Field Evaluation of the Caney Shale as an Emerging Unconventional Play, Southern Oklahoma

DE-FE0031776

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U.S. Department of Energy

National Energy Technology Laboratory

2021 Carbon Management and Oil and Gas Research Project Review Meeting

August 2021

Presentation Outline

- Caney Project is on target and delivered more than was planned by SOPO as we added NETL CT/XRF scanning of entire 650ft of core and the findings are reported by NETL in:

Paronish, T., Schmidt, R., Moore, J., Crandall, D., Bunger, A., Rihn, A., Doughty, C., Renk, J., Katende, A., Wang, Y., Puckette, J., Radonjic, M. ***Computed Tomography Scanning and Geophysical Measurements of the Caney Shale Formation from the Tomaney #1-35-34-27 Well***, NETL-TRS-X-2021; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Morgantown, WV, August, 2021

https://www.netl.doe.gov/energy-analysis/details?id=2fdcc757-199e-4d15-8b4a-c0a11611fc2a

- Present progress/findings on Tasks 4-8
- Tasks 9 and 10 are in progress as drilling of new well is in progress - August 2021
- Answer any questions and provide clarification

Task 4 Geology: Technical Status and Accomplishments

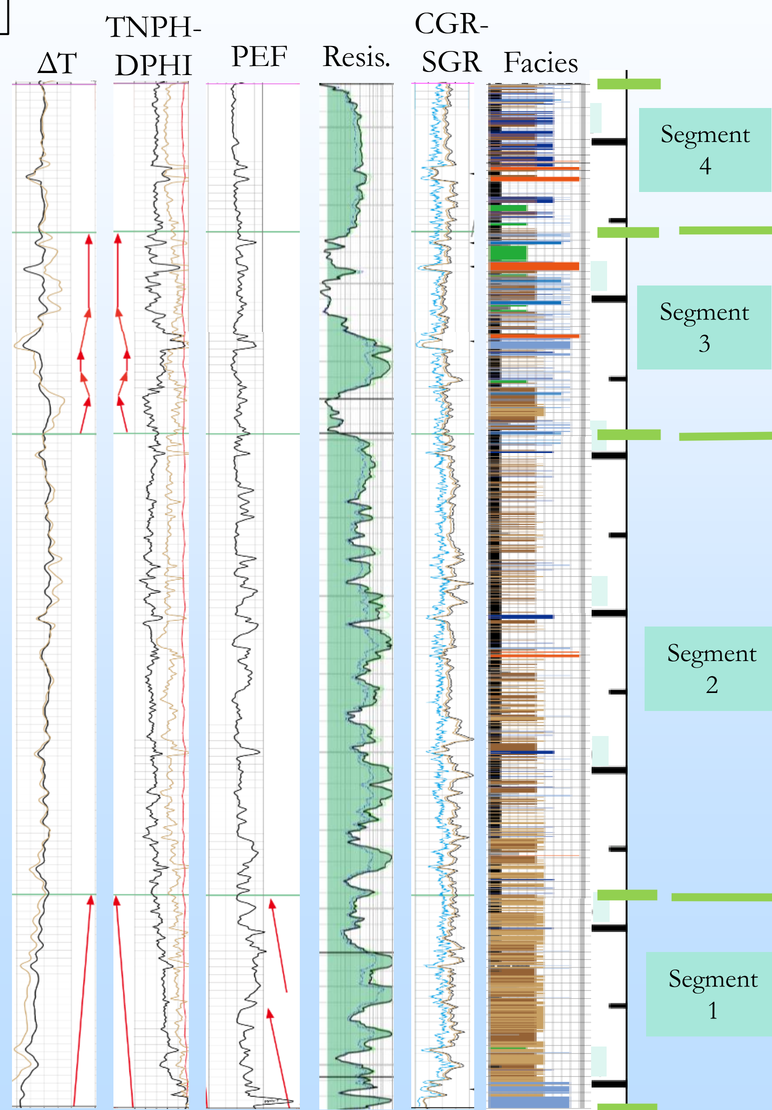
Task 4A: Facies-Core-Log Tie

Lithology	Code	Facies
carbonate	10	dolomitic facies (DLM)
	9	packstone-grainstone (Ps-Gs)
	8	packstone to rudstone (Ps-Rs)
siltstone (to mudstone)	5	massive-bedded siltstone (Sm)
	7	bioturbated calcareous siltstone (Scb)
	6	burrowed mudstone (MSb)
mixed / siltstone	4	banded facies (BF)
	3	laminated carbonate and mudstone (CMla)
mudstone	2	laminated mudstone (Mla)
	1	massive-bedded mudstone (Mm)

- 4 segments with different facies & log response
  - Potential units as stratigraphic framework for mapping
- Facies variations within each segment
  - Hierarchical facies change
- Various orders of sea-level changes (?)
  - updip sediment supply
  - in-situ water condition

all log values increases from left to right, except for TNPH-DPHI (right to left)

vertical scale in 50 ft/17 m



[Facies] similar % of Mm, MSb, Sm w/ scattered Ps-Gs
[Log Response] overall "flat" w/ thick carbonate

[Facies] abundant carbonate gravity flow deposits in Mm, MSb
[Log Response] most dynamic among four segments

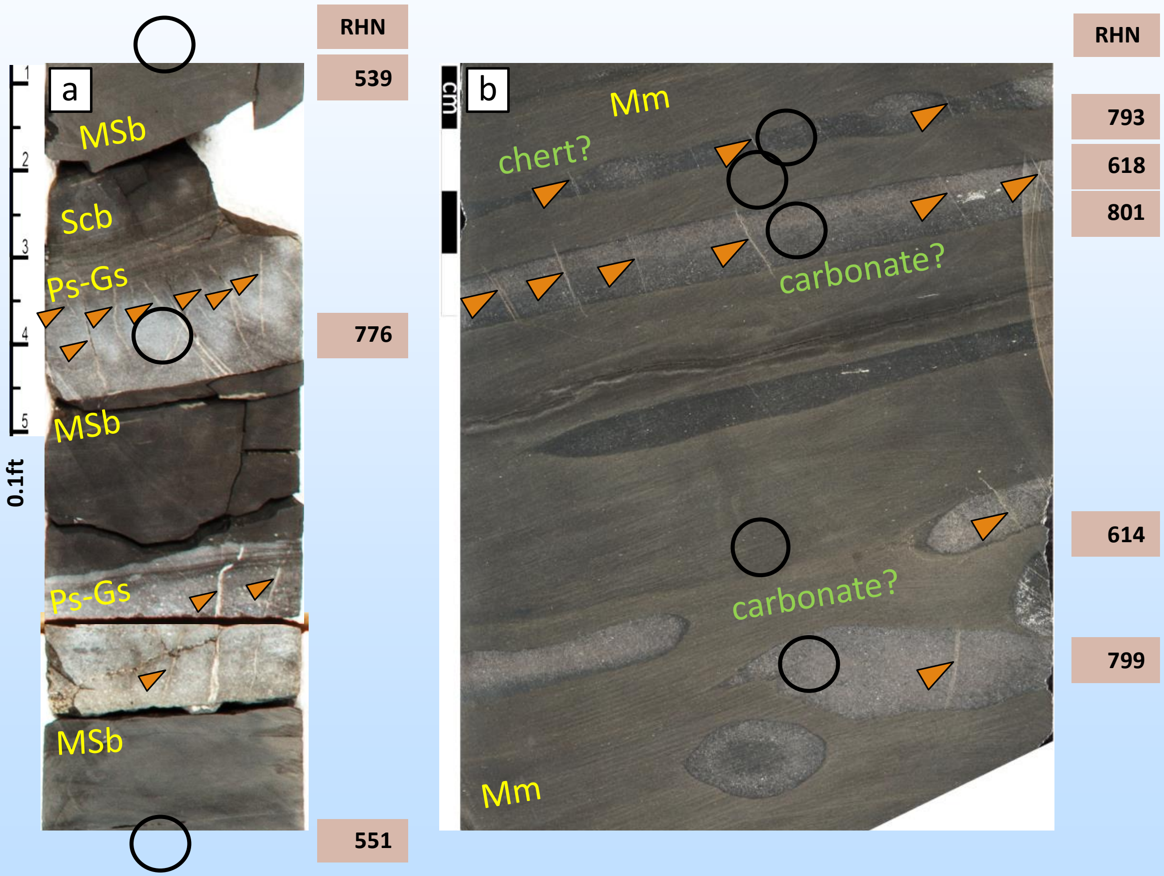
[Facies] dominantly **Mm** w/ scattered Scb, MSb, Ps-Gs
[Log Response] Overall "flat"
Fluctuations related to interspersed facies variations

Regional Flooding Event?

[Facies] dominantly **Scb, MSb** w/ Mm near top
[Log Response] "flat" GR; upward decreasing ΔT, φ, PEF

