

Oil & Natural Gas Technology

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Research Performance Progress Report

Quarterly Report: October 2014 to December 2014

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



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

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Office of Fossil Energy



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EXECUTIVE SUMMARY

As the project enters Budget Period 3, several different research activities are on track to help better characterize Utah's tight oil plays. Core analysis and regional mapping activities are helping to create a clearer understanding of the Uteland Butte tight oil play. In addition, new research on the origin and diagenesis of the Uteland Butte dolomites will aid in reservoir characterization and regional facies analysis. Several research projects are also underway looking at the Cane Creek shale. Epifluorescence analysis on Cane Creek cuttings continues and preliminary results will be presented at the May 2015 AAPG conference in Denver, CO. Also, fluid inclusion analyses of Cane Creek core are providing insights into fracture formation and timing of fluid migration within the play. Geomechanical data measured on cores from both the Uteland Butte and Cane Creek were delivered from the lab to project researchers this quarter. This 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 stake holders. Two presentations will be given at the upcoming AAPG meeting in Denver, CO: a core poster highlighting both the Uteland Butte and Cane Creek plays and a poster presentation on the aforementioned epifluorescence analyses. In addition, a paper is being prepared, in collaboration with the U.S. Geological Survey, on the geology of the Uteland Butte member of the Green River Formation.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of October 2014, the PI wrote and submitted the project's eighth quarterly report for July to September 2014. This report was subsequently sent via email to all interested parties and posted on the UGS project website. In addition, the PI updated the Project Summary in early December; it is also posted on the project website.

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 eighth quarterly report and emailed it to all interested parties. It is also available on the UGS project website.
- A delegation of Chinese energy scientists toured the Utah Core Research Center on October 2, 2014. On display were Uteland Butte and Cane Creek cores and the PI gave a presentation describing the project's goals and objectives.
- Two abstracts were submitted and accepted for the AAPG 2015 Annual Meeting: an abstract for a core poster that will include discussions of both the Uteland Butte and Cane Creek, and an abstract detailing the soon-to-be completed epifluorescence analyses on the Cane Creek.
- A paper idea (and abstract) detailing the Uteland Butte tight oil play was accepted by the editors of the upcoming 2015 Rocky Mountain Association of Geologists Source Rock Compendium volume. The PI, in collaboration with the U.S. Geological Survey, will submit the paper in late February and the volume is slated to be published in late 2015.

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

Uteland Butte Member: The PI updated the Uteland Butte play map, which shows the location of all Uteland Butte horizontal wells, individual company play areas, locations of Uteland Butte core, as well as proposed (APDs) horizontal Green River Formation wells (Figure 1). Recently, Newfield has switched to drilling ~11,000 foot laterals as opposed to the more typical ~5000 foot laterals. These new "super long

laterals” (SXL) are located in Newfield’s Central Basin play area within the overpressured zone. Figure 2 displays production bubbles for all horizontal Uteland Butte wells. In order to compare production rates and well success regardless of well age, only the first three full months of production was included. Initial production rates for shorter laterals (~5,000 ft) range from a low of ~600 barrels of oil equivalent (BOE) in the southern part of the play, up to ~70,000 BOE in the northern overpressured area, averaging ~19,000 BOE. The SXL horizontal wells in the overpressured zone range from ~74,000 BOE to ~107,000 BOE and average ~92,000 BOE. As shown on the map, the most productive area to date lies within the overpressured zone of the central basin.

The formation of lacustrine dolomite is very poorly understood. With the main reservoir of the Uteland Butte being a porous dolomite, it is vital to understand how these deposits formed and to understand how the facies change across the basin. To help investigate this problem, we have set up a collaboration with Dr. Hans Machel, renowned dolomite expert from the University of Alberta. Dr. Machel and a graduate student traveled to Salt Lake City in November to analyze several Uteland Butte cores. Several sections of each core, focusing on the dolomite intervals, but also including examples of adjacent facies, were selected for thin section analysis. In addition, the same intervals will be analyzed using a scanning electron microscope, as well as analyzed for specific isotopes and mineralogy. These tests will help determine the origin of the dolomites, whether they are the result of primary precipitation or related to diagenetic processes. A model of deposition will be created that will help delineate facies changes and reservoir characteristics across the basin. Additional samples will be collected from cores housed in Denver, CO, in mid-February.

