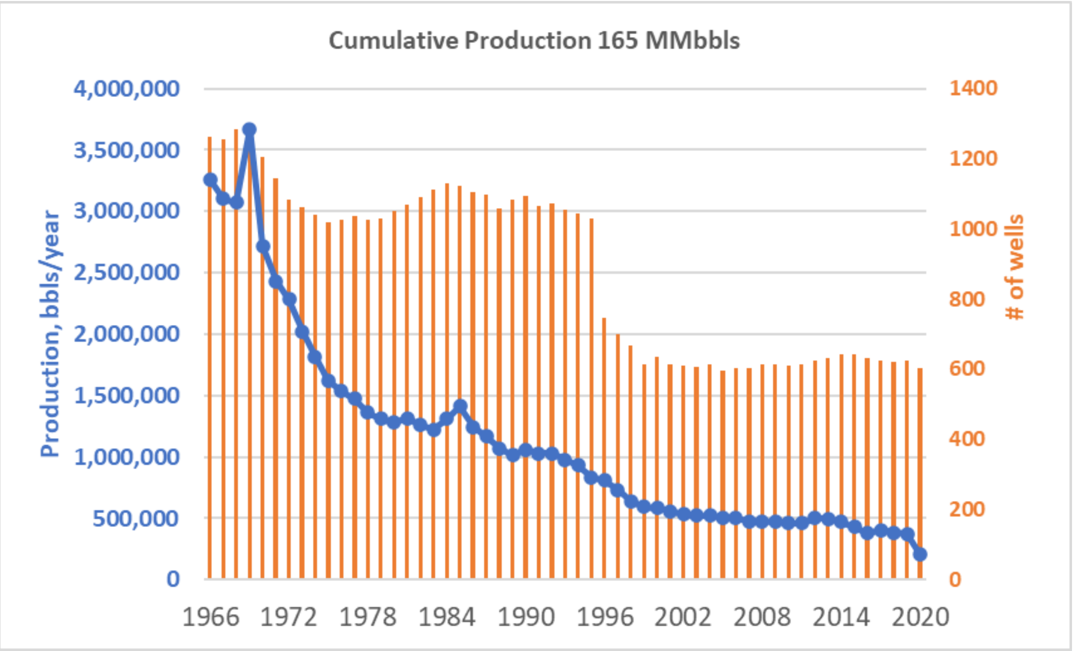


Salinity of Cambrian-Ordovician Arbuckle Group in Kansas

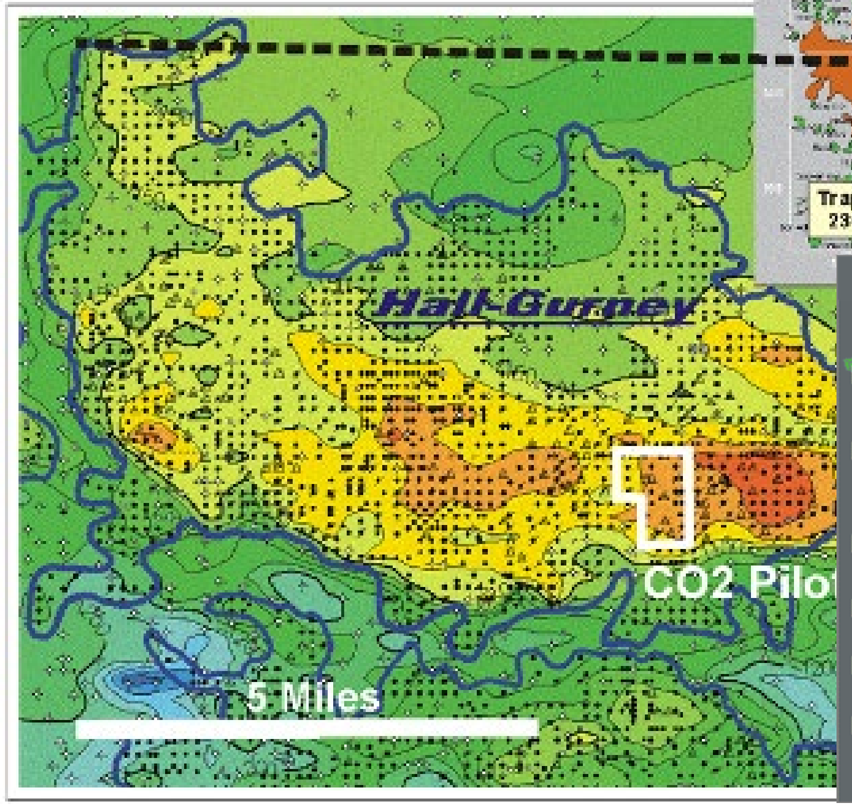


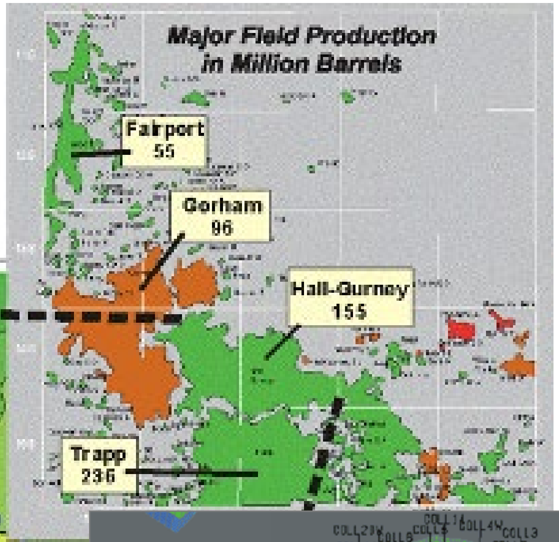
Hall-Gurney Pilot CO_2 EOR - 2005

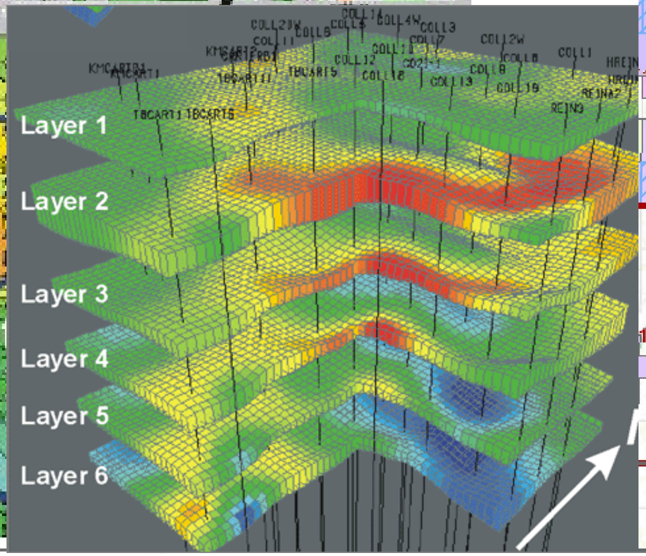
- Injected 1398 MMCF (74 m tonnes CO_2) in 2005
- Produced an estimated 27.9 MBO incremental oil
- **US DOE Grant DE-AC26-00BC15124**

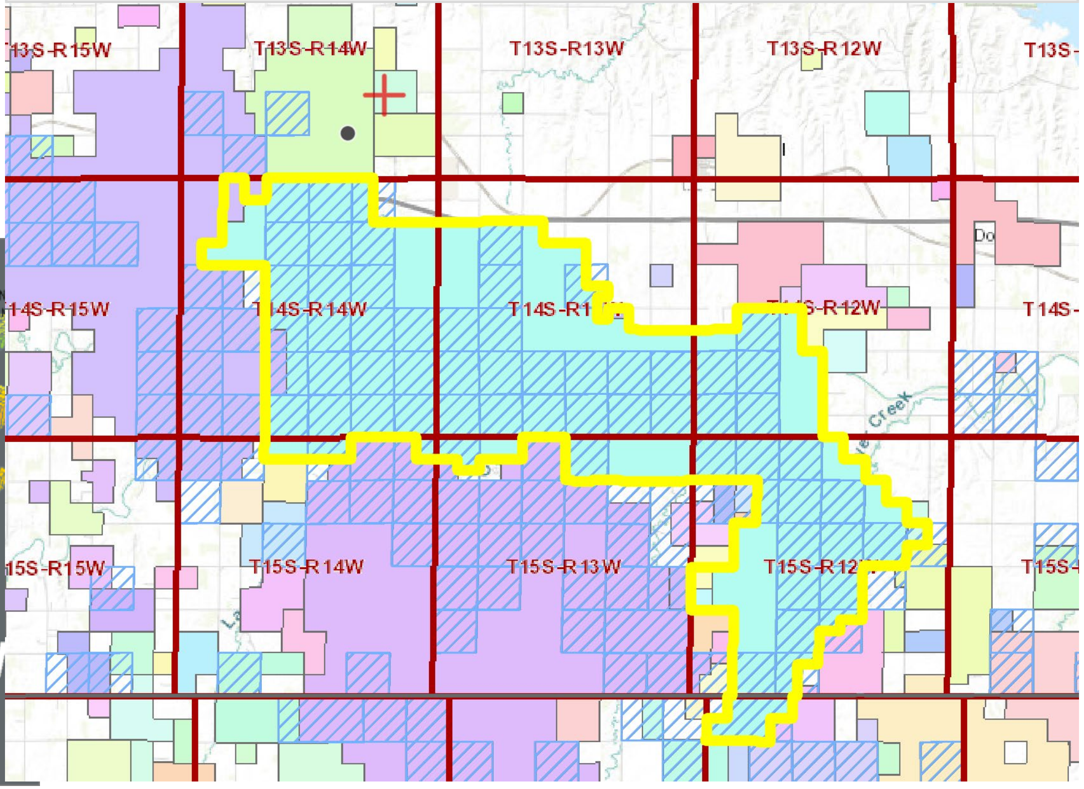


Hall-Gurney Field Area
Lansing Structure Map
Contour Interval = 10 Feet





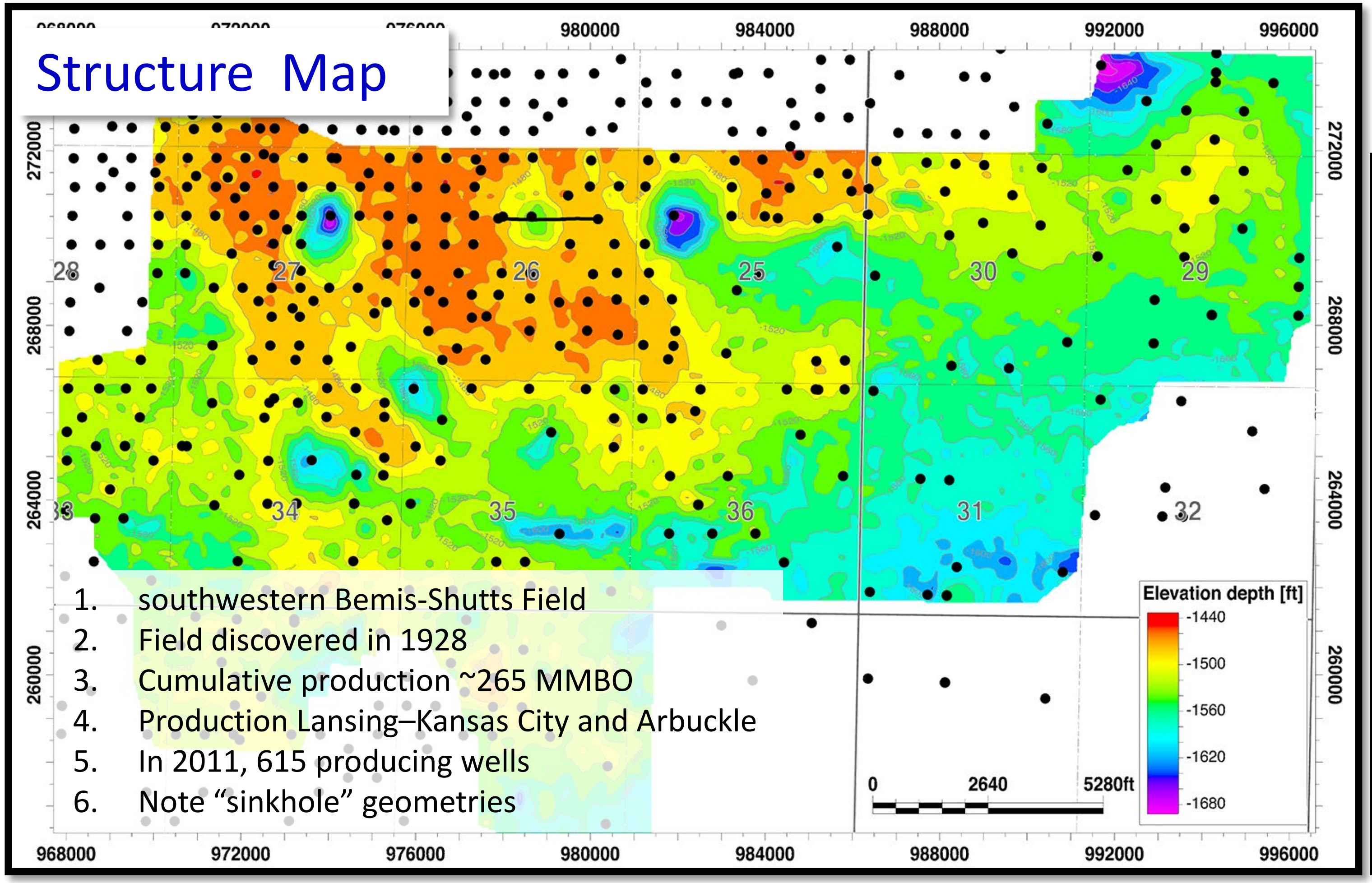




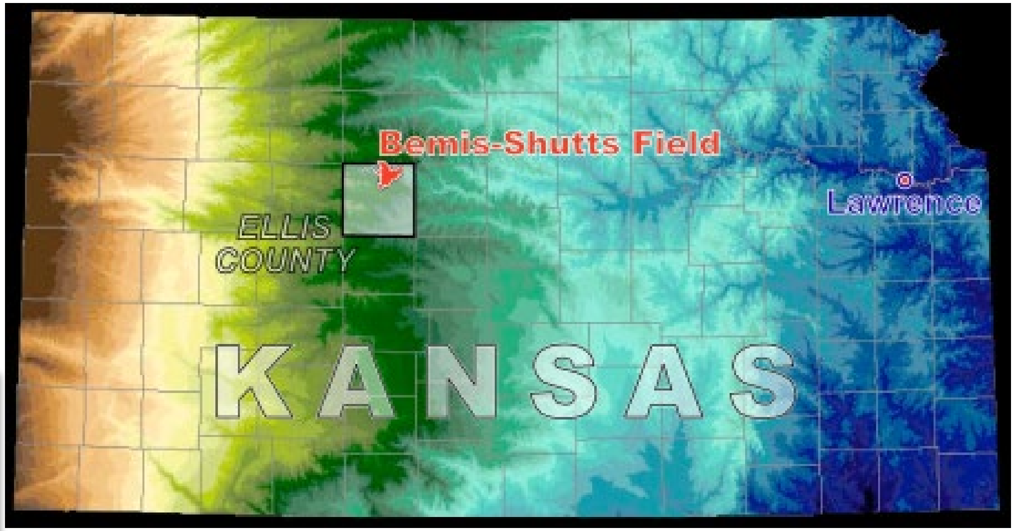
Bemis Shutts Field

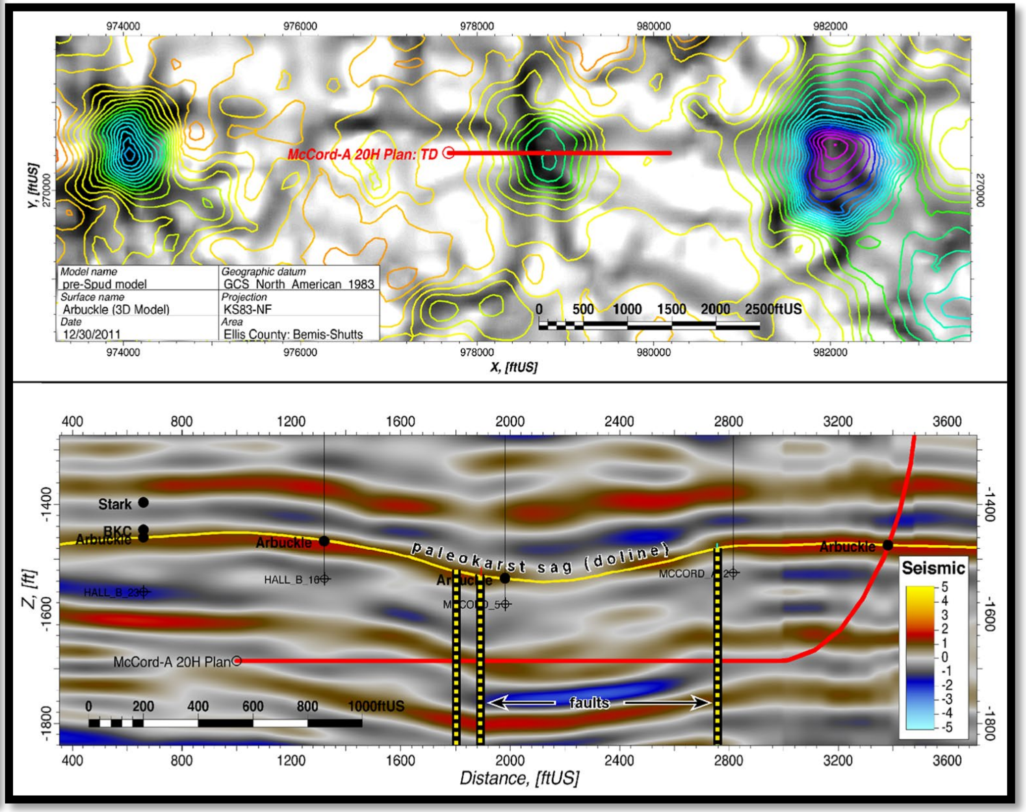
Objectives:

- Land well outside paleocavern
- Drill through paleocavern
- TD in “flat-lying” host strata
- Run Triple, Sonic, Image tools



