Tuscaloosa Marine Shale Laboratory (TMSL)

Project Number: DE-FE0031575
May 2018- July 2021

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University of Louisiana at Lafayette

U.S. Department of Energy
National Energy Technology Laboratory
Addressing the Nation's Energy Needs Through Technology Innovation – 2019 Carbon Capture, Utilization, Storage, and Oil and Gas Technologies Integrated Review Meeting
August 26-30, 2019

Tuscaloosa Marine Shale Laboratory (TMSL) Consortium

- Project Management
- Geomechanics
- Hydraulic Fracturing
- Production
- Formation Evaluation

- Geochemistry
- Core Description
- Water Chemistry

- Drilling Performance
- Wellbore Stability

- Socio-Economics

- Enhanced Recovery

TMSL Collaboratory Team: Multi-Disciplinary, Multi-Institutional, EPSCoR Region

DOE Project Manager (Bruce Brown)

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University of Louisiana at Lafayette

University of Louisiana at Lafayette (UL Lafayette)

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Missouri S&T: Wan Yang

The University of Oklahoma (OU): Saeed Salehi

Los Alamos National Laboratory (LANL): Gilles Bussod

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Research Assistants Team

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- Research Coordinator: Shelby Stewart

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- Mark Mlella
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- Raymos Kimanzi
- Nabe Konate
- Anna Hoffman
- Robert Johnson

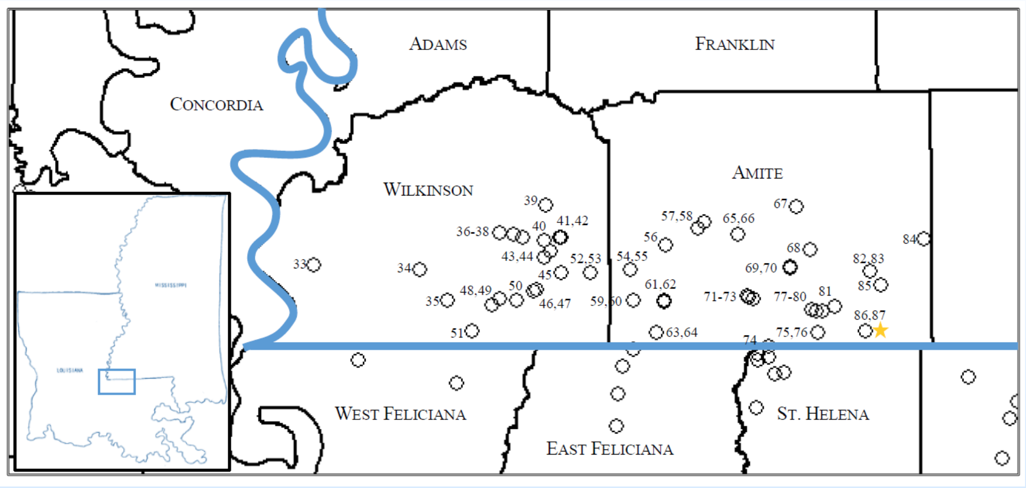
TMSL Project Timeline

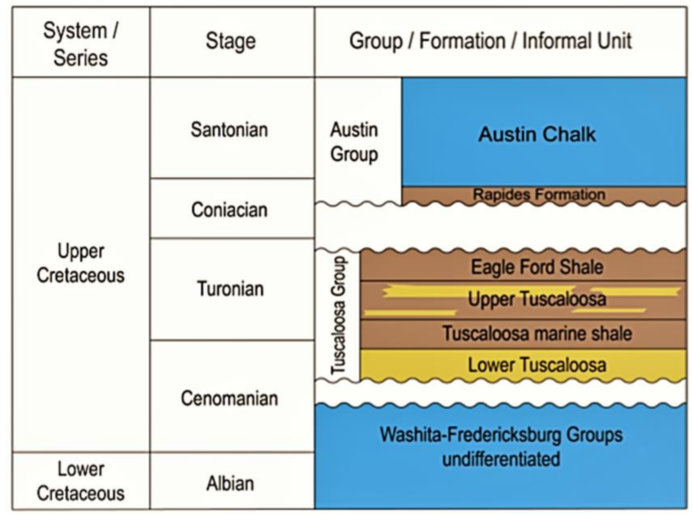
- **Proposal Submission**: August 2017
- **Proposal Acceptance**: December 2017
- **Statement of Project Objectives (SOPO)**: April 2018
- **Project Start Date**: May 2018
- **Project Management Plan (PMP)**: June 2018
- **Data management Plan**: September 2018
- **TMSL Kickoff Meeting**: September 2018
- **1st Research Performance Progress Report (RPPR)**: October 2018
- **Technical Go/ No Go Decision Point 1**: December 2018
- **2n TMSL Consortium Meeting**: February 2019
- **2nd RPPR**: February 2019
- **Continuation Application Submission**: March 2019
- **Extension of BP1 for two months to:** End of June 2019
- **3rd RPPR**: May 2019
- **4th RPPR**: July 2019
- **5th RPPR (Expected)**: October 2019
- **3rd TMSL Consortium Meeting**: 31 October & 1 November, 2019
- **6th RPPR (Expected)**: January 2020

Presentation Outline

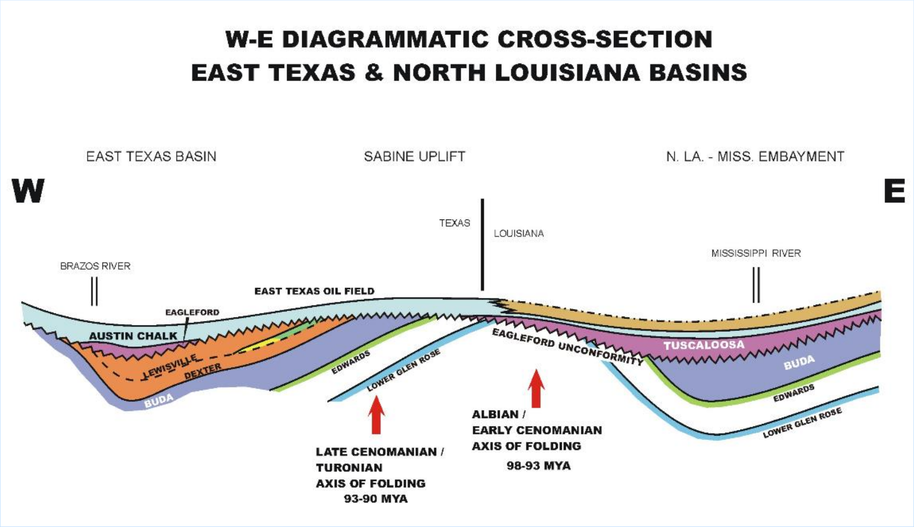
- **Production Decline Analysis**
- **Formation Evaluation**
  - Mineralogical Composition of TMS
  - TOC Analysis
  - Produced Water Chemistry
- **Geomechanical Properties using Digital Image Correlation**
  - In-direct Tensile test
  - Fracture Toughness
  - Imbibition-Induced Fracturing
  - Formation/Cement/Casing Boding
- **Enhanced Recovery**
  - Nanoparticle CO_2 Foam
  - Superhydrophobic Proppants
- **Impact**

Tuscaloosa Marine Shale

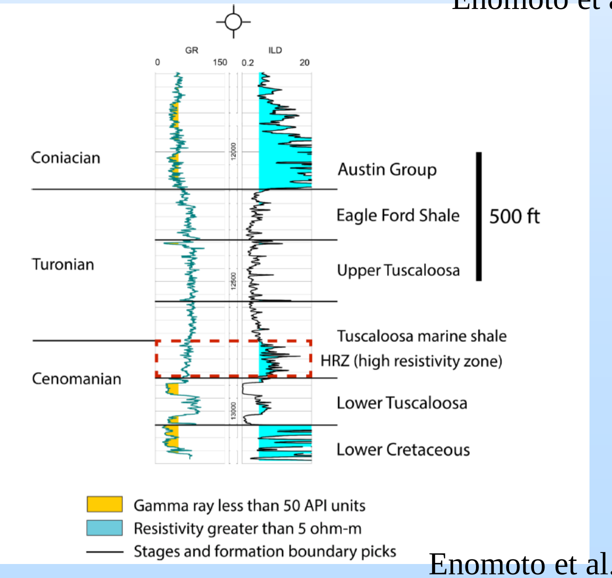




Enomoto et al. (2017)



Adams R.L. and J.P. Carr, 2010.

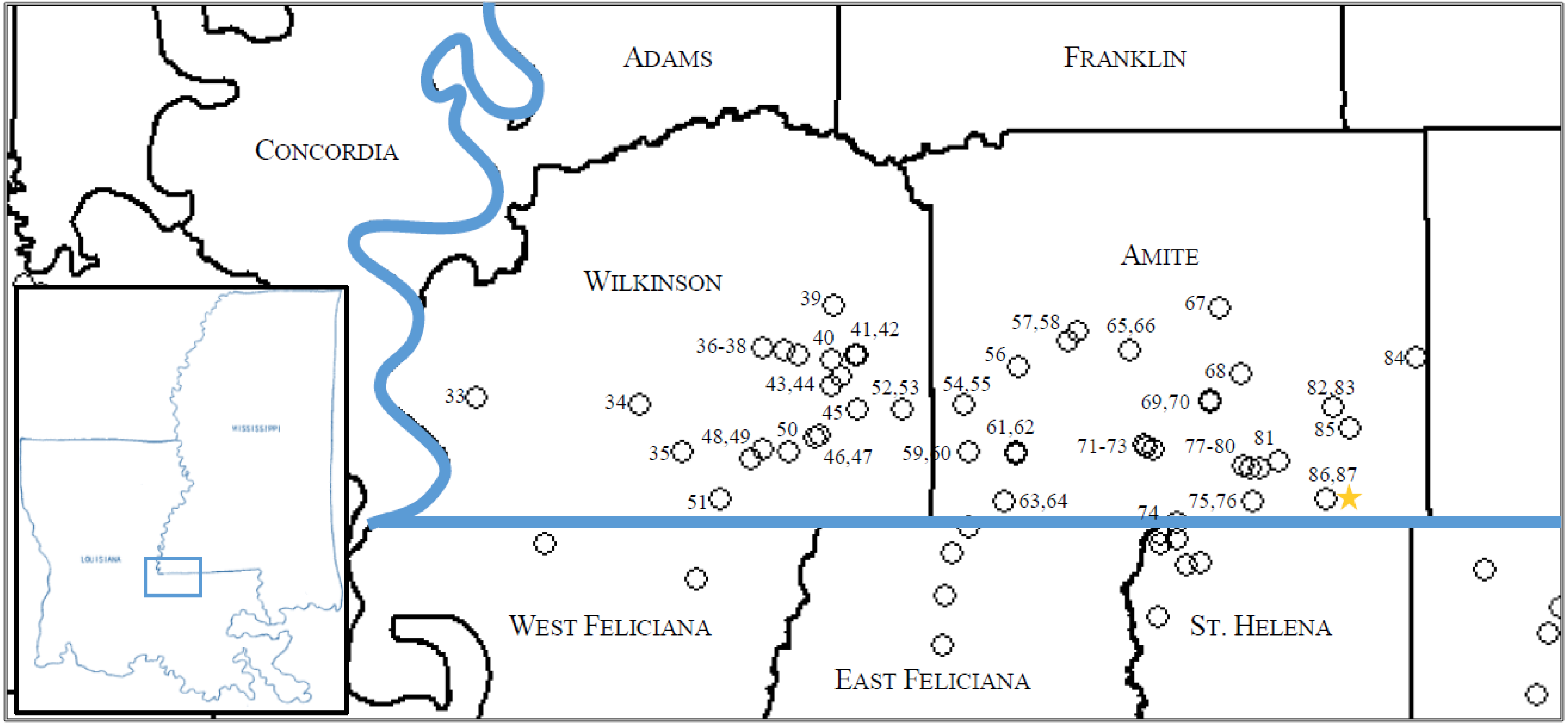


Enomoto et al. (2017)

