Quarterly Research Performance Progress Report

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Project Title	**THE EAGLE FORD SHALE LABORATORY: A FIELD STUDY OF THE STIMULATED RESERVOIR VOLUME, DETAILED FRACTURE CHARACTERISTICS, AND EOR POTENTIAL**
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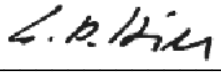
Signature of Principal Investigator:	 Dan Hill

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1. INTRODUCTION

This quarterly research progress report is intended to provide a summary of the work accomplished under this project during the fifth quarter of the first budget period (***April 1st, 2019 – June 30th, 2019***). Summarized herein is a description of the project accomplishments to date, along with the planed work to be conducted in the next quarter.

2. ACCOMPLISHMENTS

2.1. Project Goals

The ultimate objective of this project is to help improve the effectiveness of shale oil production by providing new scientific knowledge and new monitoring technology for both initial stimulation/production as well as enhanced recovery via re-fracturing and EOR. This project will develop methodologies and operational experience for optimized production of oil from fractured shale, an end result that would allow for more production from fewer new wells using less material and energy. While aspects of the proposed project are site-specific to the Eagle Ford formation, there will be many realistic and practical learnings that apply to other unconventional plays, or even apply to other subsurface applications such as unconventional gas recovery and geologic carbon sequestration and storage. The main scientific/technical objectives of the proposed project are:

- Develop and test new breakthrough monitoring solutions for hydraulic fracture stimulation, production, and EOR. In particular, for the first time in unconventional reservoirs, use active seismic monitoring with fiber optics in observation wells to conduct: (1) real-time monitoring of fracture propagation and stimulated volume, and (2) 4D seismic monitoring of reservoir changes during initial production and EOR from the re-fractured well.
- Improve understanding of the flow, transport, mechanical and chemical processes during and after stimulation (both initial and re-fracturing) and gain insights into the relationship between geological and stress conditions, stimulation design, and stimulated rock volume.
- Assess spatially and temporally resolved production characteristics and explore relationship with stimulated fracture characteristics.
- Evaluate suitability of re-fracturing to achieve dramatic improvements in stimulation volume and per well resource recovery.
- Evaluate suitability of gas-based EOR Huff and Puff methods to increase per well resource recovery.
- Optimize drilling practices in the Eagle Ford shale based on surface monitoring and near-bit diagnostic measurements during drilling.
- Conduct forward and inverse modeling to test reservoir and fracture models and calibrate simulations using all monitored data. Ultimately, provide relevant guidance for optimized production of oil from fractured shale.
- Disseminate research and project results among a broader technical and scientific audience, and ensure relevance of new findings and approaches across regions/basins/plays.

The project will start with the re-fracturing of a legacy well that was initially stimulated using now outdated fracturing technology (Task 2). The recipient will drill, complete, and instrument one vertical and one horizontal observation strategically located on both sides of the legacy well to allow for real-time cross-well monitoring of evolving fracture characteristics and stimulated volume. These observation wells will also be used for the other two main project stages, involving

a new state-of-the art stimulation effort (Task 3) and a Huff and Puff EOR test (Task 4). Task 3 will be conducted in two new wells of opportunity drilled; these wells will be situated parallel to the horizontal observation well on the other side of the re-fracturing well. Task 4 will be conducted in the re-fractured legacy well, testing the efficiency of a Huff and Puff process with natural gas injection for EOR. As described below, each main task comprises various field activities complemented by laboratory testing and coupled modeling for design, prediction, calibration, and code validation. In addition to the three main tasks aligned with re-fracturing, new stimulation, and EOR, the work plan also comprises Task 1 (Project Management and Planning) and Task 5 (Integrated Analysis, Lessons Learned, Products, and Reporting). The project milestones, description of tasks and subtasks, and current milestone status are shown in **Table 1**.

2.2. Accomplishments

This section summarizes the accomplishments for the current reporting quarter (***April 1st, 2019 – June 30th, 2019***).

2.2.1. EFSL Project Performers Summit Meeting

A summit meeting was held between key representatives from all project performer organizations, namely Texas A&M University (TAMU), Lawrence Berkeley National Laboratory (LBNL), Stanford University (Stanford), and Chesapeake Energy Corporation (CHK), to update all participants on the project status and develop a detailed project plan for Phase 1 field activities.

2.2.2. Active Seismic Monitoring Technology Tested in the Field

2.2.1. Project Plan Revisions – Observation Well Placement

2.2.2. Completion and Stimulation Fractal Design Conducted for Optimization

2.2.3. Drill Cuttings Analysis Program

A drill cuttings analysis program has been developed to identify the propped fracture locations.

2.2.4. Monitoring System Design

Design of the active source and passive monitoring arrays as well as the integrated monitoring completion has been completed (Subtask 2.1).

2.3. Opportunities for Training and Professional Development.

Nothing to Report.