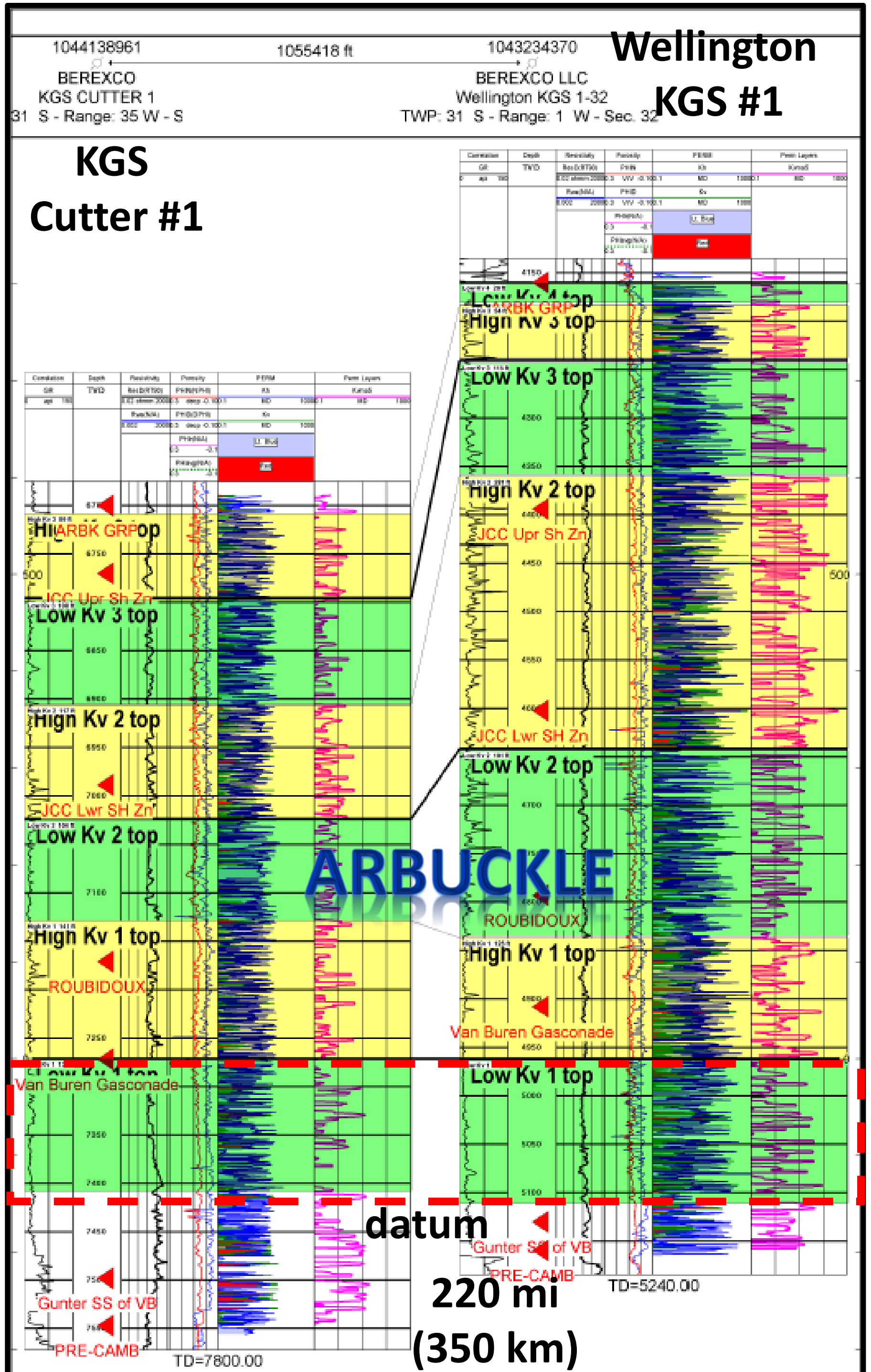
1. southwestern Bemis-Shutts Field
2. Field discovered in 1928
3. Cumulative production ~265 MMBO
4. Production Lansing–Kansas City and Arbuckle
5. In 2011, 615 producing wells
6. Note “sinkhole” geometries

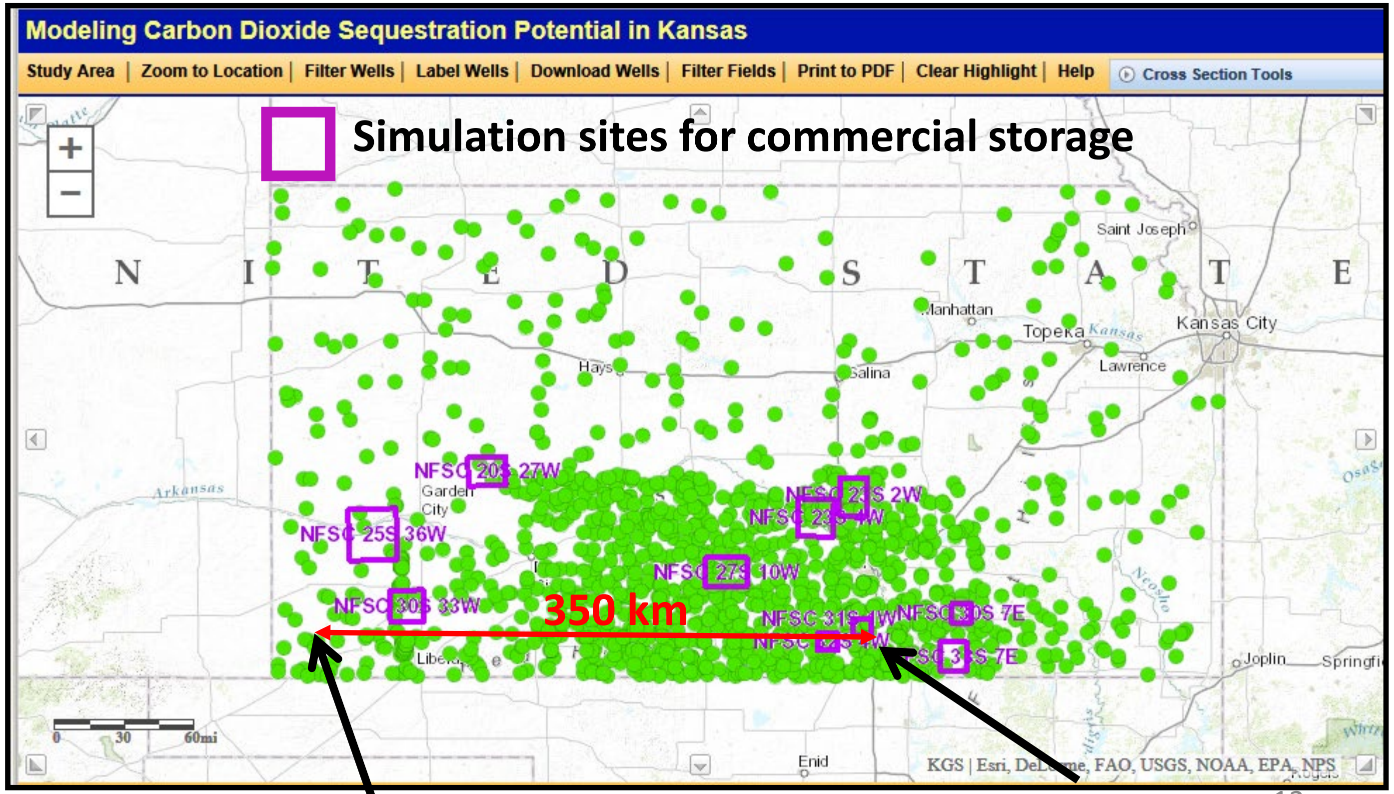




Computed Kh & Kv in Arbuckle Group for Digital Type Wells (●)

- Correlation of flow units based on K_h & k_v
- Between Cutter and Wellington Fields (350 km apart)
- Testing log-derived permeability with Class I buildup test data



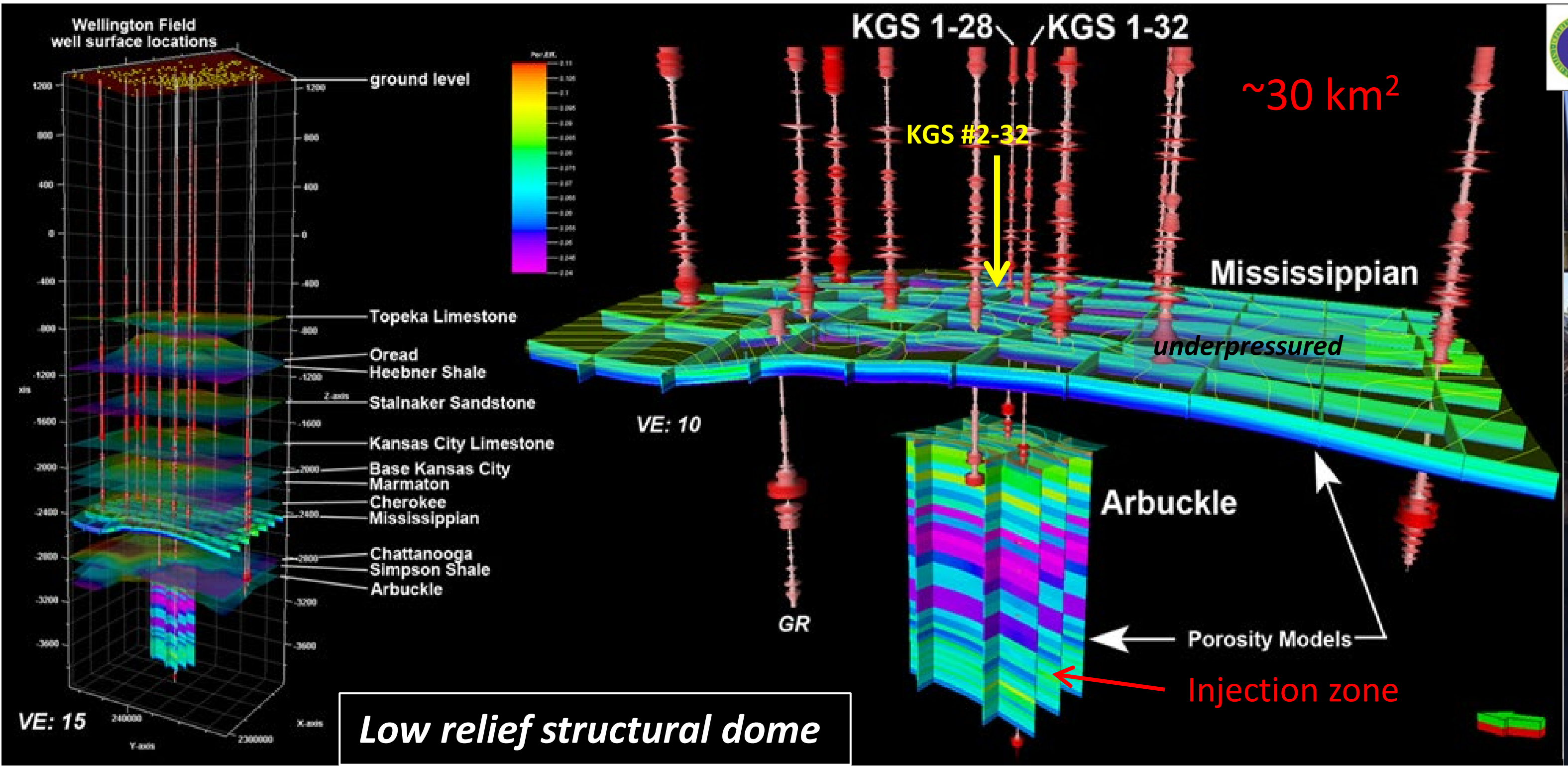


Cutter KGS #1

Wellington KGS #1-32

Wellington EOR and UIC Class VI Project

- **Demonstrated that 99% permanence of injected CO_2**
  - ➢ 20K metric tonnes injected into KGS #2-32 into *Mississippian siliceous dolomite reservoir between January-June 2016*
  - ➢ *CO_2 plume and EOR response as forecast by model* ***(Class II UIC permit)***
  - ➢ Up to 40K metric ton injection into underlying *Arbuckle Group dolomitic saline aquifer* ***(attempted Class VI UIC permit)***
- **Demonstrated reliable and cost effective MVA (monitoring, verification, and accounting) tools and techniques**
- **Developed best practices for effective and safe CO_2-EOR and CO_2 saline storage**



Low relief structural dome

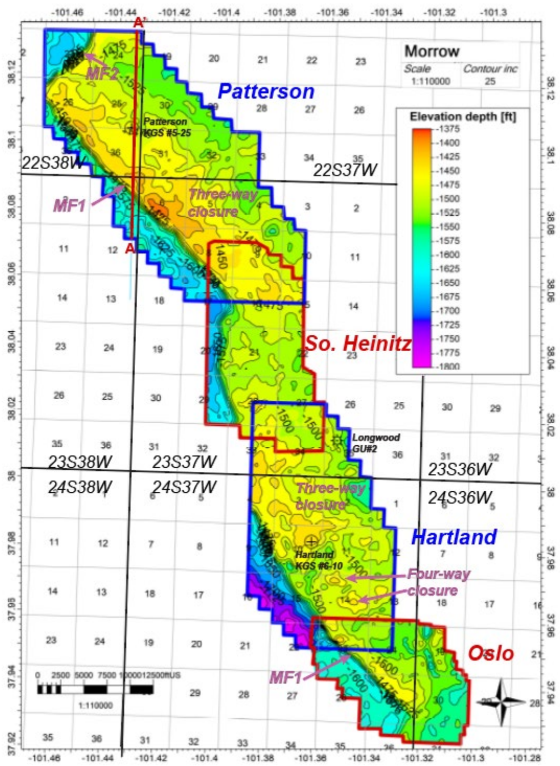
Available Data and Assessments

- Geological and engineering data and studies
  - Reservoir characterization for fluid storage and EOR
  - Core and cuttings repositories, adjacent analytical laboratories
  - Well log databases
  - Several wells drilled specifically for CCUS projects: Wellington, Cutter, Patterson, and other sites:
    - Core, well logs, well tests, 3D seismic, passive seismic, long-term pore pressure monitoring, etc.
  - Geologic and numerical models for multiple potential sites (15+)
  - Pilot EOR projects
  - Fluid injection history in the state
  - USDW data
- Preliminary studies for CO_2 emission sources
  - 45Q-qualified sources have been identified and mapped
  - Several coal power plants, refineries, ethanol plants
- Preliminary studies for pipelines and infrastructure
- Legal and regulatory developments
  - CO_2 infrastructure bill in Kansas Senate (pending)
  - Kansas CCUS Task Force Lead
  - UIC Class VI permit experience with Wellington and Patterson sites
- Economic and site risk assessment studies
- Outreach activities
  - Annual KS CCUS Conference with stakeholders (Oil and gas, utilities, ethanol, agri, regulators, investors, etc.)

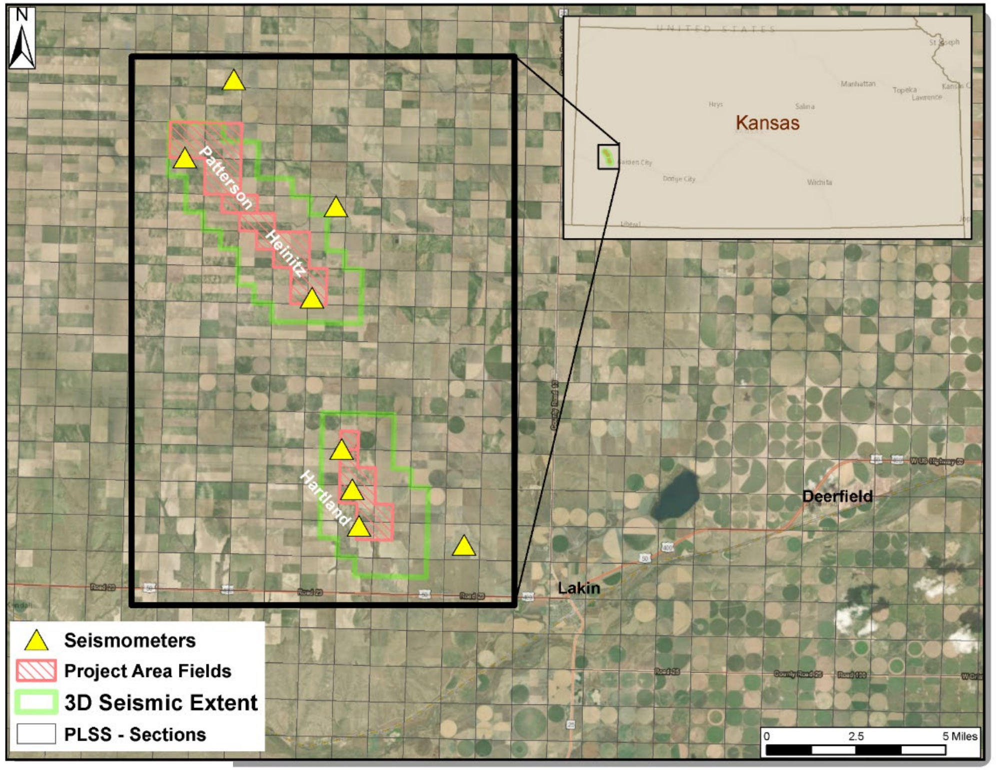
Coring Operations at Patterson KGS 5-25 April 2020

Patterson Site Characterization and preparation for UIC Class VI

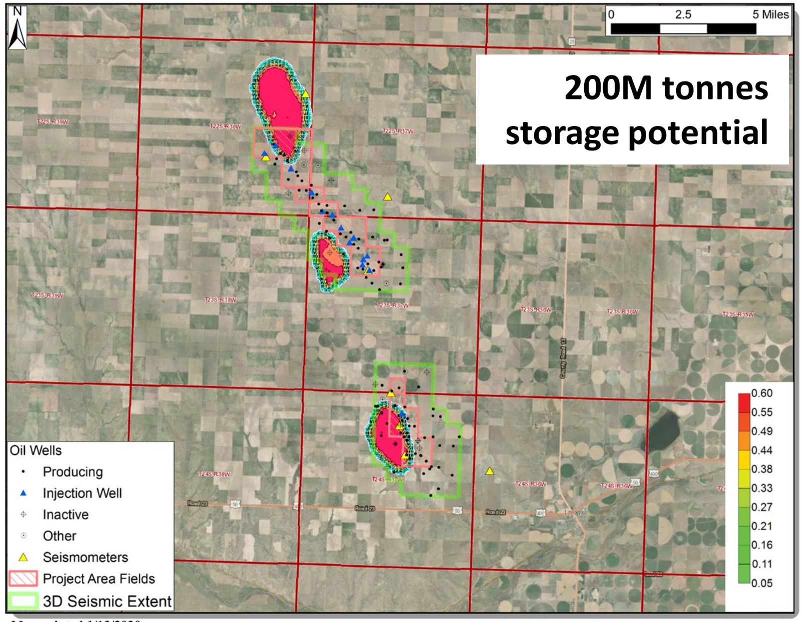
- Stacked storage concept: multiple saline formations + potential CO_2-EOR
- 26 square miles of new 3D seismic data were acquired in July 2019
- 2 new wells were drilled and logged
- ~800 ft of core recovered
- Advanced well testing program is planned summer 2020
- Close proximity to several CO_2 sources