TMS Wells

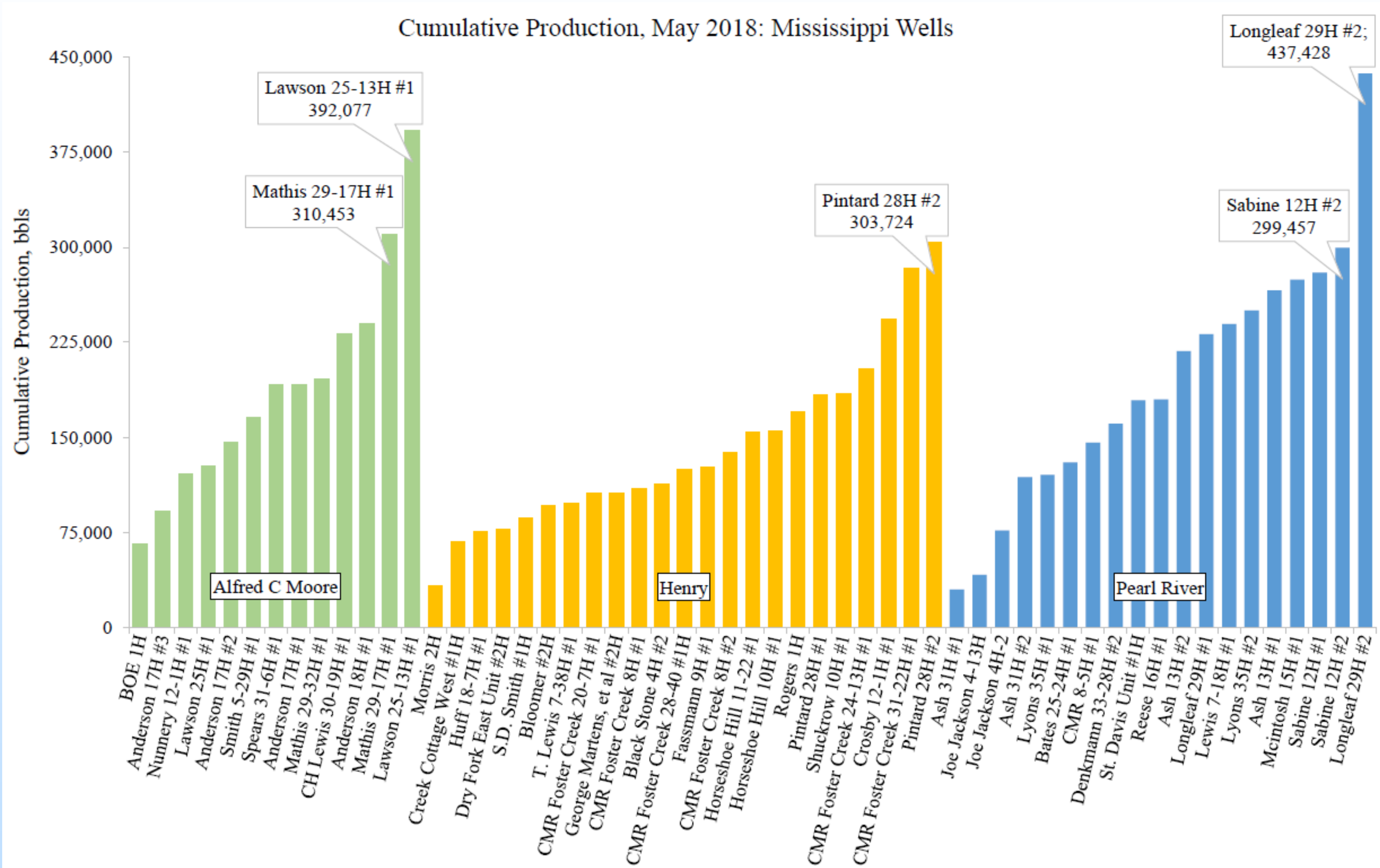
	Name of well	API	County (State)	Company	Year
1	Crosby 12-1H 1	2315722037	Wilkinson, MS	Goodrich	2013
2	Smith 5-29H #1	2300520756	Amite, MS	Goodrich	2013
3	Foster Creek 20-7H	2315722047	Wilkinson, MS	Goodrich	2013
4	Huff 18-7H #1	2300520773	Amite, MS	Goodrich	2012
5	CMR 8-5H #1	2300520774	Amite, MS	Goodrich	2013
6	Lewis 30-19 1H	2300520789	Amite, MS	Goodrich	2014
7	Nunnery 12-1H 1	2300520790	Amite, MS	Goodrich	2014
8	Denkmann 33-28H2	2300520799	Amite, MS	Goodrich	2012
9	Bates 25-24H#1	2300520791	Amite, MS	Goodrich	2014
10	Foster Creek 31 22H 1	2315722095	Wilkinson, MS	Goodrich	2014
11	Foster Creek 24-13H 1	2315722089	Wilkinson, MS	Goodrich	2014
12	Spears 31-6H #1	2300520809	Amite, MS	Goodrich	2014
13	Foster Creek 8H1	2315722097	Wilkinson, MS	Goodrich	2014
14	Foster Creek 8H2	2315722098	Wilkinson, MS	Goodrich	2014
15	T. Lewis 7-38H #1	2300520866	Amite, MS	Goodrich	2014
16	Beech Grove 94H 1	1703720157	E- Feliciana, LA	Goodrich	2014
17	SLC Inc. 81H 1	1712520132	W-Feliciana, LA	Goodrich	2014
18	Verberne 5H-1	1710520049	Kentwood, LA	Goodrich	2014
19	Blades 33H-1	1710520046	Tangipahoa, LA	Goodrich	2014
20	Williams 46H-1	1710520050	Kentwood, LA	Goodrich	2014
21	Weyerhaeuser 51 H 1	1709120152	St. Helena, LA	Goodrich	2013
22	Indigo 25 H 1	1711520230	Vernon, LA	Goodrich	2014
23	Kent 41 H 1	1710520048	Tangipahoa, LA	Goodrich	2014
24	B-Nez 43 H 1	1710520055	Tangipahoa, LA	Goodrich	2014
25	Painter Etal 5 H 1	1711720247	St. Landry, LA	Goodrich	2014
26	W Alford 10 H 1	1711720248	St. Landry, LA	Goodrich	2015
27	Joe Jackson 4-13H	2300520714	Amite, MS	Australis	2007
28	BOE 1H	2300520727	Amite, MS	Australis	2008
29	Joe Jackson 4H-2	2300520748	Amite, MS	Australis	2012
30	Horseshoe Hill 10H	2315722027	Wilkinson, MS	Australis	2012
31	Anderson 17H #1	2300520739	Amite, MS	Australis	2011
32	Anderson 18H #1	2300520741	Amite, MS	Australis	2012
33	Anderson 17H #2	2300520760	Amite, MS	Australis	2013
34	Anderson 17H #3	2300520761	Amite, MS	Australis	2013
35	Ash 31H #1	2300520745	Amite, MS	Australis	2012
36	Ash 31H #2	2300520746	Amite, MS	Australis	2012
37	Lawson 25H #1	2300520762	Amite, MS	Australis	2013
38	Lyons 35H #1	2300520786	Amite, MS	Australis	2014
39	Pintard 28H #1	2315722054	Wilkinson, MS	Australis	2014
40	Mathis 29-32H #1	2300520798	Amite, MS	Australis	2014
41	Lewis 7-18H #1	2300520801	Amite, MS	Australis	2014
42	Lyons 35H #2	2300520787	Amite, MS	Australis	2014
43	Pintard 28H #2	2315722055	Wilkinson, MS	Australis	2014
44	Sabine 12H #1	2300520796	Amite, MS	Australis	2014
45	Sabine 12H #2	2300520797	Amite, MS	Australis	2014
46	Ash 13H #1	2300520802	Amite, MS	Australis	2014
47	Ash 13H #2	2300520803	Amite, MS	Australis	2014
48	Mathis 29-17H #1	2300520857	Amite, MS	Australis	2014
49	Longleaf 29H #1	2300520794	Amite, MS	Australis	2014
50	Longleaf 29H #2	2300520795	Amite, MS	Australis	2014
51	Lawson 25-13H #1	2300520804	Amite, MS	Australis	2014
52	Reese 16H #1	2300520845	Amite, MS	Australis	2014
53	McIntosh 15H #1	2300520843	Amite, MS	Australis	2014
54	Dry Fork East Unit 2H	2315722083	Wilkinson, MS	Sanchez	2014
55	St. Davis Unit #1H	2300520819	Amite, MS	Sanchez	2014
56	Morris 2H	2315722176	Wilkinson, MS	Sanchez	2015
57	Bloomer #2H	2315722240	Wilkinson, MS	Sanchez	2015
58	Board of Education B1	2300520441	Amite, MS	Sanchez	2011
59	BOE 16-7 4	2311320232	Pike, MS	Sanchez	2011
60	Lewis "B" # 1	2300520431	Amite, MS	Sanchez	2011
61	Pike County Farm # 1	2311320234	Pike, MS	Sanchez	2011
62	Charles Spears #1A	2300520688	Amite, MS	Sanchez	2004
63	Horseshoe Hill 11-22	2315722045	Wilkinson, MS	Halcon	2014
64	Black stone 4H #2	2315722060	Wilkinson, MS	Halcon	2014
65	Fassmann 9H #1	2315722067	Wilkinson, MS	Halcon	2014
66	S.D. Smith #1H	2315722102	Wilkinson, MS	Halcon	2014
67	Shuckrow 10H #1	2315722104	Wilkinson, MS	Halcon	2014
68	George Martens #2H	2315722140	Wilkinson, MS	Halcon	2014
69	Rogers 1H	2315722156	Wilkinson, MS	Halcon	2015
70	Creek Cottage W- 1H	2315722133	Wilkinson, MS	Halcon	2014
71	Broadway H 1	1707920539	Rapides, LA	Halcon	2012
72	Beech Grove 68H-1	1703720151	E-Feliciana, LA	Devon	2011
73	Soterra 6H-1	1710520039	Tangipahoa, LA	Devon	2012
74	Richland Farms 74H-1	1703720154	E-Feliciana, LA	Devon	2012
75	Weyerhaeuser 14H-1	1709120148	St. Helena, LA	Devon	2012
76	Murphy 63H-1	1712520131	W-Feliciana, LA	Devon	2012
77	Thomas 38H-1	1710520042	Tangipahoa, LA	Devon	2012
78	Weyerhaeuser 72H	1709120151	St. Helena, LA	Devon	2014
79	Lane 64 H	1703720153	E-Feliciana, LA	Devon	
80	Weyerhaeuser 60H-1	1709120147	St. Helena, LA	Encana	2014
81	Weyerhaeuser 60H-2	1709120150	St. Helena, LA	Encana	2012
82	Weyerhaeuser 73H-1	1709120145	St. Helena, LA	Encana	2011
83	Dupuy 20H1	1700920645	Avoyelles, LA	Encana	2012
84	Dupuy Land Co 1	1700920642	Avoyelles, LA	EOG	2012
85	Gauthier 1	1700920643	Avoyelles, LA	EOG	2012
86	Gauthier 14 H 1	1700920644	Avoyelles, LA	EOG	2012
87	Paul 15 H 1	1700920648	Avoyelles, LA	EOG	2013
88	Dupuy Land Co 30H 1	1700920649	Avoyelles, LA	EOG	2013
89	Spears 1	2300520025	Amite, MS	Humble	1969
90	#1 Stockard	2300500103	Amite, MS	Humble	1950
91	Bentley Lumber 34H 1	1707920538	Rapides, LA	Indigo	2012
92	Lambert 1H	2300520664	Amite, MS	Exchange	2000
93	Blades No. 1	1710520007	Tangipahoa, LA	Tex-Pacific	1975
94	Richland Plantation A	1703720145	E-Feliciana, LA	UPRC	1998
95	#1 Braswell 24-12	2311320221	Pike, MS	Worldwide	1999
96	Montrose Plantation 1	2315721328	Wilkinson, MS	Hess	1985
97	Foster Creek 28-40 1H	2315722099	Wilkinson, MS	Comstock	2014
98	Weyerhaeuser No. 1	1709120137	St. Helena, LA	Encore	2008
99	Bentley Lumber 32-1	1711520211	Vernon, LA	Indigo	2011
100	W P Spinks 1	2311320020	Pike, MS	Sun Oil	1972

Production Data Analysis: Mississippi Wells



Nippes, V., 2019. Production Behavior and Decline Curve Analysis of Tuscaloosa Marine Shale Wells in Wilkinson and Amite Counties, Mississippi, *M.Sc. Thesis*, University of Louisiana at Lafayette

Production Data Analysis: Mississippi Wells



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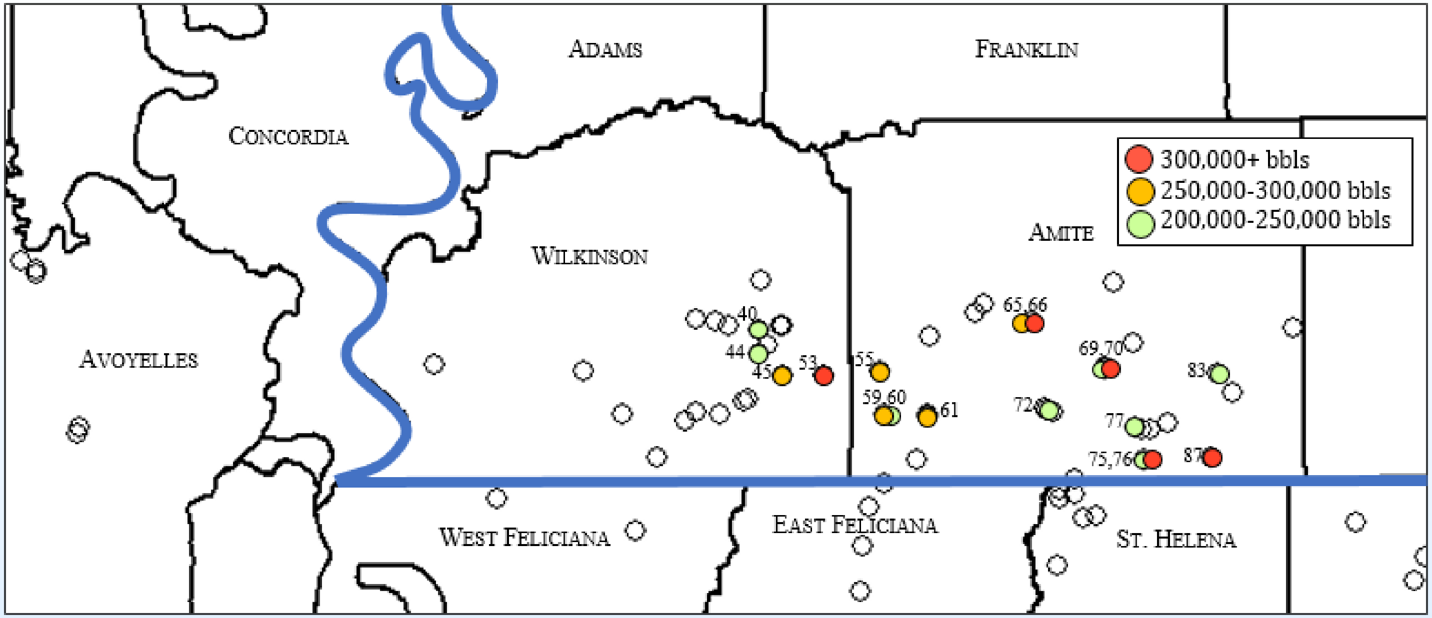
Top Producing Wells in Amite & Wilkinson Counties

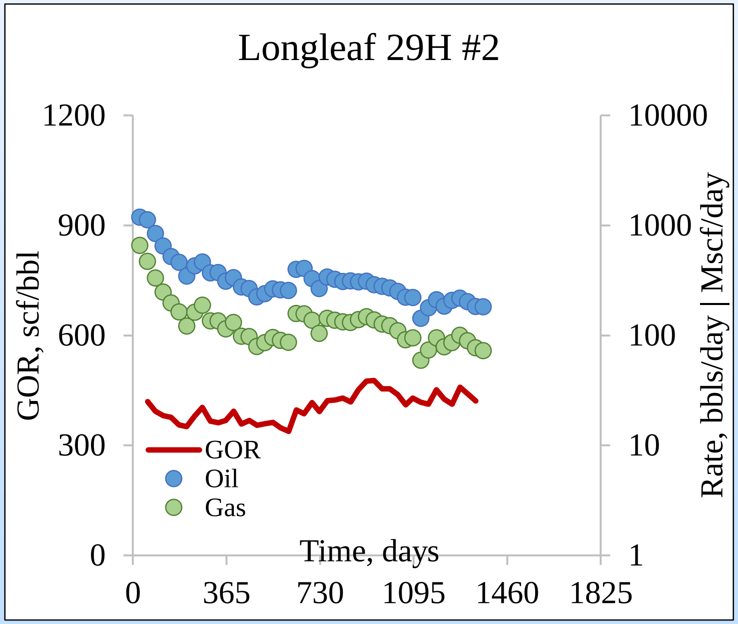


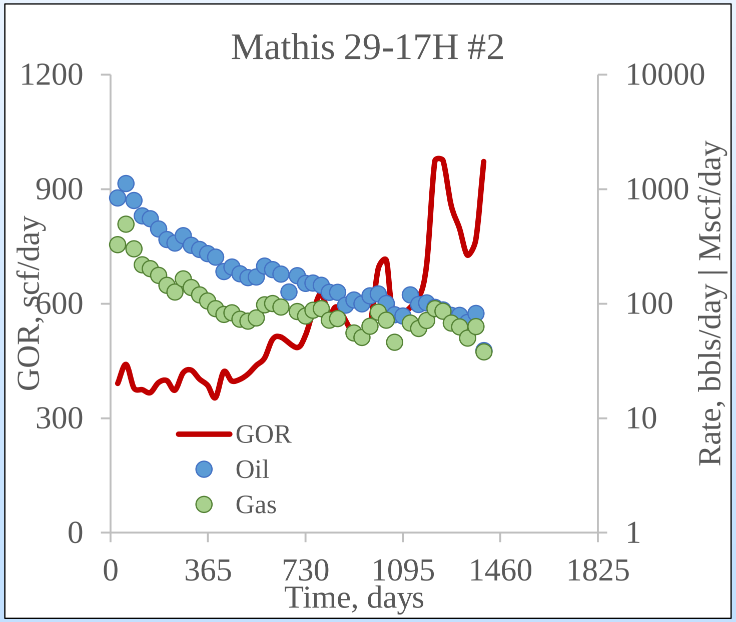
Tuscaloosa Marine Shale Wells: 200,000+ bbls Cumulative Production			
300,000+ bbls	250,000-300,000 bbls	200,000-250,000 bbls	
53. Pintard 28H 2	45. CMR FC 31-22H 1	40. Crosby 12-1H 1	75. Mathis 29-32H 1
66. Sabine 12H 2	55. Lyons 35H 2	44. CMR FC 24-13H 1	77. Anderson 18H 1
70. Longleaf 29H 2	59. Ash 13H 1	60. Ash 13H 2	83. CH Lewis 30-19 1H
76. Mathis 29-17H 1	61. Mcintosh 15H 1	69. Longleaf 29H 1	
87. Lawson 25-13H 1	65. Sabine 12H 1	72. Lewis 7-18H 1	

Nippes, V., 2019. Production Behavior and Decline Curve Analysis of Tuscaloosa Marine Shale Wells in Wilkinson and Amite Counties, Mississippi, *M.Sc. Thesis*, University of Louisiana at Lafayette

Top Five TMS Producers, MS

Well Name	Field	Test Date	N_p, bbls	Perf. Length, ft	Annual Decline Rate, %		
					Year 1	Year 2	Year 3
Longleaf #2	Pearl River	Mar-15	473,474	7,138	74	-	34
Lawson 25-13H #2	Alfred C Moore	Mar-15	412,831	9,754	70	44	27
Mathis 29-17H #1	Alfred C Moore	Feb-15	324,601	9,081	80	40	27
Pintard 28H #2	Henry	Sep-14	313,355	8,084	80	43	29
Sabine 12H #2	Pearl River	Nov-14	316,001	7,425	72	42	35

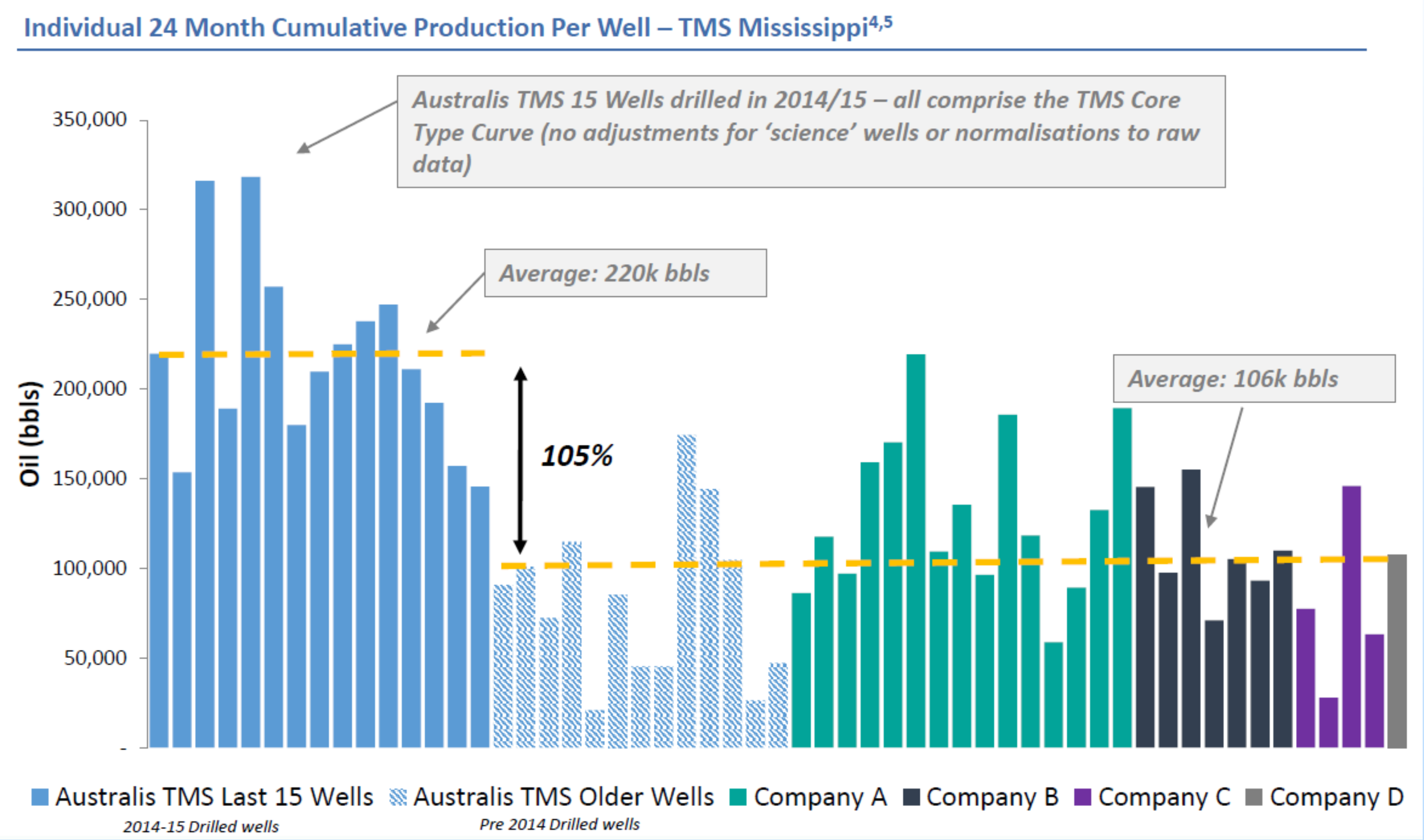




- The decline curve analysis shows **long-term transient** flow period.
- Light sweet crude in the range of **38–41 API** (premium to WTI)