Cane Creek Shale: Understanding the relationship between fractures in the Cane Creek shale and timing of oil migration will be vital to understanding the petroleum system as a whole and determining areas that might be supportive of economic production. These relationships can be investigated by analyzing the fluid inclusions trapped within the fracture-fill precipitates.

Fluid inclusions are fluid- and/or gas-filled vacuoles sealed within different minerals, including fracture-fill material. Analysis of an inclusion can provide the composition and salinity of the fluid as well as the temperature and pressure at which it became trapped (i.e., crystal mineralization). Fluid inclusion analysis can also provide insight into the migration history of fluids through a suite of rocks. Analysis of thin section samples from the Cane Creek will aid our understanding of oil maturation history and timing of fluid migration. Twenty core samples from three different Cane Creek wells (the Cane Creek 26-3 core from the productive Big Flat field, the Remington 21-1H core from the currently non-productive southwestern play area, and the Cisco State 36-13 core from the currently non-productive southeastern play area near Lisbon) are currently being analyzed. Preliminary results for the Cisco State 36-13 core indicate that trapped fluids within the fractures are saline and the minimum trapping temperature was roughly 85° to 95°C (Figure 3). Live oil has also been observed in samples from this well, with fluorescence of the oil indicating a 35° to 40° API gravity (Figure 3). These preliminary analyses indicate that at some point oil migrated through the Cane Creek in this area.

