

Oil & Natural Gas Technology

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Research Performance Progress Report

Quarterly Report: October 2015 to December 2015

Liquid-Rich Shale Potential of Utah's Uinta and Paradox Basins: Reservoir Characterization and Development Optimization

Project period: October 1, 2012 to September 30, 2015 (extended to September 30, 2016)



Submitted by:
Utah Geological Survey
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84116
DUNS # 176871572

Principal Investigator: Michael D. Vanden Berg
michaelvandenber@utah.gov, 801-538-5419

A handwritten signature in black ink, appearing to read "Michael D. Vanden Berg".

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United States Department of Energy
National Energy Technology Laboratory

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Office of Fossil Energy

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EXECUTIVE SUMMARY

As the project progresses through its one-year no-cost extension, several different research activities are still on track to help better characterize Utah's tight oil plays. Core analysis, outcrop examination, and regional mapping activities are helping to create a clearer understanding of the Uteland Butte tight oil play and several research projects on the Cane Creek shale are nearing completion. For example, geomechanical data measured on cores from both the Uteland Butte and Cane Creek are currently being analyzed by collaborators at the Energy & Geoscience Institute (EGI), University of Utah. These data will be vital in helping inform better well completion strategies and potentially improve production.

Technology transfer remains a vital tool for communicating the project results with interested stakeholders. An abstract on the dolomites of the Uteland Butte was accepted for presentation at the 2016 AAPG meeting to be held in Calgary, Alberta in June 2016, as well as an abstract on the Uteland Butte outcrops on the eastern side of the Uinta Basin.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of October 2015, the PI wrote and submitted the project's twelfth quarterly report for July to September 2015. This report was subsequently sent via email to all interested parties and posted on the UGS project website. The PI also gave a project update presentation to NETL staff in October 2015 and updated the Project Summary in November 2015.

Task 2.0: Technology Transfer

- The UGS project website was updated with new information - http://geology.utah.gov/emp/shale_oil
- The PI completed the twelfth quarterly report and emailed it to all interested parties. The report is also available on the UGS project website.
- An abstract was accepted for the 2016 AAPG Annual Meeting to be held in Calgary, Alberta, from June 19-22, 2016. University of Alberta Master's student, Federico Rueda, submitted the paper titled *Dolomitization in the Uteland Butte Member of the Eocene Green River Formation, Uinta Basin, Utah: Implications for Petroleum Production*.
- A second abstract was accepted for the 2016 AAPG Annual Meeting to be held in Calgary, Alberta, from June 19-22, 2016. Colorado School of Mines Master's student, Katie Logan, submitted the paper titled *Lacustrine Lithofacies, Depositional Processes and Diagenesis of the Uteland Butte Member, Uinta Basin*.
- The PI met with geologists from SM Energy to discuss the Uteland Butte play and look at core.
- The PI updated the Project Summary and gave a project update presentation to NETL staff.

Tasks 3.0 and 4.0: Data Compilation and Core-Based Geologic Analysis

Uteland Butte Member: Various projects are still underway on the Uinta Basin portion of the project. A paper by Dr. Rick Sarg and Katie Logan (M.S. student), with the PI as third author, on the eastern outcrops of the Uteland Butte is currently in preparation and is planned to be published as a UGS Open-File Report in spring 2016. Our collaboration with USGS is ongoing. Recently, USGS researchers extensively sampled several Uteland Butte cores for detailed mineralogy and organic geochemistry analyses. Research at the University of Alberta is ongoing, including detailed thin section petrography and mineralogy focused on the dolomites of the Uteland Butte. Over the duration of the no-cost extension, the PI will work to finalize all core descriptions, regional mapping, and facies analyses and synthesize collaborator research into a comprehensive final report.

Cane Creek Shale: Research on the Cane Creek shale in the Paradox Basin is nearly finished and the focus has shifted to preparing a comprehensive final report.