Task 4 Geology: Technical Status and Accomplishments

Task 4A: Geomechanical Properties and Fracture Distribution



Fractures Rebound hardness test location RHN Rebound hardness value

MSb: burrowed mudstone-siltstone

Ps-Gs: packstone-grainstone

Scb: bioturbated calcareous siltstone

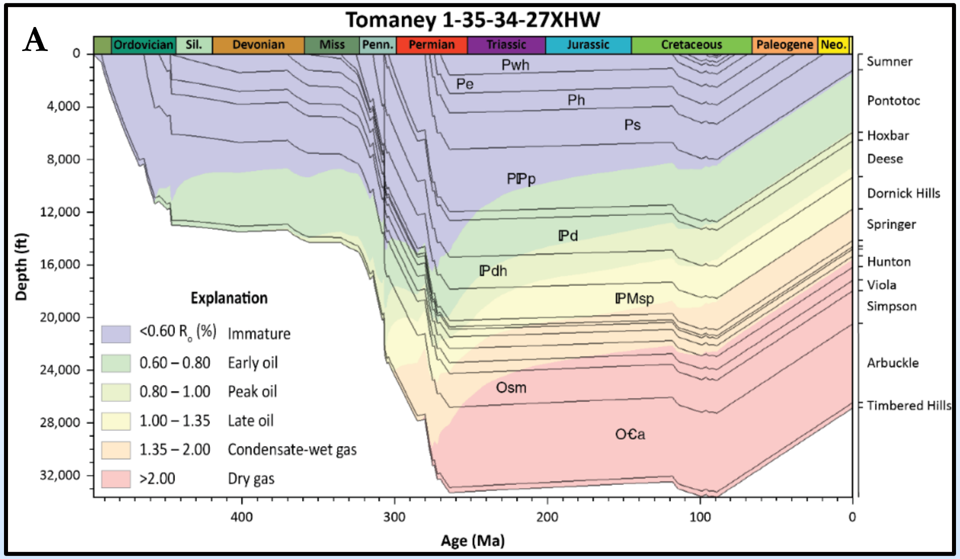
Mm: massive-bedded mudstone

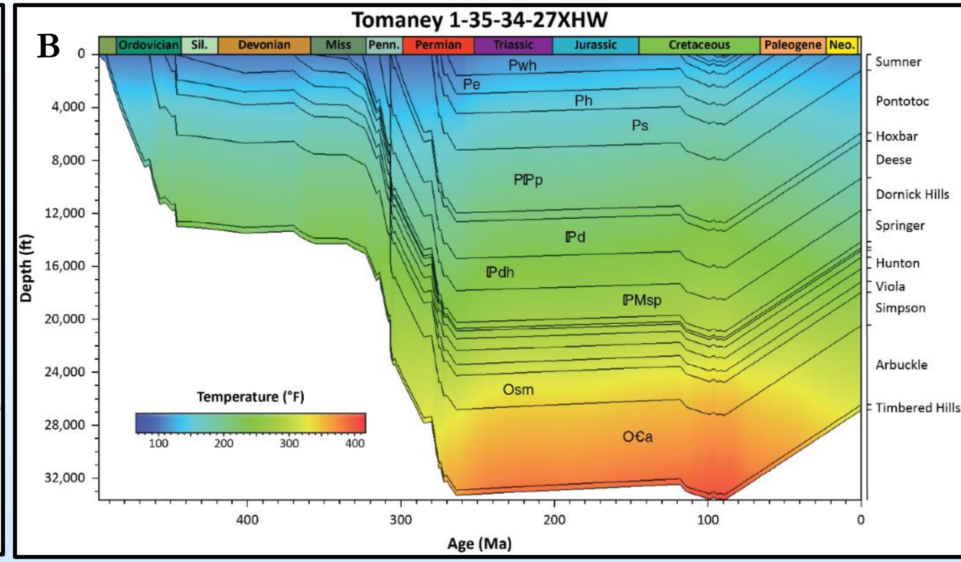
- **Fracture distribution**
  Compartmentalized across multiple scales
  - More abundant in carbonate (a)
  - Confined by thin carbonate- and silica-rich layers within mudstone (b)
- **Rebound hardness**
  Overall: chert (>800 HLD) > carbonate (700 to 800 HLD) > siliceous/calcareous mudstone-siltstone (500 to 700 HLD) > organic-rich mudstone (<500 HLD)

  Distinctive heterogeneity related to mineralogy (b)
  - Silica- and carbonate-rich layers-nodules vs. mudstone matrix

Task 4 Geology: Technical Status and Accomplishments

Task 4A: Burial and Thermal History Models



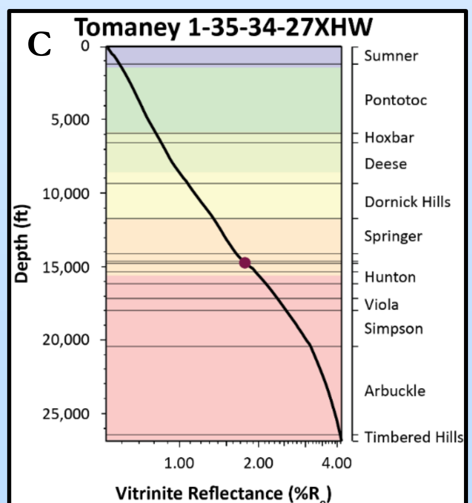


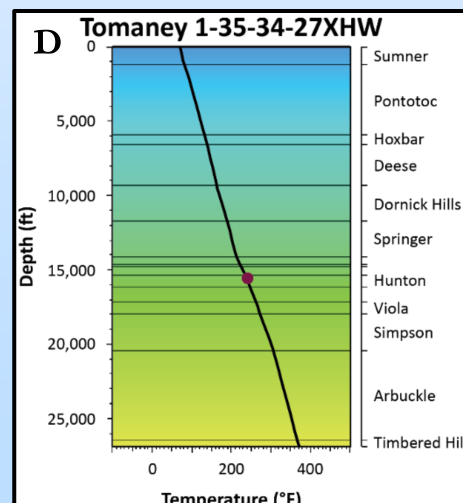
A) Burial history model with thermal maturity windows.

B) Thermal history model showing temperature and burial history.

C) Modeled vitrinite reflectance-depth plot showing match between calculated thermal maturity and control on vitrinite reflectance in Caney Shale

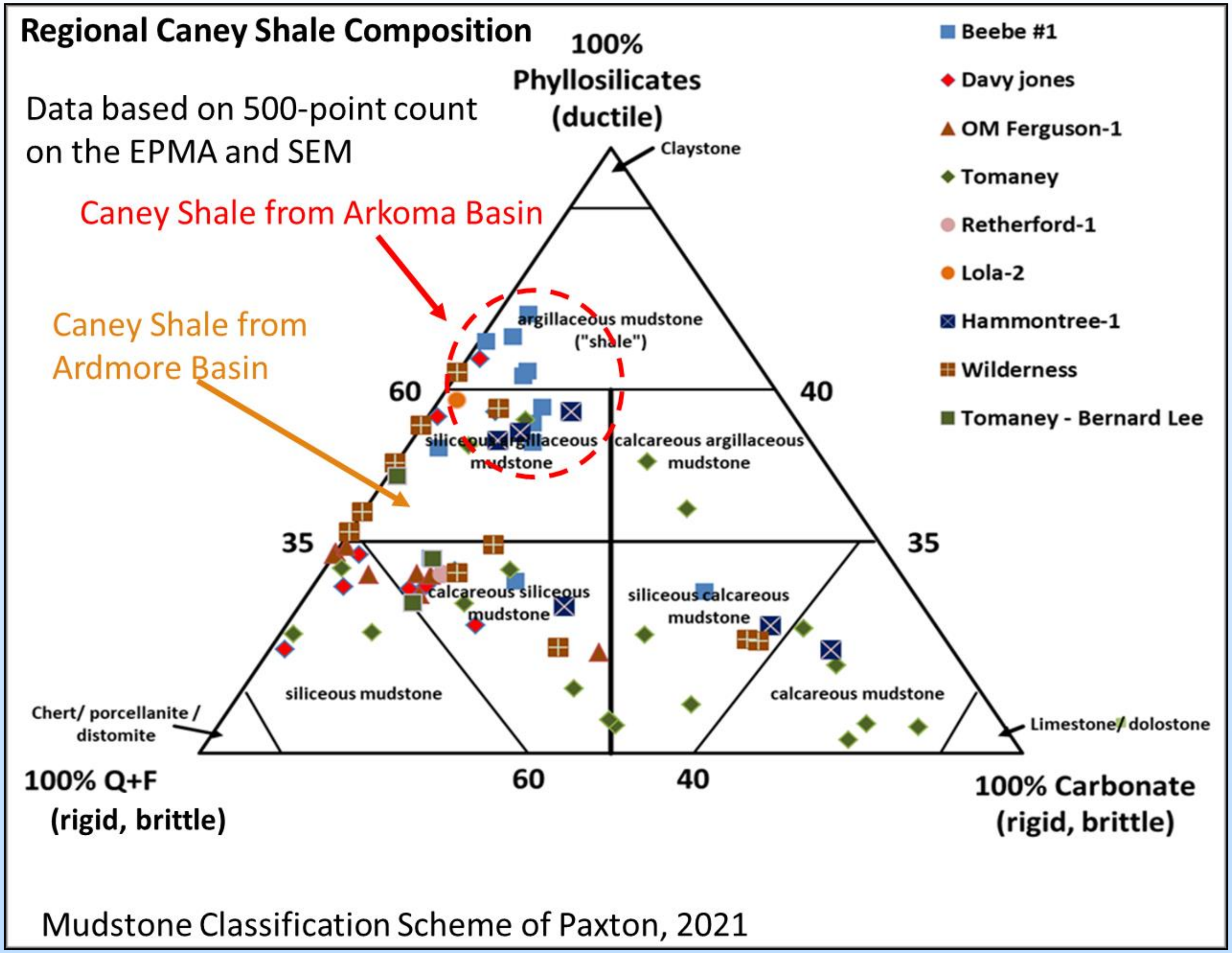
D) Modeled temperature-depth plot showing match between calculated temperature and control point in the Caney Shale.





Task 4 Geology: Technical Status and Accomplishments

Task 4B: Caney Compositional Classification



Task 4 Geology: Technical Status and Accomplishments

- Reservoir Characterization
- Facies, stratigraphic and chemostratigraphic analysis
  - Described facies in detail, analyzed depositional processes, constructed stratigraphic framework
  - Constructed elemental profiles, compared OSU and NETL data sets
  - Classified and compared facies in core from Ardmore and Arkoma basins and outcrop
  - Established basin wide generalized sequence stratigraphic framework
- Core and Conventional Analysis
- Core Acquired February 2020 – Total 650 feet – 95 Tight Rock Analysis measurements – Complete Caney Section
  - Conducted facies and log analysis across multiple scales
- Cuttings Analysis
- Analysis of Tomaney well Vertical Cuttings underway
- Source Rock and Organic Geochemistry
- Burial and Thermal History Models Constructed – Tomaney well
  - Eroded overburden calculated using Ro vs. depth and regression analysis
- Characterization of Fracture Distribution and Geomechanical Properties