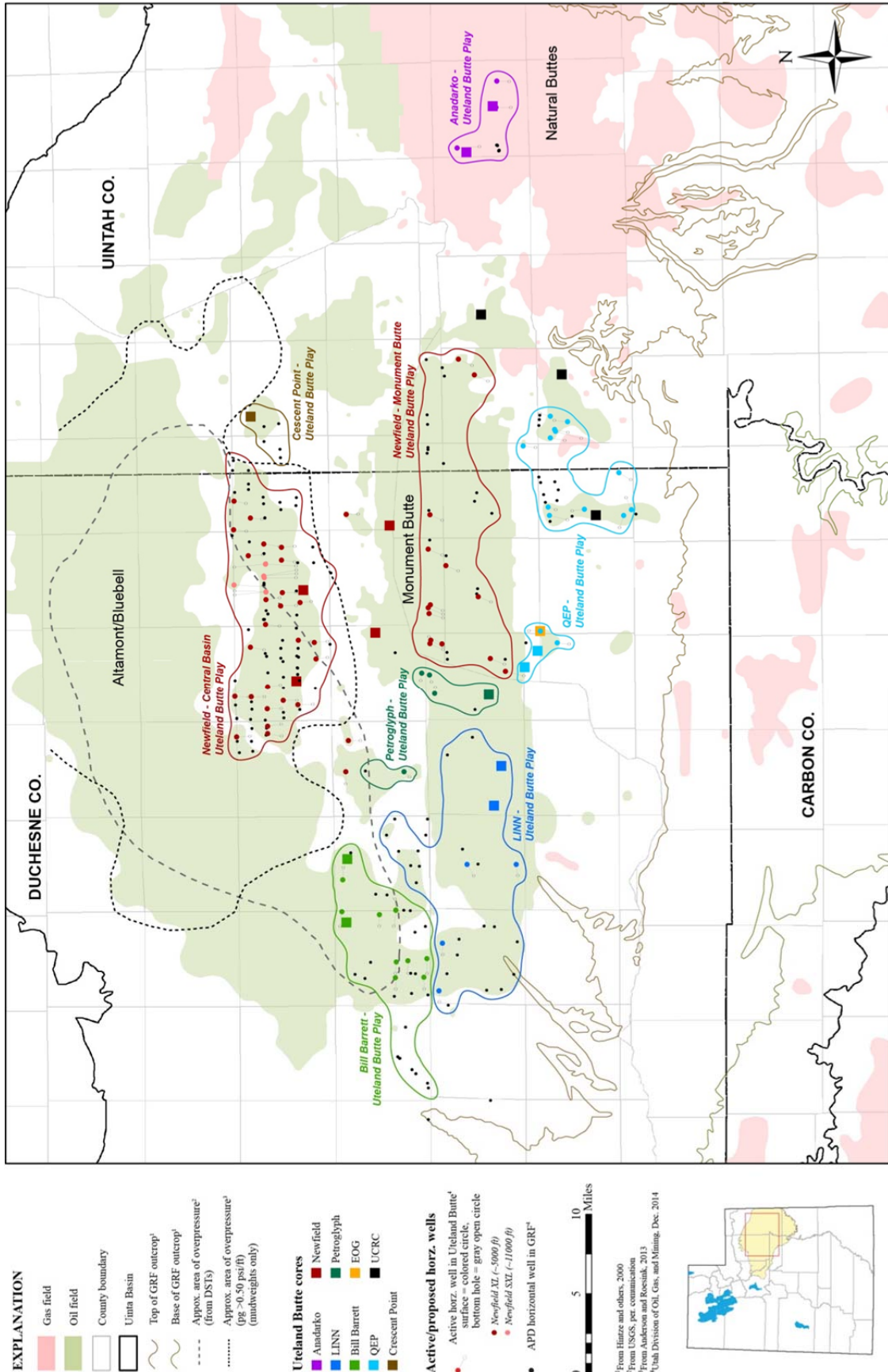


Figure 1. Updated Utealand Butte play map.