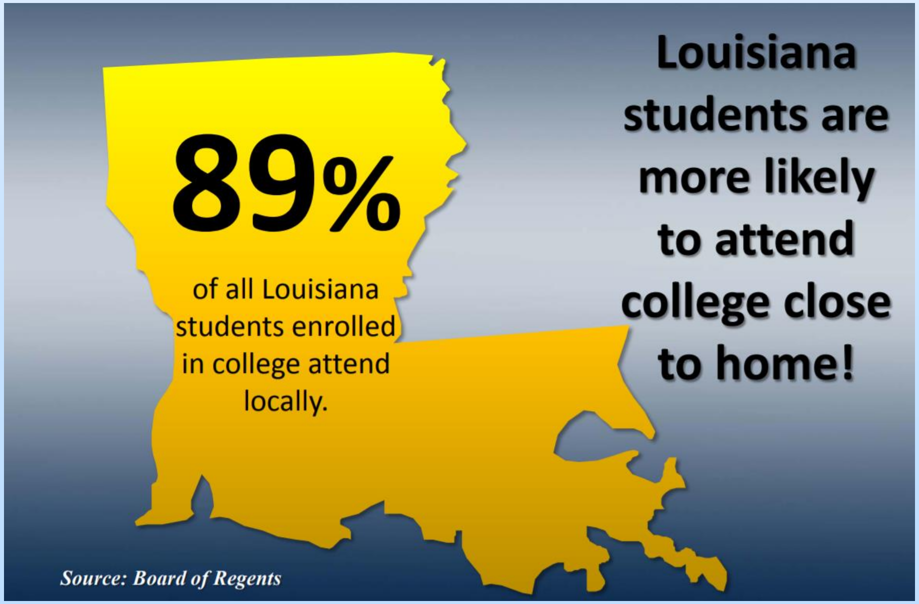
Learning Curve Improvement

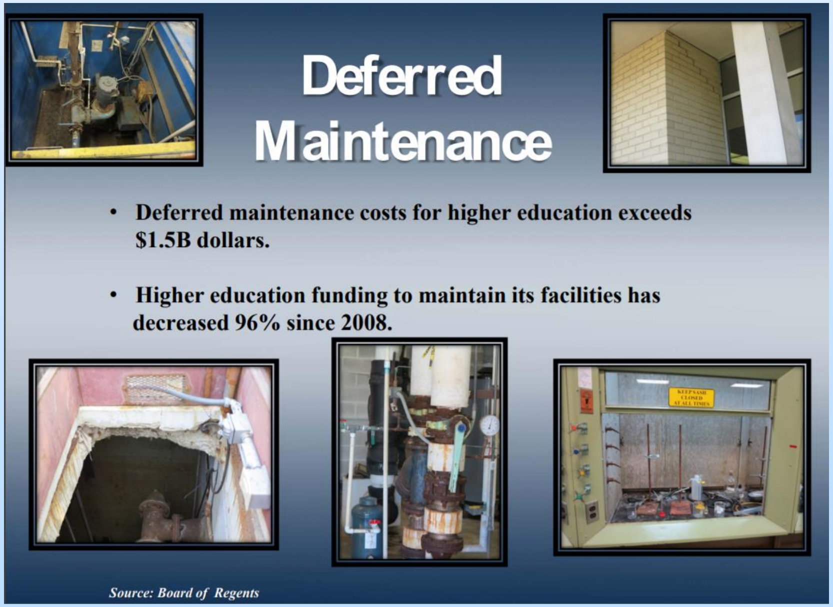
"The 15 wells drilled in 2014/15 within Australis' core acreage demonstrate significantly higher average productivity than the average of other TMS wells drilled in Mississippi..(pre-2014)"



Evaluating the Socio-Economics of TMS Region

- Jobs **decreased by 2,633**(-1%) over the last 5 years. National growth 7.4%.
- Labor force participation rate **decreased from 50.2% to 49.9%** between 2013 and 2018.
-
- Regional average earnings per job are **$19.5K below** the national average earnings of $64.7K per job.
- **Sixty percent of the population in the rural southern regions of Mississippi have a high school diploma or less** and over 17,000 are unemployed. Local, state, and federal government is by far the largest employer in the region followed by retail. (Miller & Bolton 2016)





Evaluating the Socio-Economics of TMS Region

- Identify key informants from companies and associations for interviews;
- Conduct telephone and in-person interviews;
- Conduct secondary data analysis to identify specific oil and gas supply chain companies in the TMS region;
- Benchmark supply chain operations in other shale region to identify industries in developed regions and supply chain gaps;
- Collect historical oil and gas severance tax data from Mississippi and Louisiana Departments of Revenue;
- Prepare report on TMS supply chain and gap analysis

Based on an industry concentration comparison to other regions and input/output supply chain analysis, **Oil and Gas Field Machinery and Equipment Manufacturing***(333132) has significant potential to be attracted to the region.*

Chemicals specific to hydraulic fracturing *(325998) is another industry that should be explored.*

Operators certainly appreciate any **reduction in taxes***, but once the shale play is established, both states need to make the tough policy decision of whether a continued reduction in public revenue is justified.*

Formation Evaluation

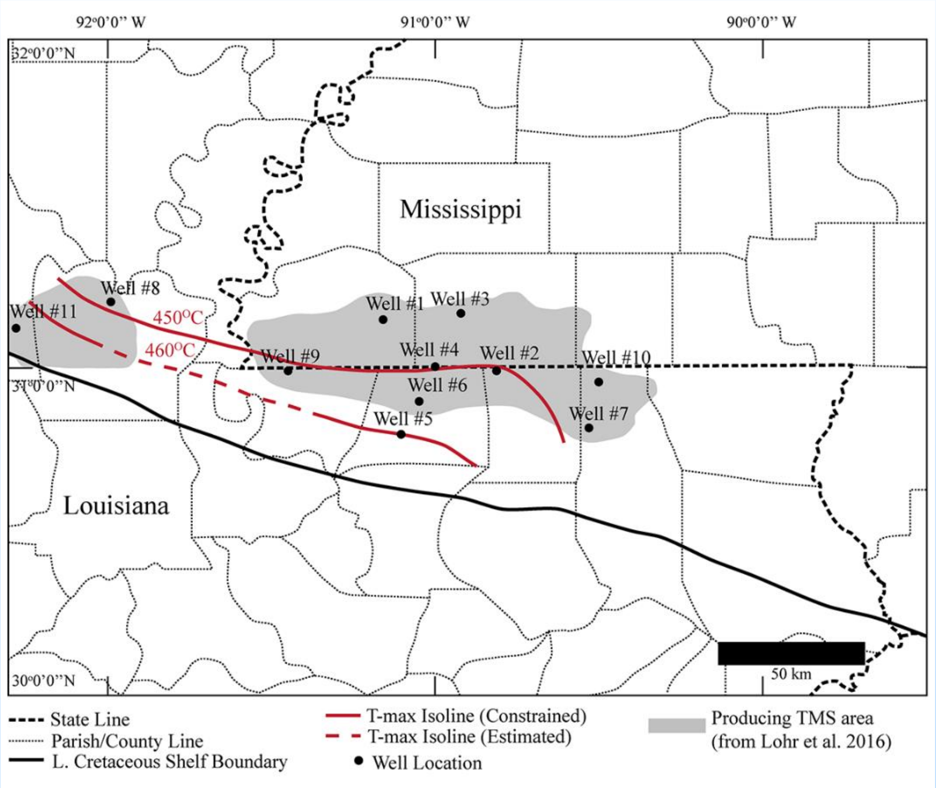
Mineralogical & Geochemical Properties of Tuscaloosa Marine Shale

XRD, pyrolysis, and other data from **11 wells**.

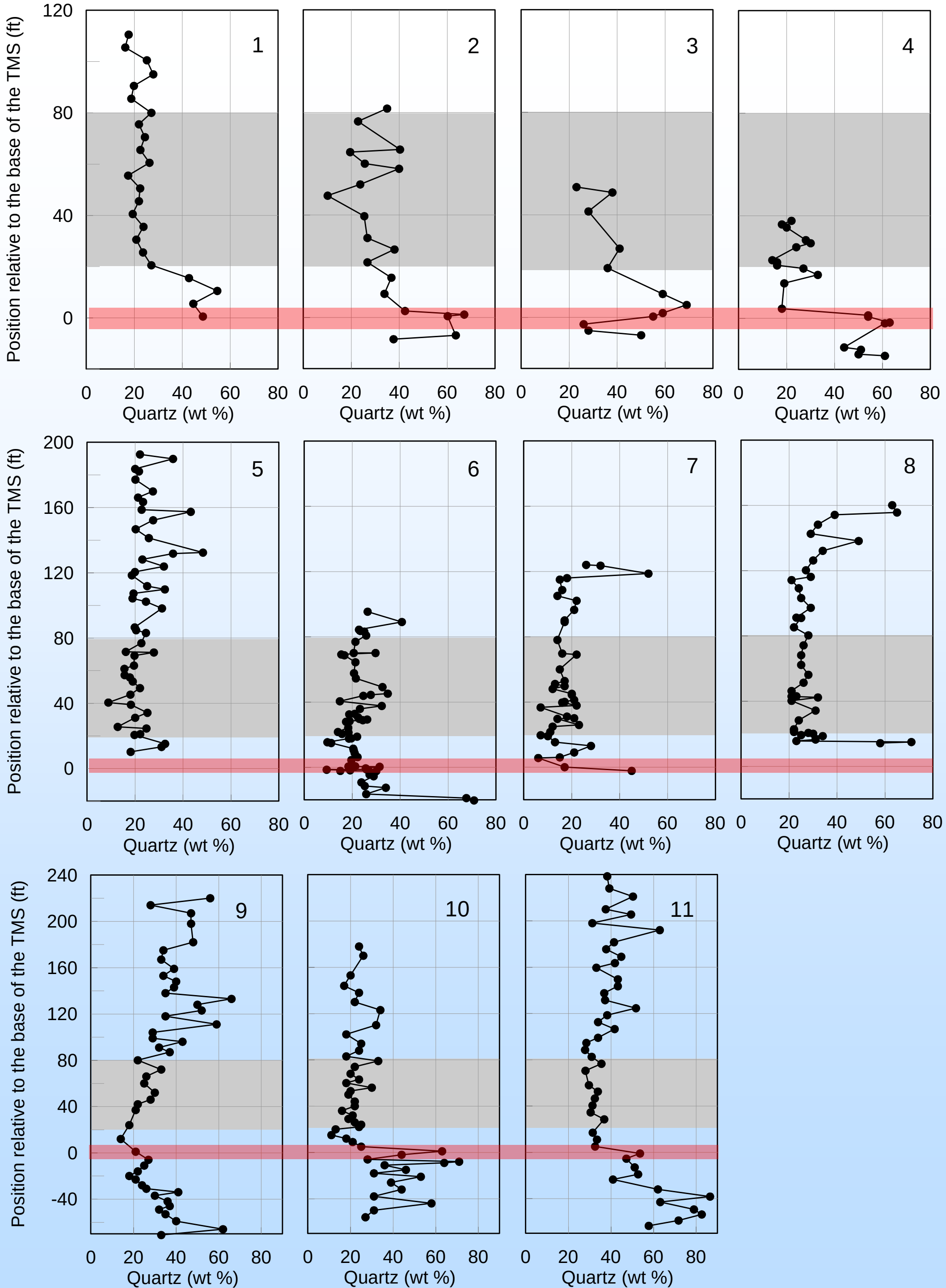
Goals:

~400 samples in total from all wells

- Evaluate the heterogeneity of the mineralogy and geochemistry of the TMS laterally and vertically.
- Link mineralogical changes and organic matter geochemistry to provide a foundation for a larger stratigraphic framework.
- Identify "sweet spots" in the TMS in terms of organic geochemistry and thermal maturity.

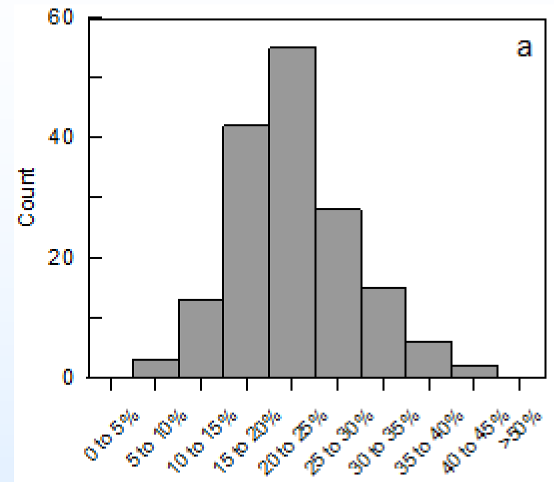


Borrok, D.M., Yang, W., Wei, M., and Mokhtari, M., 2019. **Heterogeneity of the Mineralogy and Organic Content of the Tuscaloosa Marine Shale**, *Marine and Petroleum Geology*, Vol. 109, p.717-73. https://doi.org/10.1016/j.marpetgeo.2019.06.056



Results

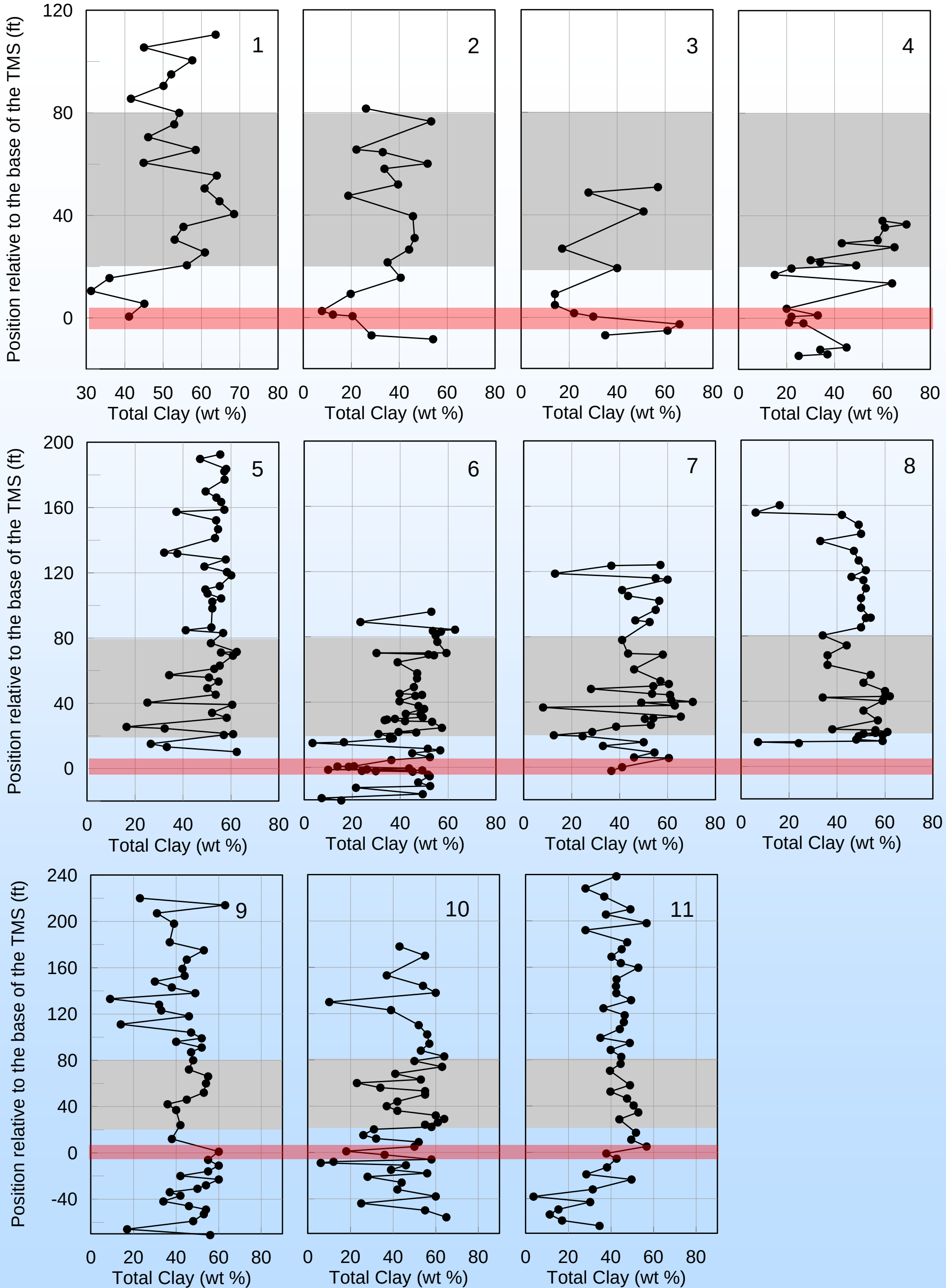
Quartz (%) vs core depth



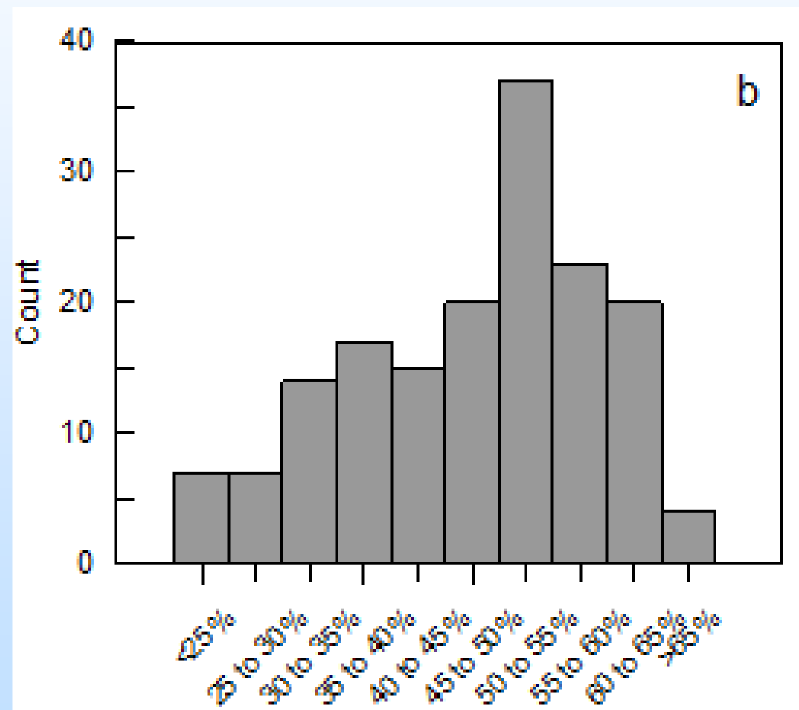
Depths have been normalized to "feet relative to the base of the TMS".