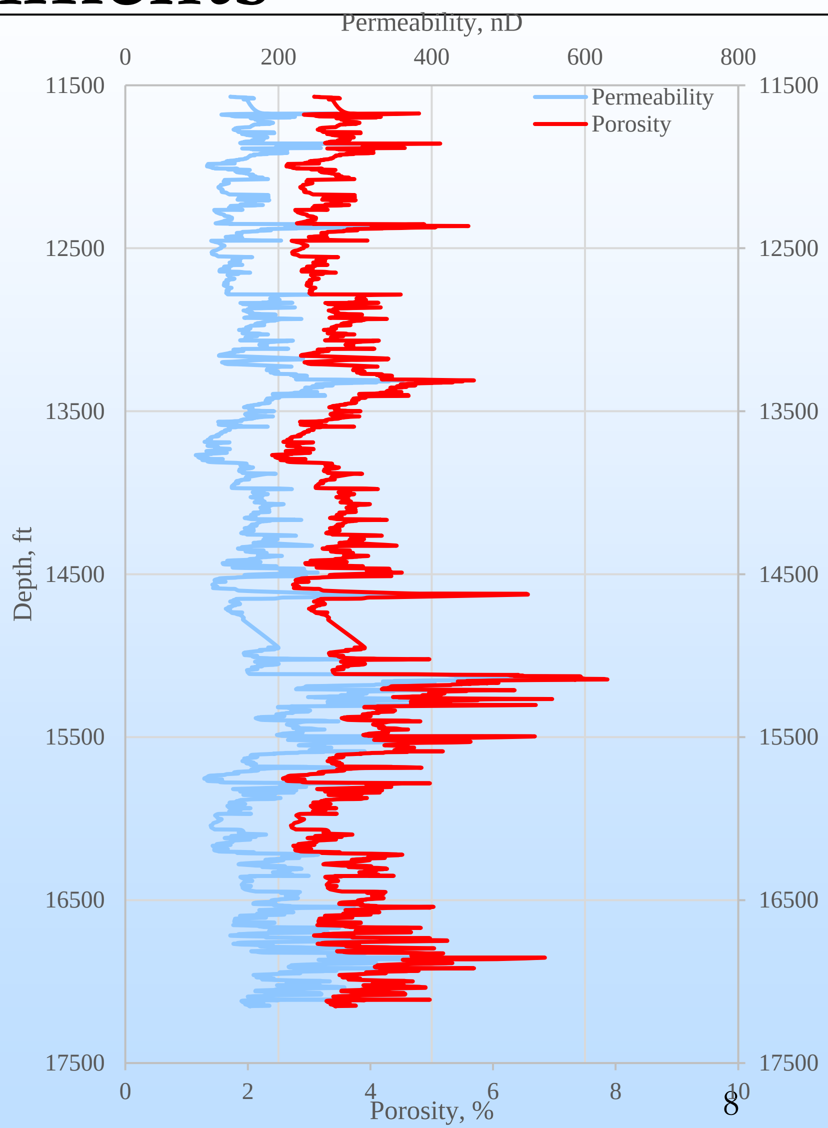
Distribution of Natural Fractures and Rebound Hardness Analysis

  - 1000 fractures described: height, orientation, kinematic aperture, mineralization, termination, spacing
  - 2100 rebound hardness data points acquired

Task 5A Drilling: Technical Status and Accomplishments

- Use drilling and core data to generate a stimulation index for selective stimulation in the Caney formation
- Utilized drilling data from the Gallaway well and rock core testing data from University of Pittsburgh in the Tomaney core
  - Utilized the D-WOB and D-ROCK software to calculate porosity, permeability, Young's modulus and Poison's Ratio of the Caney Formation
  - Combined all rock properties in the stimulation index (STIX)

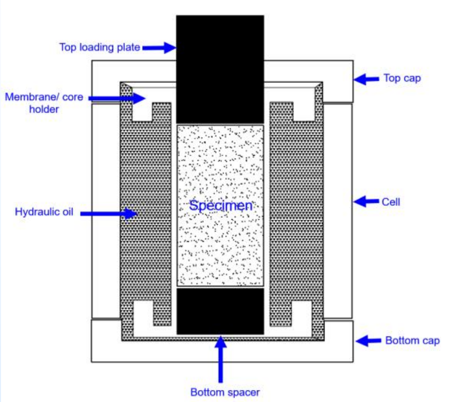
- Correlated the formation tops and strength logs to the Gallaway well
- Optimized the drilling simulation on the upcoming Gallaway well

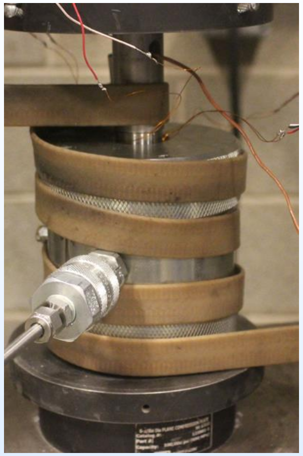


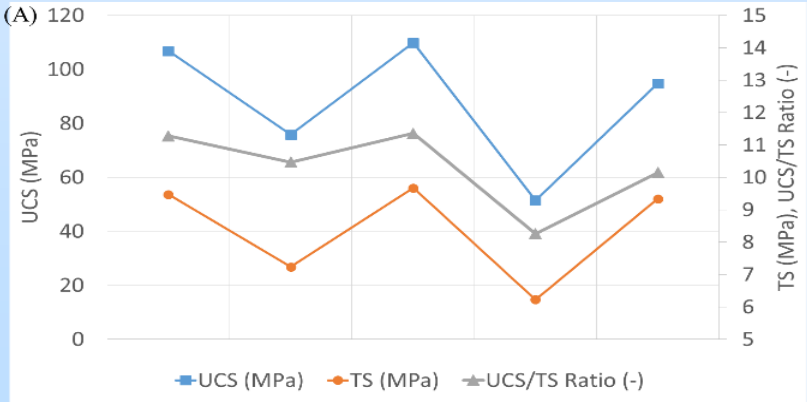
Porosity and permeability output from DROCK on Gallaway well

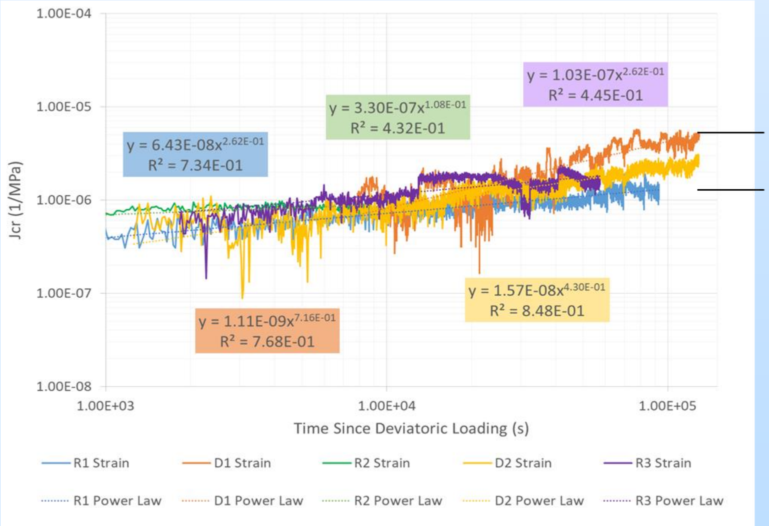
Task 5B Geomechanics : Technical Status and Accomplishments

- Strength and creep tests completed on vertical core plugs
- Nominally "ductile" zones are weaker and more prone to creep
- Zonation based on Poisson's ratio from sonic logs was successful at identifying zones expected to be more challenging for sustained production (even if nomenclature of "ductile" is technically misleading)





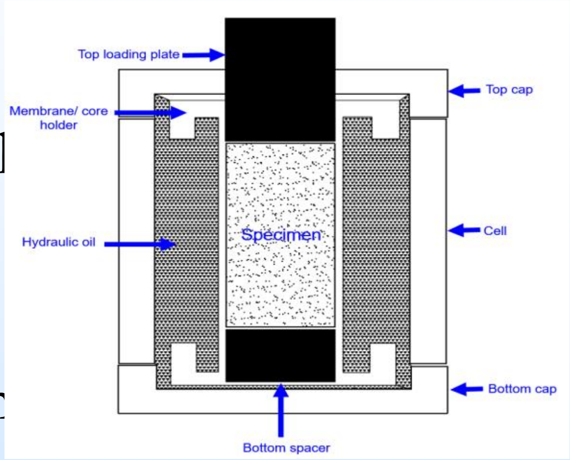


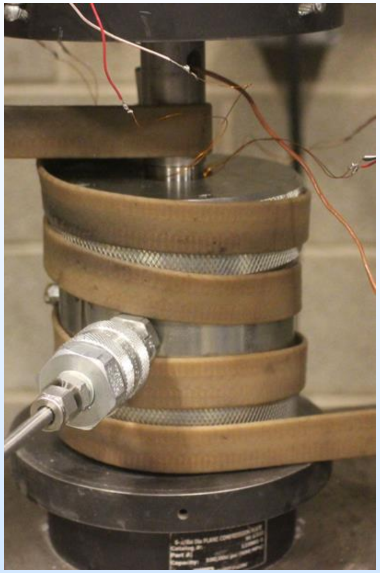


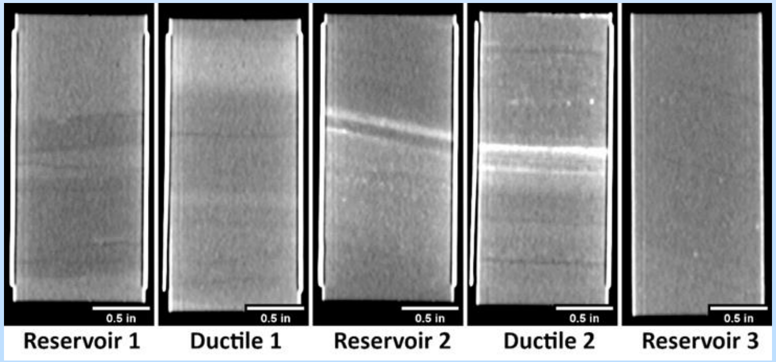
~4x greater creep compliance after 1 day for D1 compared to R1

Task 5B Geomechanics : Technical Status and Accomplishments

- Triaxial strength and creep testing completed on vertical core plugs\ (CT scans as shown)
- Next step – repeat testing on horizontal core plugs
- Incorporate results into geomechanics stress model and continued collaboration with LBNL for proppant embedment modeling