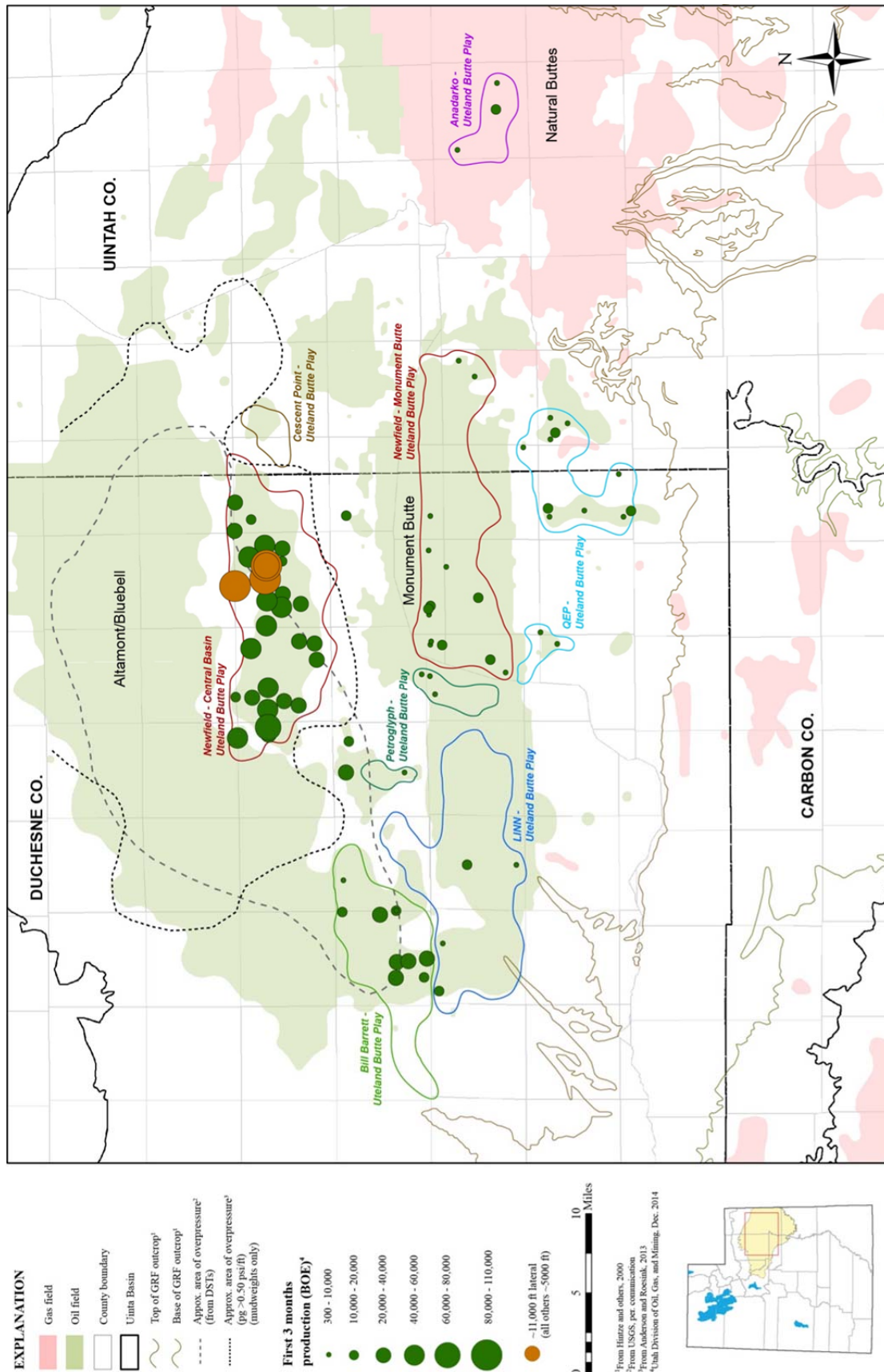


Figure 2. Uteland Butte production map showing the first three months of production from horizontal wells.