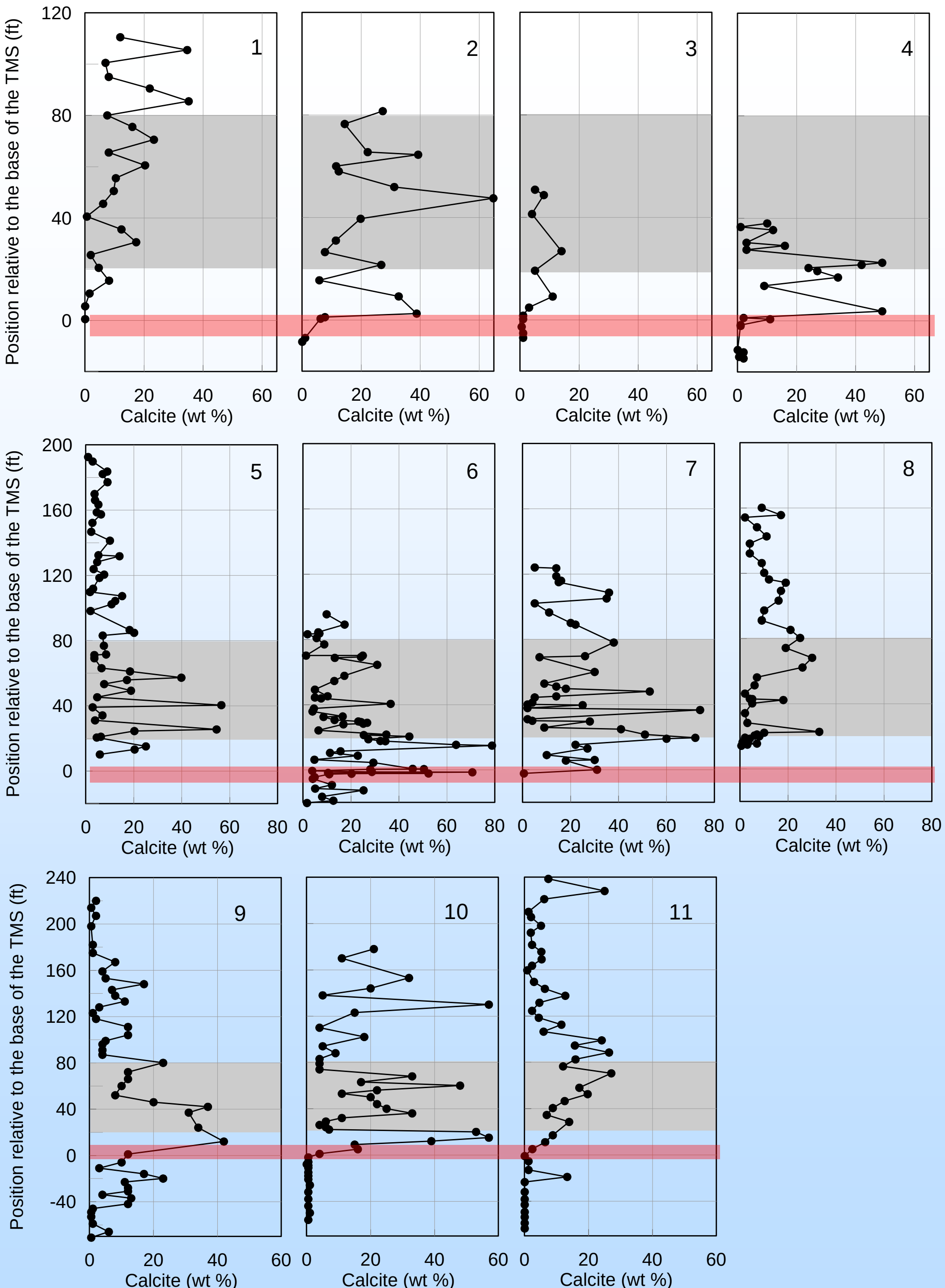
Negative depths represent samples collected from the Lower Tuscaloosa.

The gray shaded region from 20 ft to 80 ft above the base of the TMS was used for well-to-well comparisons.

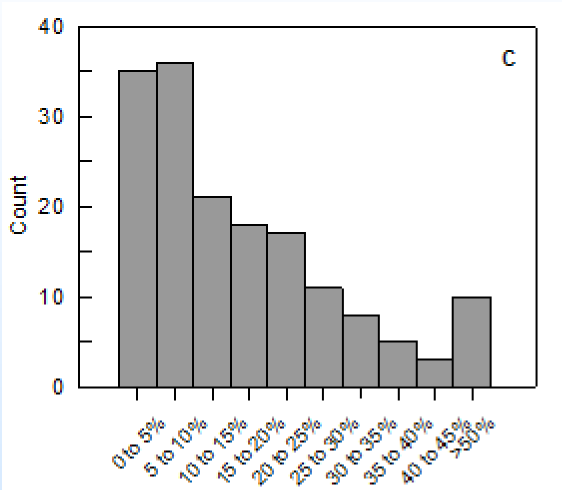

1
2
3
4
5
6
7
8
9
10
11
Position relative to the base of the TMS (ft)
Total Clay (wt %)

Clay


b
Count
40
30
20
10
0
<25 %
25 to 30 %
30 to 35 %
35 to 40 %
40 to 45 %
45 to 50 %
50 to 55 %
55 to 60 %
60 to 65 %
>65 %



Calcite



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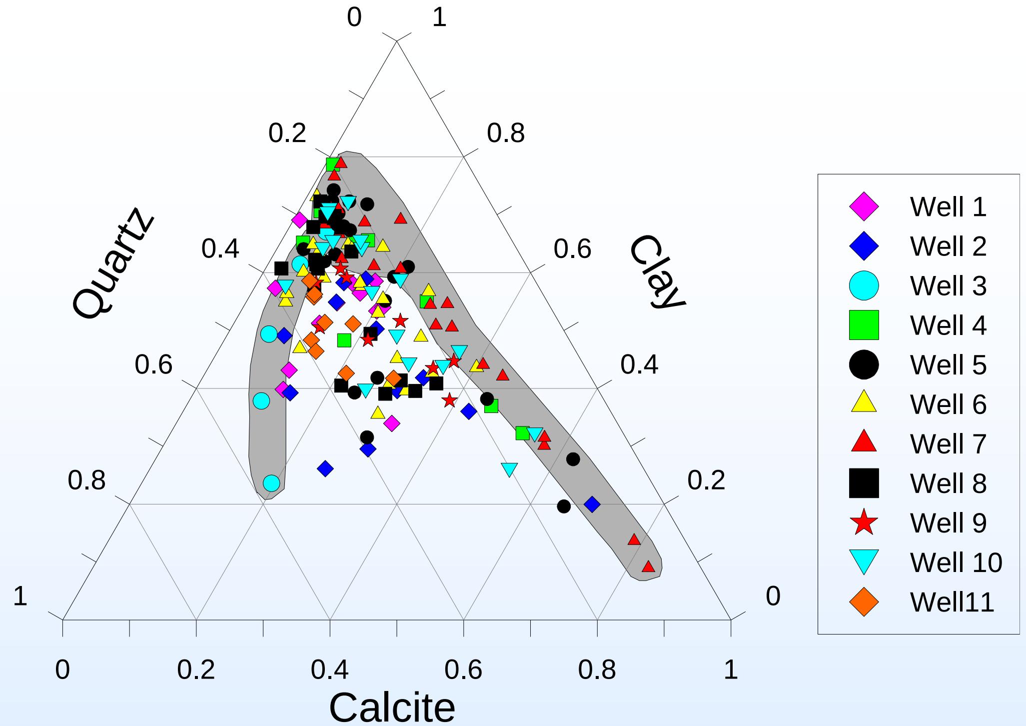
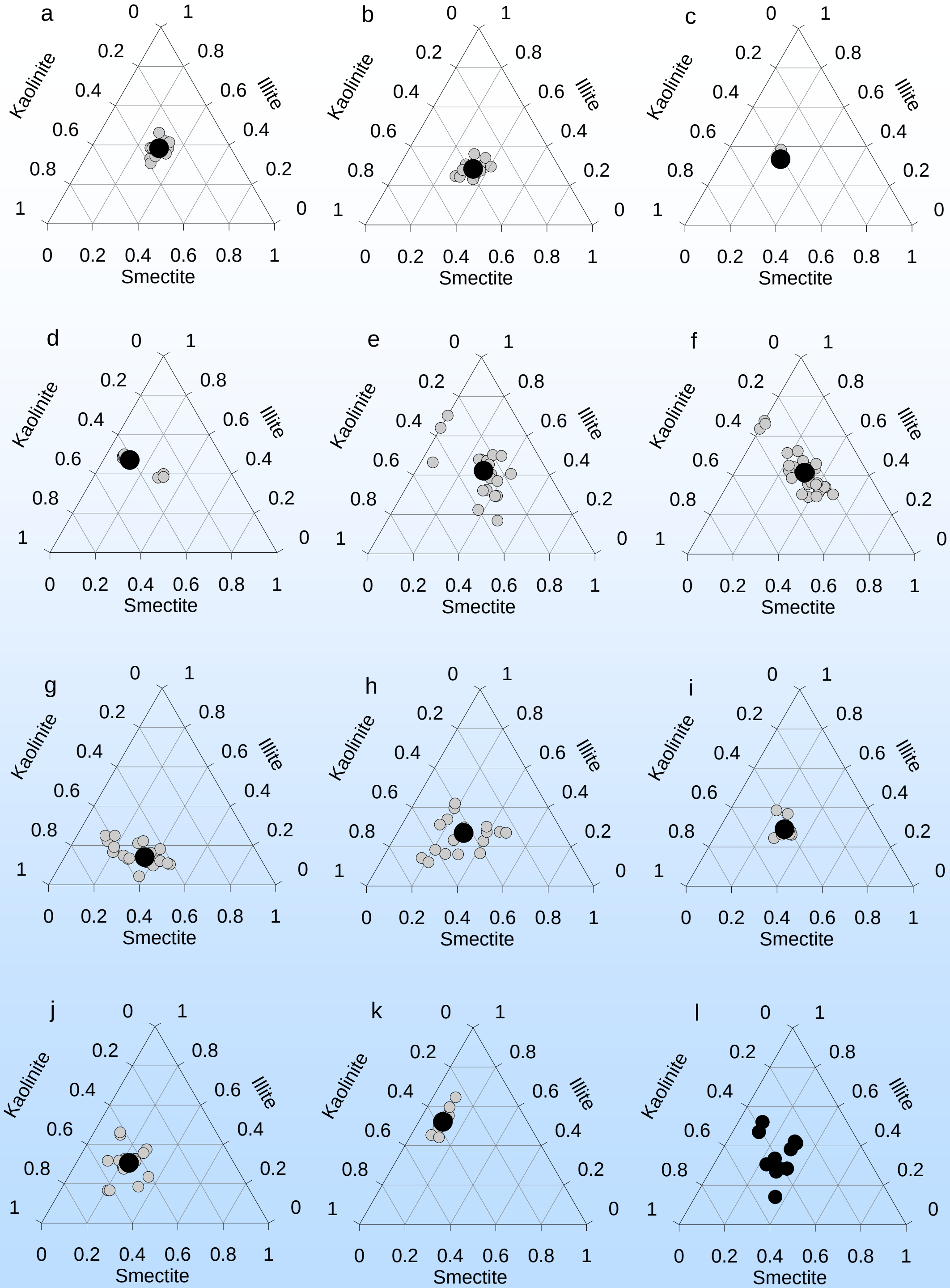
Ternary Diagram of Major Minerals



Mineral	Interquartile Range (wt %)	Mean (wt %)
Plagioclase	2.0 to 4.7	3.9
Pyrite	2.8 to 6.0	4.4
Quartz	18.4 to 26.5	22.8
Calcite	6.1 to 25.0	17.2
Total Clay	39.7 to 56.1	47.8

Abundances of individual clay minerals



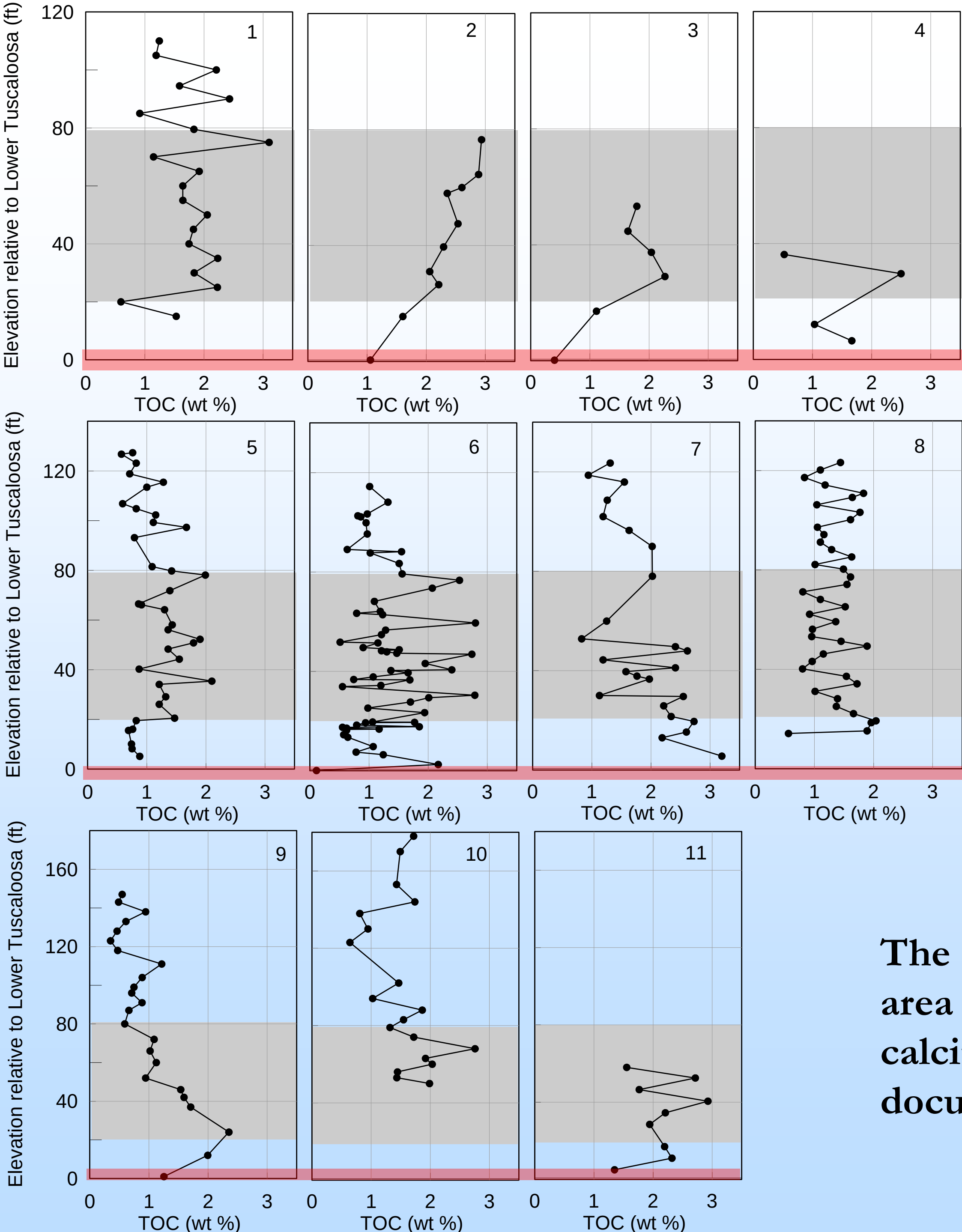
Mean values for all wells - base of TMS (n = 161)

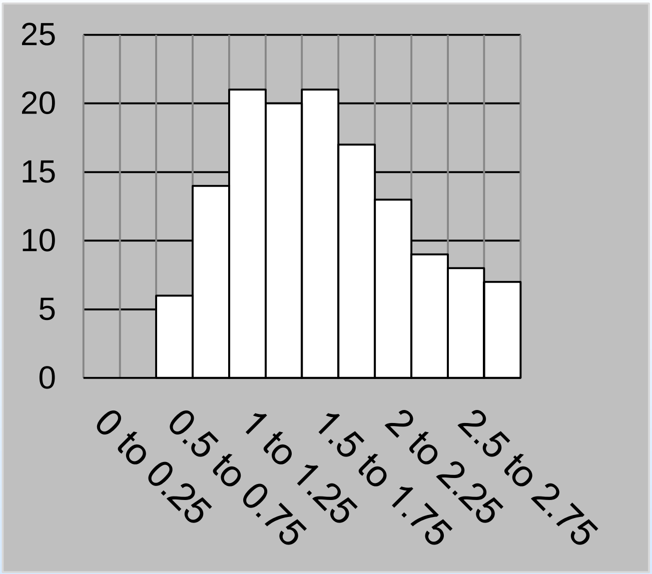
Kaolinite	**16.2%**
Illite	**14.1%**
Smectite	**11.8%**
Chlorite	**5.7%**