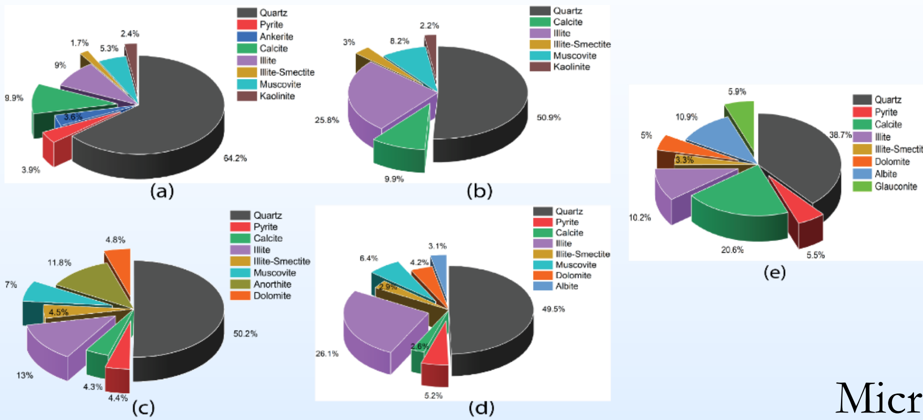




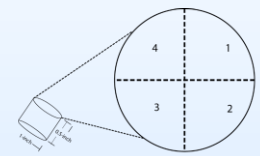
Task 6A Proppant Embedment: Technical Status and Accomplishments

Mineralogical Composition of 3 reservoir and 2 caprock-like samples

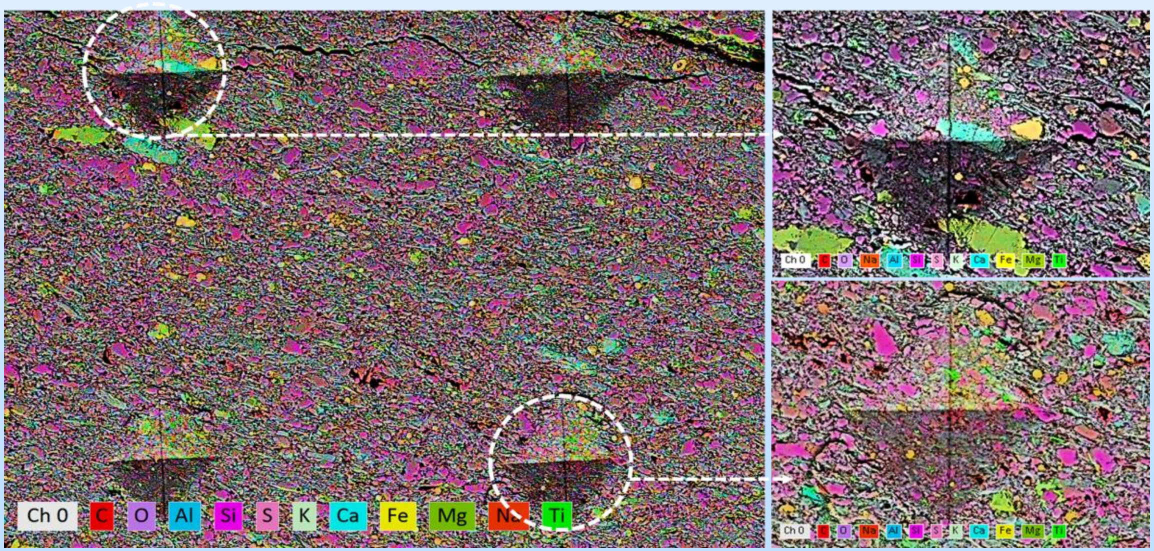
Well Depth (ft)	Formation Description	Sample Description
X006	Reservoir 1	Sample A
X087	Ductile 1	Sample B
X139	Reservoir 2	Sample C
X171	Ductile 2	Sample D
X404	Reservoir 3	Sample E

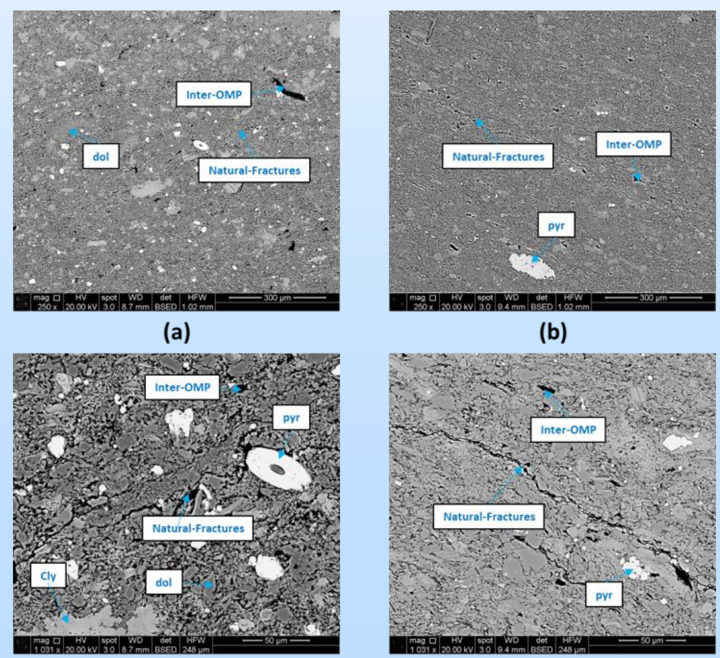


a) Res 3-45-deg-low mag
b) Res 3-90-deg-low mag
c) Res 3-45-deg-high mag
d) Res 3-90-deg-high mag



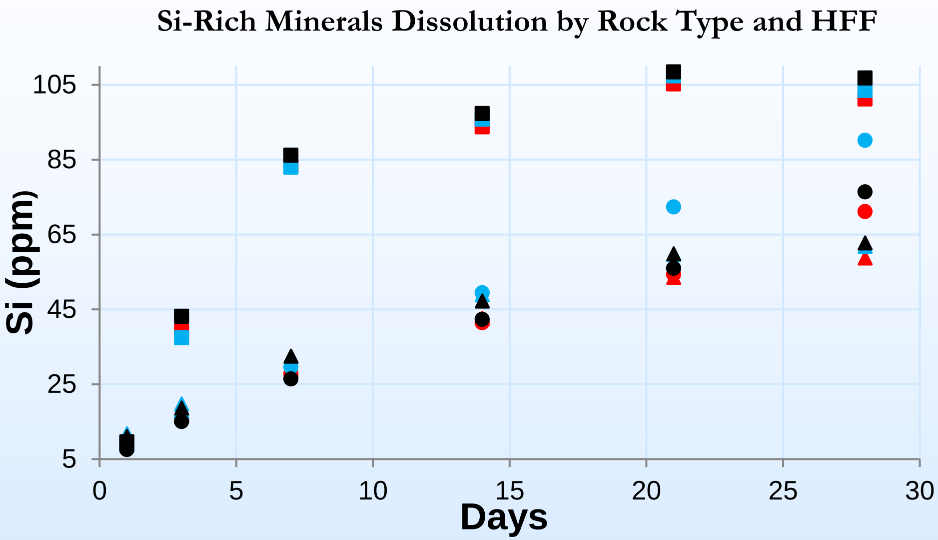
Microstructure and Microanalysis

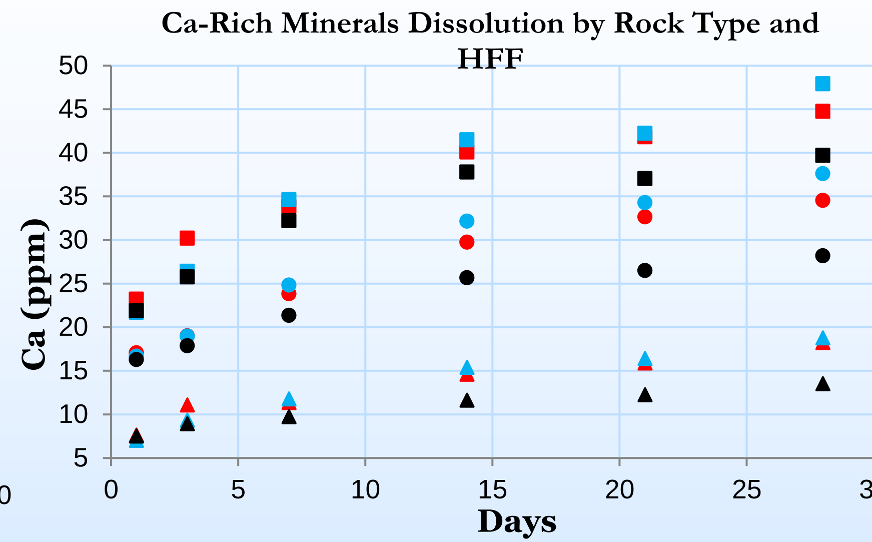




Microchemistry of Micromechanics: EDS/Micro-Indentation

Task 6A Geochemistry: Technical Status and Accomplishments





KCl ▭ CCl ○ DI △ Red -HQ Blue - MQ Black - HC

- Silicon shows continuous increase throughout sampling period
- Higher dissolution of quartz or cationic exchange in clay for clay stabilizer and low pH fluids

- Calcium shows continuous increase throughout sampling period
- Higher dissolution of carbonates in clay stabilizer and low pH fluids
- Indication of strong pH buffer for all the rock categories identified

Three fluid types as follows:

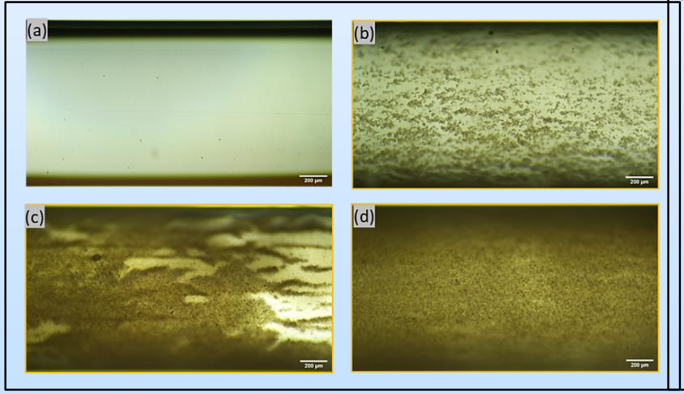
Fluid samples: Deionized Water (pH~7), 2% Potassium Chloride Solution (pH~4), and 0.5% Choline Chloride Solution (pH~4)