Osage Saturation Plume - 50 years after injection

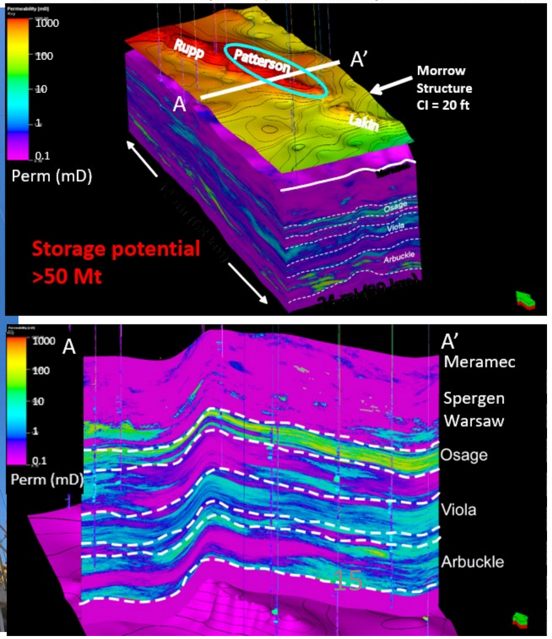


Sources: Kansas Geological Survey, DASC, Kansas Corporation Commision, USGS, IRIS

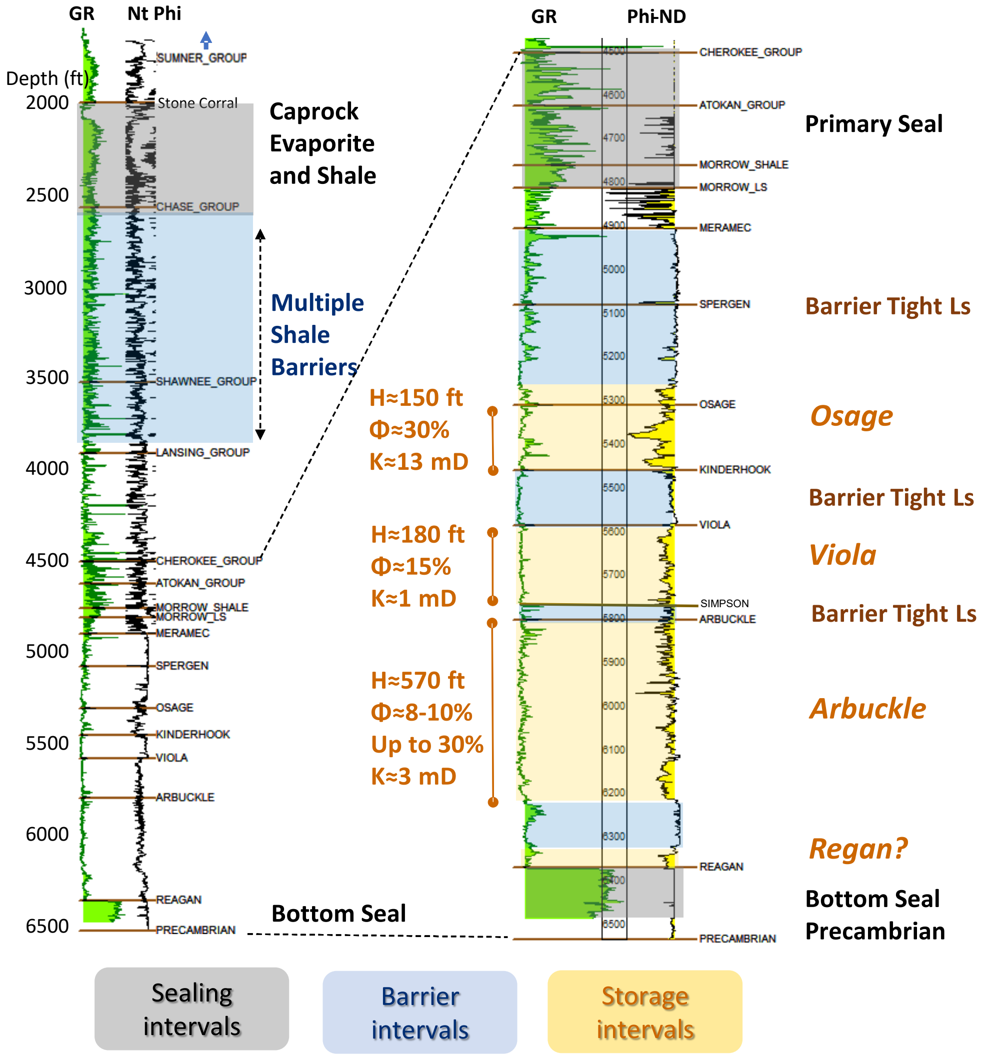


Map printed 1/13/2020

Sources: Kansas Geological Survey, DASC, Kansas Corporation Commision, USGS, IRIS

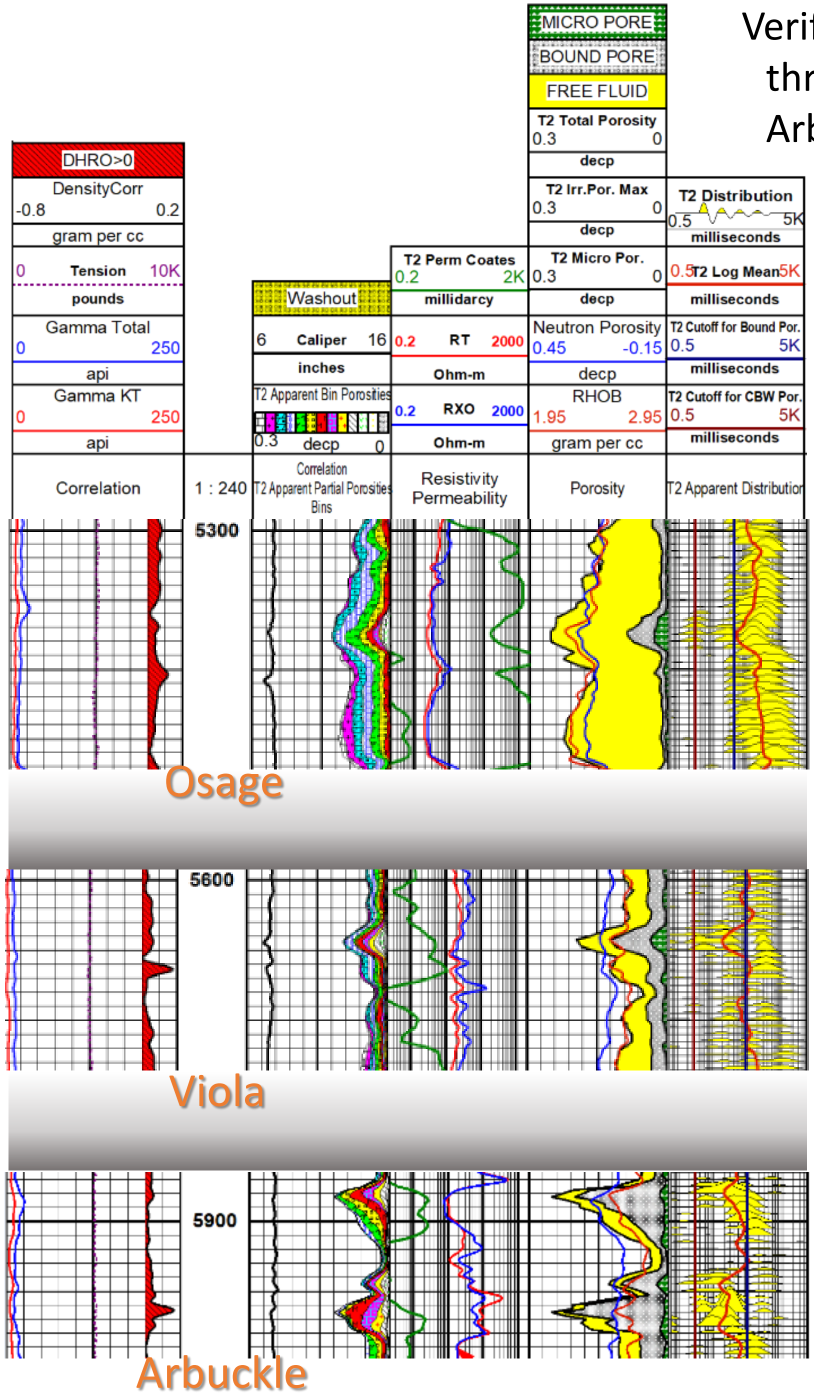


Storage complex

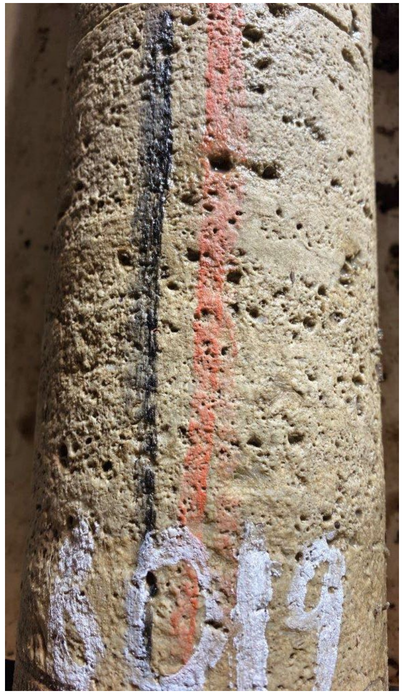


Stratigraphy illustrated by wireline log from a key well in the Patterson Site (Longwood Gas Unit #2 well).

Meng et al., 2020



Verified **15 bbl/min** flow in all three potential sink formations: Arbuckle, Viola, and Osage



Vuggy porosity of Arbuckle reservoir

CO_2 Source Economics

Facility	Capture Rate (Mtonnes/ annum)	Best Case ($/t$CO_2$)	Worst Case ($/t$CO_2$)
Jeffrey Energy Center	2.70	$45	$67
Holcomb Station, Case 1a	1.70	$46	$72
Holcomb Station, Case 1b	1.20	$50	$79
Holcomb Station, Case 2	1.70	$35	$61
Holcomb Station, Case 3	1.70	$46	$71
CHS SMR refinery	0.80	$60	$94

Integrated CCS for Kansas (ICKan); Award Number: DE-FE0029474
DUNS NUMBER: 076248616 Final Technical Report

Westar Energy Jeffrey Energy Center, Eastern Kansas

- 3 separate 800 MWe coal-fired units
- Annual CO_2 emissions – 12.5 million tonnes
- Units were built in the 1980s but fitted recently with selective catalytic reduction (SCR) based NOx removal, activated carbon sorbent-based Hg removal and scrubber-based flue gas desulfurization (FGD)

Sunflower Electric Power Corporation's Holcomb Station

- Single subcritical 348 MWe unit (387 MVA; 0.9 PF)
- Annual CO_2 emissions – 1.5-2 million tonnes
- Began operation in 1983; uses low sulfur, sub-bituminous coal from Wyoming
- Plant is fitted with environmental controls including low-NO_X burners, over-fire air (OFA), a powdered activated carbon (PAC) injection system, a dry scrubber, and baghouse

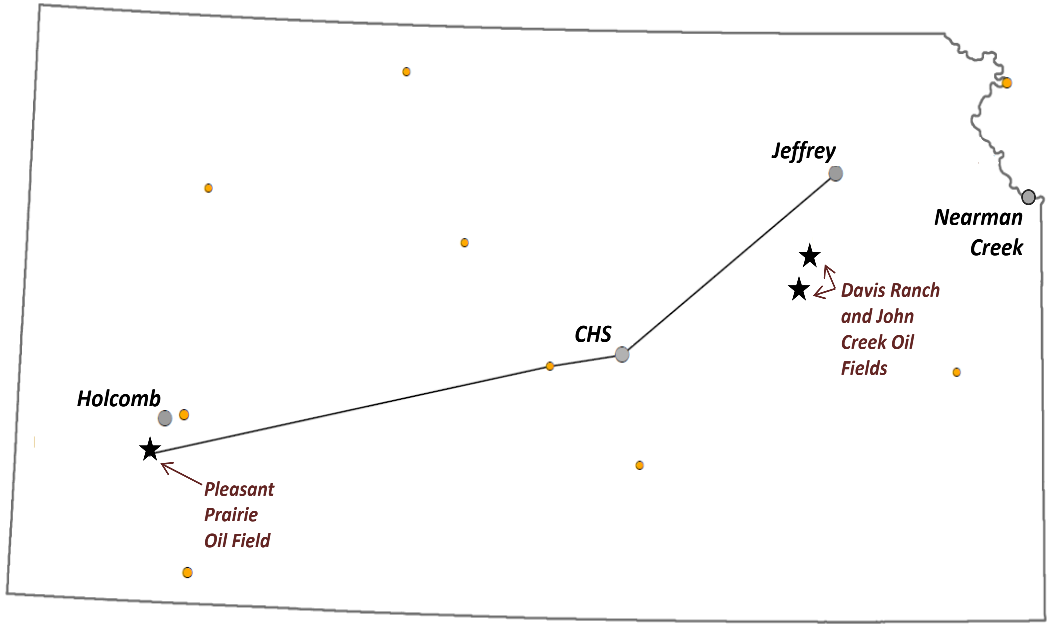
CHS Refinery, South-Central Kansas

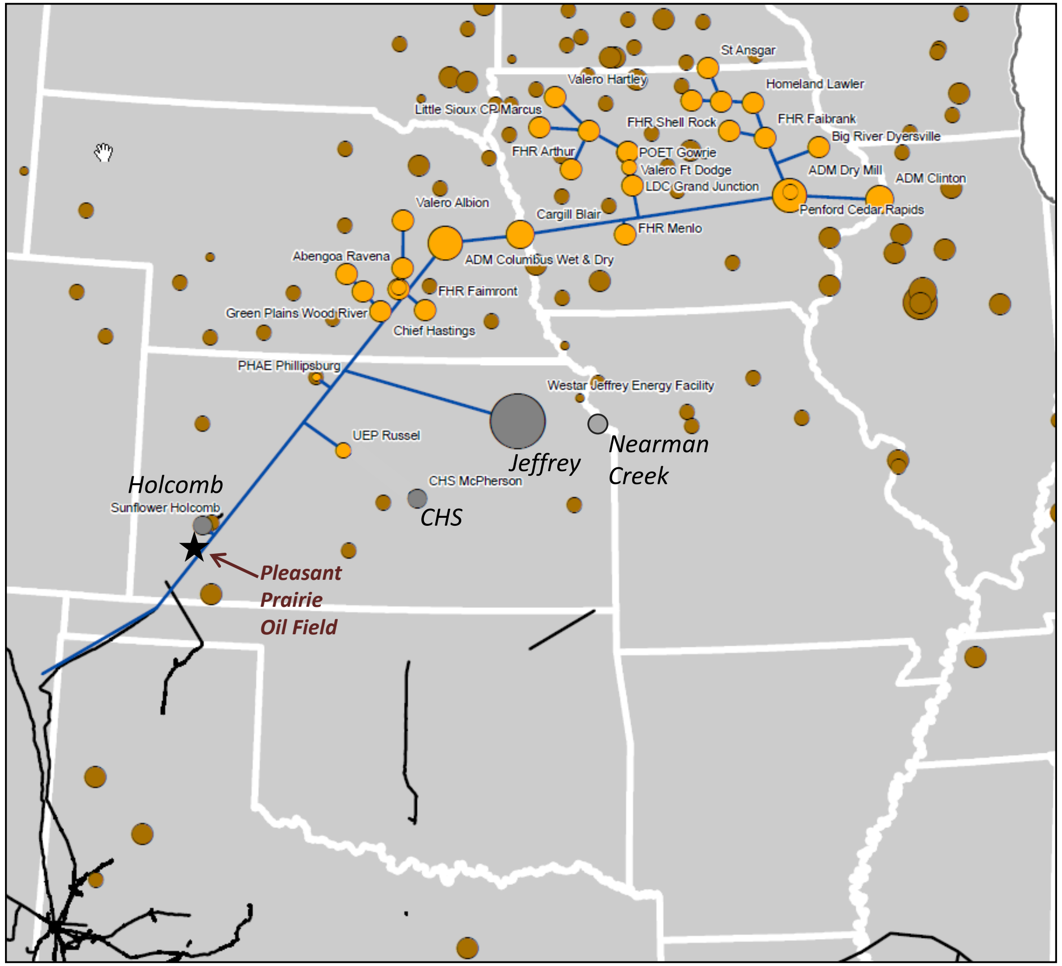
- 2 steam methane reformer (SMR) hydrogen plants
- Annual CO_2 emissions – 0.76 + 0.62 million tonnes