Task 5.0: Outcrop Examination and Characterization – Uinta Basin

An important collaboration was set up with Dr. Rick Sarg, prominent carbonate geologist at the Colorado School of Mines (CSM). UGS partially funded a CSM graduate student, S. Katie Logan, to research the Uteland Butte on the eastern side of the Uinta Basin. Logan measured several Wasatch-Green River-transition outcrop sections on the western flank of the Douglas Creek arch and compared them to the Anadarko Uteland Butte cores from the Natural Buttes gas field. Logan recently completed the study and defended her thesis titled *Lacustrine Lithofacies, Depositional Processes, and Diagenesis of the Uteland Butte Member, Green River Formation, Eastern Uinta Basin, Utah & Colorado*. As stated above, this study is planned to be published as a UGS Open-File Report in spring 2016.

Task 6.0: Well Completion Optimization

The EGI team continues to develop experimental protocols for a unique methodology of fracture toughness assessment and is now comfortable with high speed methodologies for capturing data at frequencies consistent with the rate of fracture growth. A rudimentary schematic is shown in figure 1.

The top portion of the three-point bending apparatus is fixed to the load frame (figure 2). The span length is set for the bottom rollers and the load frame is used to position the top roller in line with the pre-crack. An acoustic sensor is fixed to the sample to monitor the creation of micro-cracks. Two high-speed cameras (infrared and video) will monitor the macro-crack propagation. The infrared camera is used to monitor heat energy created during crack formation and the video camera is used to find crack tip opening displacement for the calculation of fracture toughness as well as the crack propagation speed. Due to the high frame rates, an external light source is used to illuminate the sample so that the crack is visible and the images can be later processed.

Since the crack propagates in the sample on the order of the speed of sound, the cameras will be running at frame rates on the order of 104-105 Hz. Frame rates this high will quickly fill the internal memory of the cameras. As a result it is important to have these cameras capturing data for as little time as possible in order to capture the entire fracture propagation event. This is achieved by using the acoustic sensor to trigger the cameras. This is the reason for monitoring microcrack formation with the acoustic sensor. Microcracks are a precursor to macrofracture propagation. In an ideal scenario, once a certain number of these microcracks form, the pre-crack will propagate (nominally) in the direction of maximum principal stress. A set number of events detected by the acoustic sensor will be used as a threshold value. Once this value is reached, a 5 volt TTL signal is sent to both cameras to switch them on. This control is achieved with a simple solution, an Arduino UNO board and the Arduino programming space. The data are displayed and saved with open source software.

The EGI team continues to evaluate the core and stimulation data and will be calibrating those against the upcoming test results in the next quarter.

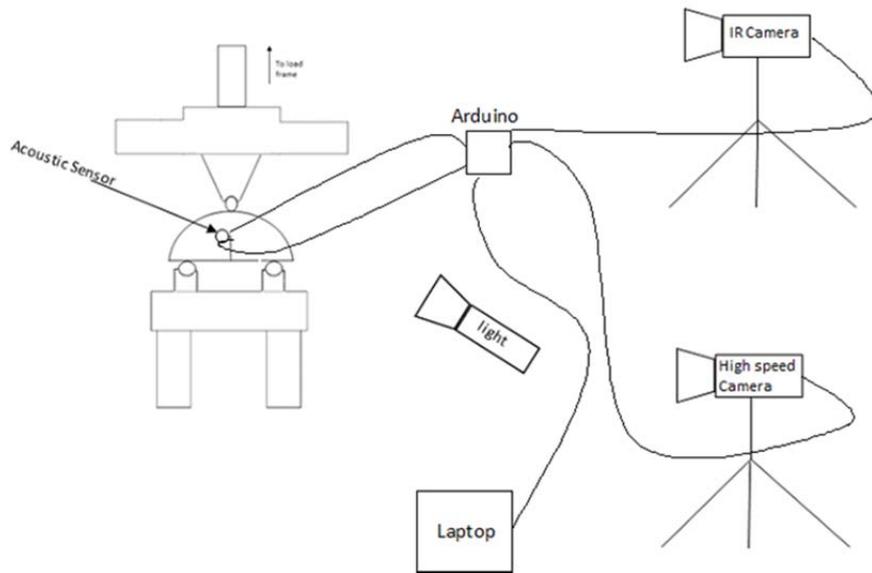


Figure 1. Task 6 experimental setup. The three-point bending fixture has been adapted to fit into a servo-controlled load frame. The starter notch is shown. As the load is applied to the notched sample, acoustic activity is measured. With an acceleration in acoustic emissions, the high-speed camera is tripped and the high-speed and IR cameras are fired and information is stored on the laptop.