Task 6A: Proppant Embedment & Geochemistry: Technical Status and Accomplishments

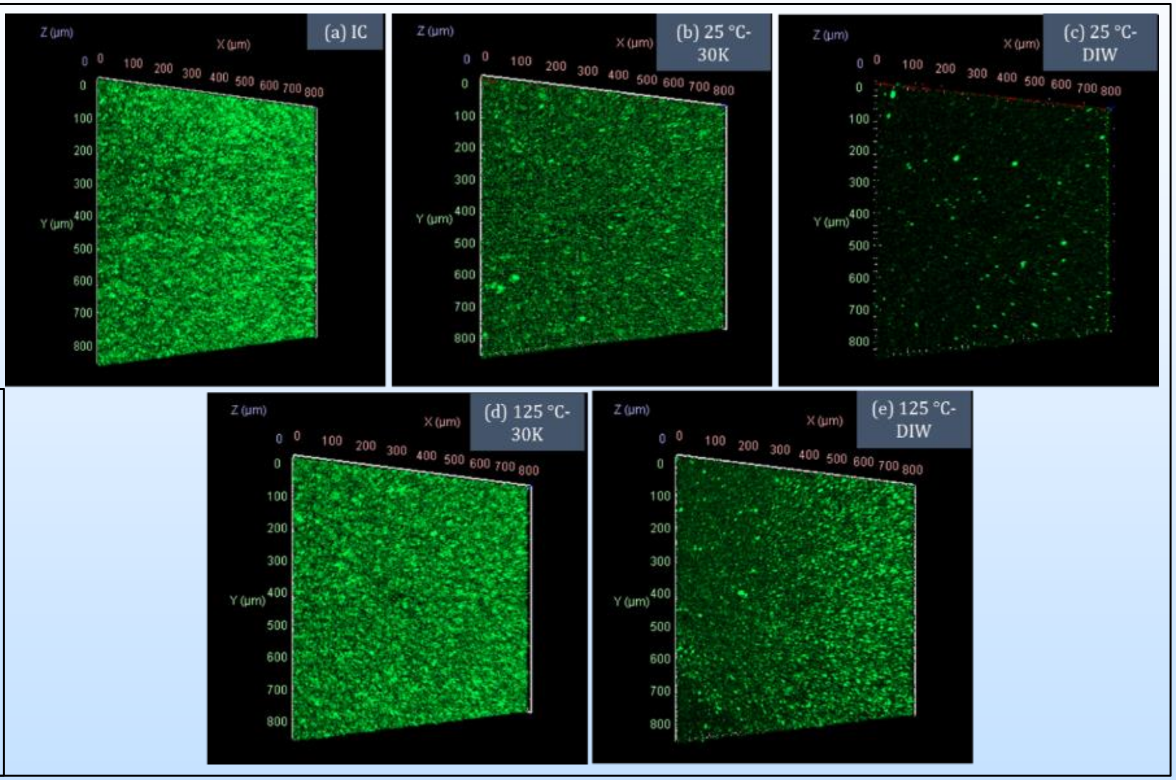
- Completed micro-geochemistry and mircro-geomehanical testing and provided data sets to LBNL for modeling
- Reported to CLR team on micro-geochemistry and mircro-geomehanical testing relevant to proppant embedment
- Bulk XRD analysis of all relevant rock depths has been completed
- For all categorized compositions of Caney Shale tested, there is a general good pH buffering potential
- Clay stabilizers are effective in preventing clay swelling
- Integration of XRF data and clay stabilizer reaction data provides a tool to understand the type of reactions expected at various depth of the Caney Shale
- Though pH buffering for all shale compositions was observed, its continuous upward trajectory needs to be investigated to ascertain where it flattens.
- NEXT:

Task 6B Clay-fluid Interaction : Technical Status and Accomplishments

Prepare a geomaterial micromodel representing clay chemistry of Caney Shale. Investigate following pore-scale behaviors of clays: Swelling, Fines migration, Wettability alteration, Porosity & permeability impairment



Glass capillary tubes coated with 10 wt.% Illite clay slurry prepared with Illite: (a) DI water, (b) 5000 ppm NaCl, (c) 10000 ppm NaCl, and (d) 30000 ppm NaCl.



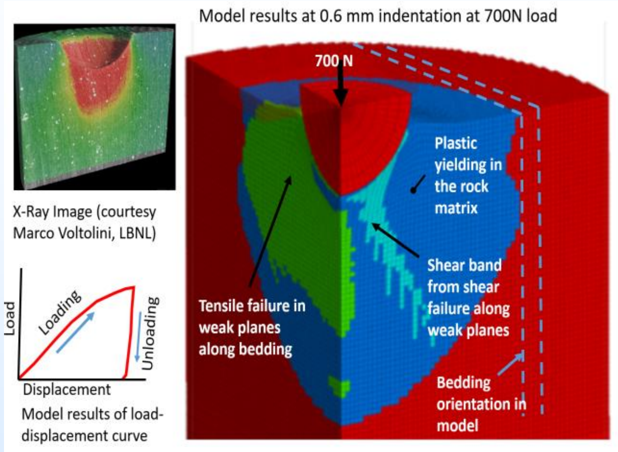
(a) The initial condition of the coated surface before flooding any fluid; (b-c) state of the coated surface dried at 25 °C after exposed to 30,000 ppm (30K) of NaCl brine and DI water for 6 hours; (d-e) state of the coated surface dried at 125 °C after exposed to 30,000 ppm of NaCl brine and DI water for 6 hours.

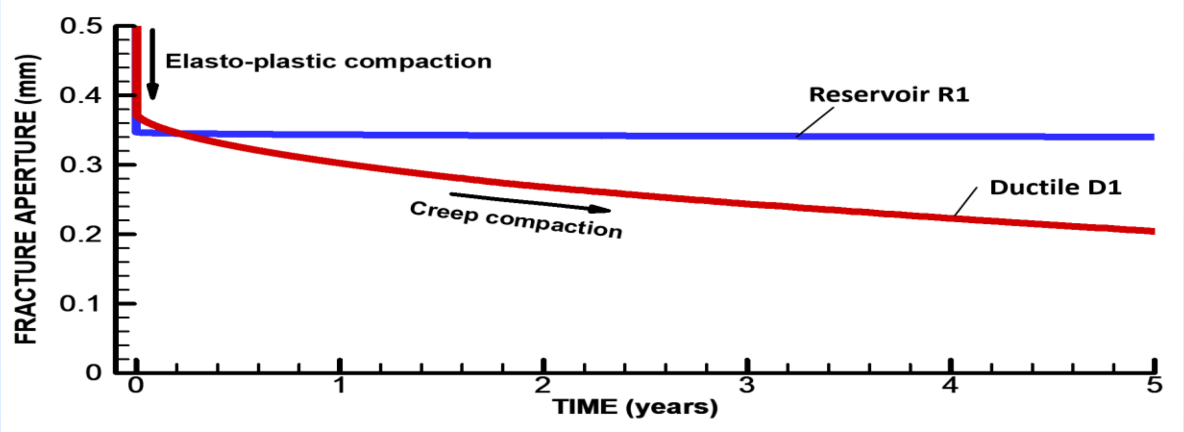
Task 6B Clay-fluid Interaction : Technical Status and Accomplishments

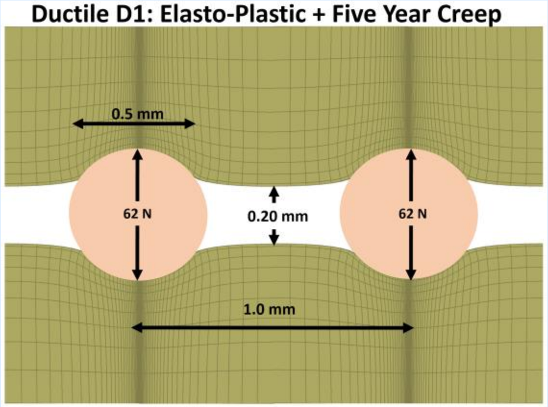
- Illite clay mineral coated micromodel (geomaterial surface) is developed and effect of temperature and base fluid's salinity on clay coating is studied
- Infusing air through clay saturated flow cell makes narrow channel of air inside the cell and a large portion of clay slurry remains unswept.
- Vacuum suction is found to be more effective than forward infusion to improve displacement efficiency of air
- While developing clay coated surface, it has been found that presence of brine in clay slurry significantly affects clay adsorption to glass surface. As brine concentrations increased clay adsorption to glass surface also improved
- Air drying coated surface at high temperature (125 °C) is found to be effective to improve coating stability
  - **Moving forward**, we plan to study fines migration, clay swelling, and formation damage inside clay coated chip upon exposure to different injection fluids
  - Measure interfacial tension (IFT), and contact angle (CA) data of solid-fluid systems of relevance to Caney shale
  - To Measure interfacial tension (IFT), and contact angle (CA) to provide data to LBNL for two phase flow modelling

Task 7 Modeling : Technical Status and Accomplishments

- Performed geochemical modeling of OSU batch reactor experiments using LBNL numerical simulator TOUGHREAC
- Completed micro-mechanical indentation modeling of ductile shale with comparison to x-ray tomography (Journal paper in Fuel)
- Modeled UPITT and OSU rock mechanics core-scale and micro-indentation experiments and predicted long-term proppant embedment for Caney shale (URTeC paper)



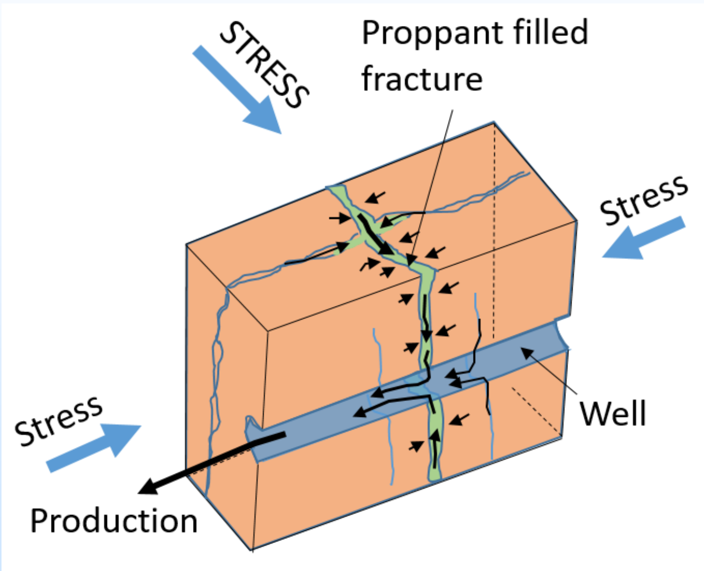




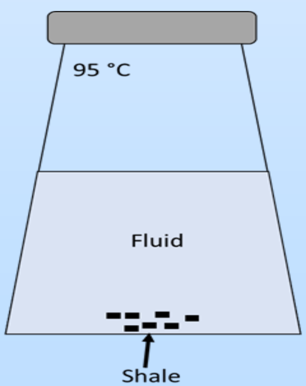
Task 7 Modeling : Technical Status and Accomplishments