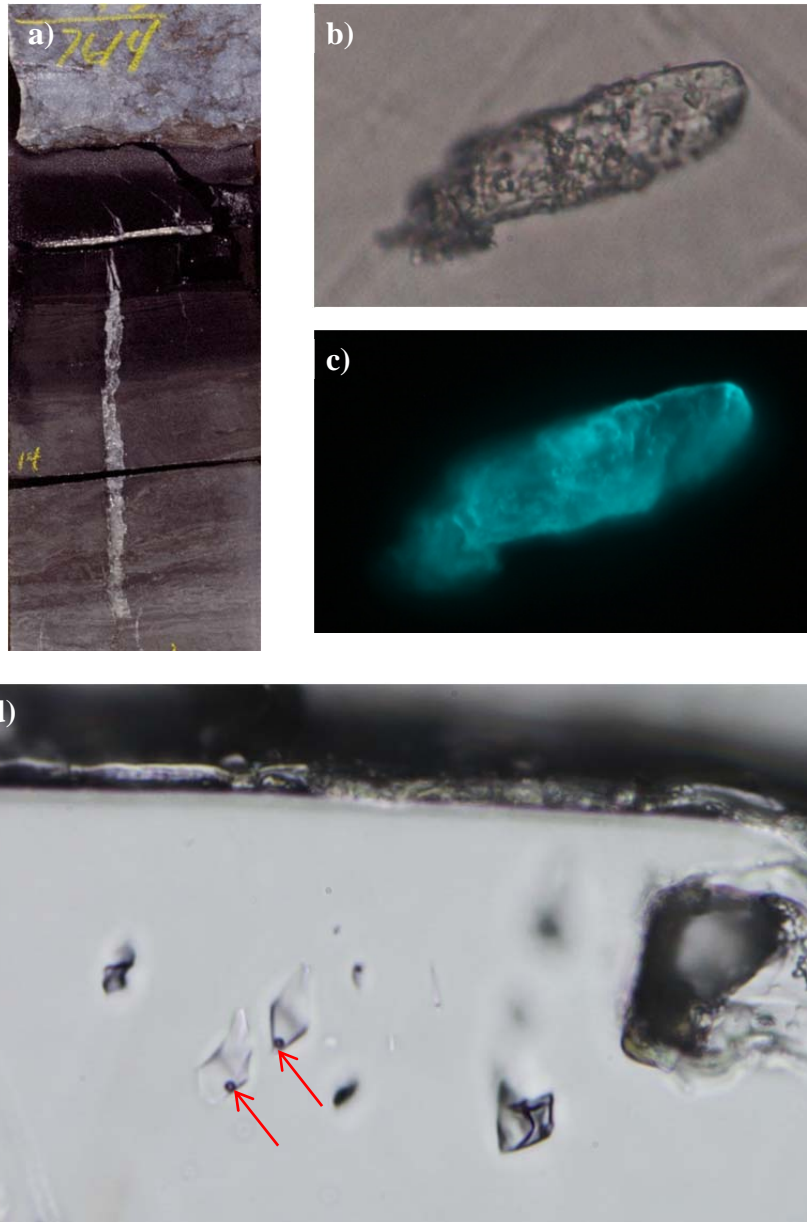


Figure 3. Examples of fluid inclusions within halite-filled fractures from the Cisco State 36-13 core, depth 7614.6 ft, scale ~50x. a) Halite-filled fracture as seen in the core. b) Thin section photo of fluid inclusion under plane light. c) The same inclusion under fluorescence; analysis indicates 85-95°C minimum trapping temperature, while the blue fluorescence indicates oil at roughly 40° API. d) Examples of air bubbles (red arrows) within fluid inclusions.

Task 5.0: Outcrop Examination and Characterization – Uinta Basin

Two members of the project team traveled to the Uinta Basin to examine and describe several outcrop sections of the Uteland Butte. Two sections were described near the intersection of Minnie Maud Creek and Nine Mile Canyon in the south-central portion of the basin and two sections were described near Missouri Creek on the far eastern side of the Uinta Basin. In addition to describing the geology, spectral gamma ray profiles were collected on all sections. After the outcrop descriptions are drafted, they will be compared to the described core and incorporated into our overall regional reservoir mapping.

An important collaboration has been set up with Dr. Rick Sarg, prominent carbonate geologist at the Colorado School of Mines (CSM). UGS is partially funding a CSM graduate student to research the Uteland Butte on the eastern side of the Uinta Basin. The student has measured several Wasatch-Green River-transition outcrop sections on the western flank of the Douglas Creek arch and will compare them to the Anadarko Uteland Butte cores from the Natural Buttes gas field. Meanwhile, the UGS will continue to focus its research efforts on the main producing area of the Uteland Butte (the distal portion) on the western side of the Uinta Basin, and CSM will help determine how the unit changes to the east. The Uteland Butte is much shallower to the east and the organic-rich intervals are thermally immature. Preliminary core interpretations by the PI suggest that the overall facies changes eastward and represents a more proximal, fresher water lacustrine depositional setting. Even though the Uteland Butte in this area is not “self-sourcing,” hydrocarbons are most likely migrating to these shallower reservoirs from deeper, mature rocks to the west, but the overall play in this eastern area is much more speculative.

Task 6.0: Well Completion Optimization

Geomechanical testing at TerraTek, A Schlumberger company, is now complete and all data have been delivered. The data will be used by Dr. John McLennan, Energy & Geoscience Institute, and his PhD student to accomplish the goals outlined in Task 6.

CONCLUSION

Progress continues to be made on both parts of this project, the Uteland Butte and Cane Creek tight oil plays. Research into the origin and diagenesis of the Uteland Butte dolomites has commenced as several cores are being analyzed via thin section and a range of other analyses. Fluid inclusion and epifluorescence analyses on Cane Creek cores and cuttings are nearing completion, and a presentation on the epifluorescence will be given at the upcoming AAPG meeting. All geomechanical testing is now complete and data was delivered to project researchers. This data will be used to help reach the goals outlined in Task 6 of this project.

COST STATUS

Table 1. Project costing profile for Budget Period 3.