Interquartile ranges

Kaolinite	11.8% to 21.0%
Illite	8.7% to 18.3%
Smectite	8.0% to 15.6%
Chlorite	3.0% to 8.2%

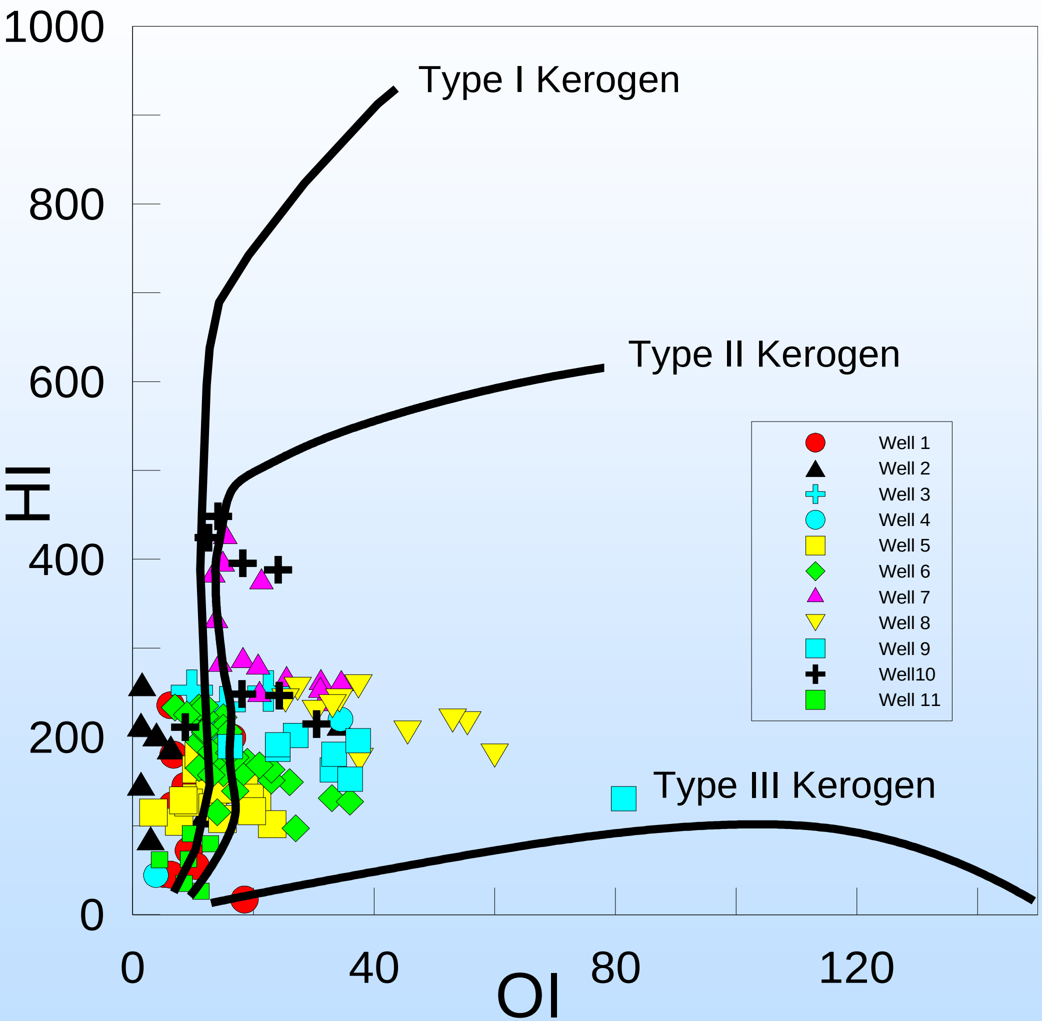
TOC





The base of the TMS in the producing area appears to have more TOC, more calcite, and lower quartz than has been documented in surrounding areas.

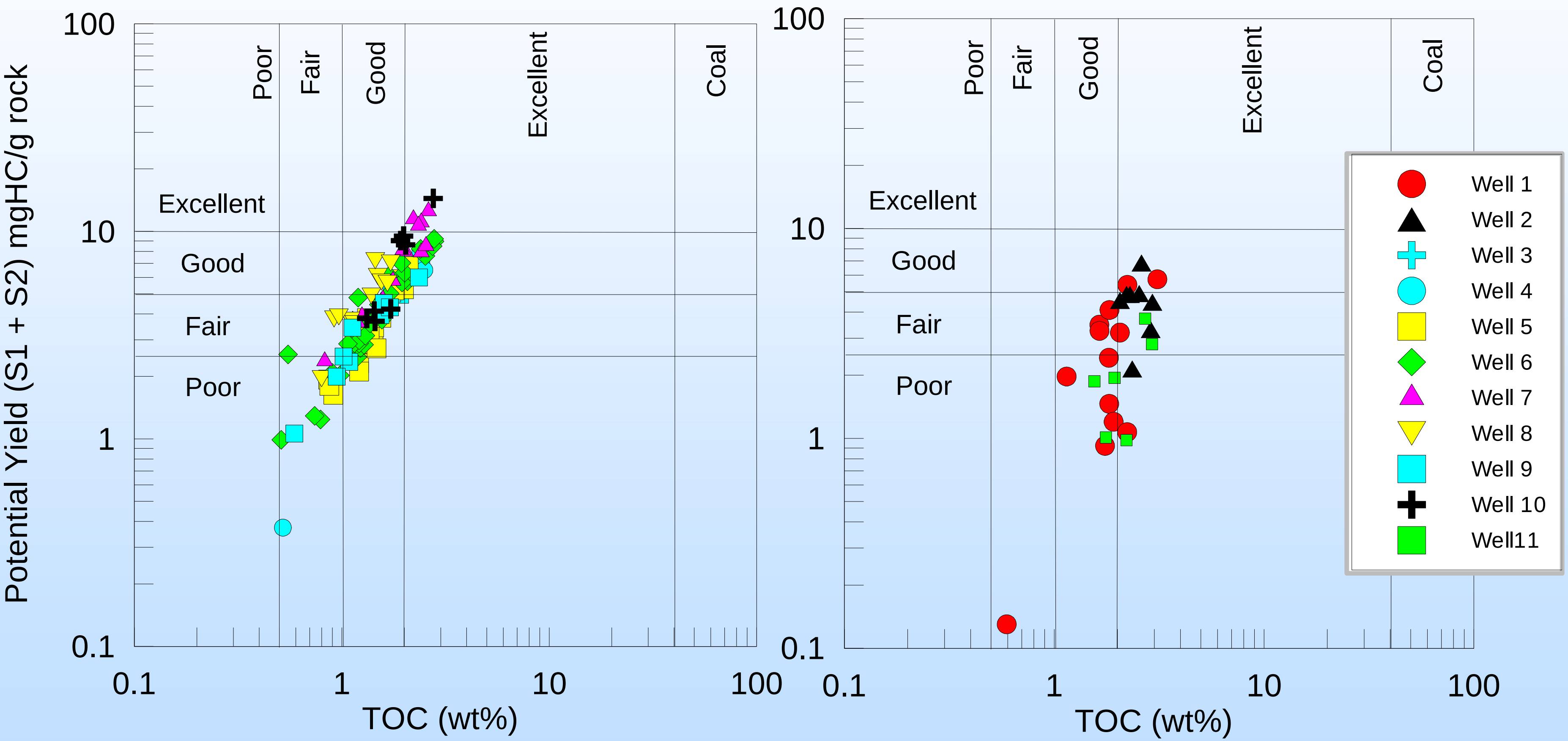
Organic Geochemistry (n = 136) near Base of TMS



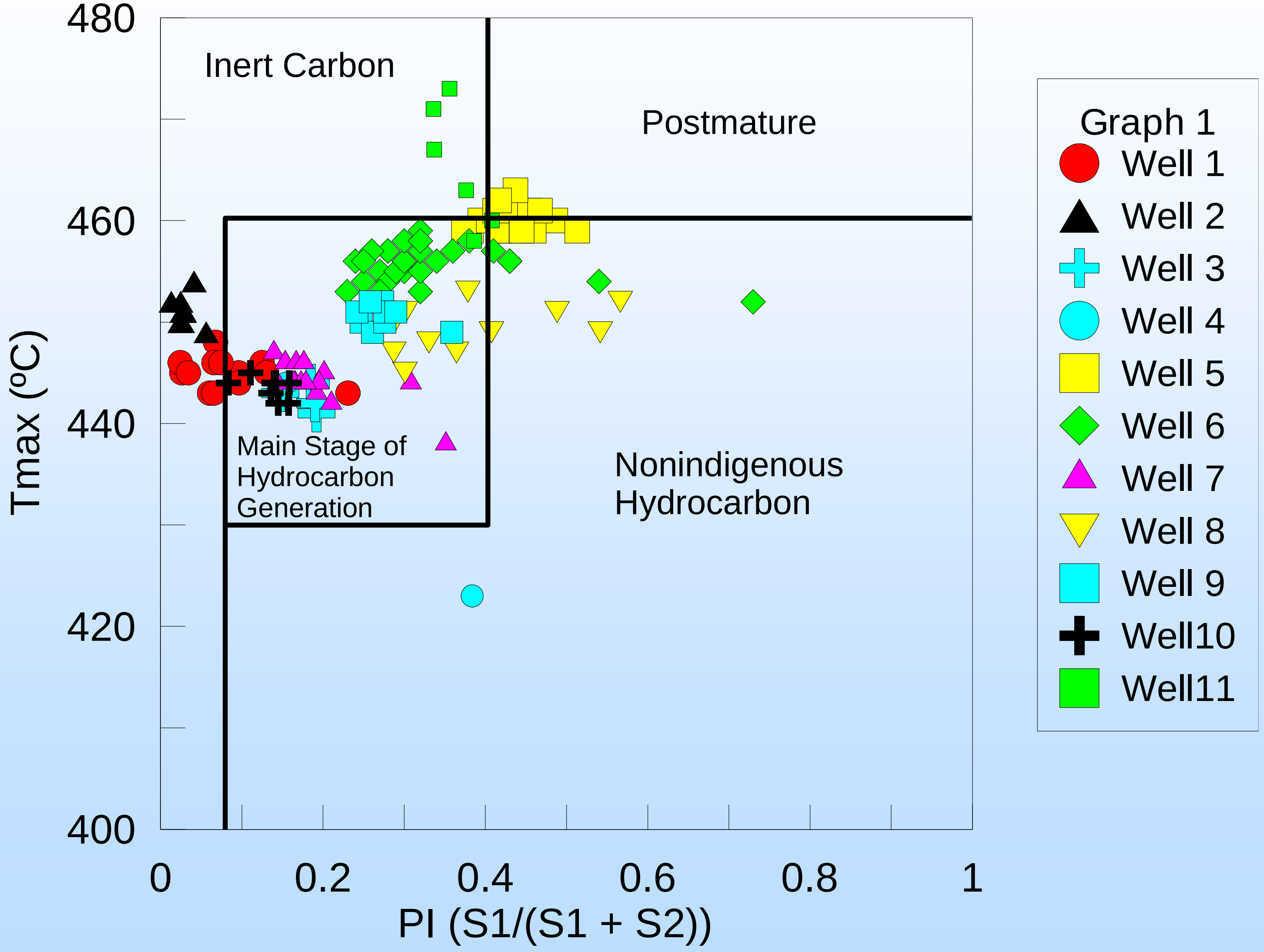
Measurement	Interquartile Range	Mean
TOC	1.2 to 2.0 (wt %)	1.6 (wt %)
S1 + S2 (Potential Yield)	2.5 to 5.8 (mg/g)	4.5 (mg/g)
HI	110 to 214 (mg/g)	158 (mg/g)
Tmax	445 to 457 (°C)	451.4 (°C)

Mixed Type II and Type III Kerogen

Generative Potential for Samples near the Base of TMS



Thermal Maturity of Samples near the Base of the TMS



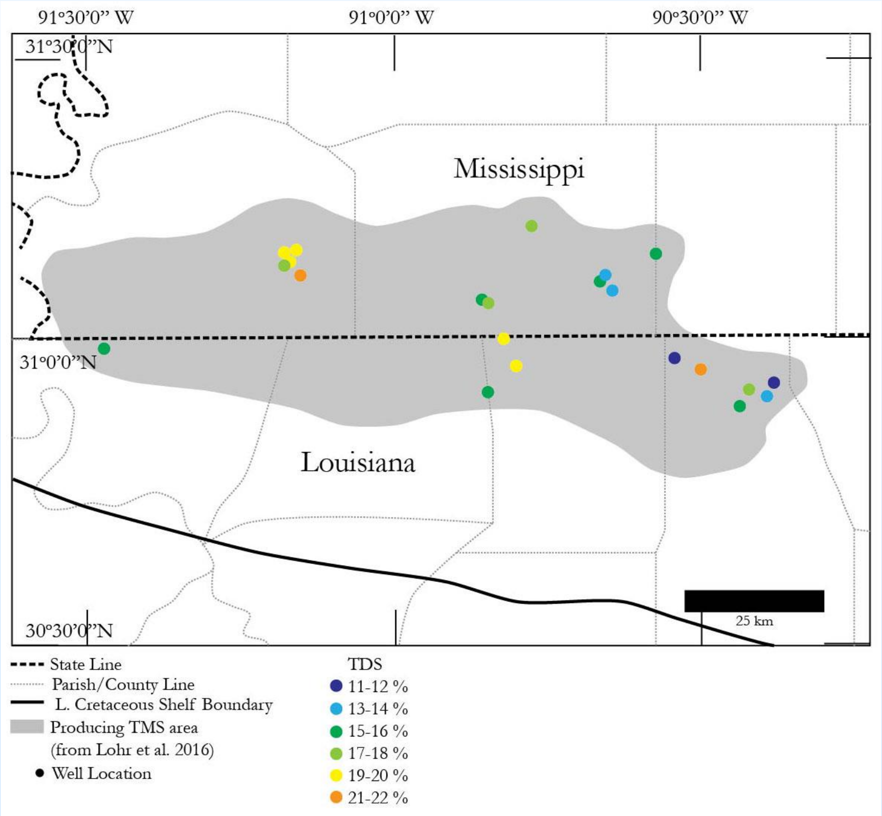
Chemical Analysis of Produced Waters from the Tuscaloosa Marine Shale

Goals:

- Analyze produced water samples to determine their elemental compositions.
- Provide a baseline for water-rock experimentation within the TMSL group.
- Determine the origin and evolution of the produced waters.
- Evaluate the potential of these brines to:
  a. Serve as identifiers of the geological units
  b. Provide information on the effectiveness of fracking or fracture densities

Major elements: Na, Mg, Ca, K, Sr, Fe, Cl, SO_4

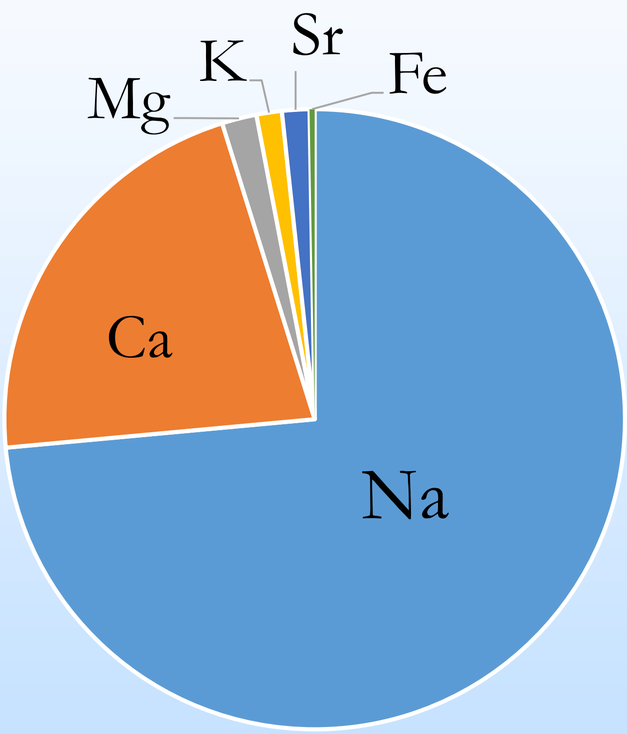
Trace elements: B, P, Al, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Mo, Cd, Ba, Pb, Tl, Br, HCO_3



Summary of Major Element Data

Produced waters from 24 wells: Quite Saline with average **16.2 weight% TDS.**

The anions are dominated (>98%) by chloride



Element	Average	Standard Deviation
Cl	11.0 wt%	2.4 wt%
Na	3.8 wt%	0.5 wt%
Ca	1.1 wt%	0.4 wt%
Mg	943 mg/L	248 mg/L
K	689 mg/L	140 mg/L
Sr	744 mg/L	151 mg/L
SO_4	<500 mg/L	NA
Fe	137 mg/L	49 mg/L
Alkalinity	157 mg/L	85 mg/L
pH	5.7	0.2
TDS	16.2 wt%	3 wt%

- **Early flowback water is less saline** with a different bulk chemistry.
- **As salinity increases the Na/Ca ratio decreases**, which is indicative of chemical evolution from processes such as albitization and dolomitization.