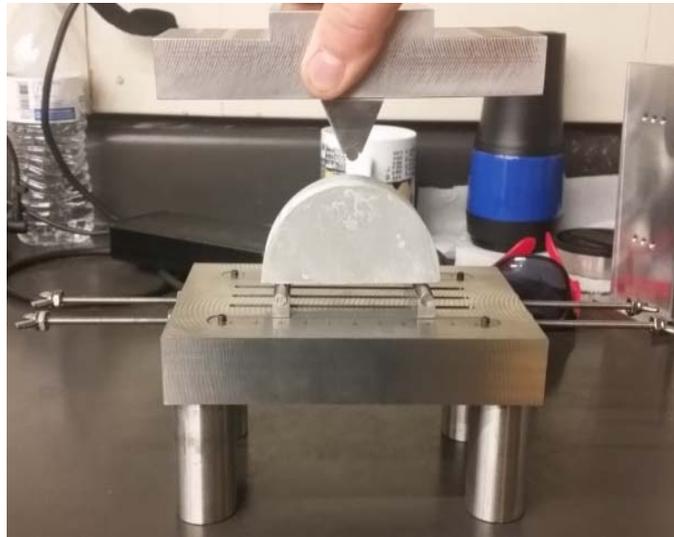


Figure 2. Photograph of three-point bending fixture. A customized loading fixture is used in a servo-controlled loading frame to apply axial load. This particular sample does not have a starter crack.

CONCLUSION

The project has now transitioned into a one-year no-cost extension and is projected to be finished in September 2016. Several collaborations are still underway, including research with students at the University of Utah (EGI) and the University of Alberta. The PI and other UGS geologists are currently finalizing research tasks and synthesizing collaborator research into a comprehensive final report.

COST STATUS

Table 1. Project costing profile for one-year no-cost extension.

	Oct 2015		Nov 2015		Dec 2015	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel		\$3,369		\$5,133		\$1,000
Travel Expenses						
Analyses						
Miscellaneous ¹		\$739		\$213		
SUBTOTALS		\$4,107		\$5,345		\$1,000
UGS OVERHEAD (34.44%)		\$1,415		\$1,841		\$345
SUBCONTRACTS						
EGI				\$1,335		
Eby ²						\$5,014
CSM				\$2,171		
EGI - Moore						
U. of Alberta						
GRAND TOTALS		\$5,522		\$10,692		\$6,359