2.4. Dissemination of Results to Communities of Interest

Nothing to Report.

2.5. Plan for Next Quarter (BP1-Q6: July 1st – September 30th, 2019)

Building on the current progress achieved by the research team, work planned for the next quarter will include, but is not limited to, the following:

- Continue work related to the observation wells in support of Subtask 2.2 and 2.5:
  - ✓ Surface location selection.
  - ✓ Planning for permitting.
  - ✓ Vertical pilot and well path design (for HOW).
  - ✓ Casing design to accommodate coring and subsequent instrumentation.
- Continue ongoing design and planning for seismic monitoring in support of Subtask 2.5:
  - ✓ Procure seismic source components.
  - ✓ Seismic source location determination, planning, and permitting.
  - ✓ Initiate development of EFSL-specific seismic data processing and interpretation tools.
- Finalize proppant tracing program.
- Design of geomechanical testing experiments to be conducted on core and cuttings.
- Continue simulation and modeling efforts in support of Subtask 2.9.

2.6. Summary of Tasks for Next Quarter (BP1-Q6: July 1st – September 30th, 2019)

The following provides a summary of the tasks, subtasks, and activities planned in BP1-Q6:

- Task 1 – Project Management and Planning
- Task 2 – Phase 1: Evaluation of Re-fracturing
  - ✓ Subtask 2.2 – Drill, Complete, & Instrument Horizontal Observation Well
    - *Activity 2.2.1 Drill Pilot Hole*
    - *Activity 2.2.2 Drill Horizontal Well Parallel to Refrac Well*
    - *Activity 2.2.3 Log Horizontal Observation Well (Open-hole logs)*
    - *Activity 2.2.4 Installation of Fiber Optic Cable, Pressure Gauges, and Seismic Source*
  - ✓ Subtask 2.4 – Recomplete Well to be Re-Fractured
  - ✓ Subtask 2.5 – Monitoring of Re-Fracturing
    - *Activity 2.5.1 Re-fracturing Operation*
    - *Activity 2.5.2 Active & Passive Seismic Mapping of Propagating Fracture*
    - *Activity 2.5.3 Tracer Monitoring*
    - *Activity 2.5.4 DTS/DAS/DSS Monitoring in Refrac and Monitoring Well*
    - *Activity 2.5.5 Pressure Monitoring in Observation Wells*
    - *Activity 2.5.6 Logging Horizontal Observation Well for RA Proppant Tracers*

2.7. Summary of Milestone Status

The following table provides a summary of milestones and updated planned completion dates:

Table 1. Summary of Milestone Status

Milestone	Task	Sub-task	Title/Description	Planned Completion Date	Actual Completion Date	Comments
A	1	1.1	Project Management & Planning	12/31/2021	-	*Ongoing*
	2 - Phase 1: Re-Fracturing Evaluation	2.1	Evaluation of Existing Data and Design of Observation Wells	9/30/2018	8/1/2019	*Complete*
B		2.2	Drill, Complete, & Instrument Horizontal Observation Well	11/1/2019	-	-
		2.3	Drill, Complete, & Instrument Vertical Observation Well	11/1/2019	-	-
		2.4	Recomplete Well to be Re-Fractured	11/1/2019	-	-
C		2.5	Monitoring of Re-Fracturing	11/1/2019	-	-
		2.6	Analysis of Re-Fracturing Monitoring	7/31/2020	-	-
D		2.7	DTS/DAS/DSS & Seismic Monitoring During Production	7/31/2020	-	-
		2.8	Laboratory Evaluation of EOR Potential	7/31/2020	-	-
E		2.9	Coupled Modeling for Design, Prediction, Calibration & Code Validation	7/31/2020	-	-
	3 - Phase 2: Fracturing Evaluation	3.1	Drill, Complete & Instrument Two New Producing Wells	5/30/2020	-	-
F		3.2	Drilling Optimization	12/31/2020	-	-
		3.3	Monitoring of Fracturing of Two New Producing Wells	6/30/2020	-	-
		3.4	Analysis of Fracturing Monitoring of Two New Producing Wells	12/31/2020	-	-
		3.5	Coupled Modeling for Design, Prediction, Calibration & Code Validation	12/31/2020	-	-
	4 - Phase 3: EOR Pilot Test	4.1	Conduct Huff & Puff EOR Pilot Test	1/30/2021	-	-
		4.2	Monitor Injected Gas Placement with Active & Passive Seismic Monitoring	6/30/2021	-	-
		4.3	Monitor Injected Gas Distribution with DTS/DAS in Pilot Well	6/30/2021	-	-
G		4.4	Modeling of the Huff & Puff EOR Pilot Test	12/31/2021	-	-
	5 - Final Report	5.1	Multi-Purpose Optimization & Lessons Learned	12/31/2021	-	-
		5.2	Products & Reporting	12/31/2021	-	-

3. PRODUCTS
Nothing to Report.

4. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS
Nothing to Report.