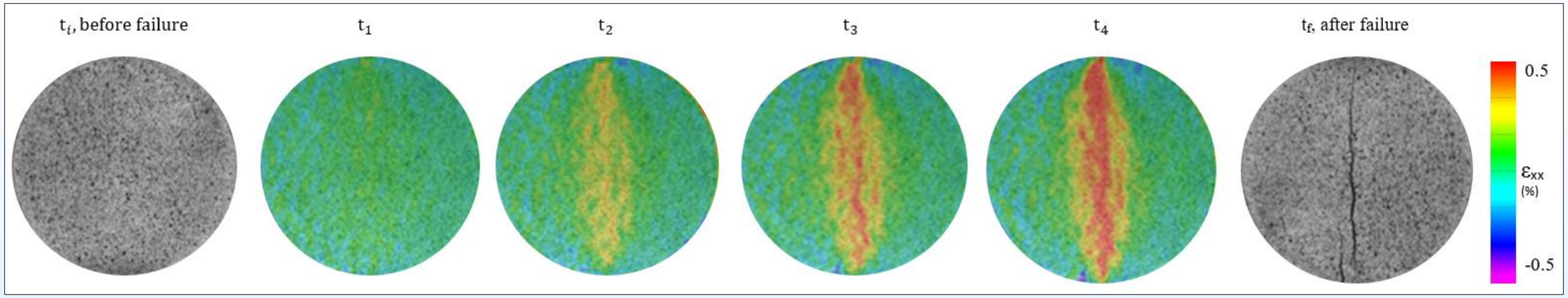
Geomechanics

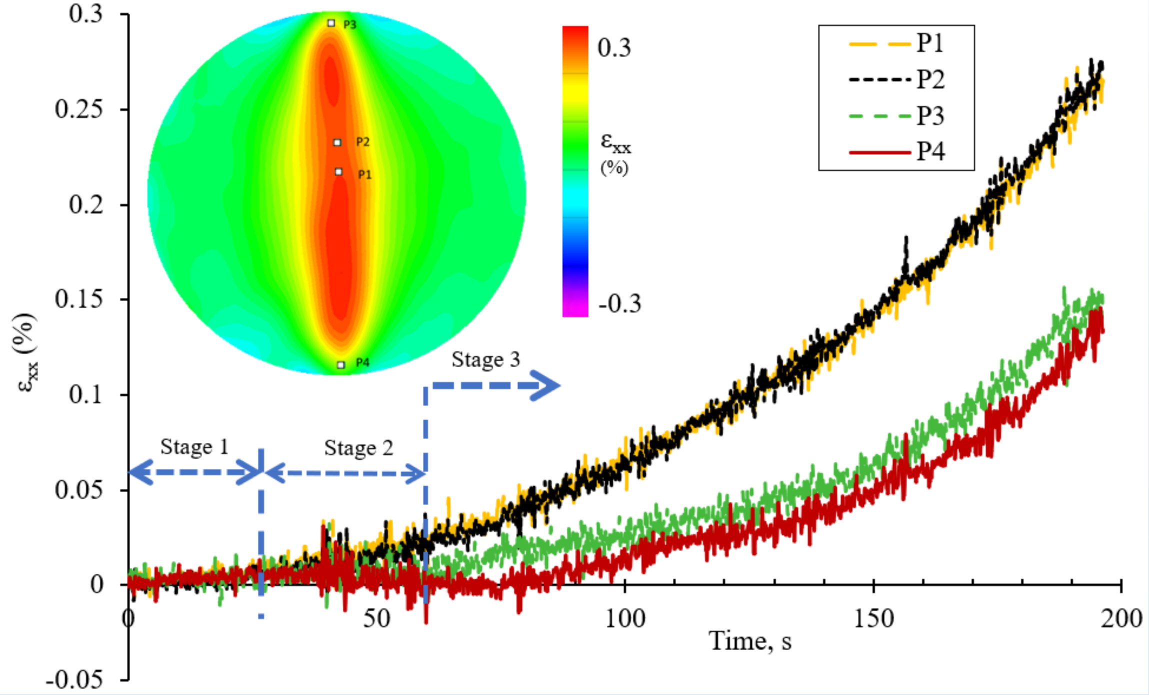
Using Digital Image Correlation (DIC) to Evaluate Rock and Cement Mechanical Properties

- DIC is based on camera recording of an object monitoring the random contrast speckle pattern painted at facing surface of the specimen.

- Purchased and installed a new loading machine.
- Purchased and installed a 3D DIC system.

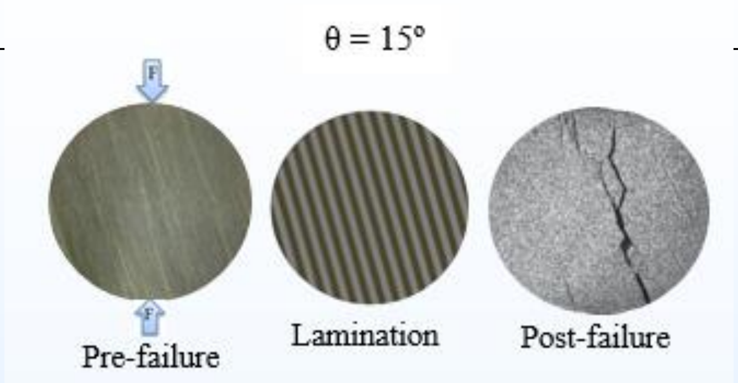
Homogenous Sandstone under Brazilian Testing

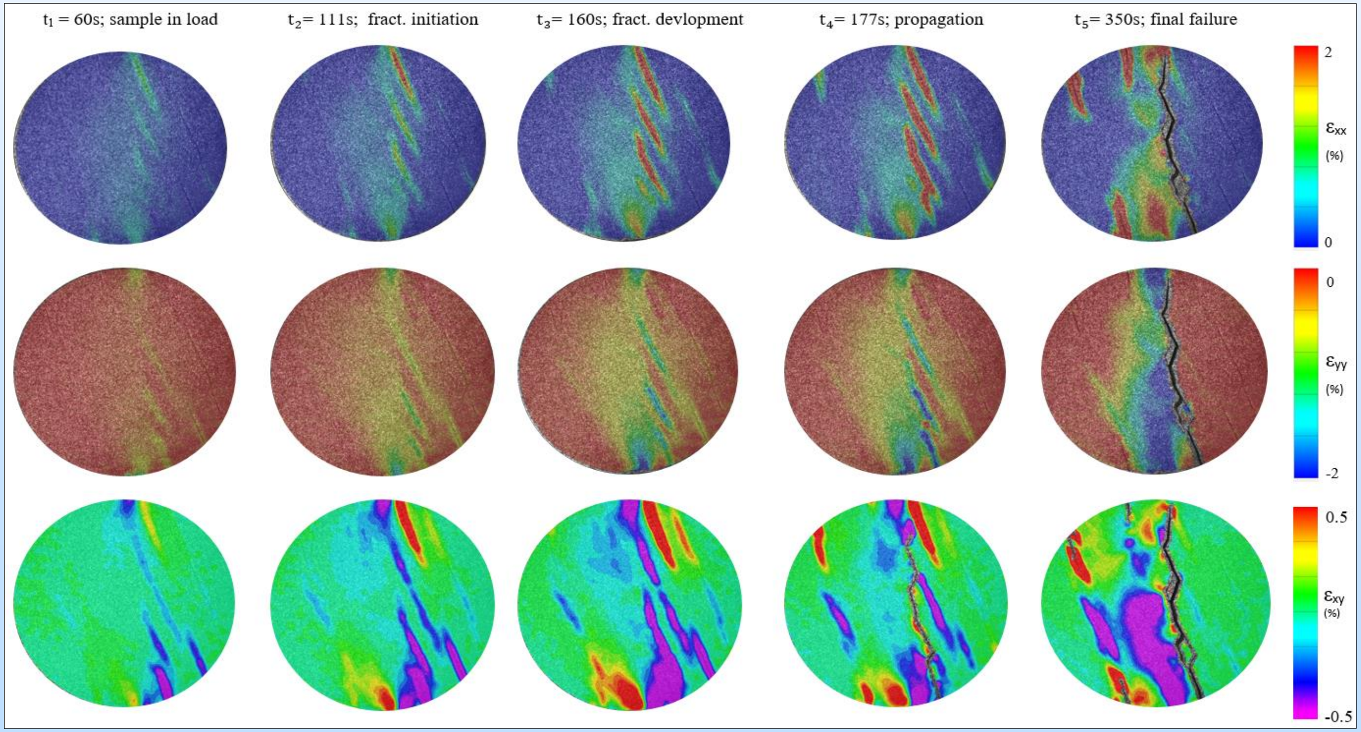




Mokhtari et al. 2019. Complex Deformation of Naturally Fractured Rocks, Journal of Petroleum Science and Engineering

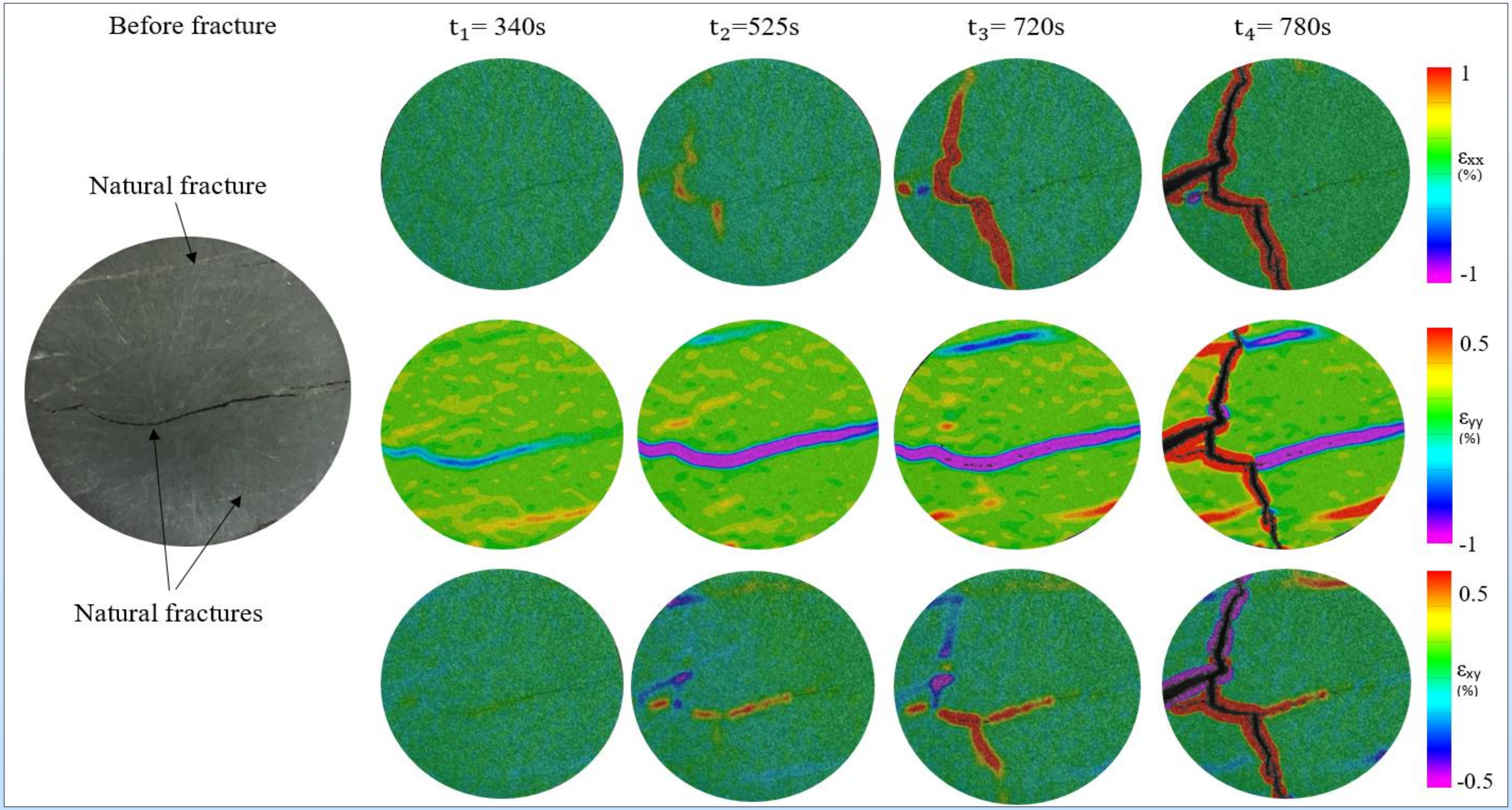
Laminated Shale Under Brazilian Testing (15-degree)



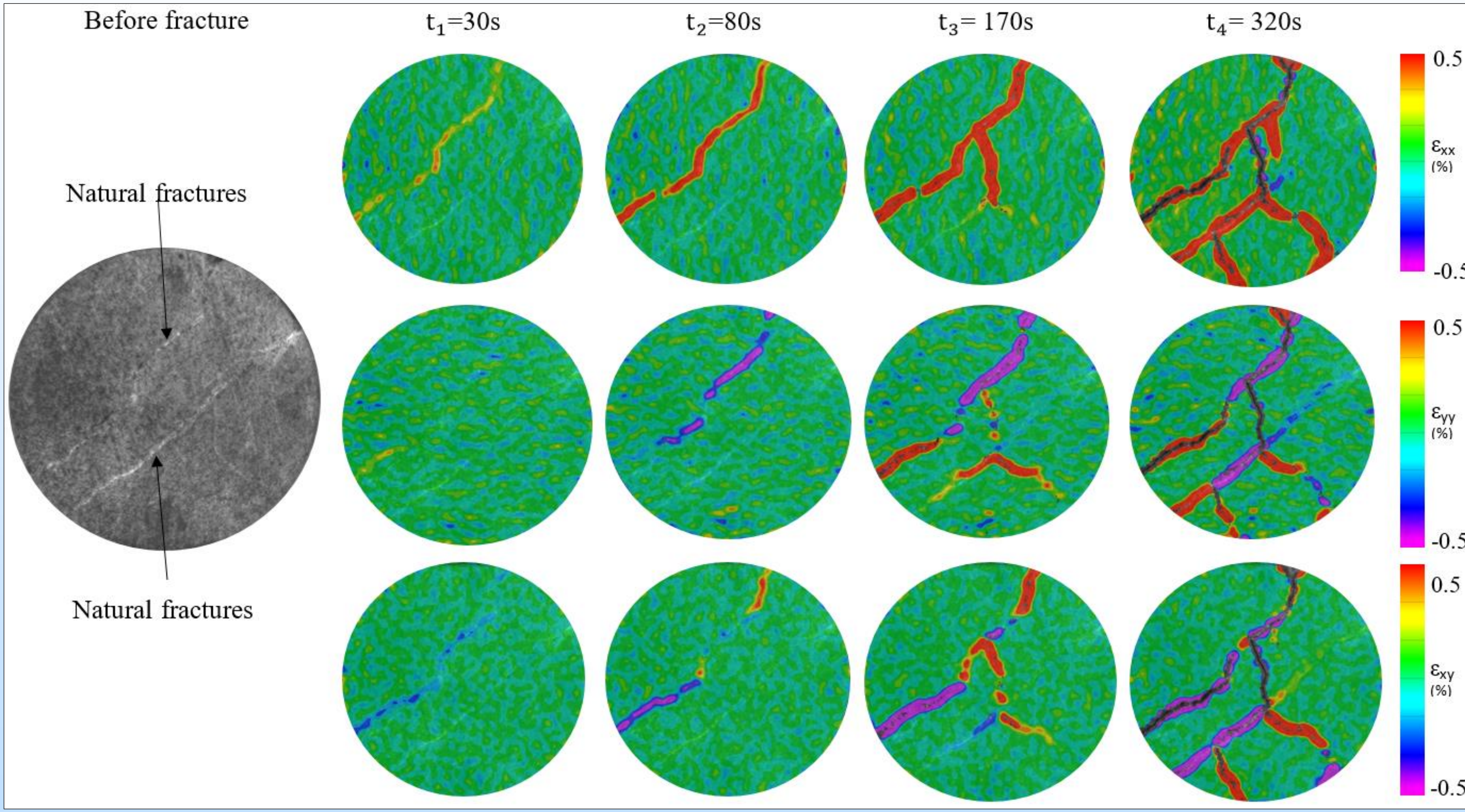


Nath and Mokhtari, 2018

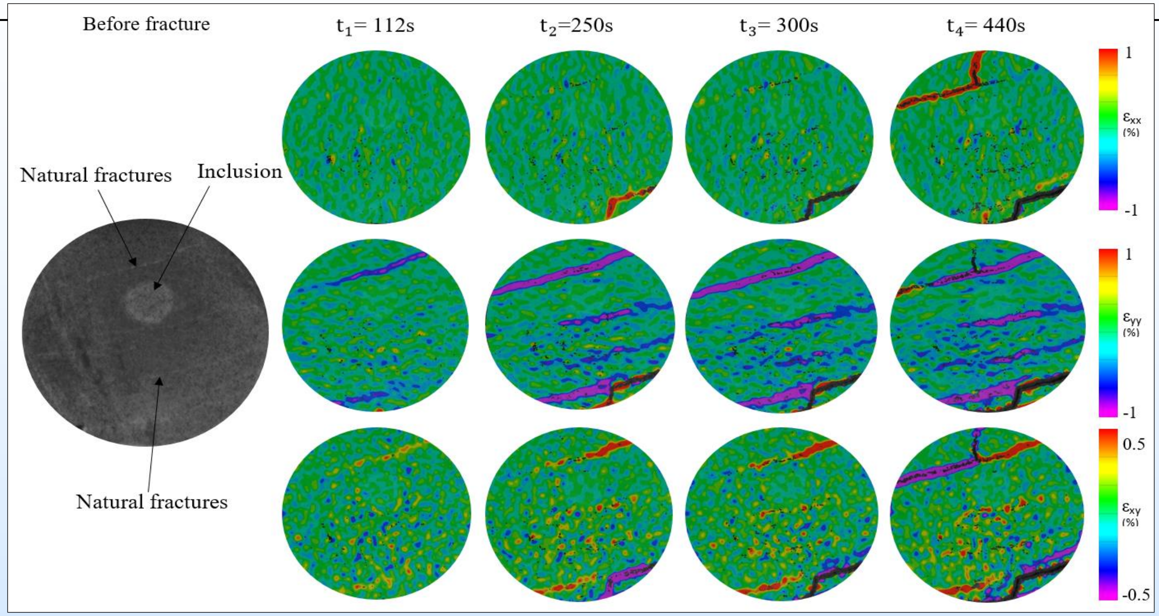
Partially-Open Horizontal Natural Fracture Under Brazilian Testing