- Improved geochemical modeling of OSU batch reactor experiments
- Model flow through proppant-filled fracture experiments from OSU
- Coupled flow and geomechanical modeling on generic production scenarios constrained by Caney Shale properties
- Modeling impact of proppant shapes, distribution and sizes on short- and long-term fracture closure

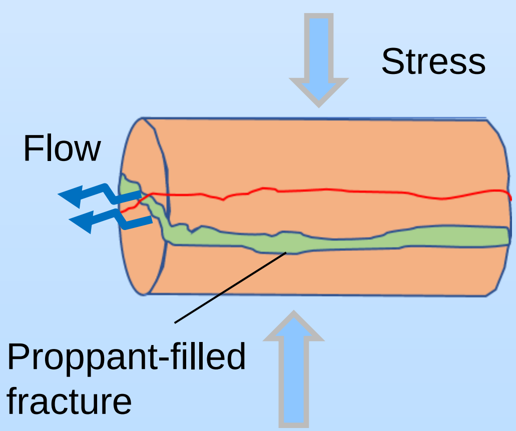
Long-term Production Modeling

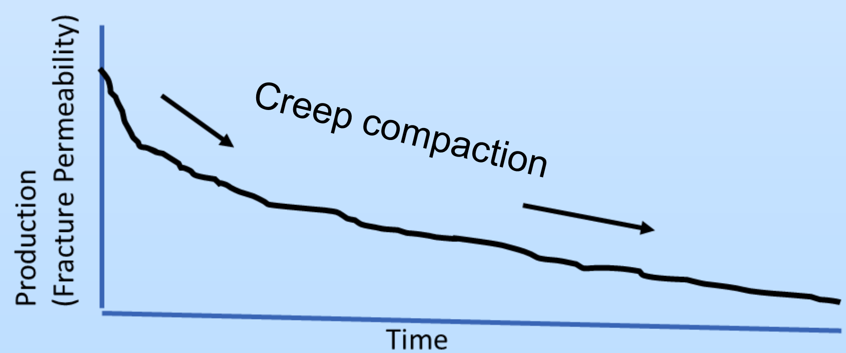


OSU Batch Experiment



OSU Fracture Permeability Test



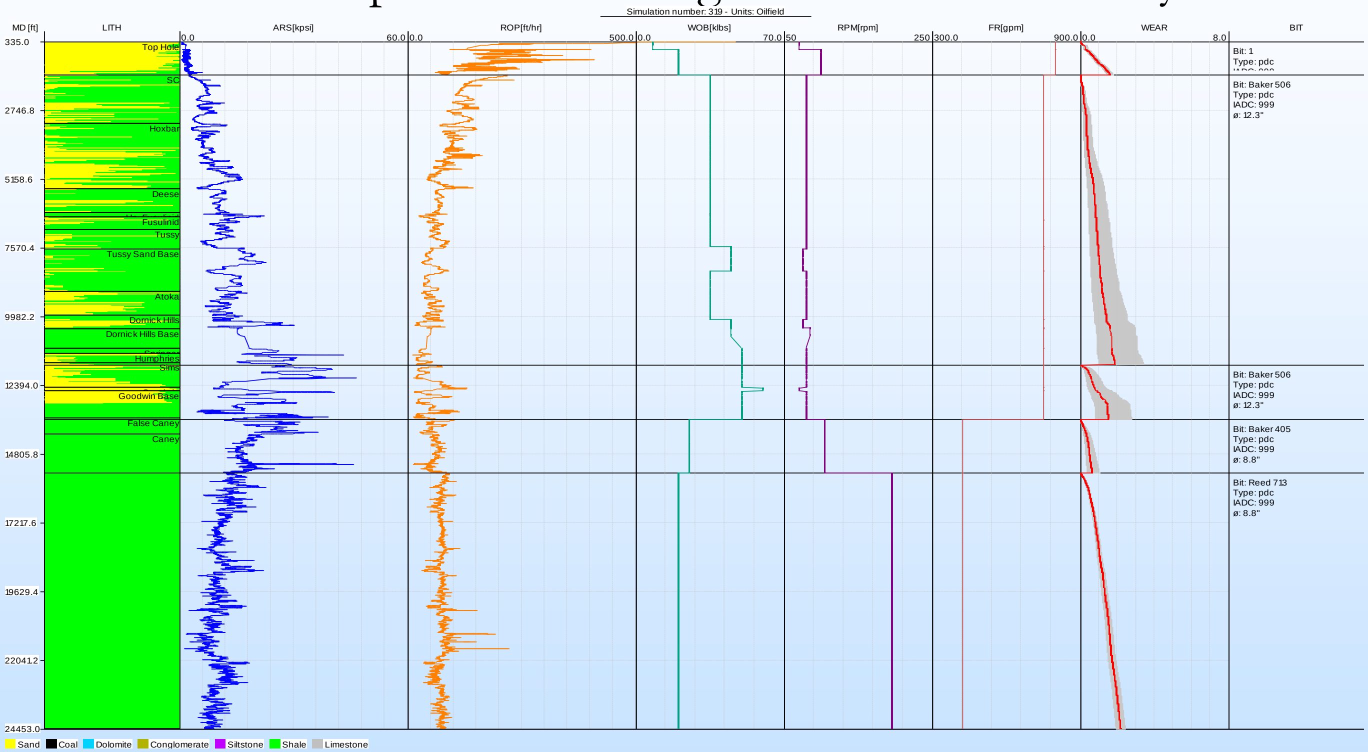


Task 7 Modeling : Technical Status and Accomplishments

- Multi-phase Flow and Geomechanical Modeling
  - Flow and transport modeling using lab-scale experimental data on fracture flow-through as it becomes available from OSU
  - Generic coupled flow and geomechanical modeling on generic production scenarios constrained by Caney Shale properties
  - Modeling to investigate impact of proppant distribution and sizes on short- and long-term fracture closure
- Geochemical Modeling
  - Iterate with experimentalists to determine conditions during batch reactor experiments more accurately and repeat geochemical simulations
  - Improve numerical model by incorporating air in vessel head space

Task 8 Economics : Technical Status and Accomplishments

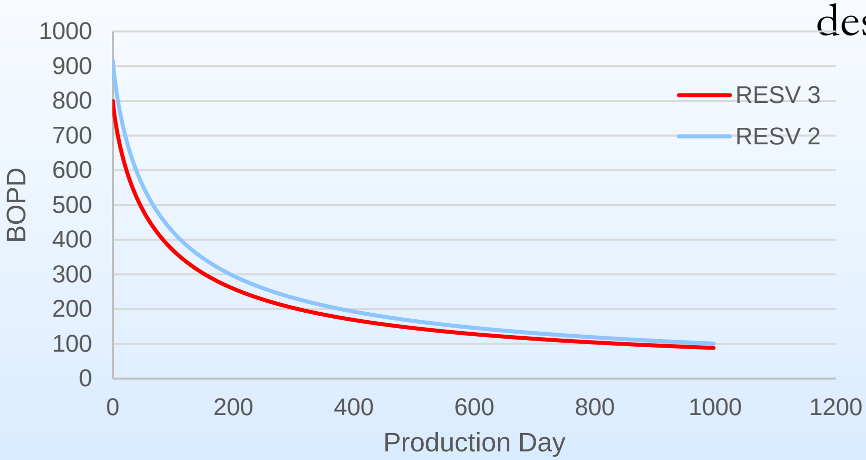
Optimized Drilling Plan for the Gallaway well



- Utilize offset drilling data to prepare a drilling strength log and generate an optimized drilling plan.
- Detailed drilling analysis of the Garrett and Wynell offset wells
  - Correlate offset strength log and formation tops to the Gallaway well to be drilled in August 2021
  - Presented an optimized drilling optimization plan for the Gallaway well to CLR

Task 8 Economics : Technical Status and Accomplishments

Estimated Caney Production Gallaway for Reservoir 2 and 3 using original proposed stimulation design



Detailed Optimized Operational Parameters for the Gallaway Well

Bit #	Bit Size	Bit ID	Nozzle Size	Depth In	Depth Out	Interval Section	WOB	Surface RPM	Motor RPM	Bit RPM	MW	GPM	Section Sim.	Avg. ROP	Avg. IADC Wear Out	Bit Hours
1	17.5	Baker HC6055	7x12	335	620	285	8	70	0	70	8.6	800	204		0.3	
1	17.5	Baker HC6055	7x12	620	1520	900	20	100	0	100	8.9	800	158	167	1.6	7
2	12.25	Baker 506	6x16	1521	7530	6009	35	20	60	80	9.2	750	81		0.9	
2	12.25	Baker 506	6x16	7530	7607	77	45	20	60	80	9.4	750	62		1	
2	12.25	Baker 506	6x16	7607	8400	793	45	15	60	75	9.3	750	48		1.1	
2	12.25	Baker 506	6x16	8400	10100	1700	35	20	60	80	9.5	750	48		1.4	
2	12.25	Baker 506	6x16	10100	10380	280	45	15	60	75	9.8	750	30		1.6	
2	12.25	Baker 506	6x16	10380	11100	720	45	25	60	85	9.8	750	44		1.7	
2	12.25	Baker 506	6x16	11100	11700	600	50	20	60	80	10	750	27	58	1.9	175
3	12.25	Baker 506	6x16	11700	12471	771	50	20	60	80	10.8	750	35		0.8	
3	12.25	Baker 506	6x16	12471	12581	110	60	10	60	70	10.9	750	49		0.9	
3	12.25	Baker 506	6x16	12581	13600	1019	50	20	60	80	10.9	750	38	37	1.5	51
4	8.75	Baker 405	5x13	13600	15486	1886	25	20	85	105	11	425	54			
														54	0.6	35
5	8.75	Reed 713	7x12	15486	24453	8967	20	110	85	195	11.1	425	72			
														72	2.2	125
															Avg Well ROP	61
															Time	394

- Set the stimulation cost baseline with corresponding production by optimizing the stimulation in the Caney formation using the GOHPER software
  - Performed decline curve analysis on Garret, Wynell and Springer wells
  - Simulated planned CLR stimulation in Reservoir 2 and 3
  - Performed economic analysis of planned stimulation in Reservoir 3 of the Galloway well
  - Performed parametric studies on;
    - Sand Volume Evaluation
    - Treatment Volume Evaluation
    - Proppant and Fluid Type Analysis
    - Treatment Rate Evaluation
    - Cluster Spacing Analysis

Task 8 Economics : Technical Status and Accomplishments

- Analyzed the offset wells Garrett and Wynell and correlated the formation tops and strength logs to the upcoming Gallaway well
- Simulated and optimized the drilling of Gallaway well and presented to CLR
- Performed decline curve analysis on Wynell, Garrett and Spring wells
- Developed reservoir model for Reservoir 2 and 3 in the Caney formation
- Simulated original CLR stimulation design in Reservoir 3 and performed 3 year economic analysis
- Performed parametric Caney stimulation studies on Sand Volume, Treatment Volume, Proppant and Fluid Type, Treatment Rate and Cluster Spacing (Results presented to CLR)

Takeaway Message

- Heterogeneity matters BIG TIME and is obviously present in all the data sets. How to address it successfully?
- Focus on Integration of all the data sets and field empirical observations as we move forward.
- Placing Caney Shale in context of other Shales could help in optimizing production.
- Start thinking beyond this project: What next for Caney Shale?