¹Oct/Nov – Thin section preparation for fluid inclusion analyses

²Dec – Includes \$975 in cost share

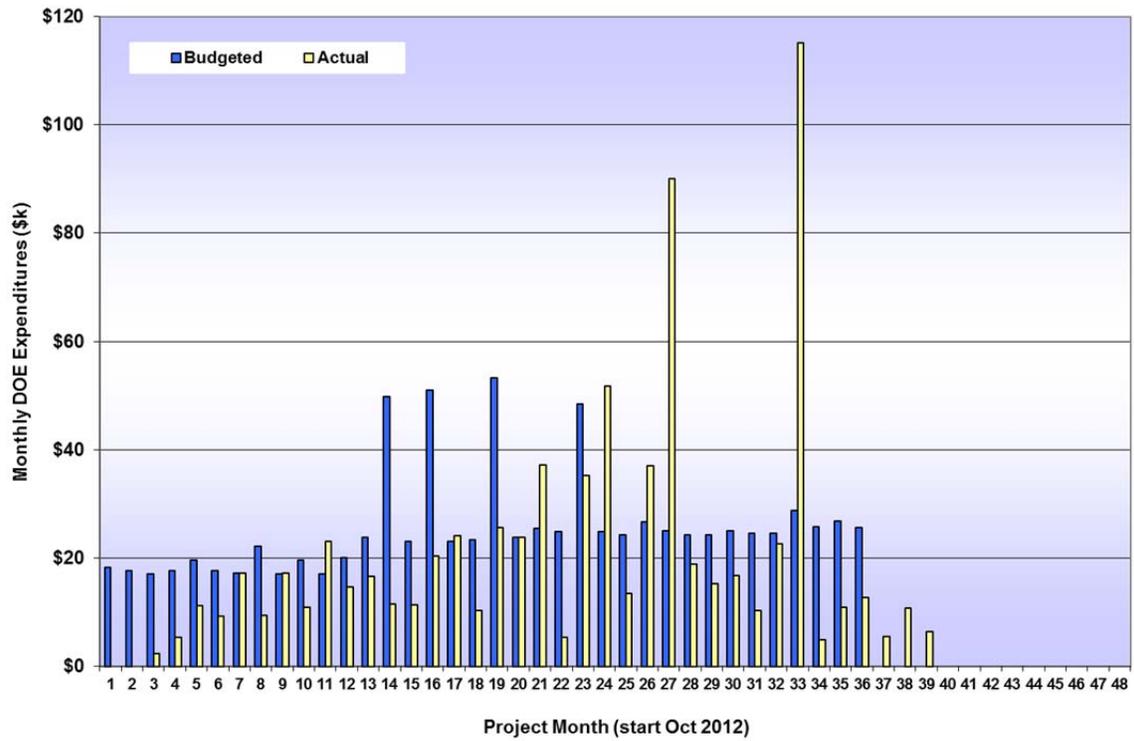


Figure 3. Project costing profile.

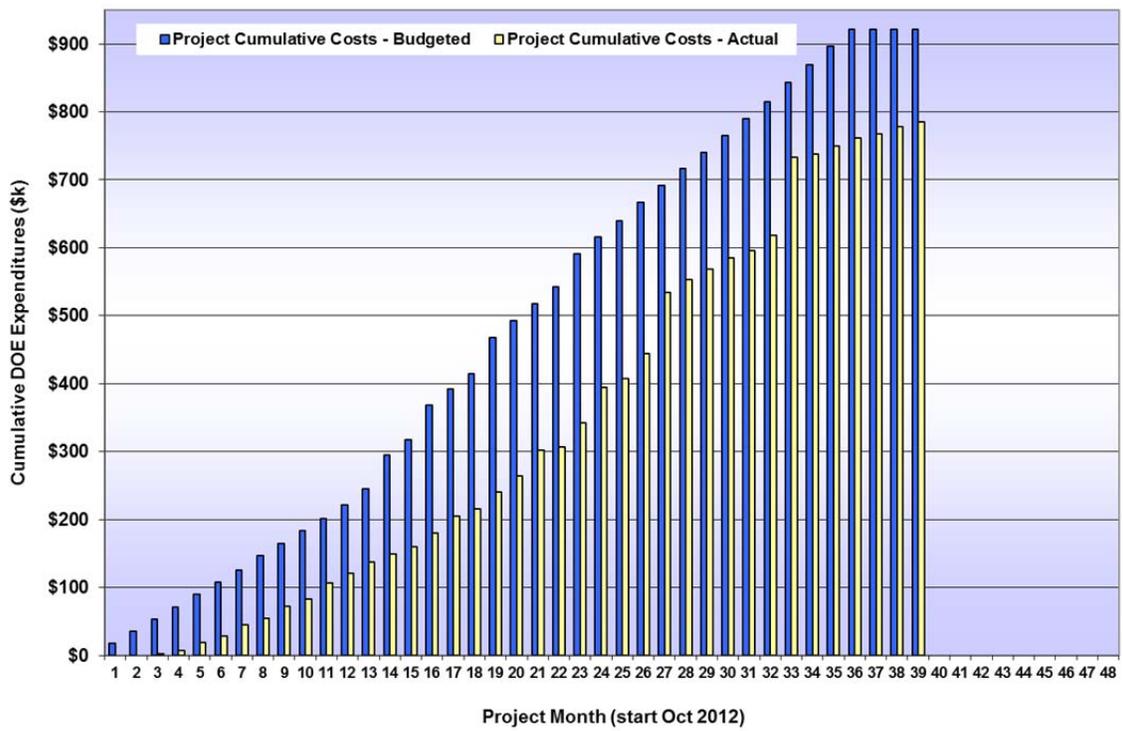


Figure 4. Project cumulative costs.