	Oct 2014		Nov 2014		Dec 2014	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	\$11,027	\$6,350	\$11,027	\$6,721	\$11,027	\$11,295
Travel Expenses ¹			\$1,790	\$1,064		\$777
Analyses				Listed below		Listed below
Miscellaneous ²					\$500	\$72
SUBTOTALS	\$11,027	\$6,350	\$12,817	\$7,785	\$11,527	\$12,145
UGS OVERHEAD (34.44%)	\$3,798	\$2,187	\$4,414	\$2,681	\$3,970	\$4,183
SUBCONTRACTS						
EGI ³	\$6,771	\$4,853	\$6,771	\$18,063	\$6,771	\$4,771
Eby ⁴	\$2,724	\$0	\$2,724	\$0	\$2,724	\$2,375
CSM				\$1,845		\$225
TerraTek (analyses)				\$6,600		\$66,396
GRAND TOTALS	\$24,320	\$13,390	\$26,726	\$36,974	\$24,992	\$90,093

¹Nov and Dec – trip to Denver to examine Cane Creek cuttings using epifluorescence

²Nov – Sample shipping

³Oct – Only includes cost share amount; Nov – Includes \$4853 in cost share; Dec – Only includes cost share amount

⁴Dec – Includes \$475 in cost share

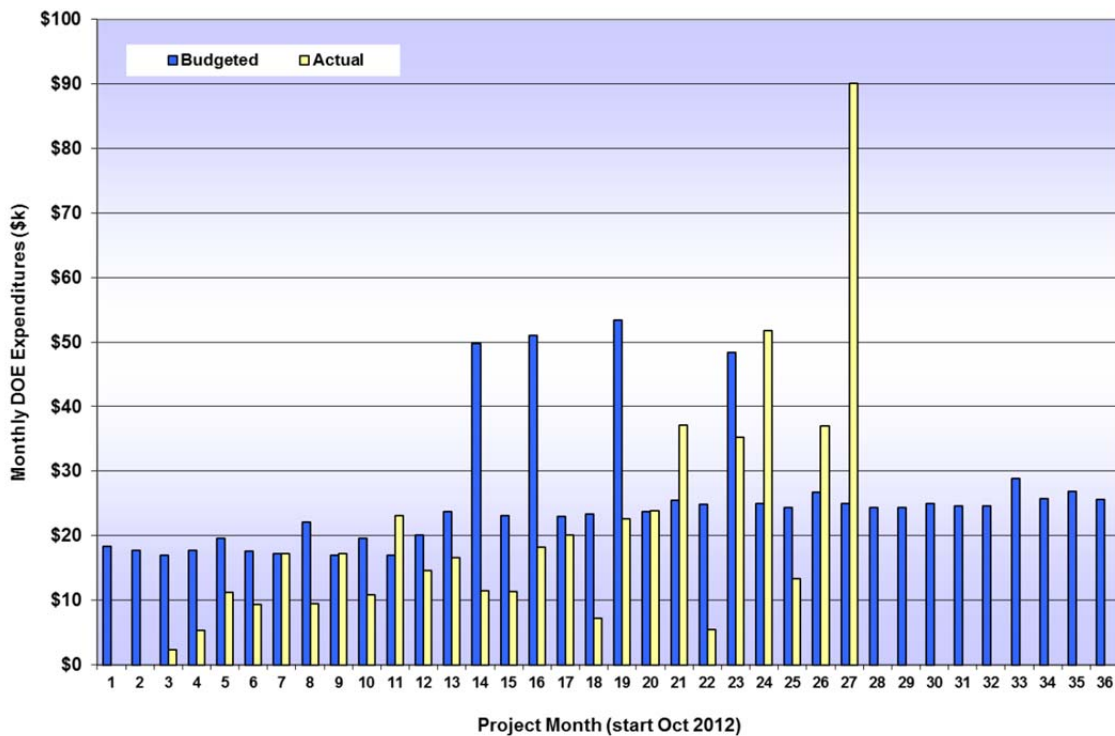


Figure 4. Project costing profile.