Synergy Opportunities

- Discuss how collaboration among projects could have a synergistic effect on advancing the technologies described during the session in which you are presenting.
  - Because this is an emerging play, collaboration is difficult at this time due to the capital investment of our industry partner

Project Summary

- Key Findings.
  - Caney Shale is heterogeneous with facies hierarchy that reflects depositional processes
  - Reservoir properties including pore types and distribution are closely related to facies mineralogy, which controls mechanical properties and generates specific elemental and petrophysical responses
- Next Steps.
  - Nano-scale analysis of rock fabric and pore distribution to assess the role of maturity and subtle changes in mineralogy in pore evolution
  - Integration of data sets to establish practices that result in successful wells

Acknowledgments

- NETL: Joe Renk. Dustin Crandall and Thomas Paronish and numerous others at the DOE.
- CRL: Andy Rihn, Adam Haecker, Barry Dean
- LBNL: Nicolas Spycher, Seiji Nakagawa
- Caney Team Students and Postdocs
- All admin Staff who support the project at all institutions
- OSU Microscopy Lab
- George King, Caney Project Technical Advisor
- And all who are responsible for various tasks contribution

TASK 4A-OSU Geology: Grammer, Pashin, Wang

TASK 4B- OGS: Seyedolali, Cardott

TASK 5 A- OSU ENG: Hareland

TASK 5B - PITT: Bunger

TASK 6A-OSU ENG: Xiong

TASK 6B OSU ENG: Bikkina

TASK 7 LBNL: Rutqvist, Doughty

TASK 8 OSU ENG: Hareland

Appendix

– These slides will not be discussed during the presentation, but are mandatory.

Project Scope and Objectives

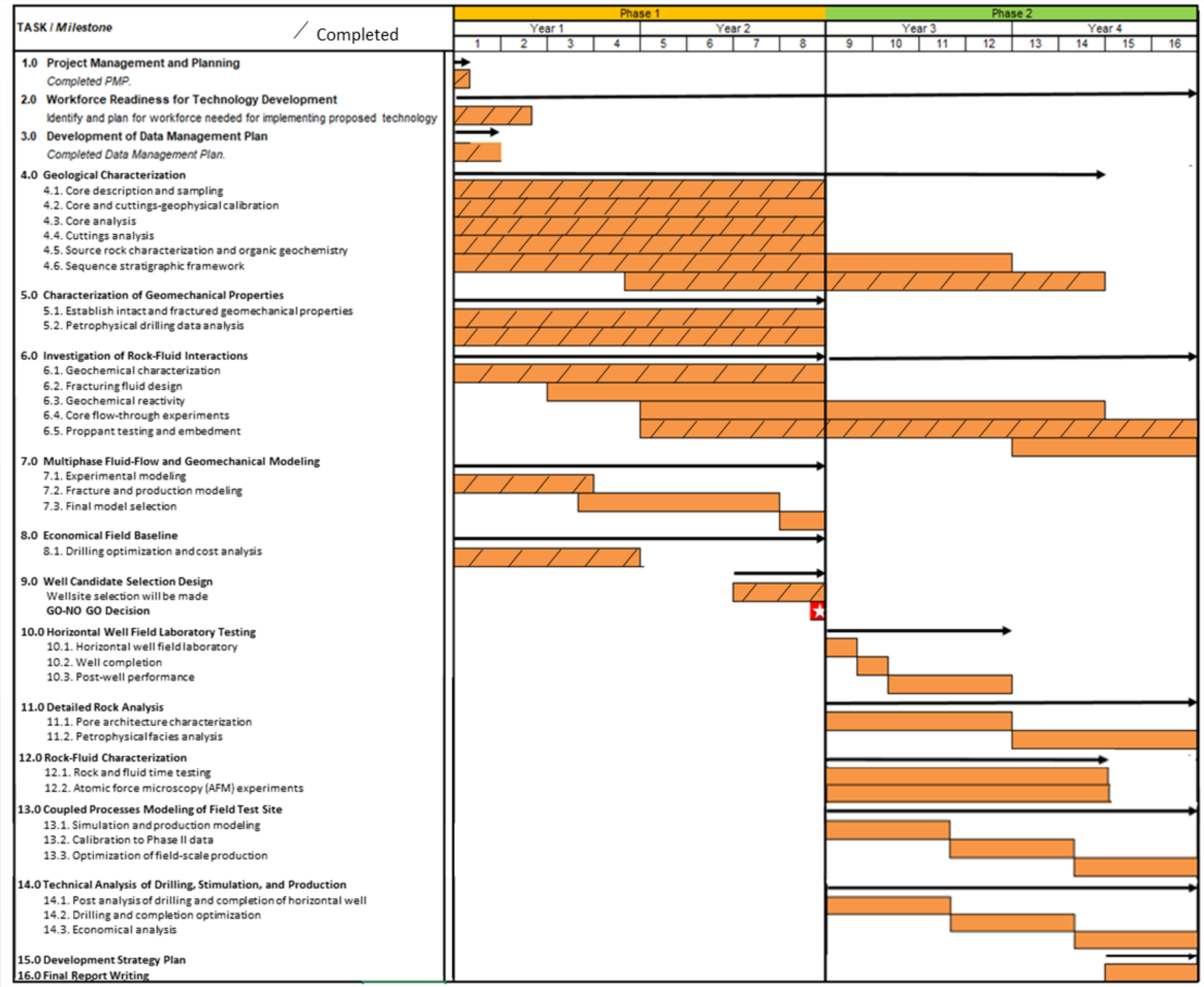
- ✓ **Key objectives for Phase I are completed as planned:**
- ✓ Sound project management and planning.
- ✓ Effective data management.
- ✓ Coring and logging of the Caney Shale interval.
- ✓ Geological and petrophysical reservoir characterization, as well as geochemical and microstructural characterization of existing outcrop and core data as well as newly drilled cores from Caney shale.
- ✓ Establishing geomechanical properties from geophysical well logs, cores and drilling data.
- ✓ Simulate hydraulic fractures and flow to optimize stimulation design.
- ✓ Investigate and optimize applicable fracturing options including fracturing fluids, and fluid/rock interactions, relevant to water usage, proppant embedment and wellbore integrity.

- **Key objectives planned for Phase II are:**
- Drilling, logging and stimulating a horizontal well at the Caney Shale Field Laboratory.
- Geological, geomechanical, petrophysical, and geochemical analysis of well cuttings and produced fluids to further understand reservoir architecture and variability of production streams among hydro-fracture stages and how it might impact fracture conductivity over time.
- Apply hydraulic fracture-flow simulators for optimizing stimulation of multistage-fractured horizontal wells and verification against laboratory and field data.
- Prepare a field development plan for Caney Shale that is safe, economically and technically sound.

Organization Chart

- **TASK 4A Rock characterization: OSU Geology**: Puckette, Grammer, Pashin
- **TASK 4B Rock characterization: OGS,** Seyedolali, Cardott
- **TASK 5 A Drilling: OSU ENG,** Hareland
- **TASK 5B Geomechanics: PITT,** Bunger
- **TASK 6A Proppant Embedment, Geochem: OSU** Radonjic
- **TASK 6B Clay-fluid interactions: OSU ENG,** Bikkina
- **TASK 7A Geomechanics Modeling**: **LBNL,** Rutqvist
- **TASK 7B Geochemistry Modeling: LBNL,** Doughty
- **TASK 8 Economics: OSU ENG,** Hareland
- **TASK 9 Gallaway Well planning/drilling: Continental Resources,** Killian

Gantt Chart


TASK / Milestone
Completed
Phase 1
Phase 2
Year 1
Year 2
Year 3
Year 4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1.0 Project Management and Planning
Completed PMP.
2.0 Workforce Readiness for Technology Development
Identify and plan for workforce needed for implementing proposed technology
3.0 Development of Data Management Plan
Completed Data Management Plan.
4.0 Geological Characterization
4.1. Core description and sampling
4.2. Core and cuttings-geophysical calibration
4.3. Core analysis
4.4. Cuttings analysis
4.5. Source rock characterization and organic geochemistry
4.6. Sequence stratigraphic framework
5.0 Characterization of Geomechanical Properties
5.1. Establish intact and fractured geomechanical properties
5.2. Petrophysical drilling data analysis
6.0 Investigation of Rock-Fluid Interactions
6.1. Geochemical characterization
6.2. Fracturing fluid design
6.3. Geochemical reactivity
6.4. Core flow-through experiments
6.5. Proppant testing and embedment
7.0 Multiphase Fluid-Flow and Geomechanical Modeling
7.1. Experimental modeling
7.2. Fracture and production modeling
7.3. Final model selection
8.0 Economical Field Baseline
8.1. Drilling optimization and cost analysis
9.0 Well Candidate Selection Design
Wellsite selection will be made
GO-NO GO Decision
10.0 Horizontal Well Field Laboratory Testing
10.1. Horizontal well field laboratory
10.2. Well completion
10.3. Post-well performance
11.0 Detailed Rock Analysis
11.1. Pore architecture characterization
11.2. Petrophysical facies analysis
12.0 Rock-Fluid Characterization
12.1. Rock and fluid time testing
12.2. Atomic force microscopy (AFM) experiments
13.0 Coupled Processes Modeling of Field Test Site
13.1. Simulation and production modeling
13.2. Calibration to Phase II data
13.3. Optimization of field-scale production
14.0 Technical Analysis of Drilling, Stimulation, and Production
14.1. Post analysis of drilling and completion of horizontal well
14.2. Drilling and completion optimization
14.3. Economical analysis
15.0 Development Strategy Plan
16.0 Final Report Writing

Student’s Success within Caney Project:

Kolmer, H. P.
Title: The Use of Core and Drilling Data for Selective Stimulation Selection in the Caney Shale, MS Thesis, Oklahoma State University. TASK 5A, Advisor: Hareland, 2021

Bhattacherjee, R.
Title: **Preparation of Clay-Coated Glass Surfaces for Microfluidics-Based Study on Clay-Fluid Interactions**, MS Thesis, Oklahoma State University. TASK 6B, Advisor Bikkina, 2021

Jones, J., Benge, M., and Bunger, A., 2021. **“Is the Caney Shale a Brittle or Ductile Formation?”.** University of Pittsburgh, 19th PGS-AEG-ASCE-GI Student Night. A poster presented by J Jones received an award for the best poster from the American Society of Civil Engineering.