THE LINDE GROUP Linde

CO_2 Transportation Assessment

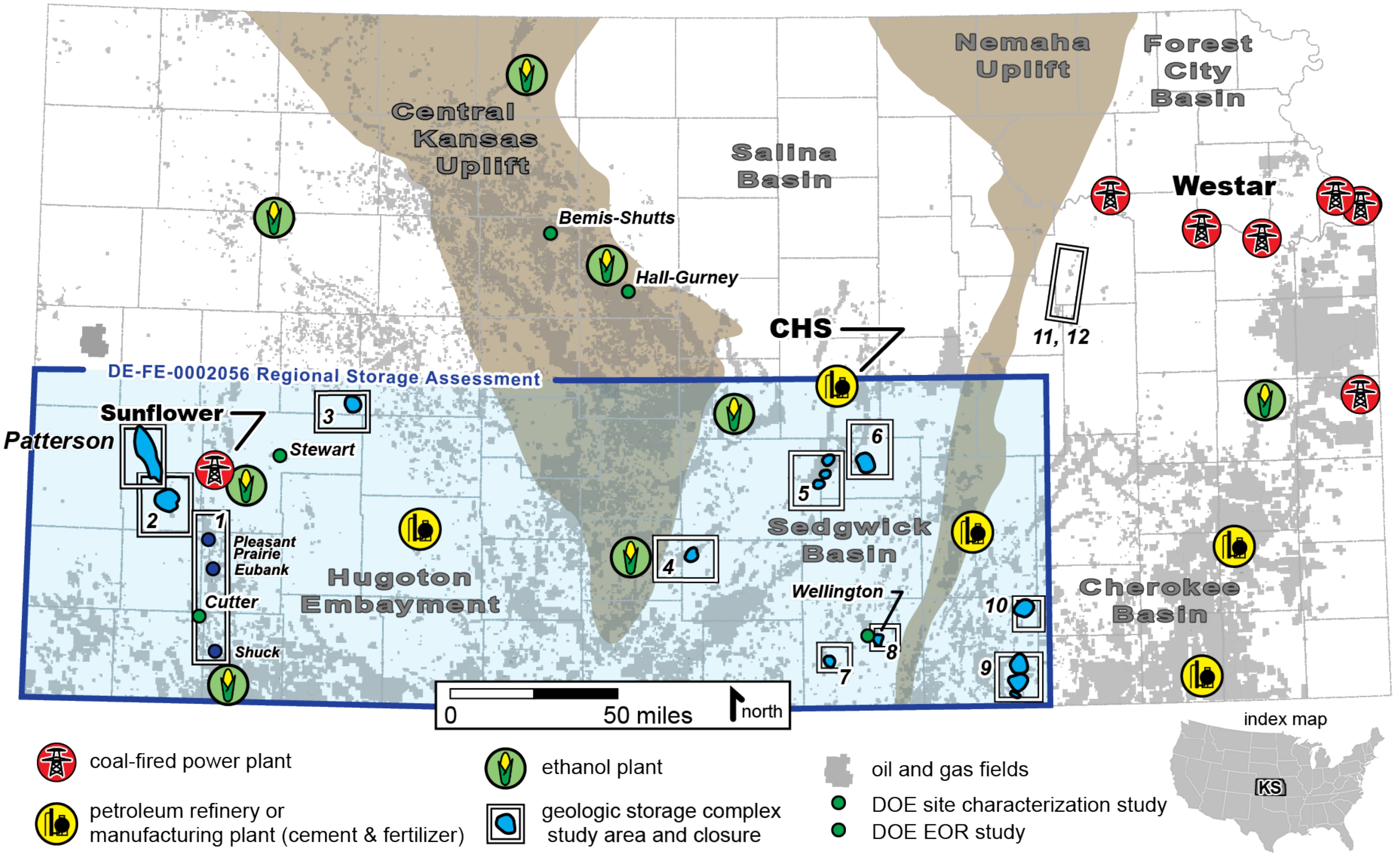
- Modified FE/NETL CO_2 Transport Cost Model
- 7 inputs (e.g., length, pumps, capacity, pressures, etc.)
- 12 outputs, including CapEx and OpEx





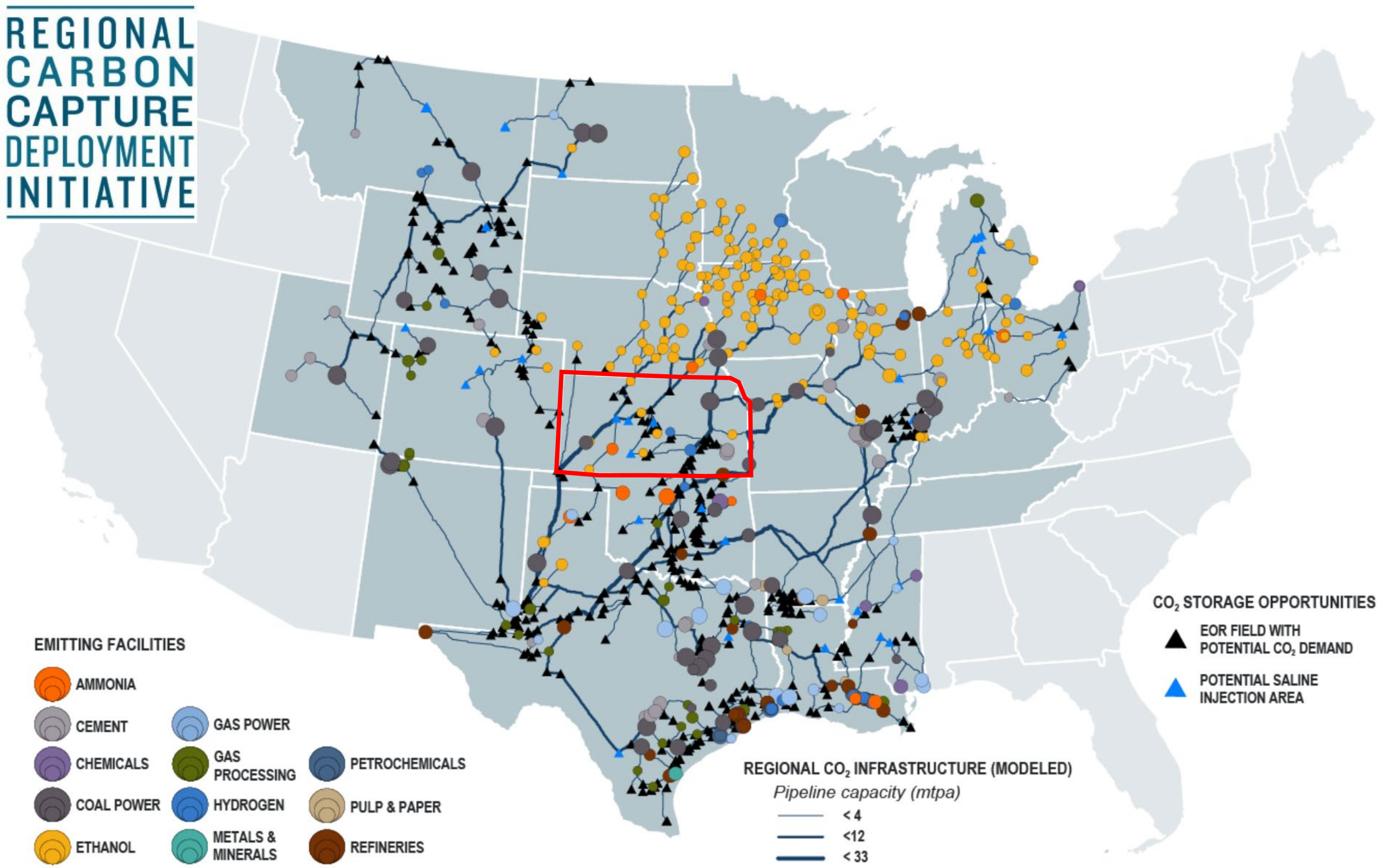
	Scenario	Distance (mi)	Distance (mi) X 1.2	Volume (MT/yr)	Size (inches)	CapEx ($M)	Annual OpEx ($M)
Jeffrey to MidCon Trunk	**part of 1**	151	181	2.5	12"	$164	$3.8
Jeffrey to Davis Ranch and John Creek	**2**	42	51	2.5*	12" & 8"	$47	$1.3
Jeffrey to CHS and Pleasant Prairie	**3**	294	353	3.25**	12"	$323	$8.0
Jeffrey to Pleasant Prairie	**4**	294	353	2.5	12"	$322	$7.2

KGS CarbonSAFE Projects Phase I and II



Many Potential Pipeline Routes Cross Kansas

- Potential pipeline scenarios RCCDI
- Several commercial operators expressed interest in building pipelines connecting CO_2 sources in Upper Midwest and KS, OK, TX, and NM
- Kansas can become a CCUS hub with multiple businesses and communities benefiting from this technological breakthrough



Elizabeth Abramson, Great Plains Institute, 2020

KGS Experience with UIC Class VI Permitting

Constructed 3 shallow wells at EPA's request to prove absence of USDW

Installed **Wellington Seismic Array**

Prepared **Opinion on Induced Seismicity** in Kansas

Wellington Seismic Action Plan prepared in response to EPA's concern about induced seismicity

Conducted analytical studies to demonstrate absence of **USDW** at site

Conducted **modeling for 26,000 tons** and prepared new report

Prepared **Site Structure and Induced Seismicity Report**

Permit application submitted April 2014

Work with EPA to prepare permit documents

Apr 14	Aug 14	Dec 14	Apr 15	Aug 15	Dec 17	Apr 16	Aug 16	Dec 16	Mar 17

Respond to Request For Information on all sections of permit

Permit reformatted, resubmitted using new GS Tool

Kickoff meeting in August 2014

Water Quality Testing and Analysis at shallow wells

Prepares Quality Assurance and Surveillance Plan (QASP)

Operation Plan for Safe and Efficient Injection (OPSEI) prepared as a monitoring response plan.

Conducted STOMP simulations to assist EPA in AoR evaluations

At EPA's request, prepare plan for monitoring pressures in Mississippian reservoir

Address Financial Responsibility requirements – Lower cost estimate

EPA Class VI Review Process

Completeness Review

Technical Review and Decision Making

- RAI Tables
- Ad hoc reports
  - USDW Waiver
  - Seismicity
- Requests through GS Tool

Finalization

- Draft Permit
- Public Comments
- Public Outreach
- Town Hall Meeting

Class VI Guidance documents: https://www.epa.gov/uic/class-vi-guidance-documents

The GS Data Tool and the Input Advisor: https://epa.velo.pnnl.gov

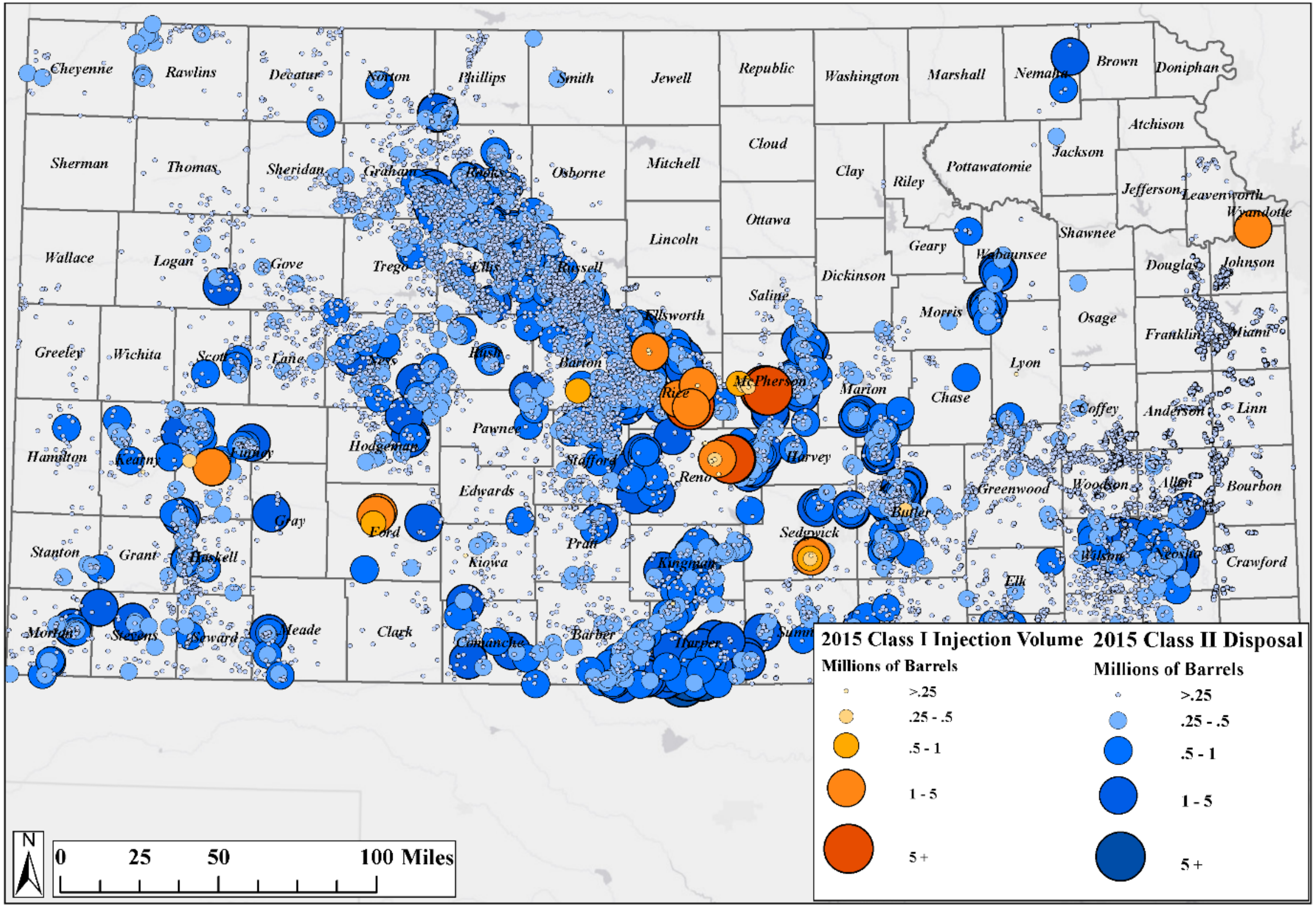
Wellington Rapid Response Plan

Monitoring Activity	Frequency of Evaluation	Monitoring Objective	Expected Range	Deviation Triggering Reevaluation	Potential Causes of Deviation	Level 1 Response Action(s)	Level 2 Response (Actions)	Notes
CASSM - Early detection of plume at KGS2-28	weekly	Determine plume front/validate CO2-brine model	Plume expected to arrive at KGS 2-28 within 45-60 days	Plume arrival at KGS 2-28 within 15 days of commencement of injection	Presence of preferential flow pathway(s)/	• Validate plume detection with U-Tube sampling • Conduct Hall Plot analysis • Recalibrate model • Make projections new plume and pressure front • Recalculate AoR • Determine if any Corrective Action (CA) required • Report finding to EPA Director.		
CASSM – Non-detection of plume at KGS2-28	weekly	Determine plume front/validate CO2-brine model	Plume expected to arrive at KGS 2-28 within 45-60 days	Plume not detected within 90 days of commencement of injection	Non-radial migration of CO_2 through preferential pathway(s), escape into basement, breach of caprock, well integrity failure	• Conduct Hall Plot analysis • Review annulus pressure data • Sample Mississippian and shallow well • Conduct MIT • Recalibrate model • Make projections new plume and pressure front • Recalculate AoR • Determine if any Corrective Action (CA) required • Report finding to EPA Director.		Procedure to be repeated every 30 days if breakthrough at KGS 2-28 not achieved.
Sudden loss of downhole and/or wellhead pressure at injection well	Continuous	Monitor for leakage from well or caprock	Near steady pressures, increasing mildly with injection (except during start and stoppage of injection)	> 20% drop in pressure (over average of past 5 minutes)	Potential leakage from well or caprock, escape into basement, or formation of new fracture	• Pause injection • Review downhole, wellhead, and annulus pressure data. • Determine if loss of pressure due to CO_2 supply. If positive, rectify problem, report findings to EPA Director and resume injection. • Conduct Hall Plot analysis. • Sample and test water quality in the Mississippian and shallow monitoring wells • Conduct MIT • Utilize other monitoring technology to predict and calibrate model • If necessary, implement Level 2 response • Report finding to EPA Director.	• Conduct Pressure Fall-Off Test (to determine if loss of pressure due to formation enhancement • Conduct seismic survey • Obtain InSAR scene and analyze for caprock breach (if deemed feasible)	
Unexpected increase of downhole wellhead pressure at injection well	Continuous	Monitor for interception of barrier boundary and well	Near steady pressures, increasing mildly with	Unexpected increase in pressure gradient	Interception of barrier boundary, well plugging, reduced formation permeability due to chemical reactions, reduction of permeability due lower downhole temperature	• Review downhole and wellhead temperature and pressure data. • Conduct Hall Plot analysis. • Determine if increase in pressure due to cooling effect of CO_2 or supply, formation		

Fluid Disposal History in Kansas

- 49 Class I and 2381 Class II Arbuckle wells across Kansas
- Volumes increase in 2005, peak in 2013-2014 to >750 million barrels, and drop to 500 million barrel in 2015
- Equivalent of 9M CO_2 tones/year for one county
- Class I wells show increase in pressure and SFL
- Class II would show similar tendencies if data is available

Class I & Class II Disposal Volumes (2015)

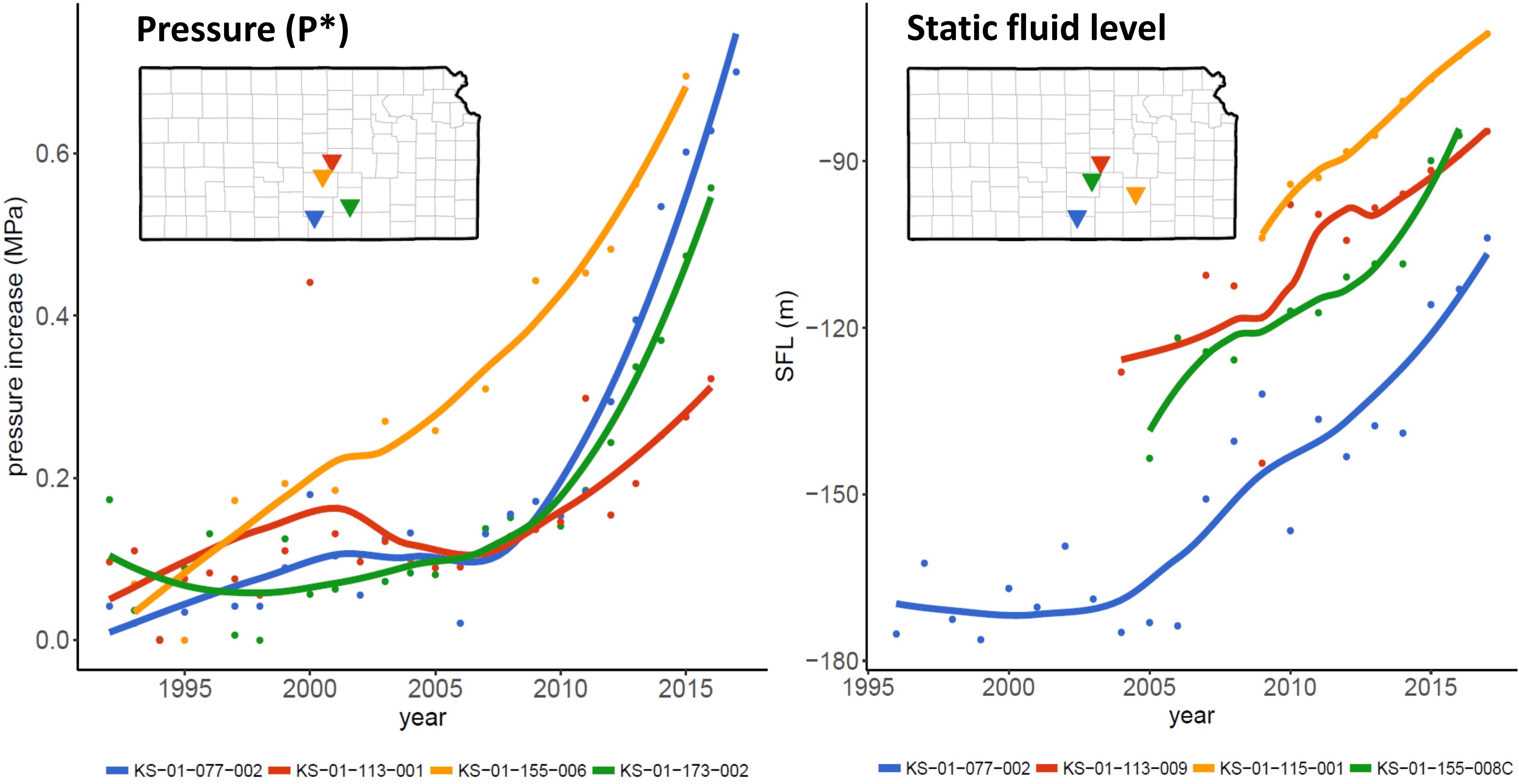


Map printed 3/1/2017

Sources: Kansas Department of Health and Environment, ESRI, USGS, Kansas Corporation Commission, Kansas Geological Survey