5. IMPACT
Nothing to Report.

6. CHALLENGES/PROBLEMS
Nothing to Report.

7. SPECIAL REPORTING REQUIREMENTS
7.1. No Cost Time Extension for Budget Period 1 (NCTE - BP1)
A no cost time extension (NCTE) has been approved to extend Budget Period 1 to a current end date of August 31st, 2019. Under this approved NCTE, the current budget period start and end dates are as follows:

- BP1: 04/01/2018 - 08/31/2019
- BP1: 09/01/2019 - 08/31/2020
- BP1: 09/01/2020 - 08/31/2021

8. BUDGETARY INFORMATION
A summary of the budgetary information for Q1-Q5 of BP1 for the project is provided in **Table 3**. This table shows the original planned costs, the actual incurred costs, and the variance. The costs are split between federal share and non-federal share.

Table 2. Budgetary Information for Budget Period 1, Q1- Q5

Baseline Reporting Quarter	EFSL Budget Period 1 (04/01/2018 - 06/30/2019)					
	Q1		Q2		Q3	
	04/01/2018 - 06/30/2018		07/01/2018 - 09/30/2018		10/01/2018 - 12/31/2018	
	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share
Baseline Cost Plan						
TAMU	$182,669.50	$0.00	$182,669.50	$0.00	$182,669.50	$0.00
Chesapeake	$850,000.75	$500,000.00	$850,000.75	$500,000.00	$850,000.75	$500,000.00
LBNL	$166,750.00	$0.00	$166,750.00	$0.00	$166,750.00	$0.00
Stanford	$31,456.25	$0.00	$31,456.25	$0.00	$31,456.25	$0.00
Total Planned	$1,230,876.50	$500,000.00	$1,230,876.50	$500,000.00	$1,230,876.50	$500,000.00
Actual Incurred Cost						
TAMU	$119,579.07	$0.00	$152,177.46	$0.00	$108,898.29	$0.00
Chesapeake	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
LBNL	$57,679.00	$0.00	$104,547.00	$0.00	$168,294.00	$0.00
Stanford	$29,084.28	$0.00	$4,847.38	$0.00	$16,552.39	$0.00
Total Incurred Cost	$206,342.35	$0.00	$261,571.84	$0.00	$293,744.68	$0.00
Variance						
TAMU	$63,090.43	$0.00	$30,492.04	$0.00	$73,771.21	$0.00
Chesapeake	$850,000.75	$500,000.00	$850,000.75	$500,000.00	$850,000.75	$500,000.00
LBNL	$109,071.00	$0.00	$62,203.00	$0.00	($1,544.00)	$0.00
Stanford	$2,371.97	$0.00	$26,608.87	$0.00	$14,903.86	$0.00
Total Variance	$1,024,534.15	$500,000.00	$969,304.66	$500,000.00	$937,131.82	$500,000.00

Baseline Reporting Quarter	EFSL Budget Period 1 (04/01/2018 - 06/30/2019)					
	Q4		Q5 - NCTE 1		Total	
	01/01/2019 - 03/31/2019		04/01/2019 - 06/30/2019		04/01/2018 - 06/30/2019	
	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share	Federal Share	Non-Federal Share
Baseline Cost Plan						
TAMU	$182,669.50	$0.00	$0.00	$0.00	$730,678.00	$0.00
Chesapeake	$850,000.75	$500,000.00	$0.00	$0.00	$3,400,003.00	$2,000,000.00
LBNL	$166,750.00	$0.00	$0.00	$0.00	$667,000.00	$0.00
Stanford	$31,456.25	$0.00	$0.00	$0.00	$125,825.00	$0.00
Total Planned	$1,230,876.50	$500,000.00	$0.00	$0.00	$4,923,506.00	$2,000,000.00
Actual Incurred Cost						
TAMU	$110,749.32	$0.00	$207,650.59	$0.00	$699,054.73	$0.00
Chesapeake	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
LBNL	$303,022.00	$0.00	$9,811.00	$0.00	$643,353.00	$0.00
Stanford	$34,658.84	$0.00	$31,992.78	$0.00	$117,135.67	$0.00
Total Incurred Cost	$448,430.16	$0.00	$249,454.37	$0.00	$1,459,543.40	$0.00
Variance						
TAMU	$71,920.18	$0.00	($207,650.59)	$0.00	$31,623.27	$0.00
Chesapeake	$850,000.75	$500,000.00	$0.00	$0.00	$3,400,003.00	$2,000,000.00
LBNL	($136,272.00)	$0.00	($9,811.00)	$0.00	$23,647.00	$0.00
Stanford	($3,202.59)	$0.00	($31,992.78)	$0.00	$8,689.33	$0.00
Total Variance	$782,446.34	$500,000.00	($249,454.37)	$0.00	$3,463,962.60	$2,000,000.00

9. PROJECT OUTCOMES

Nothing to Report