MILESTONE STATUS

Table 2. Milestone log – one-year no-cost extension

	Title	Related task or subtask	Completion Date	Update/comments
Milestone 32	Quarterly updates of website	Subtask 2.1	Quarterly	Ongoing, 1-year extension
Milestone 33	Quarterly reports	Subtask 2.2	Quarterly	Ongoing, 1-year extension
Milestone 34	Profiles of mechanical stratigraphy	Subtask 6.5	31-Mar-15	Ongoing, 1-year extension
Milestone 35	Regional Correlation and Mapping	Subtask 7.1	31-Mar-15	Ongoing, 1-year extension
Milestone 36	Regional cross sections	Subtask 7.2	31-Mar-15	Ongoing, 1-year extension
Milestone 37	Sweet spot maps	Subtask 7.3	31-Mar-15	Ongoing, 1-year extension
Milestone 38	Technical presentations at National AAPG	Subtask 2.4 & 5	Apr-15	1 abstract submitted to AAPG 2016
Milestone 39	Core workshop and/or field trip	Subtask 2.7	Jul-15	Delayed until summer 2016
Milestone 40	Locating completions	Subtask 6.4	30-Sep-15	Ongoing, 1-year extension
Milestone 41	Stimulation diagnostics modeling	Subtask 6.6	30-Sep-15	Ongoing, 1-year extension
Milestone 42	Reservoir simulations/stimulation locating	Subtask 6.7	30-Sep-15	Ongoing, 1-year extension
Milestone 43	Final publications	Subtask 2.6	30-Sep-15	1-year extension
Milestone 44	Final interpretation	Task 8	30-Sep-15	1-year extension

ACCOMPLISHMENTS

- Two abstracts about the Uteland Butte tight oil play were accepted for presentation at the 2016 AAPG meeting.

PROBLEMS OR DELAYS

The project is one quarter into the one-year no-cost extension. The PI did not project expenditures for each month of the extension, but the project costs are on target for completion in September 2016. The project is currently 85.1% of total budget.

PRODUCTS AND TECHNOLOGY TRANSFER ACTIVITIES

- Project website
 - The project website has been updated with new reports and abstracts.
 - http://geology.utah.gov/emp/shale_oil
- Quarterly Report – July to September 2015
 - Completed late October and is available on the project website.
- Abstract (accepted) – 2016 AAPG Annual Meeting, Calgary, Alberta, Canada, June 19-22, 2016
 - Rueda, F. (M.S. student at the University of Alberta), Vanden Berg, M.D., and Machel, H.G. (Professor at the University of Alberta) - *Dolomitization in the Uteland Butte*

Member of the Eocene Green River Formation, Uinta Basin, Utah: Implications for Petroleum Production.

- The poster will be presented on Monday, June 20, 2016, in the Modeling of Carbonate and Evaporite Systems session.
- The abstract has been uploaded to the UGS project website.
- Abstract (accepted) – 2016 AAPG Annual Meeting, Calgary, Alberta, Canada, June 19-22, 2016
 - Logan, K. (M.S. [graduated] student Colorado School of Mines) and Sarg, R. (Professor at Colorado School of Mines) – *Lacustrine Lithofacies, Depositional Processes and Diagenesis of the Uteland Butte Member, Uinta Basin.*
 - The poster will be presented on Tuesday, June 21, 2016, in the Advances in Carbonate Diagenesis session.
- The PI gave a project update presentation to NETL on October 22, 2015.
- The PI updated the Project Summary in November 2015.
- The PI met with geologists from SM Energy to discuss the Uteland Butte play and look at core.

National Energy Technology Laboratory

626 Cochran Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

One West Third Street, Suite 1400
Tulsa, OK 74103-3519

1450 Queen Avenue SW
Albany, OR 97321-2198

2175 University Ave. South
Suite 201
Fairbanks, AK 99709

Visit the NETL website at:
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