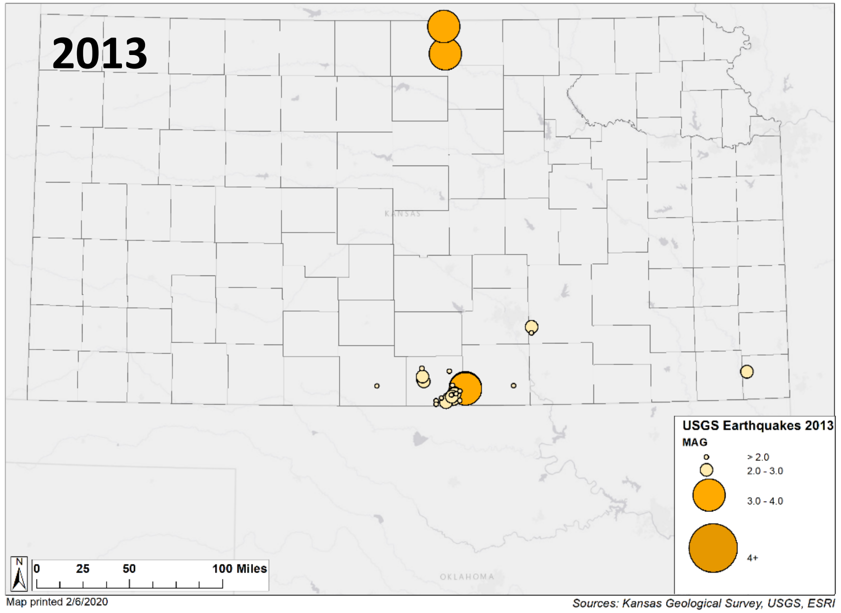
Increases In Pressure And Static Fluid Level

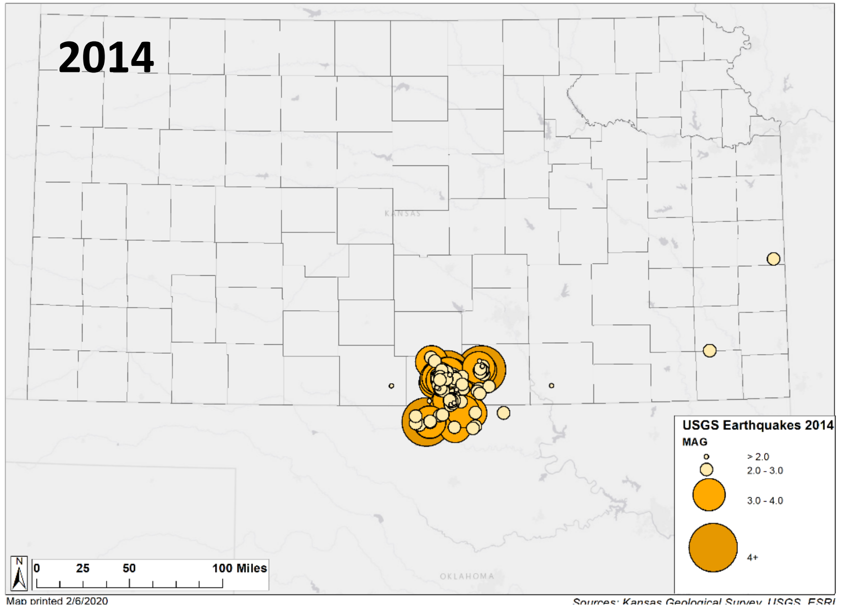
- Class I wells show increase in pressure and SFL
- Class II would show similar tendencies if data is available
- Pressure increase more pronounced near Harper and Sumner counties
- Reno County well(orange) shut-in for two decades

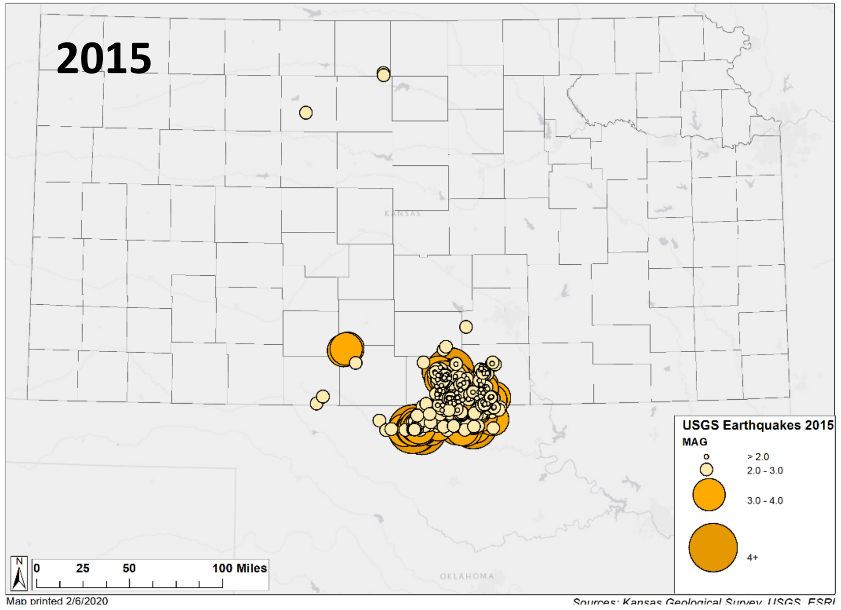


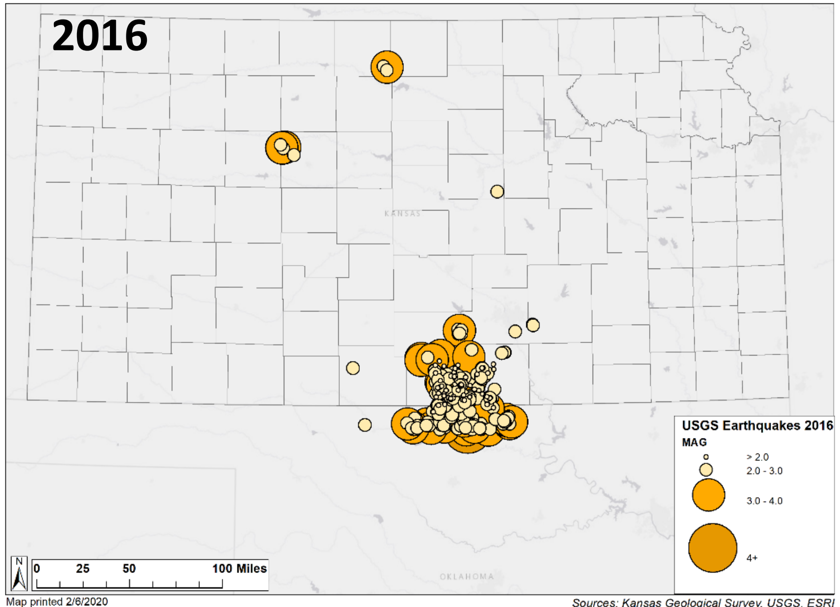
Bidgoli et al., 2019

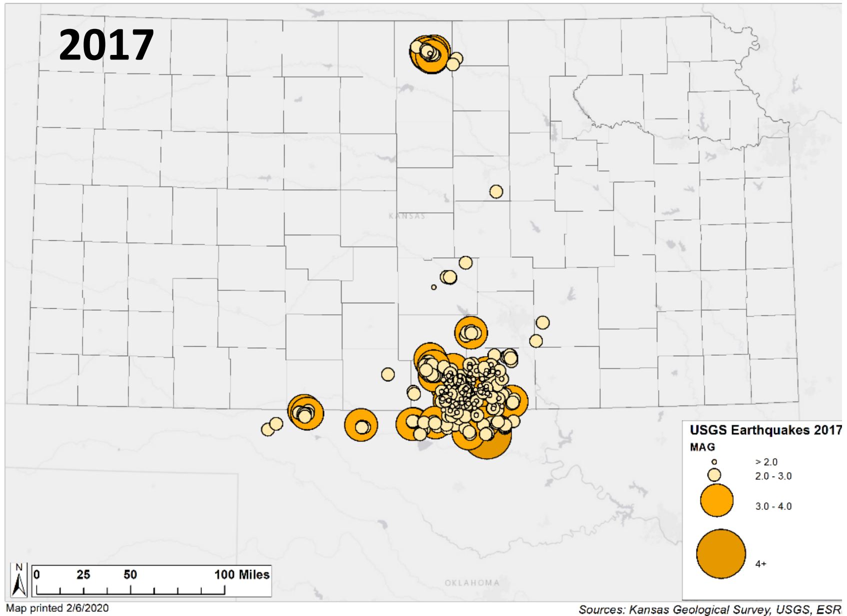
Earthquakes over time

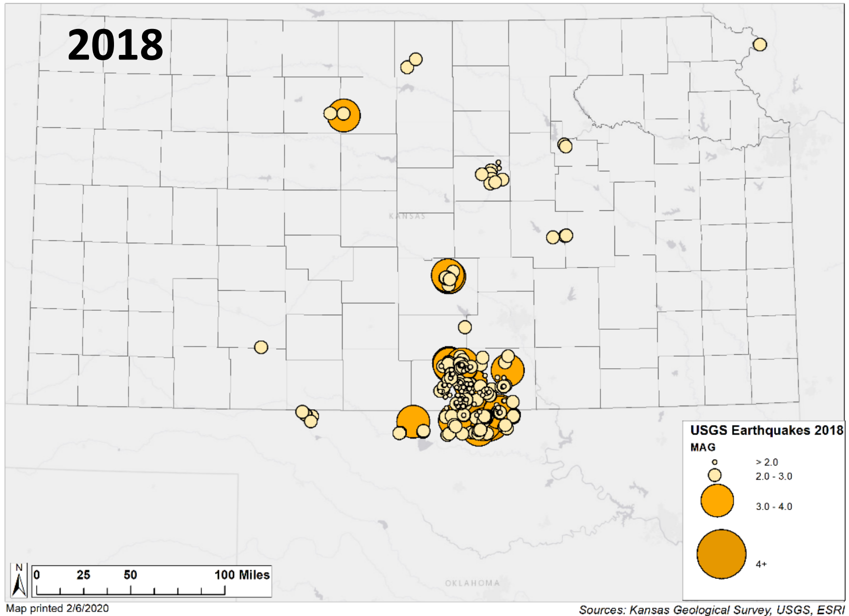






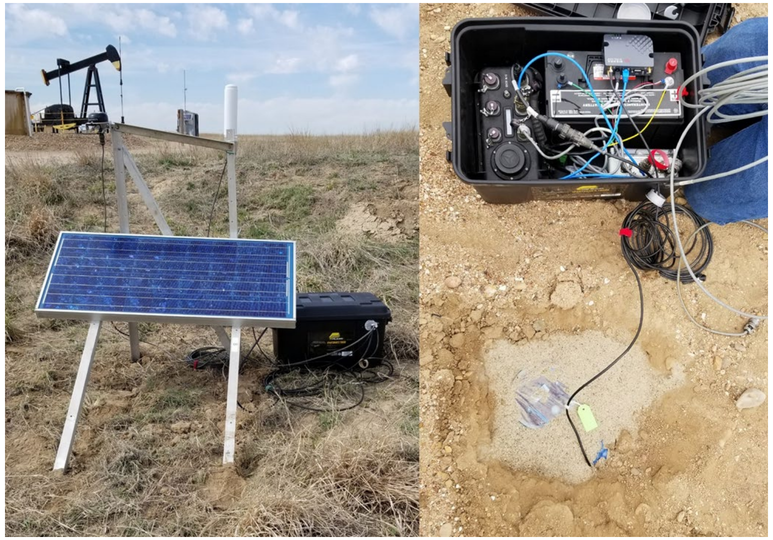




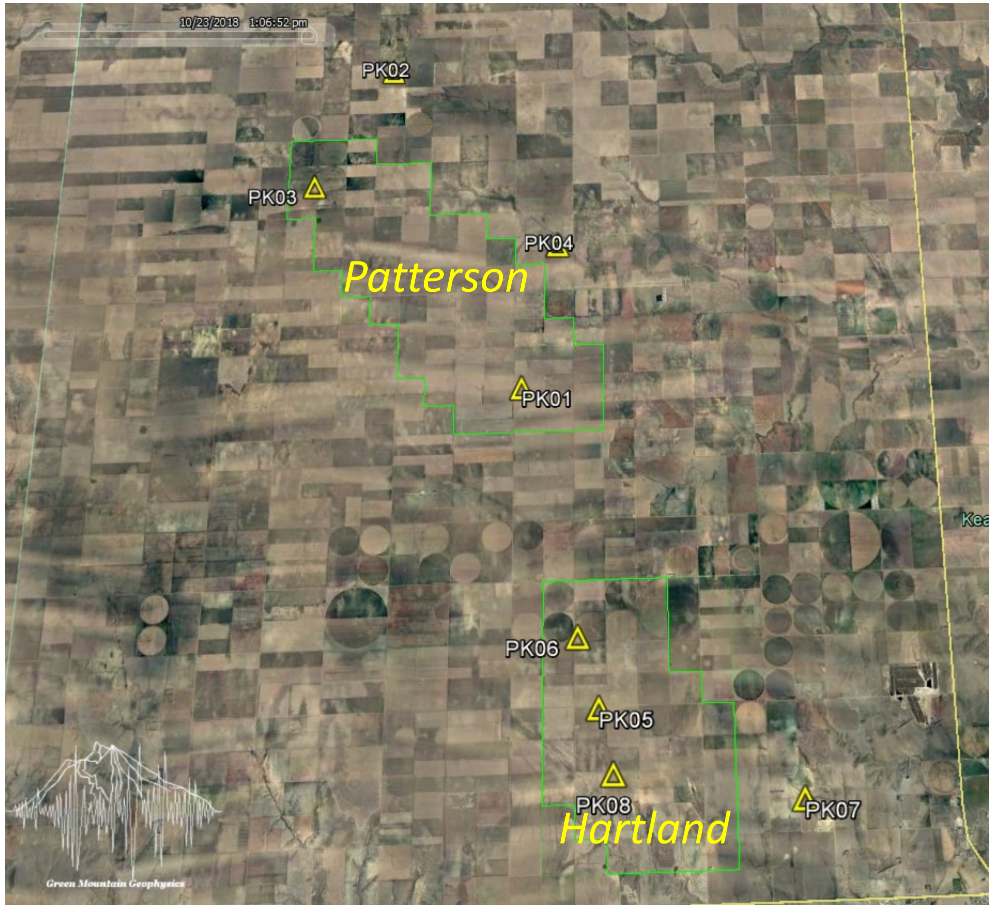


Earthquake Monitoring Array

- Monitor baseline local seismicity near Patterson and Hartland fields in Kearny Co., Kansas
- Detect small magnitude (M_w > 1), local (10-20 km distance) events
- Installed network of eight seismic stations April 22-23, 2019



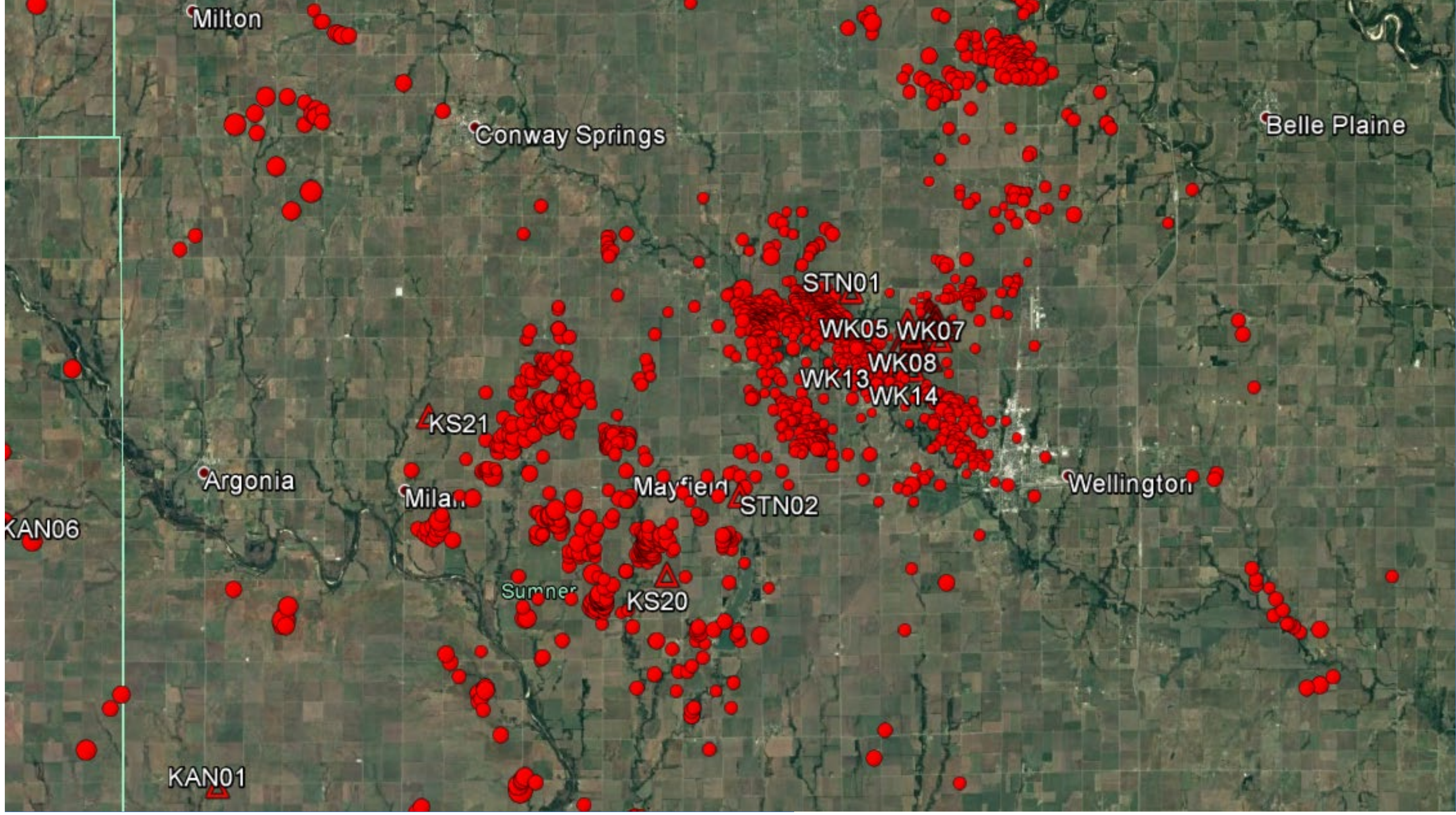
Patterson field seismic station installation of a Sercel L-22 Short Period seismometer