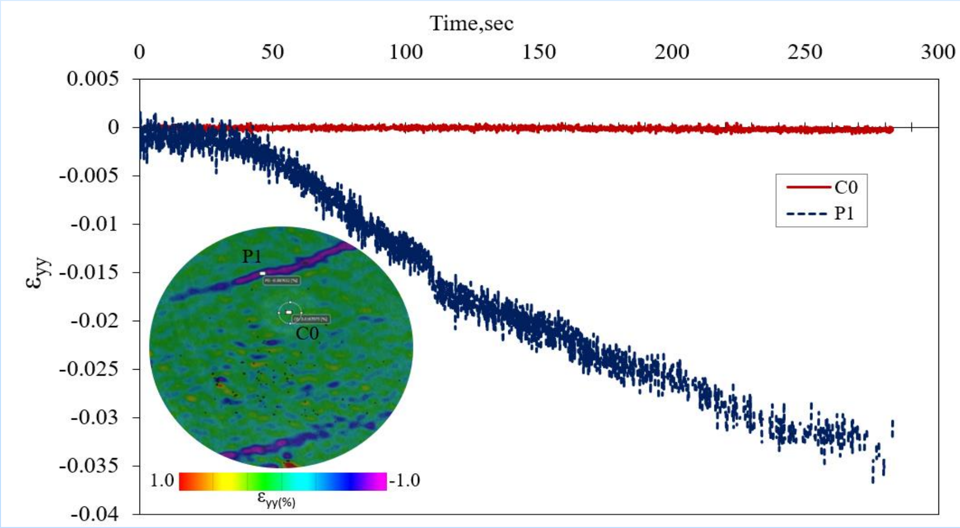


Natural Fracture Network Under Brazilian Testing



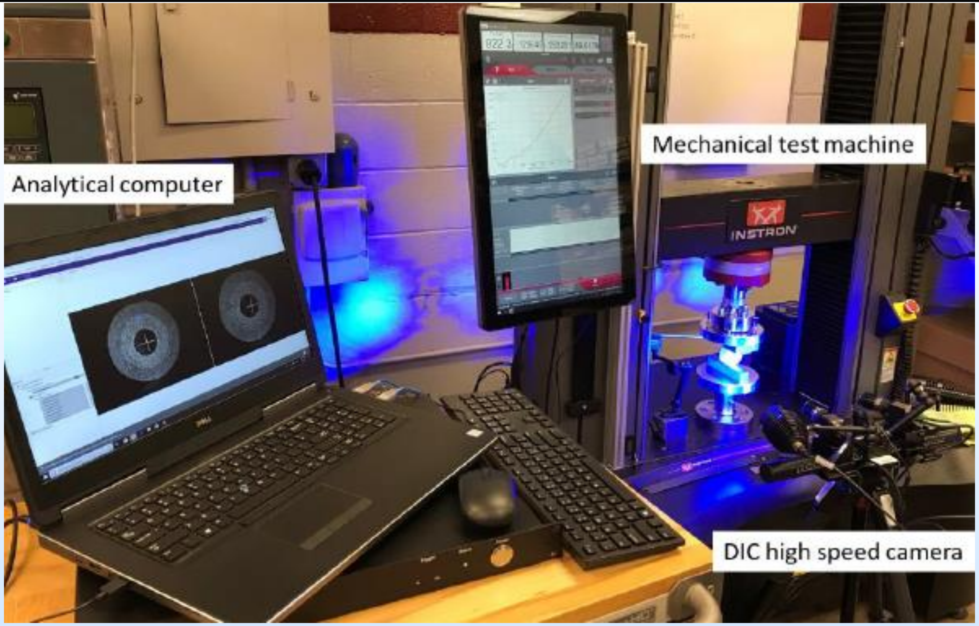
Effect of Inclusion

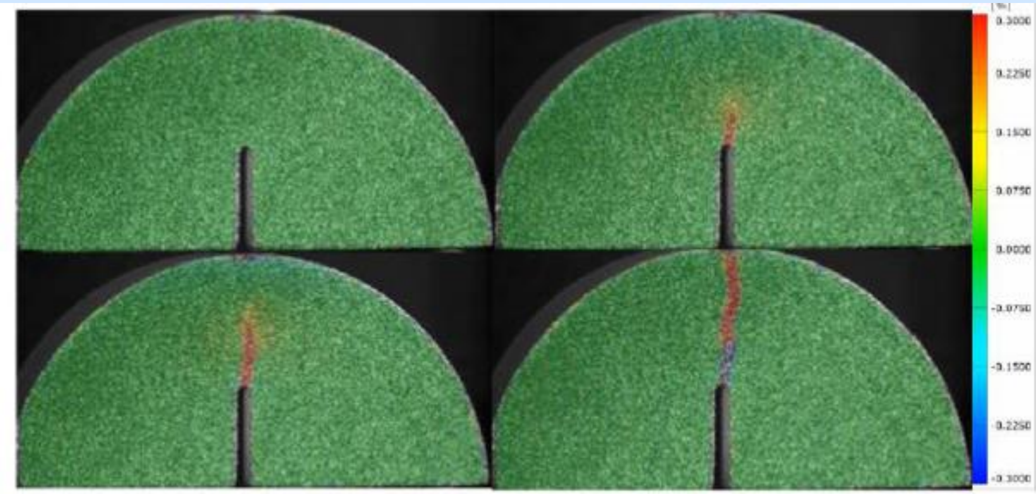




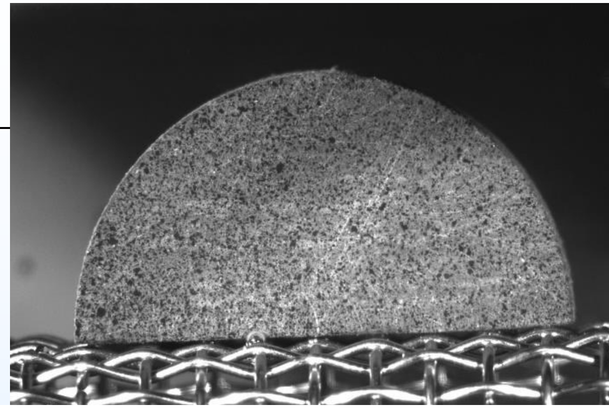
Fracture Toughness Testing

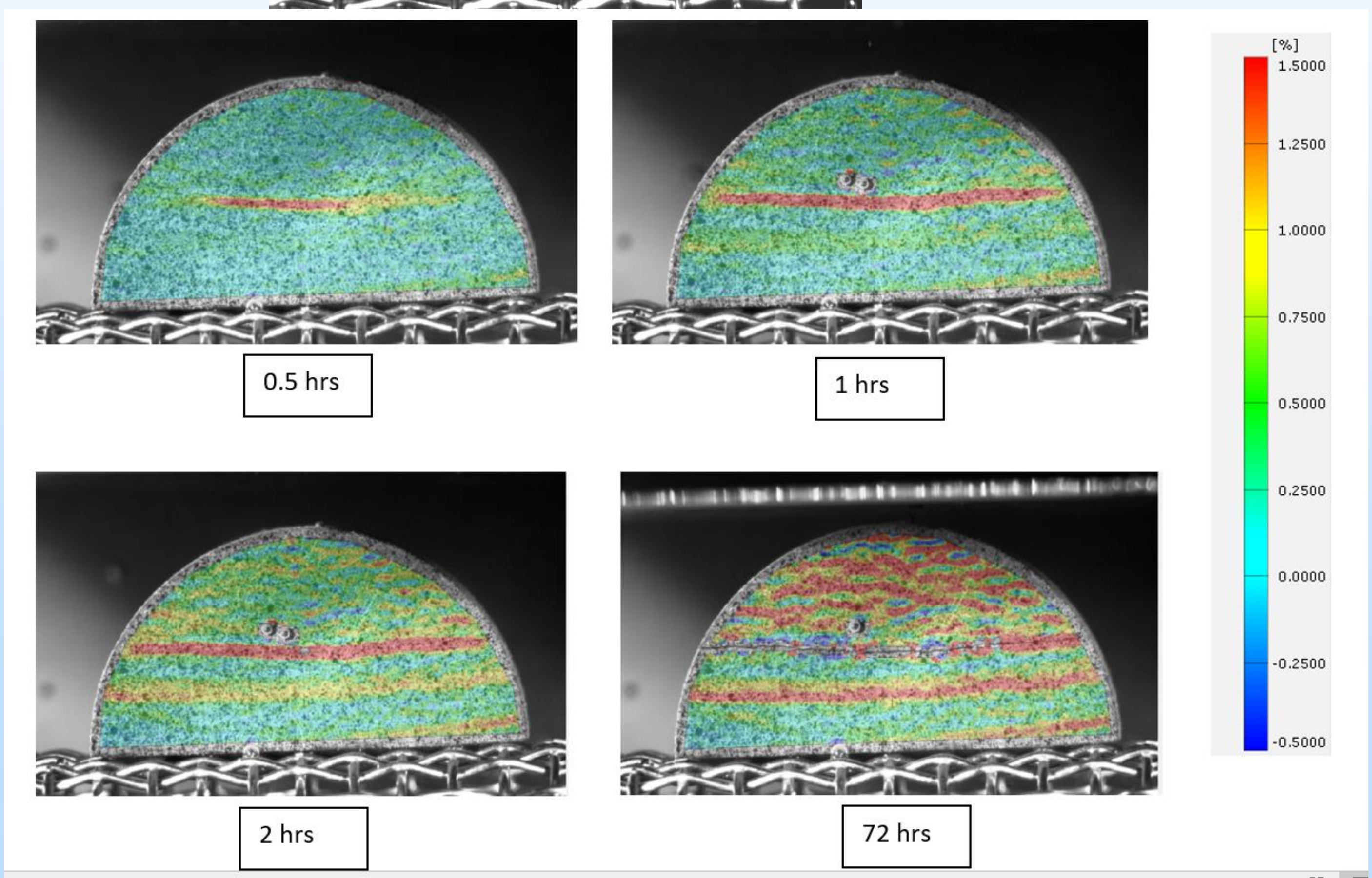
- A Postdoc was hired.
- Procurement of 3D DIC system: Successfully installed of newly procured ARAMIS 3D DIC system in University of Louisiana at Lafayette facility in October, 2018.
- Procurement of Instron Universal Testing System: Under comprehensive investigation of several industry standard load frames, a new Instron UTM is successfully procured and installed in University of Louisiana at Lafayette facility in March, 2019.
- Semicircular Bend test (SCB) associated with Digital Image Correlation (DIC) has been conducted. A manuscript will be submitted for peer-review in Fall 2019.