Katende, A., MS, Calvin & Marilyn Vogt Graduate Fellowship in OSU CEAT, for his exemplary performance as PhD student, GPA 4.0., Fall 2021 / Spring 2022

Kolmer, H., **Using Drilling Data of Offset Wells and Core Data to Optimize Perforation Selection for the Caney Shale**. 2021 Mid-Con Region Student Paper Contest 3rd Place Finalist, Oklahoma City, 2021.

Publications: Journal Papers, Book Chapter, NETL Report

Paronish, T., Schmidt, R., Moore, J., Crandall, D., Bunger, A., Rihn, A., Doughty, C., Renk, J., Katende, A., Wang, Y., Puckette, J., Radonjic, M. *Computed Tomography Scanning and Geophysical Measurements of the Caney Shale Formation from the Tomaney #1-35-34-27 Well,* NETL-TRS-X-2021; NETL Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Morgantown, WV, August, 2021.

Voltolini, M., Rutqvist, J., Kneafsey, T., 2021. Coupling Dynamic In Situ X-Ray Micro-Imaging And Indentation: A Novel Approach To Evaluate Micromechanics Applied To Oil Shale. Fuel 300, 120987.

Katende, A., O'Connell, L., Rich, A., Rutqvist, J., and Radonjic, M., 2021. A comprehensive review of Proppant embedment in shale reservoirs: Experimentation, modeling and future prospects. Journal of Natural Gas Science and Engineering, in press.

Wang, Y., Luo, G., Achang, M., Cains, J., Wethington, C., Katende, A., Grammer, G.M., Puckette, J., Pashin, J., Castagna, M., Chan, H., King, G.E., and Radonjic, M., 2021. Multiscale Characterization of the Caney Shale - an Emerging Play in Oklahoma. Midcontinent Geoscience, in press.

Awejori, G. and Radonjic, M., 2021. Review of Geochemical and Geo-mechanical Impact of Formation Clay-Fluid Interactions: Focus on Hydraulic Fracturing. IntechOpen, April 2021, in press.

Katende, A., Rutqvist, J., Benge, M., Seyedolali, A., Bunger, A., Puckette, J.O., Rhin, A., and Radonjic, M., 2021. Convergence of micro-geochemistry and micro-geomechanics in search of mitigation for proppant embedment Caney shale field laboratory case study in southern Oklahoma, USA. Submitted for publication July 2021.

Publications and Presentations

Full Reviewed Conference Papers and Presentations

Benge, M., Lu, Y., Jones, J., Katende, A., Rutqvist, J., Doughty, C., Crandall, D., Haecker, A., King, G., Renk, J., Radonjic, M., Bunger, A.P., 2021b, Connecting Geomechanical Properties with Potential for Proppant Embedment and Production Decline for the Emerging Caney Shale, Oklahoma, Paper presented at the Unconventional Resources Technology Conference (URTeC), Houston, Texas, 26-28 July 2021.

Kolmer, H.P.., Mayibeki, D.., Hareland, G,. 2021, Using Drilling Data of Offset Wells and Core Data to Optimize Perforation Selection for the Caney Shale, Paper published in Proceedings 55th US Rock Mechanics/Geomechanics Symposium, The Woodlands-Houston, Texas, USA 20-23 June 2021.

Benge, M., Lu, Y., Jones, J., Bunger, A.P., Haecker, A., Rihn, A., Crandall,. D, Luo, G., Radonjic, M,. 2021a, Mechanical Properties of Nominally Ductile and Brittle Zones within the Caney Shale Formation, Paper submitted to Proceedings 55th US Rock Mechanics/Geomechanics Symposium, The Woodlands-Houston, Texas, USA 20-23 June 2021.

Awejori, G.A., Luo, G., Grider, C., Katende, A., Radonjic, M. Doughty, C., Spycher, N. Paronish, T. O'Connell, L. Rihn, Fracturing Fluid-Induced Mineralogy Changes and Impact on Elastic Properties for the Caney Shale, Oklahoma, Paper published in Proceedings 55th US Rock Mechanics/Geomechanics Symposium, The Woodlands-Houston, Texas, USA 20-23 June 2021.

Radonjic, M., Luo, G., Wang, Y., Achang, M., Cains, J., Katende, A., Puckette, J., Grammer M., and King G.E., Integrated Microstructural Characterization of Caney Shale, OK, Manuscript published in the Unconventional Resources Technology Conference (URTeC), July 2020.

Presentations

Katende, A., Rutqvist, J., Benge, M., Seyedolali, A., Bunger, A., Puckette, J.O., and Radonjic, M., Convergence of micro-geochemistry and micro-geomechanics towards understanding proppant shale rock interaction: a Caney shale case study in southern Oklahoma, USA, 2021 Stim-Lab Consortium, July 2021.

Bhattacherjee, R., Bikkina, P., Functionalizing glass micromodels with illite clay: Effect of salinity and heat treatment, ACS Spring 2021, Virtual, Apr 14, 2021.

Bikkina, P., Application of Nano- and Micro-fluidics in Petroleum Industry, SPE Student Chapter, Department of Petroleum Engineering & Petrochemical Engineering, University College of Engineering Kakinada (A), JNTUK, Virtual, Apr 9, 2021.

Bikkina, P., Application of Nano- and Micro-fluidics in Petroleum Industry, Petroleum Engineering Graduate Seminar, University of Wyoming, WY, Virtual, Mar 11, 2021.

Grider, C., Awejori, Katende, A., G., and Radonjic, M., Application of correlative Raman microscopy and micro-indentation for proppant shale rock interaction: a Caney Shale case study, 2021 Stim-Lab Consortium, February 2021.

Wang, Y., and G. M. Grammer, Sequence Stratigraphy, Fracture Distribution, and Rebound Hardness Analysis of the "Miss Lime"/"STACK" Play, Oklahoma, USA: 2020 AAPG Annual Convention and Exhibition, poster presentation.

Seyedolali, A., Cardott, B.J., Torres, E.J., Full, W., Stroud, B., Hunt, L.E., Integrated geological and geochemical characterization of the Mississippian Caney Shale, Oklahoma - Subsurface and outcrops delineation, Oklahoma Geological Survey, Shale Resource Plays of Oklahoma - workshop Nov. 10-13, 2020.

Suriamin, F., Cardott, B.J., and Seyedolali, A., An Overview of Oklahoma Shale Resource Plays, Oklahoma Geological Survey, Shale Resource Plays of Oklahoma - workshop Nov. 10-13, 2020.

Wang, Y., J. Puckette, G. M. Grammer, J. C. Pashin, J. Cains, I. Cox, C. Wethington, and C. Hart, Characterization of Caney Shale Play, Ardmore Basin, Southern Oklahoma: Society of Petrophysicists and Well Log Analysts (SPWLA) Tulsa Chapter November 2020 Webinar.

Radonjic, M., Katende, A., Luo, G., Caney Field Lab Project- An introduction, 2020 Stim-Lab Consortium, June 2020, Virtual presentation, and acceptance to the STIM LAB Consortium.

Publications and Presentations

UPCOMING:

Seyedolali, A., Rottmann, K., Torres Parada, E.J., Full, W., and Stroud, B.V., Geological Influences upon the Mississippian Pitkin Limestone/Caney Shale Formations in the Arkoma Basin, Kansas Geological Survey Midcontinent Carbonates Research Symposium, September 14-15, 2021, extended Abstract.

Benge, M., Jones, J., Bunger, A.P., Critical Assessment of Brittleness Indices as Proxies for Rock Mechanical Impacts on Hydrocarbon Recovery: Case Study from the Caney Shale, Oklahoma, Accepted for 2021 American Institute of Chemical Engineers (AIChE) Annual Meeting, Boston, Massachusetts, 7-12 November 2021.

Awejori, G. and Radonjic M., Chemical Reactivity of Caney Shale to KCl-Brines at Elevated Temperature and Pressure, Accepted for 2021 American Institute of Chemical Engineers (AIChE) Annual Meeting, Boston, Massachusetts, 7-12 November 2021.

Wang, Y., J. Cains, G. M. Grammer, J. C. Pashin, and J. Puckette, Facies Architecture and Reservoir Characteristics of the Caney Shale, Ardmore Basin, Southern Oklahoma, USA: 2021 AAPG Annual Conference and Exhibition abstract, accepted for presentation.

Wang, Y., G. Luo, A. Katende, J. Cains, M. Achang, C. Wethington, J. Puckette, G. M. Grammer, G. E. King, M. Radonjic, Multiscale Characterization of the Caney Shale – A Case Study from Southern Oklahoma: 2021 AAPG Midcontinent Meeting, submitted.

Allan Katende1, A., Rutqvist, J., Benge, M., Seyedolali, A., Bunger, A., Puckette, J.O., Rhin, A., and Radonjic, M., Micro-geochemistry and Micro-geomechanics towards understanding proppant shale rock interaction: A Caney Shale case study, USA, AGU , New Orleans, LA, December 2021.

Cox, I., and Pashin, J., Integrated Stratigraphic, Structural, Tectonic, and Petroleum Systems Analysis of the Mississippian Caney Shale, Ardmore Basin, Southern Oklahoma: 2021 AAPG Annual Conference and Exhibition abstract, accepted for presentation.