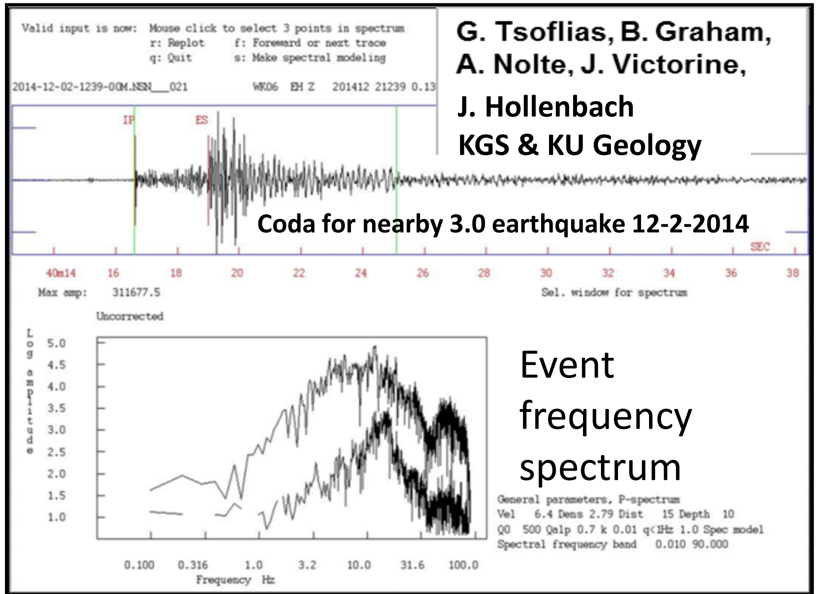


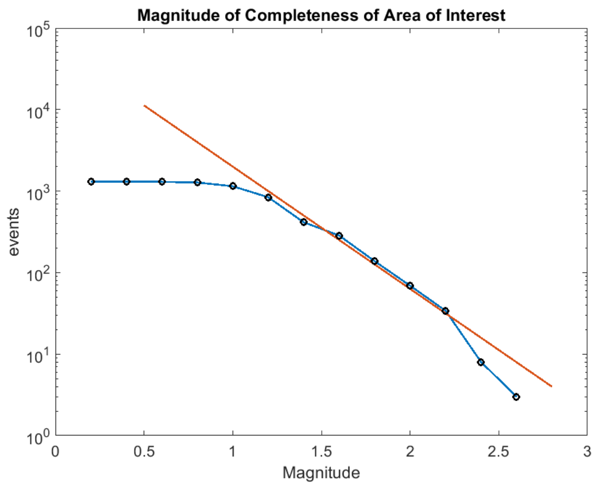
Seismic station locations PK1 through PK8 (yellow triangles) shown with the outlines of 3D seismic surveys (green outlines).

Seismicity Monitoring

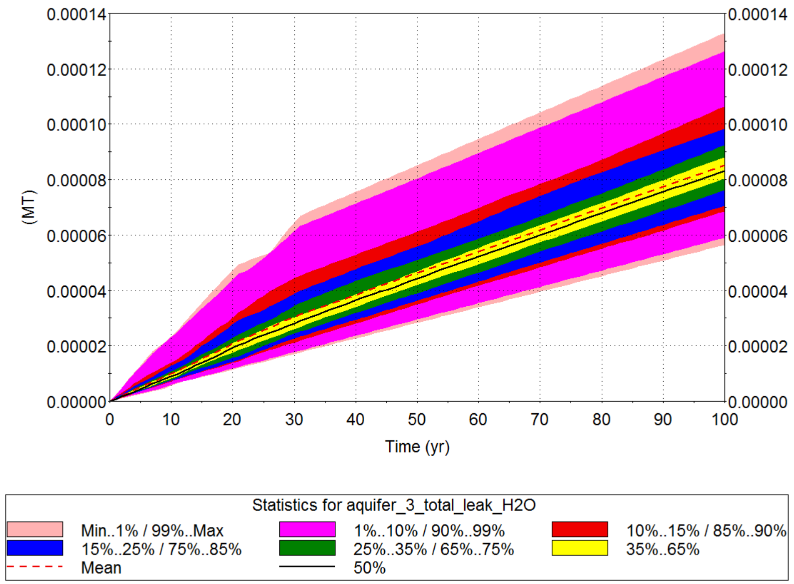
- Seismic monitoring network at Wellington pilot injection site
- M_c ~1.2
- Smallest measured has been M_w 0.4
- **No earthquake has been detected** within Wellington field in association with the CO_2 pilot injection into KGS #2-32

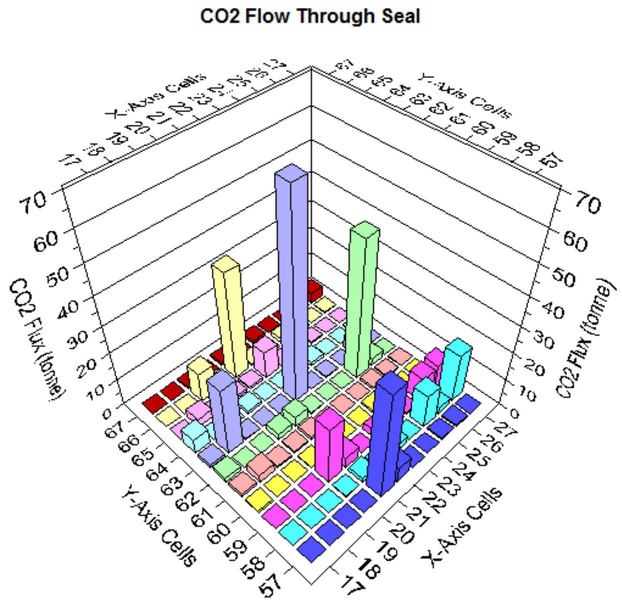


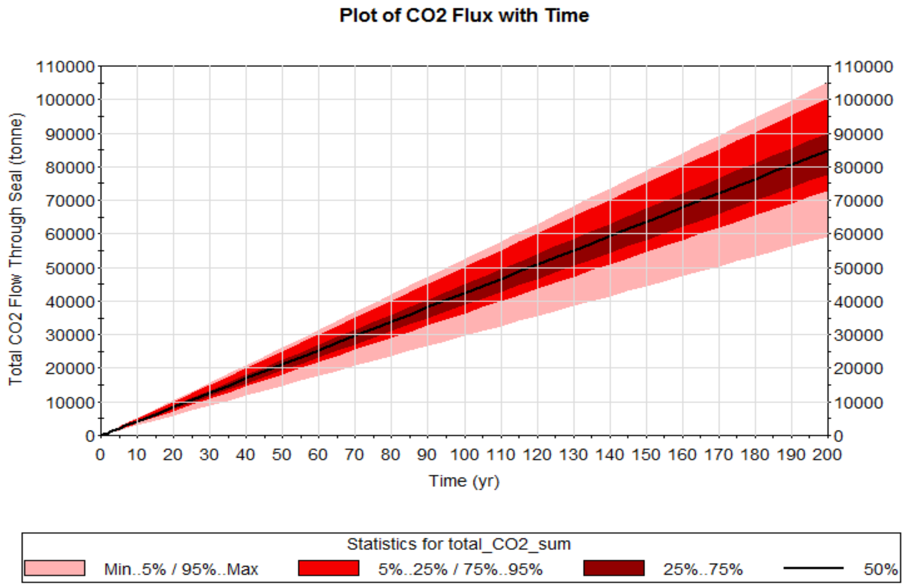




Risk Assessment using NRAP Tools





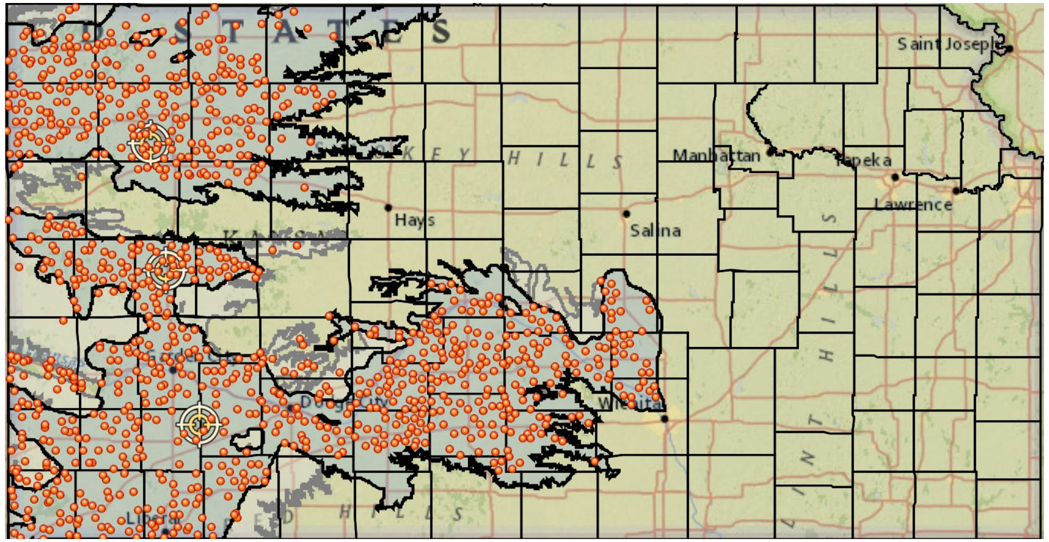


Other Risk Assessment Techniques

- Fluid injection history evaluations
- Experience with local geology, resources, and trends
- Seismicity monitoring
- Access to well records
- Experience with UIC programs, including Class VI
- Development of MVA program, specific to local needs

High Plains Interactive Mapper

http://www.kgs.ku.edu/HighPlains/HPA_Atlas/InteractiveAtlas.html



KGS has been central in CCUS Outreach in Kansas

- **Effective public outreach is critical to support state regulatory changes and for public acceptance**
  - Induced seismicity
  - Infrastructure development
  - Economic impact and opportunity
- **3rd Annual Kansas CCUS Conference**
  - October 14-15, 2019, Lawrence, KS
  - More than 70 participants from industry, regulators, and academia
  - Main conclusion of a conference: economic opportunity is there but legal/regulatory framework is not ready
- **Heartland US CCUS Forum**
  - Two sessions Spring 2021
  - Near 300 participants from industry, regulators, and academia
  - Main conclusion of a conference: we need to continue efforts on legal and regulatory framework
- **Kansas CCUS Task Force**
  - Meetings since September 2019
  - Infrastructure bill: http://kslegislature.org/li/b2019_20/measures/sb395/

Kansas Legal and Regulatory Framework

Challenge		CO_2 EOR	Storage/ Sequestration	Possible Remedies
Statutory framework		Adequate	Not developed	Statutes for Sequestration
Pore Space	**Ownership**	Minerals owner	Surface owner	Statute to make definitive
	Aggregation (pooling / unitization)	Covered (KSA 1301-1303), but is rather weak	Needs to be addressed	Make less difficult to unitize (EOR). Expand for Sequestration. Eminent domain under a utility model (Sequestration).
Regulatory	**Well permitting**	Class II; State primacy; no issues	Class VI; EPA primacy; Tough to get permitted	States may file for Class VI primacy
CO_2 ownership	**During operations**	Determined by contracts	Determined by contracts	Sequestration - utility model would simplify
	Post-closure, long-term liability	No issue?	Long-term liability	Sequestration - utility model could pass liability to State

Source: Mostly condensed from results from ICKan legal and regulatory studies (Steincamp, Schremmer, et.al.)

Few issues for EOR

Multiple challenges with saline aquifer storage

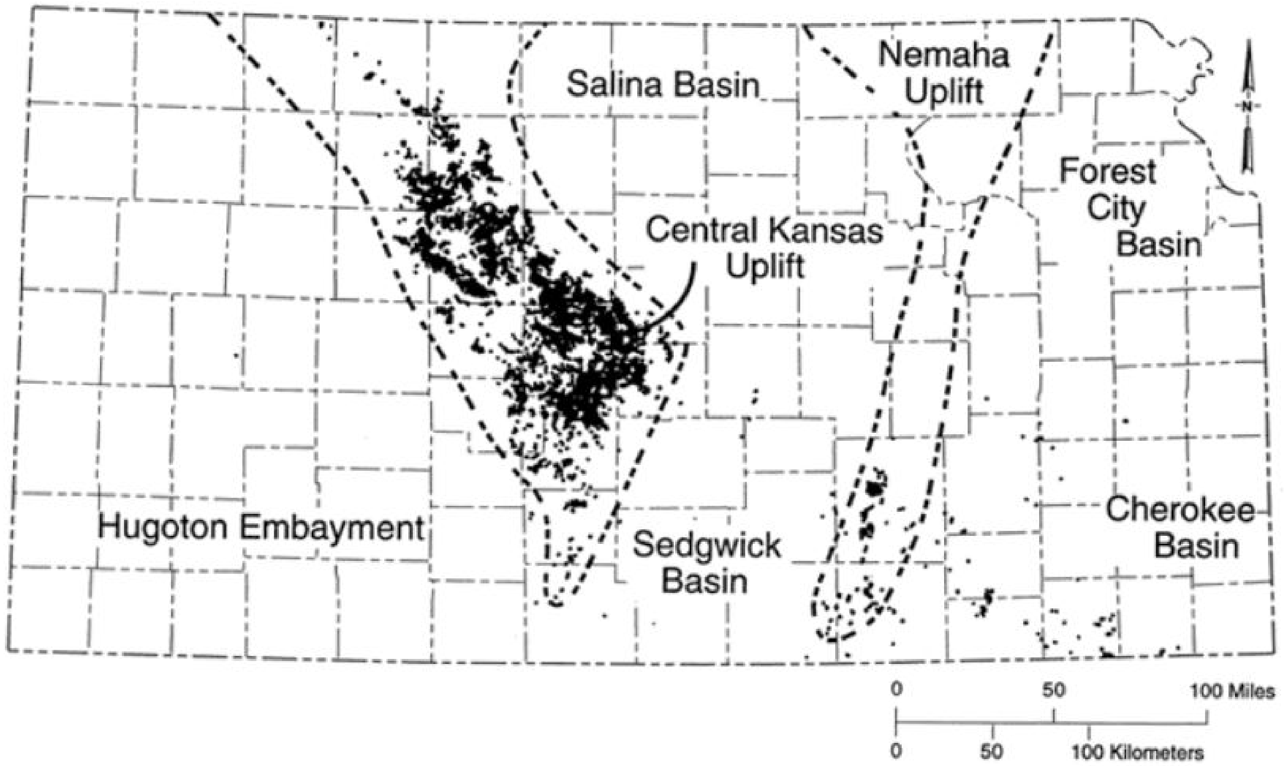
Lessons Learned and Recommendations

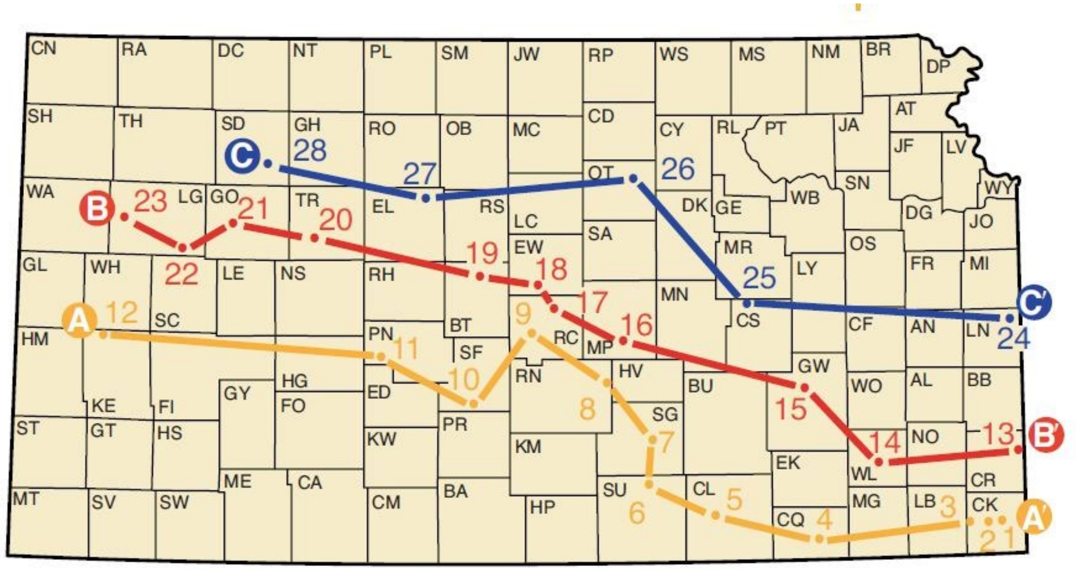
- Kansas is centrally positioned to become a distribution HUB for CO_2
- Competition for resources means that careful site selection is essential
- Alternative resources for disposal/storage are likely available, more research is needed
- CO_2-EOR option is important for CCUS success in the Mid-Continent
- Source to sink problem: nation-wide infrastructure is required
- State-level legislation is necessary

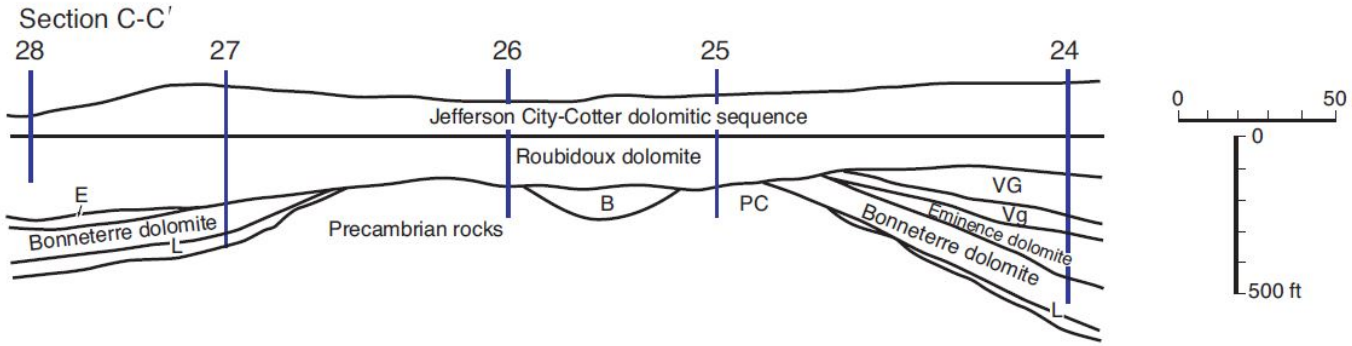
- Next steps?