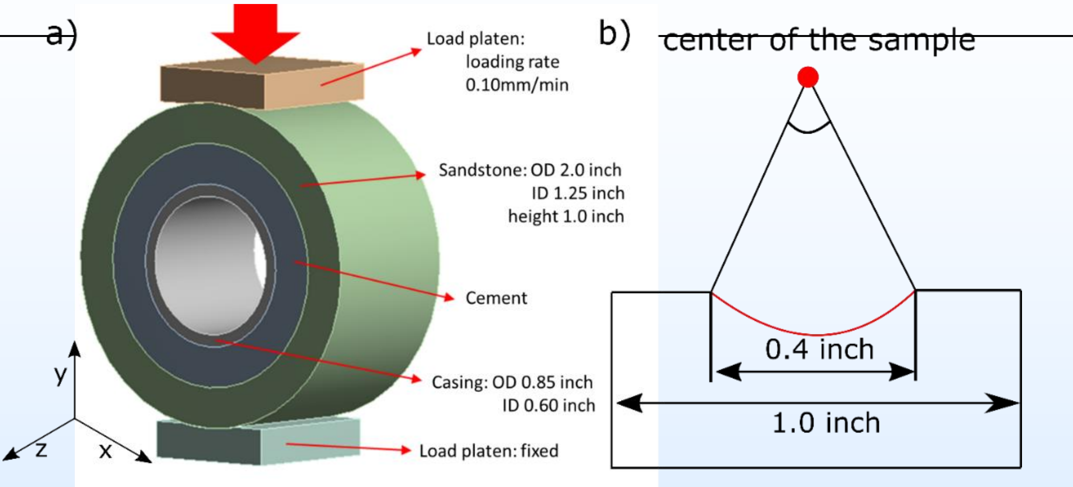


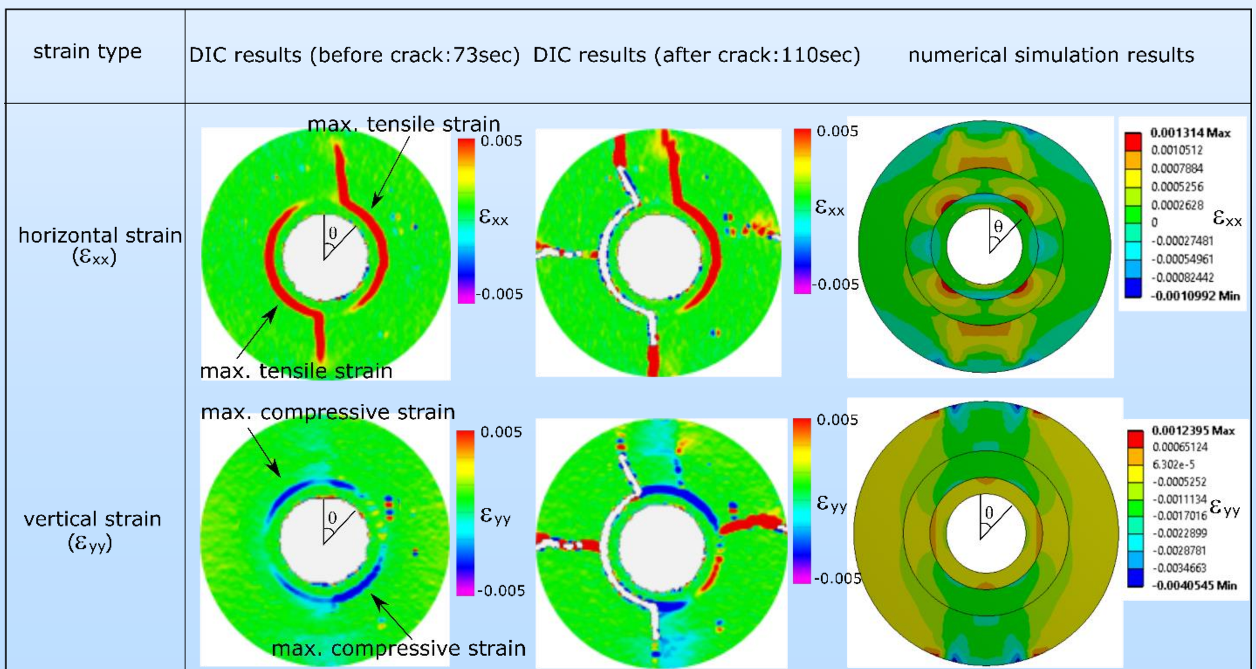
Imbibition-Induced Fracturing





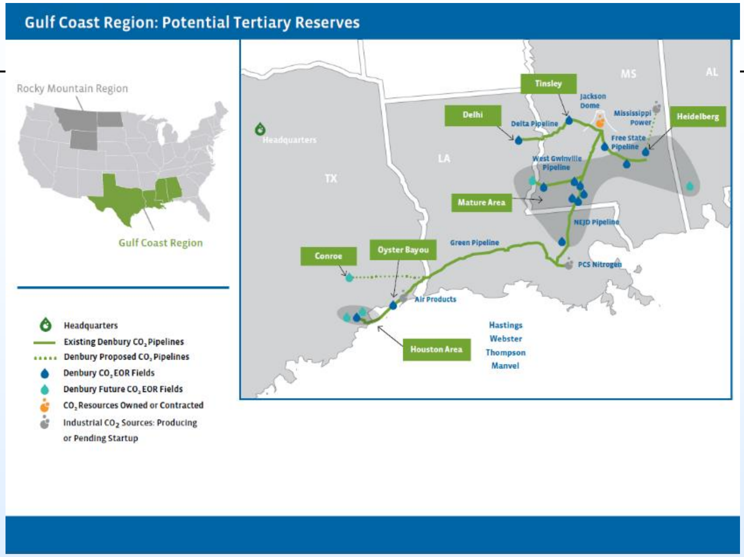
Formation/Cement/Casing Boding Test



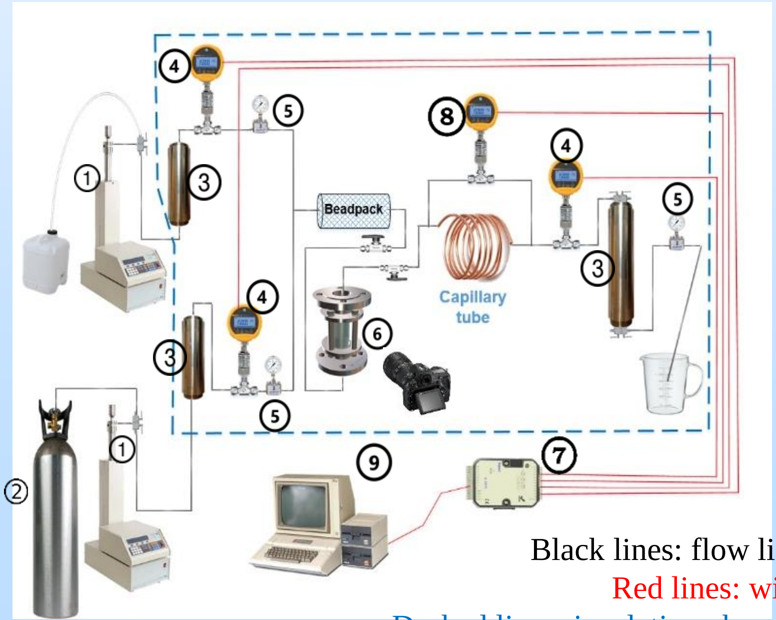


Enhanced Oil Recovery

Investigation of CO_2 Foam Generation with Nanoparticles for TMS



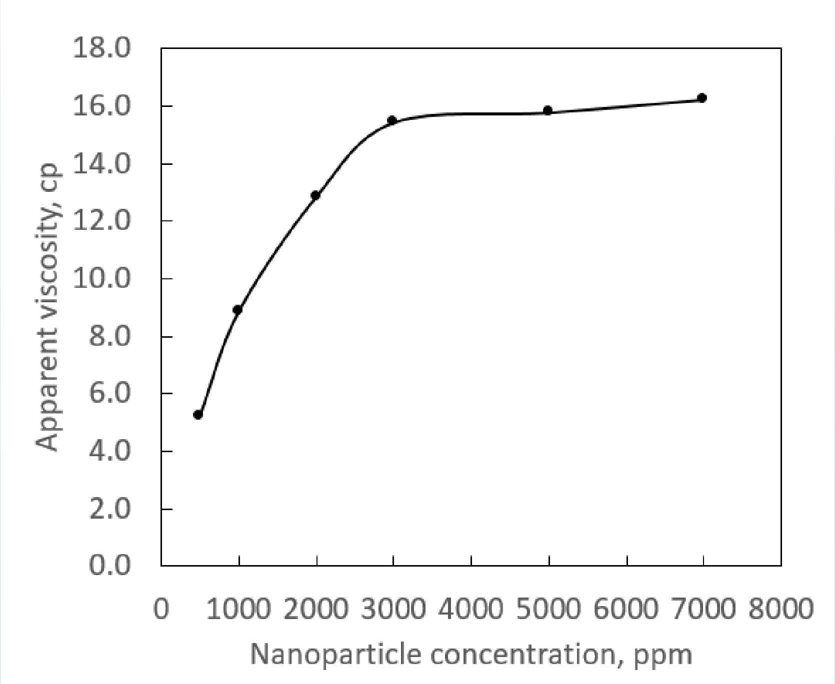
- Due to high clay content, water/rock interaction is a major issue for the TMS fracturing performance.
- As an alternative, nanoparticle-stabilized CO_2 foam as a fracturing fluid for TMS is investigated.
- Investigate the process of particle-stabilized CO_2 foam generation under reservoir conditions.
- Factors such as particle concentration, brine/CO_2 phase ratio, brine salinity, and temperature effect on CO_2 foam generation and the foam stability will be investigated.



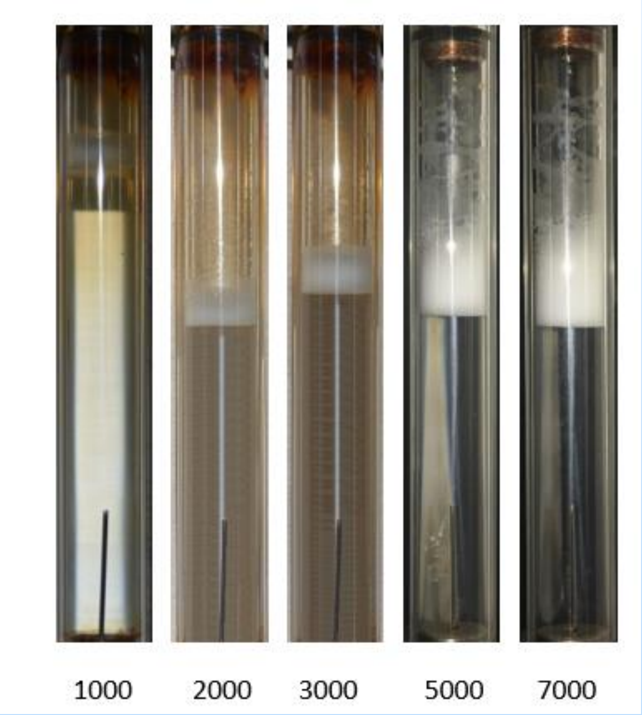
Black lines: flow lines
Red lines: wires
Dashed lines: insulation chamber

Investigation of CO_2 Foam Generation with Nanoparticles for TMS

- **Stable CO_2 foams stabilized with silica nanoparticles under high pressure conditions were successfully generated** with an apparent viscosity up to 24.5cp (2895s^{-1}) and foam half life up to 96 hours.
- **Foam stability increases with the increase of silica nanoparticle concentration**. Foam apparent viscosity increases with the increasing nanoparticle concentration from 500ppm to 3000ppm, and remains at a plateau from 3000ppm to 7000ppm.



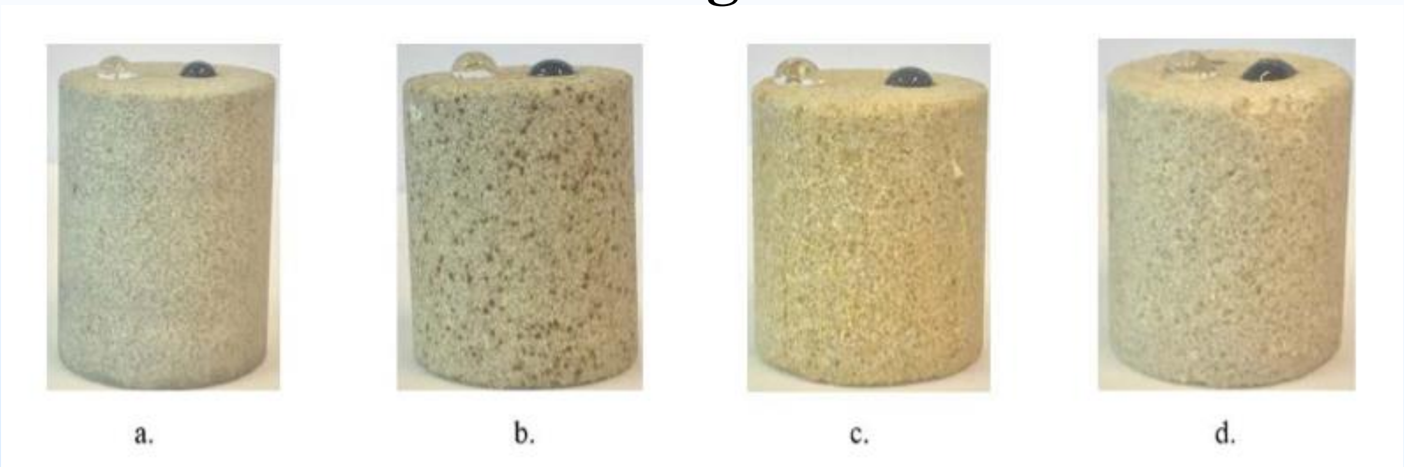
Effect of nanoparticle concentration

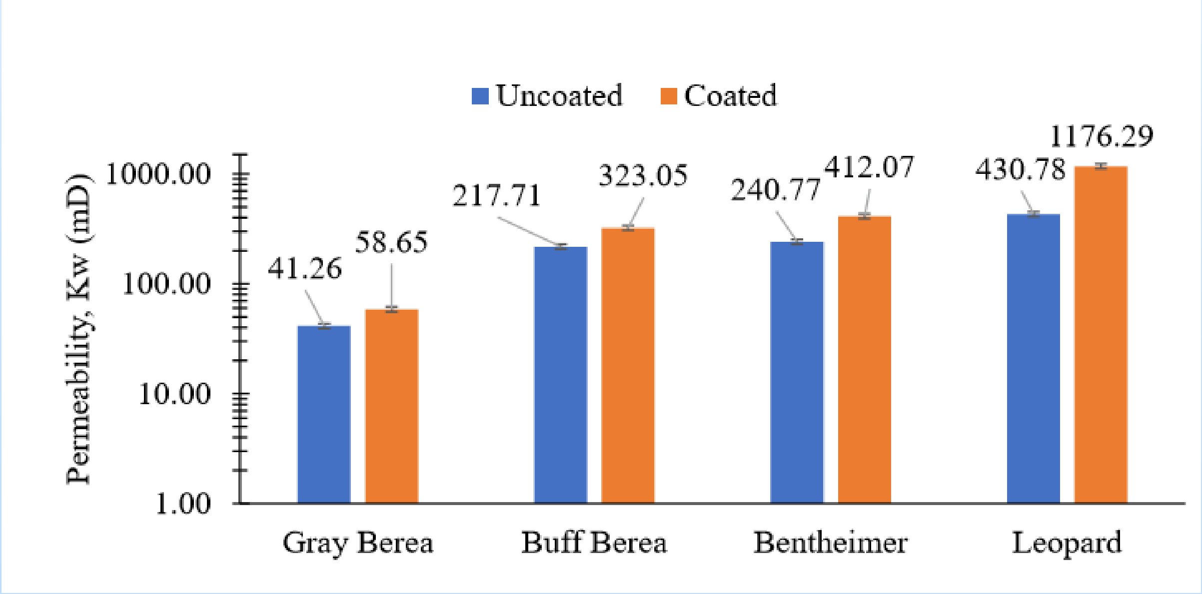


Superhydrophobic Coating of Proppants

Before Coating

Post Coating





Impact

SOUTHERN UNCONVENTIONAL RESOURCES COLLABORATORY OF EXCELLENCE

SOURCE

: the Source for Knowledge on Source Rocks & Beyond.

- To push the boundaries of science, technology and best practices in hydrocarbon extraction from tight formations.
- To contribute to the development and well-being of society through research on energy production.
- To train the next generation of petroleum engineers with intellectual merit and potential to benefit society.
- To enhance the economic development of the State of Louisiana through scientific research projects on oil and gas.
- To provide a platform for effective and efficient collaboration among academia, industry and State/Federal government.
- To promote environmental stewardship with regard to the development of unconventional resources.
- To empower qualified women, minorities and low-income students with an advanced education in engineering.
- To disseminate knowledge on unconventional resources.

SOURCE Laboratory (~$150K)

2018

2019

Upgrade of UL Lafayette Undergraduate Petroleum Engineering Computer Lab

Replacing 32 PCs
Grant: $40,000

UNIVERSITY OF LOUISIANA AT LAFAYETTE

STEP Committee

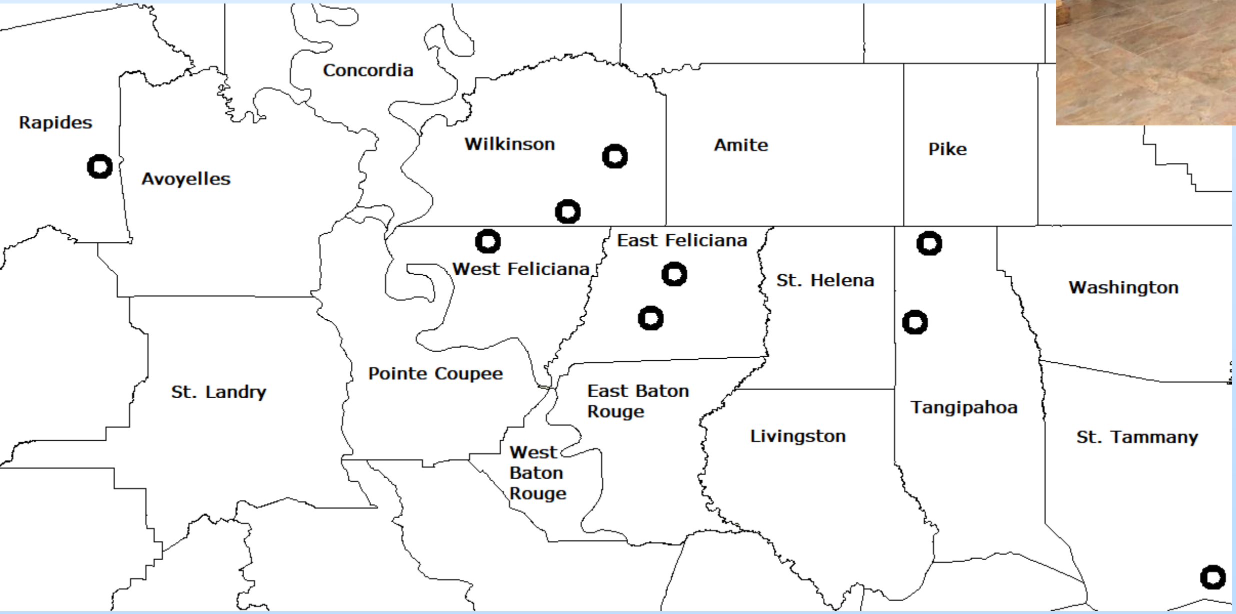
Technology Fee Application

Petroleum Engineering Computer Lab Upgrade to Meet the Requirements of Simulation in Curriculum and Professional Development

TMS Virtual Laboratory

Established a virtual laboratory with:

- Whole Cores/ Sidewall cores available for 9 wells (Original proposed study: 5 wells).
- Water and oil samples from 25 wells.
- Production data of more than 70 wells.
- Cuttings from 37 TMS wells.



New Collaborations

GOODRICH PETROLEUM CORPORATION

ExxonMobil

SIGNAL

BERKELEY LAB

HELIS OIL & GAS

Los Alamos NATIONAL LABORATORY EST. 1943

LSU

Dissemination of Knowledge

- Borrok, D.M., Yang, W., Wei, M., and Mokhtari, M., 2019. **Heterogeneity of the Mineralogy and Organic Content of the Tuscaloosa Marine Shale**, *Marine and Petroleum Geology*, Vol. 109, p.717-73. https://doi.org/10.1016/j.marpetgeo.2019.06.056

- Fu, C., and Liu, N., 2019. Waterless fluids in hydraulic fracturing – A Review. *Journal of Natural Gas Science and Engineering*, Vol. 67, p. 214-224. https://doi.org/10.1016/j.jngse.2019.05.001

- Fu, C., Yu, J., and Liu, N., 2019. The effect of foam quality, particle concentration and flow rate on nanoparticle-stabilized CO_2 mobility control foams. *RSC Advances*. Issue 16, p. 9313-9322. https://doi.org/10.1039/C8RA10352F

- Yang, X., Guo, B., and Zhang, X., 2019. An Analytical Model for Capturing the Decline of Fracture Conductivity in the Tuscaloosa Marine Shale Trend from Production Data, *Energies*, 12(10), 1938; https://doi.org/10.3390/en12101938

- Yang, X., and Guo, B., 2019. A Data-Driven Workflow Approach to Optimization of Fracture Spacing in Multi-Fractured Shale Oil Wells, *Energies*, 12(10), 1973; https://doi.org/10.3390/en12101973

- Kimanzi, R., 2019. Experimental Investigation of the cement bond integrity by application of digital image correlation (DIC) technique, *M.Sc. Thesis*, University of Oklahoma.

- Nippes, V., 2019. Production Behavior and Decline Curve Analysis of Tuscaloosa Marine Shale Wells in Wilkinson and Amite Counties, Mississippi, *M.Sc. Thesis*, University of Louisiana at Lafayette. (Adviser: Dr. M Mokhtari)

- Konate, N., Ezeakacha, C. P., Salehi, S., and Mokhtari, M., 2019. Application of an Innovative Drilling Simulator Set Up to Test Inhibitive Mud Systems for Drilling Shales. *SPE Oklahoma City Oil and Gas Symposium*, 9-10 April, Oklahoma City, Oklahoma, USA.

- Kiran, R., Salehi, S., Mokhtari, M., and Kumar, A., 2019. Effect of Irregular shape and Wellbore Breakout on Fluid Dynamics and Wellbore Stability. 53rd *US Rock Mechanics/Geomechanics Symposium*. American Rock Mechanics Association.

- Hoffmann, A.A., Thompson A., and Borrok, D.M., 2019. The origin and evolution of produced waters from the Tuscaloosa Marine Shale in Mississippi and Louisiana. *Geological Society of America Joint Regional Meeting*, Manhattan, Kansas, March 25-27.

SOURCE Lecture Series

Name	Institution	Title of Presentation	Date
Mr. Chad W. Hurlburt	Instron	Universal Testing System Training	April 16, 2019
Mr. Rick Ramsey	Bruker	Portable XRF Spectrometer Demonstration	February 14, 2019
Dr. Wan Yang	Missouri S&T	TMS Core Description	February 12, 2019
Dr. Mohsen Kariminia	ALS Oil & Gas	Biostratigraphy Application in TMS Hydrocarbon Exploration	January 23, 2019
Dr. Anthony Salem	Shell	Geology of the Haynesville Shale Play in North Louisiana	November 26, 2018
Ms. Archana Jagadisan	UT Austin	Experimental Quantification of Kerogen Wettability as a Function of Thermal Maturity	November 19, 2018
Mr. DJ Winterhoff	Trilion	Process Optimization Using Digital Image Correlation for Petroleum Engineering Applications	November 12, 2018
Dr. Manika Prasad	Colorado School of Mines	Using Geophysics to Understand Pore Compliance and Poroelasticity in Reservoirs	November 1, 2018
Mr. Matt Hoover	Kruss	Surface Science Workshop	October 30, 2018

TMSL Consortium Meetings and Events

Appendix