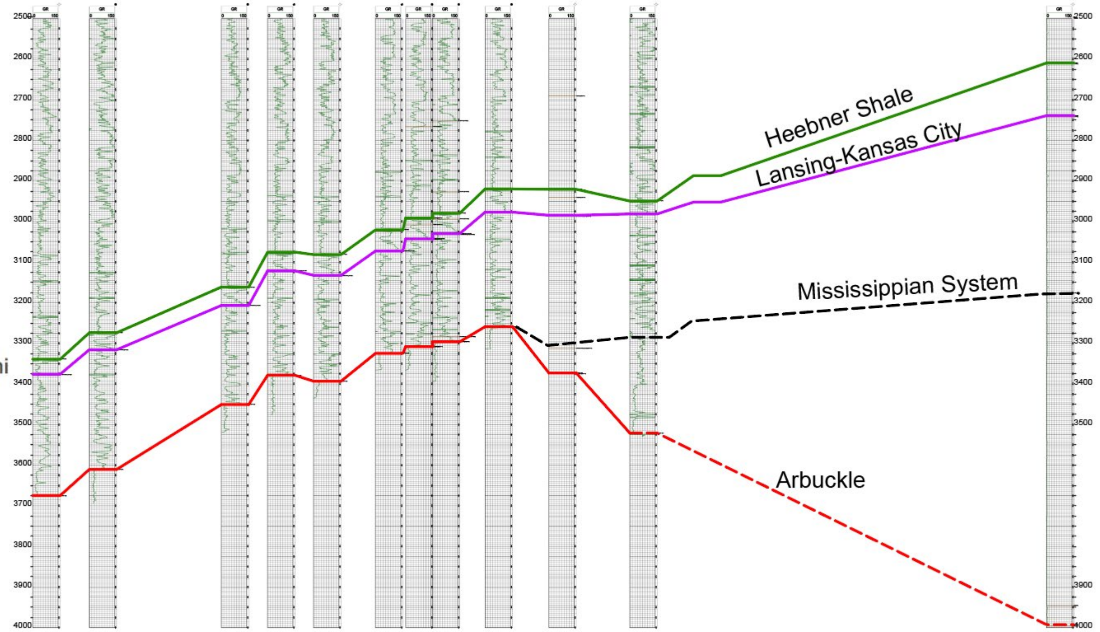
La Cygne Generating Station, KS, 1.5 gigawatts, 4.2 Mt CO_2

Salina Basin - ?

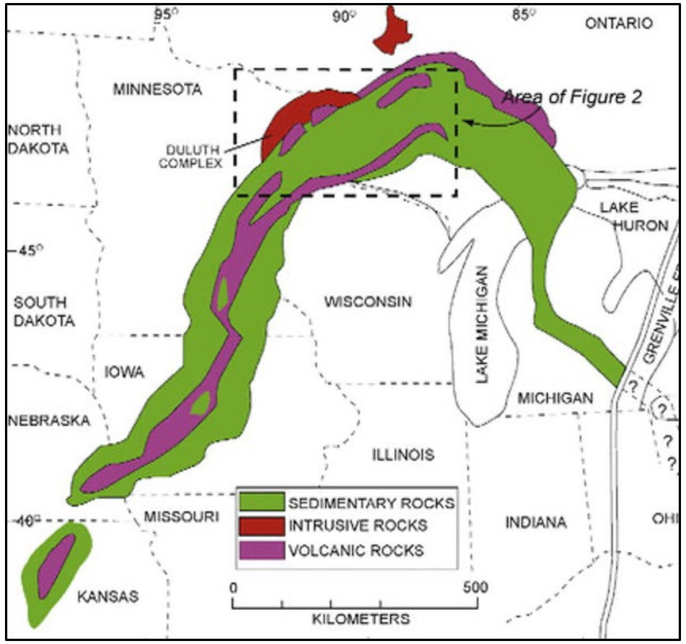








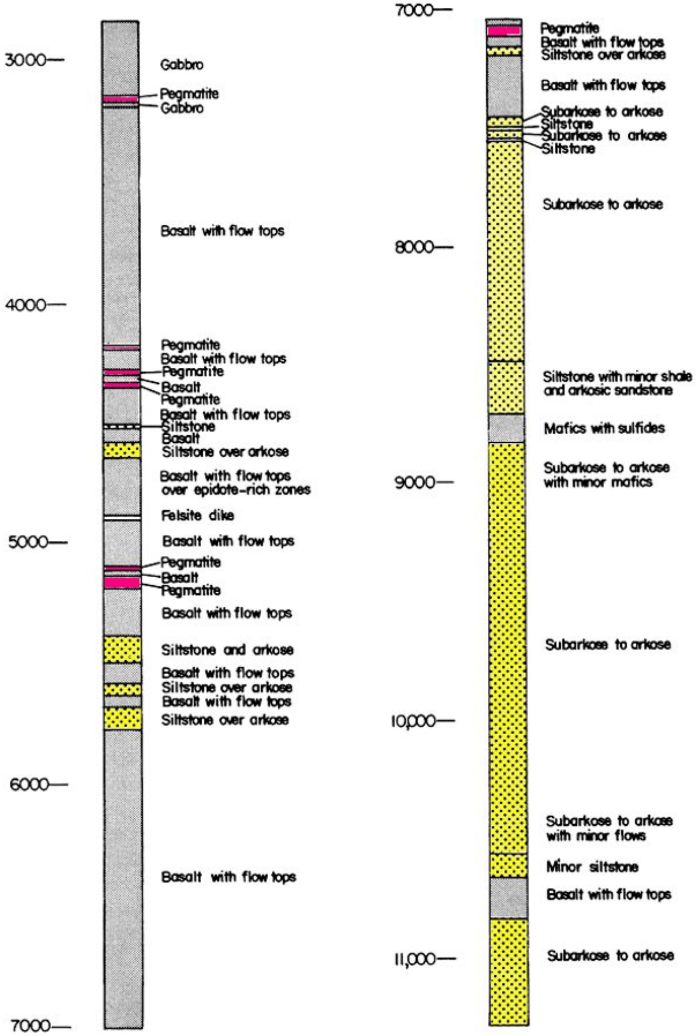
Basalts in Kansas - ?



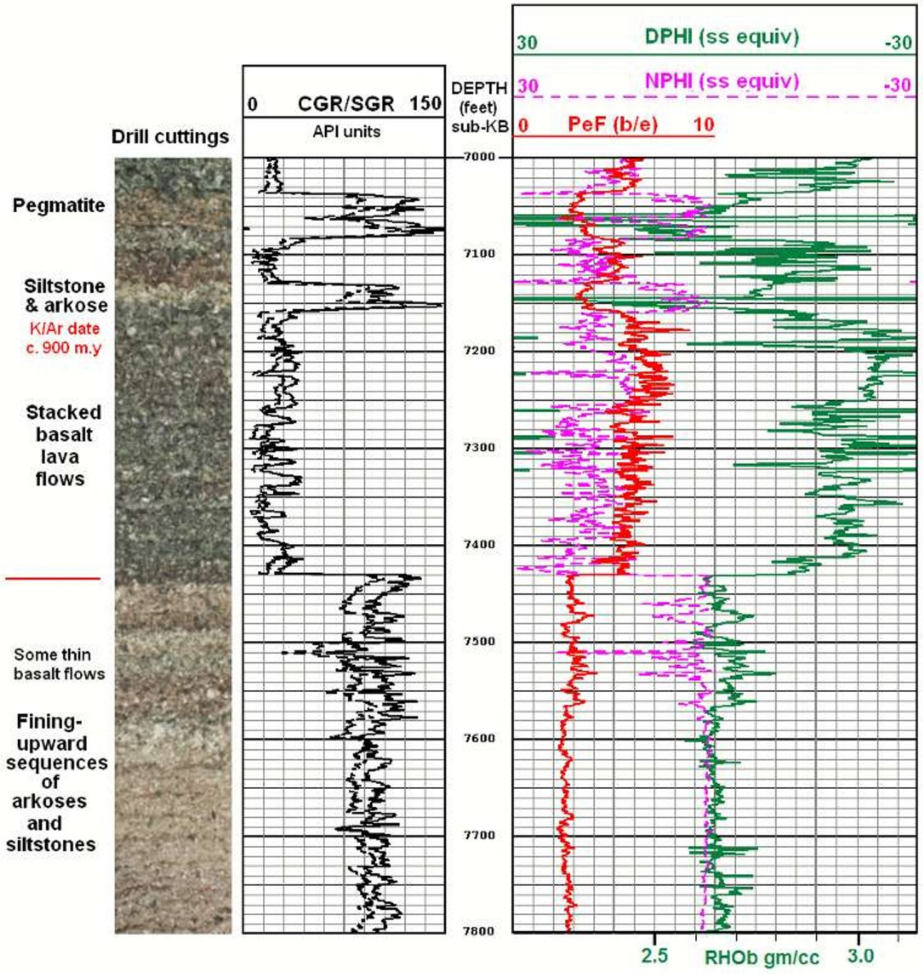
Midcontinent Rift's southernmost expression is in Kansas

One type well (Poersch #1) shows ~4000 ft of plus interbedded feldspar-rich sand/siltstones

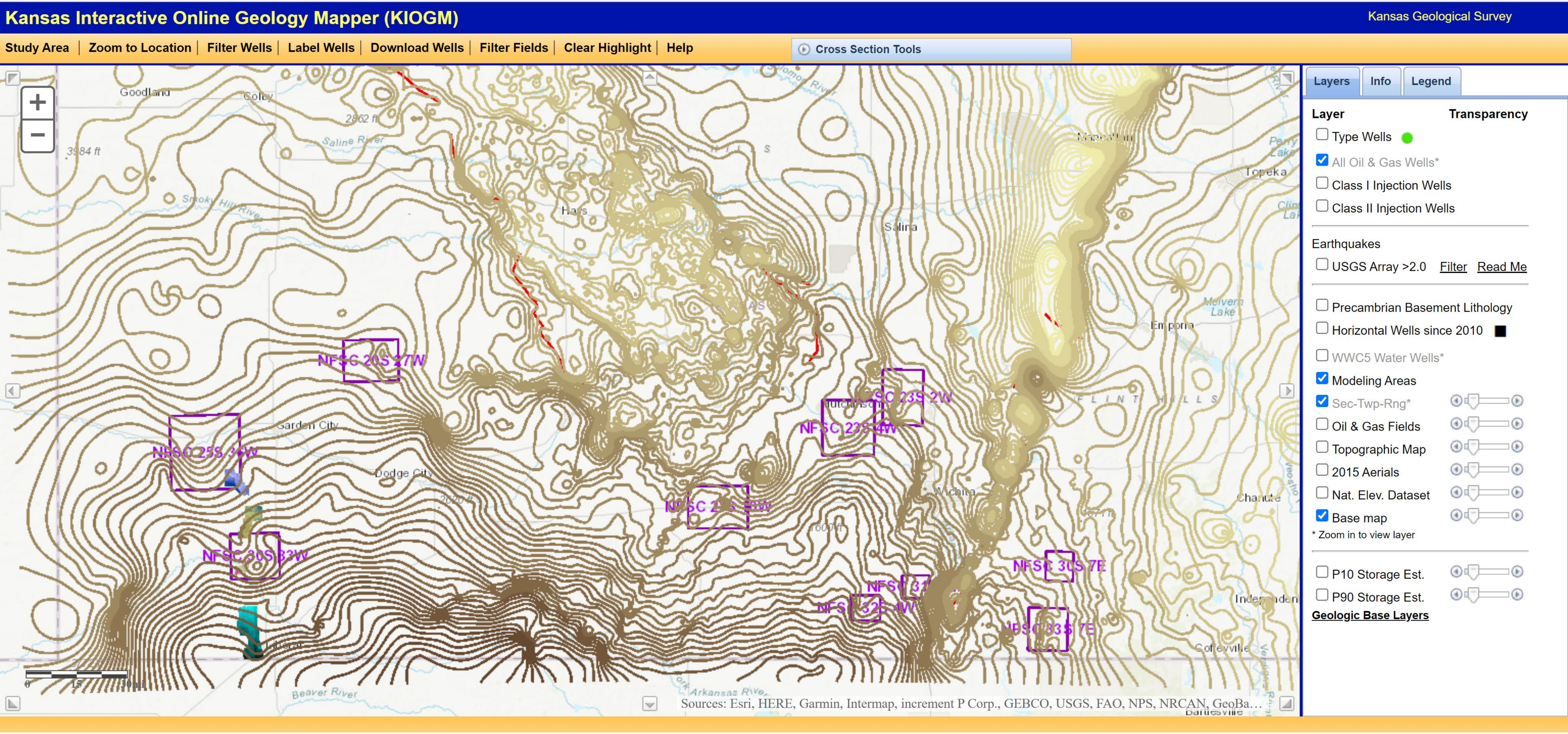
Depth is over 3000 ft



Texaco Poersch #1

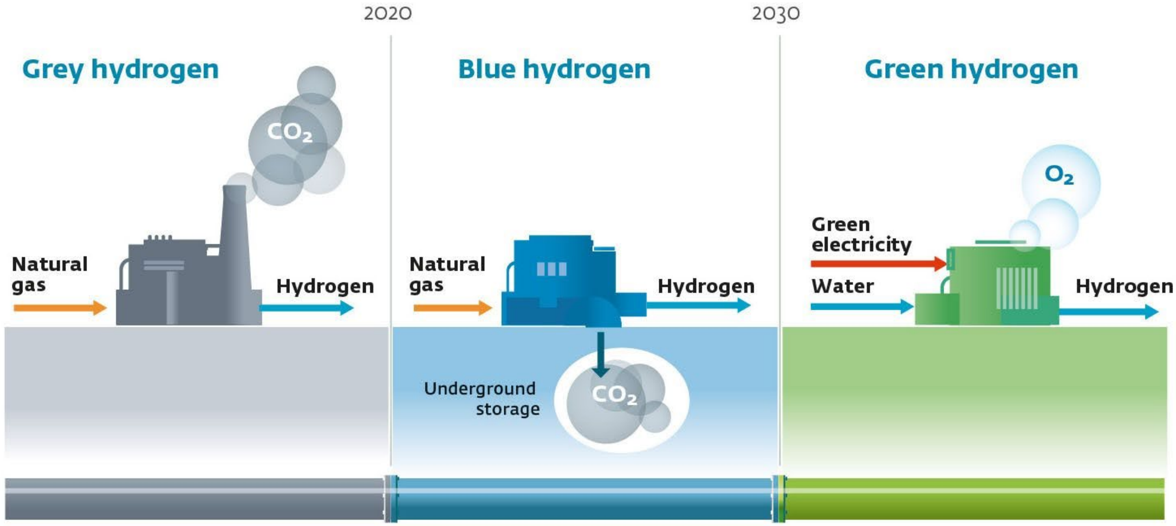


Precambrian Top – Basement Research -?



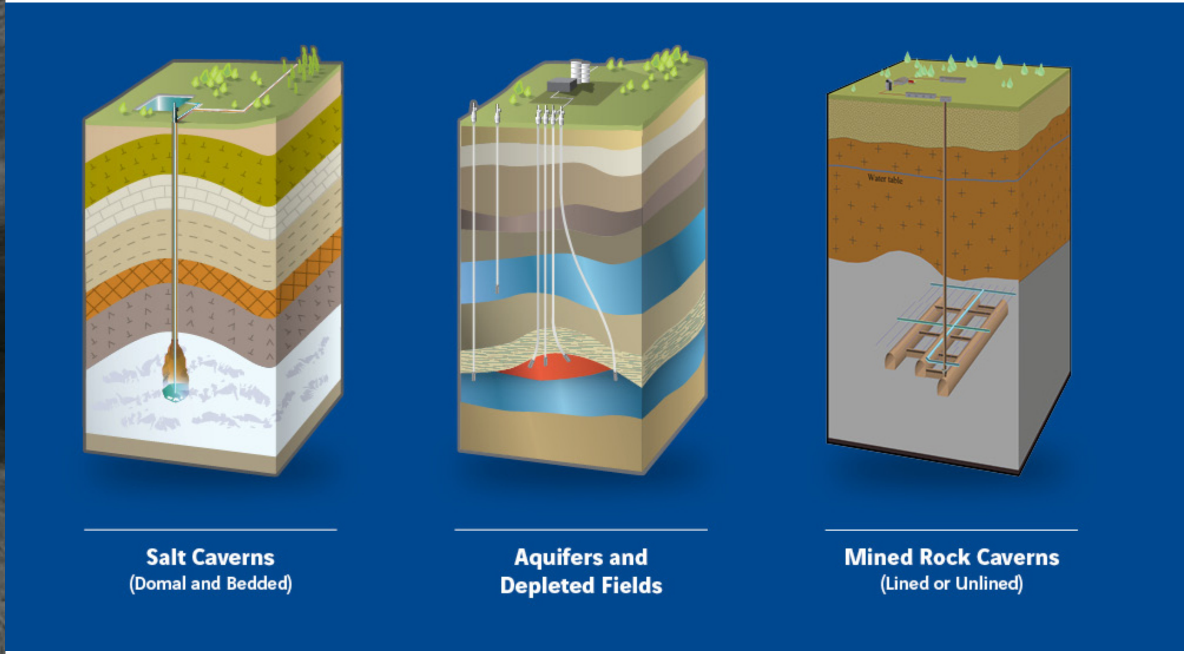
Hydrogen Infrastructure?

- Global hydrogen energy boom is coming?
  - According to Forbes, CNBC, Popular Mechanics, but also
  - US DOE, IEA, EU Commission, and others
- Infrastructure boom is inevitable – scalability is critical
- Commercial technology exist but not wide spread and depends heavily on geology and resources



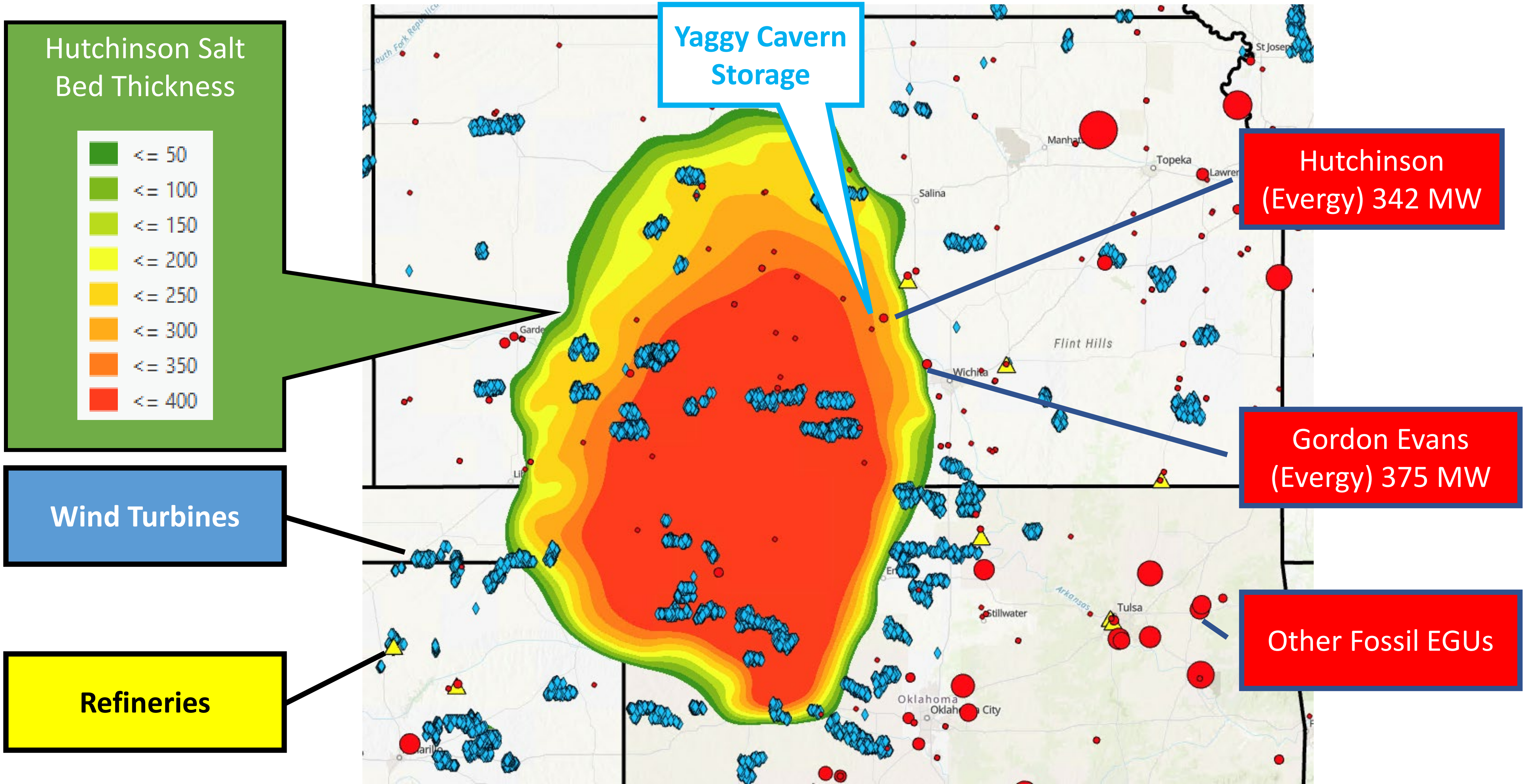
https://www.theworldofhydrogen.com/

Forbes: In Utah, Hydrogen And A Massive Salt Dome Are Winning The West For Renewable Energy

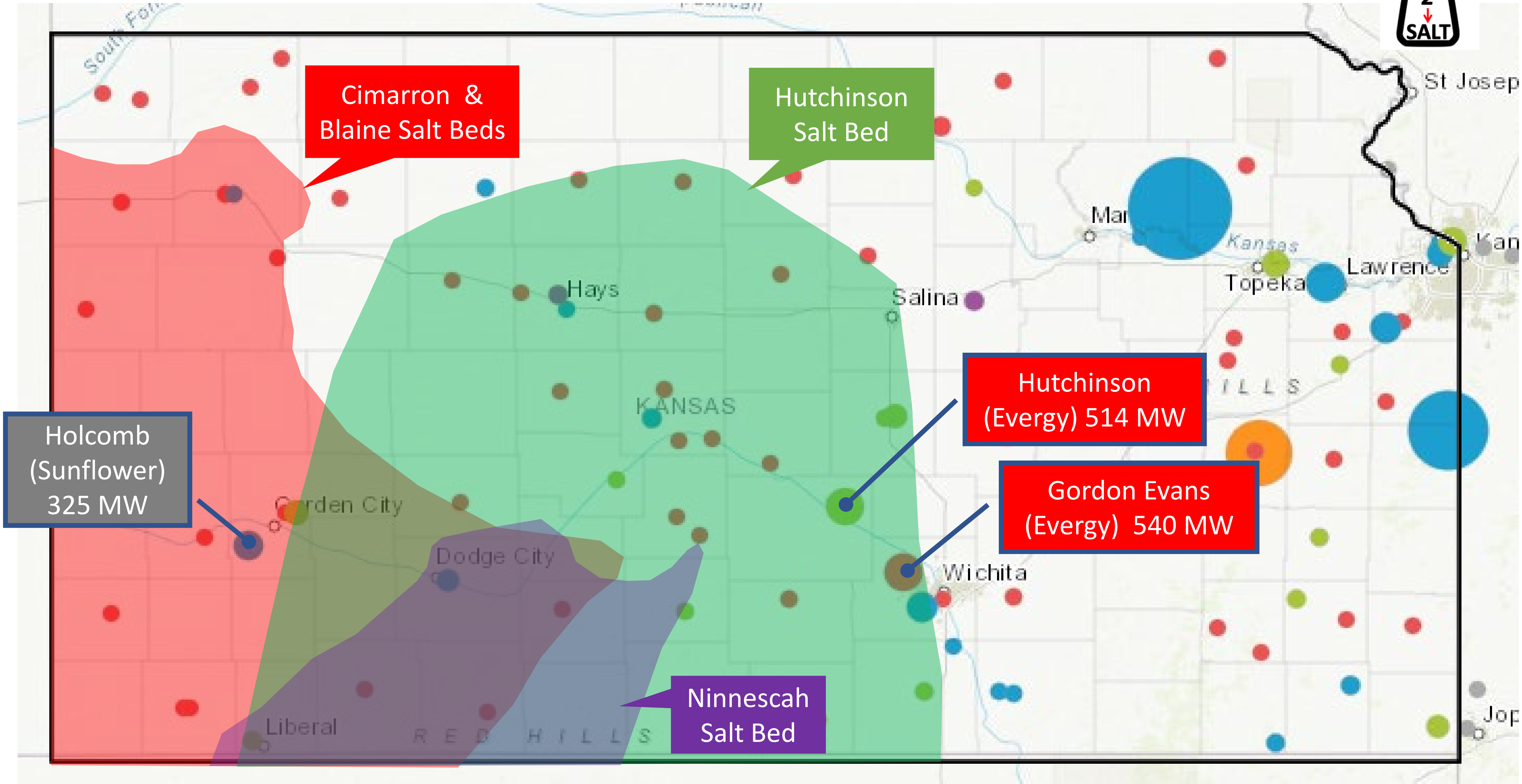


https://www.entrepose.com/en/geostock-sandia/

H2Salt: Geography of Storage in Kansas



H2Salt: Kansas Salt Beds

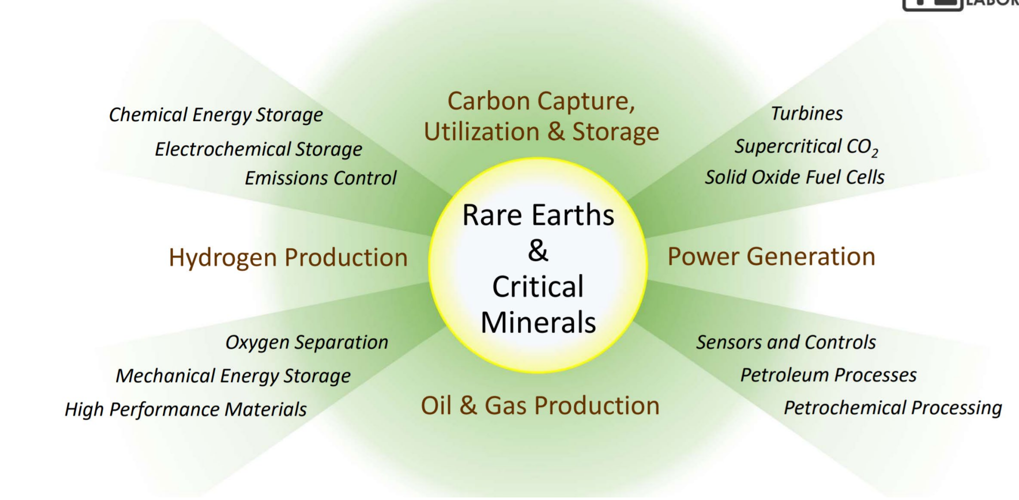


Critical Minerals

Wind turbines—permanent magnets	**REE (Nd, Dy, Sm, Pr)**
Photo-voltaics (PV)	**In, Sb, Ga, Te, Ag, Cu, Se**
Electric cars—batteries	**REE (La, Ce, Nd, Pr), Li, Ni, Co, Mn, graphite**
Electric cars—magnets	**REE (Nd, Dy, Sm, Pr)**
Electric cars—fuel cells	**PGE, Sc**
Cars—light metals	Al, Mg, **Ti**

REE-CM Critical Commodity & Technology

NATIONAL ENERGY TECHNOLOGY LABORATORY



PBS NEWS HOUR

The U.S. is worried about shortages of critical minerals for electric vehicles, military tech

Nation Apr 13, 2021 5:14 PM EDT

When U.S. companies build military weapons systems, electric vehicle batteries, satellites and wind turbines, they rely heavily on a few dozen "critical minerals" – many of which are mined and refined almost entirely by other countries. Building a single F-35A fighter jet, for example, requires at least 920 pounds of rare earth elements that come primarily from China.

That level of dependence on imports worries the U.S. government.

Deloitte. Insights

Trend 10: Meeting demand for green and critical minerals

The conversion to renewable energy and electrification are central to the world's clean energy future...

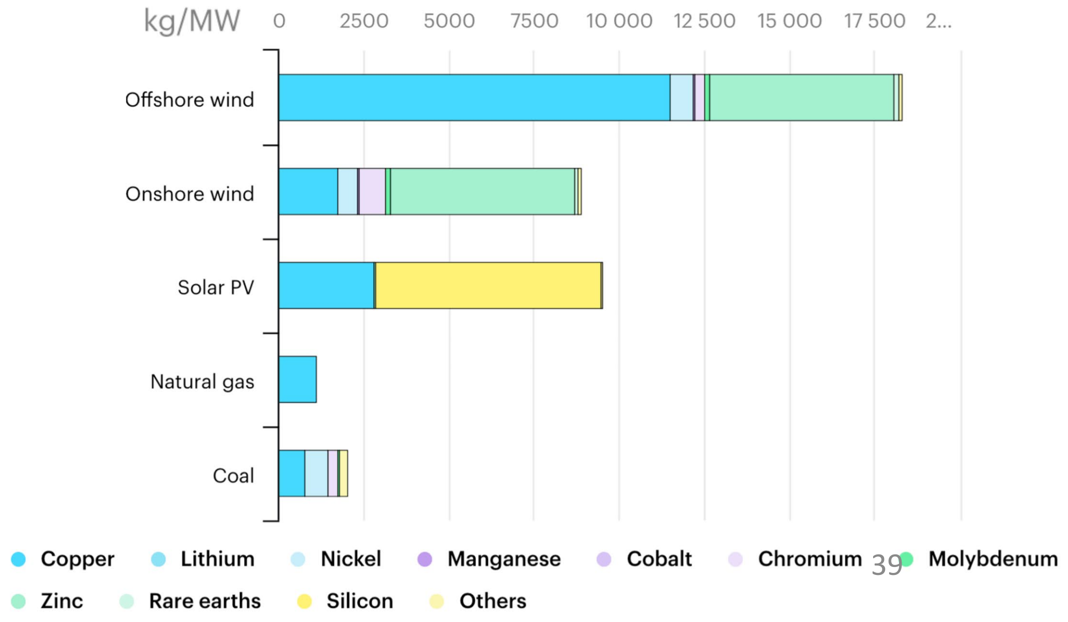
THE CONVERSATION

February 16, 2020 1.55pm EST

Critical minerals are vital for renewable ener

As the world shifts away from fossi fuels, we will need to produce enormous numbers of wind turbines, solar panels, electric vehicles and batteries. Demand for the materials needed to build them will skyrocket.

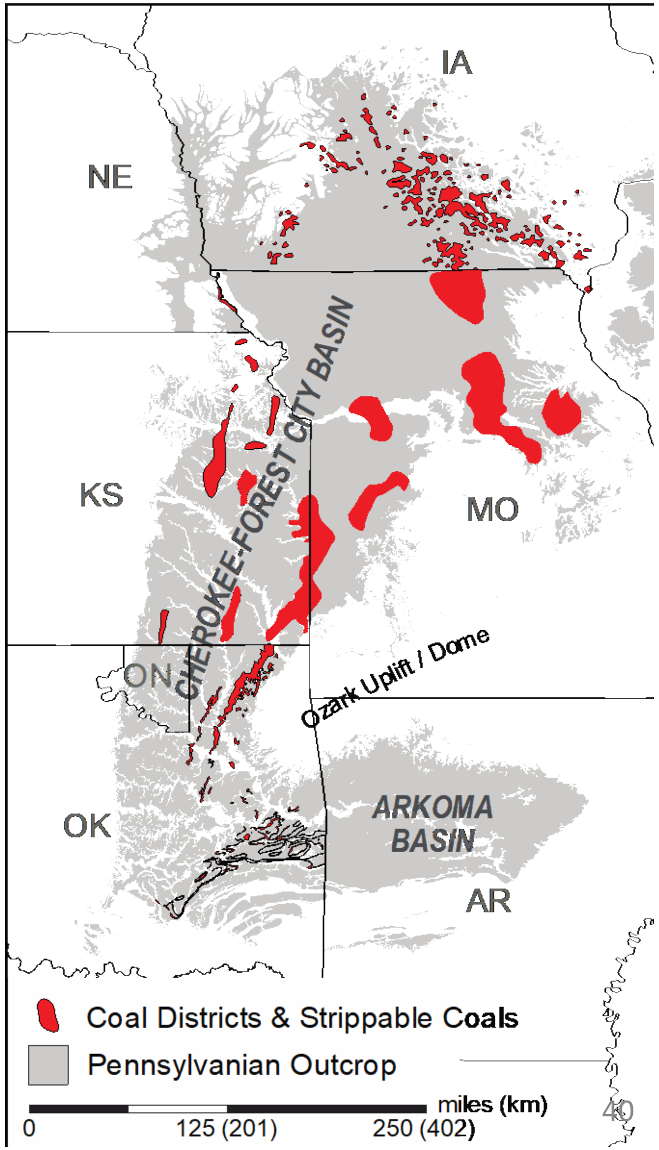
Minerals in selected power generation technologies



Critical Minerals: Cherokee-Forest City Basin

- Stretches across several Midwestern states and Indian nations
- Legacy of coal mining and reclamation
- Close to industry

CORE-CM INITIATIVE



Summary & Conclusions

- CCUS is rapidly developing and becoming commercially viable technology thanks to 45Q and other incentives. There is a strong momentum building in many industrial sectors to use CCUS, hydrogen generation, energy storage, and other technologies as an alternative to "business as usual".
- KS is a strategic region due to available resources
  - Geographic position
  - Developed power generation, ethanol, agriculture, infrastructure, and oil & gas
  - Geological resources: available and accounted
- If positioned correctly, KS could become a HUB platform for many future sustainable energy projects
- CCUS R&D projects performed by KGS and partners are strategic resource:
  - Industry connections
  - Geology and engineering know-how
  - Regulatory and policy issues: UIC Class VI, 45Q, etc.
  - Economics
- Characterization, assessments, data, and analysis performed for CCUS projects could be used as leverage for other industries including other waste-fluid injection operations

Acknowledgements & Disclaimer

Acknowledgements

The work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) under Grants DE-FE0029474 and DE-FE0031623. DE-FE0031623 project was managed by Joint Pis Andrew Duguid, Eugene Holubnyak, Jared Walker, Neil Wildgust and administered by Battelle Memorial Institute, Kansas Geological Survey/KUCR at the University of Kansas, and Energy and Environment Research Center at the University of North Dakota. Project DE-FE0029474 was managed by Joint Pis Eugene Holubnyak, Marty Dubois, and Tandis Bidgoli and administered by Kansas Geological Survey/KUCR at the University of Kansas. Both projects were funded by DOE/NETL and cost-sharing partners: Berexco LLC, Nebraska Public Power District, Evergy, ADM, Cargil, Linde, Sunflower Energy, and others.

Questions?

http://www.kgs.ku.edu/PRS/petroProj.html

Jeffrey Energy Center, KS, 2.16 gigawatts, ~12Mt CO_2