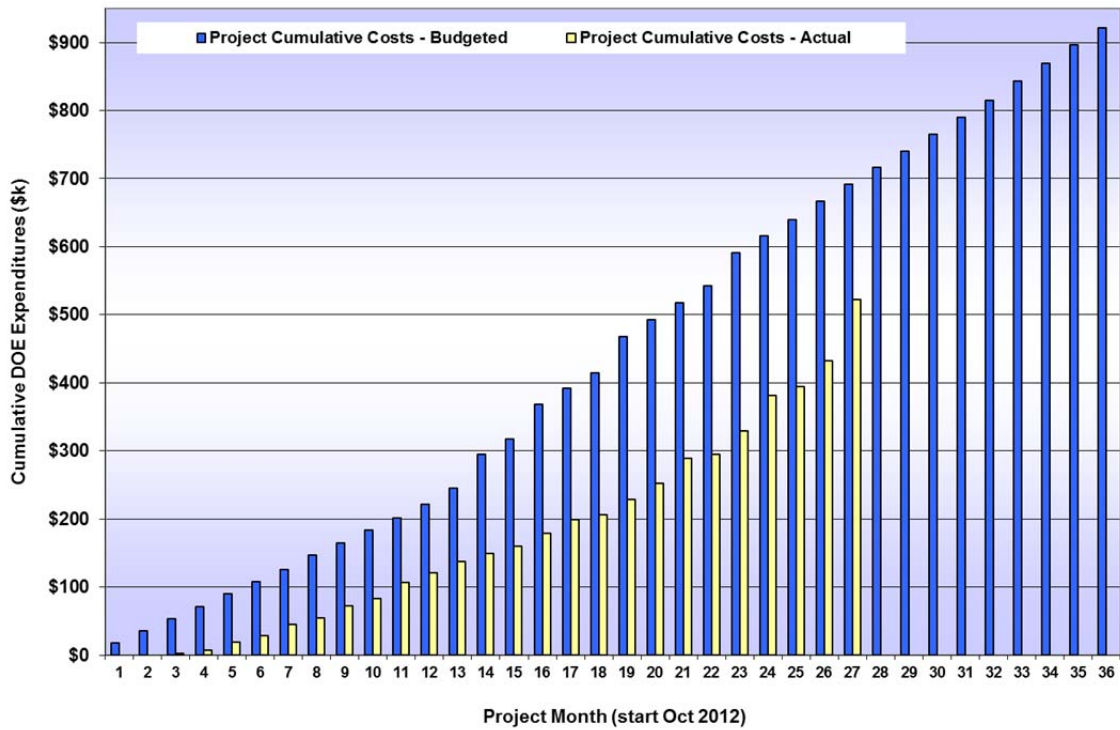


Figure 5. Project cumulative costs.

MILESTONE STATUS

Table 2. Milestone log for Budget Period 3.

	Title	Related task or subtask	Completion Date	Update/comments
Milestone 32	Quarterly updates of website	Subtask 2.1	Quarterly	Ongoing
Milestone 33	Quarterly reports	Subtask 2.2	Quarterly	Ongoing
Milestone 34	Profiles of mechanical stratigraphy	Subtask 6.5	31-Mar-15	Ongoing
Milestone 35	Regional Correlation and Mapping	Subtask 7.1	31-Mar-15	Ongoing
Milestone 36	Regional cross sections	Subtask 7.2	31-Mar-15	Ongoing
Milestone 37	Sweet spot maps	Subtask 7.3	31-Mar-15	Ongoing
Milestone 38	Technical presentations at National AAPG	Subtask 2.4 & 5	Apr-15	2 abstracts accepted for 2015 AAPG
Milestone 39	Core workshop and/or field trip	Subtask 2.7	Jul-15	
Milestone 40	Locating completions	Subtask 6.4	30-Sep-15	
Milestone 41	Stimulation diagnostics modeling	Subtask 6.6	30-Sep-15	
Milestone 42	Reservoir simulations/stimulation locating	Subtask 6.7	30-Sep-15	
Milestone 43	Final publications	Subtask 2.6	30-Sep-15	
Milestone 44	Final interpretation	Task 8	30-Sep-15	

ACCOMPLISHMENTS

- Received all rock mechanics data from TerraTek, A Schlumberger company.
- Commenced research partnership with University of Alberta and began Uteland Butte dolomite investigation.

PROBLEMS OR DELAYS

Several subcontracts (EGI, TerraTek, Eby Petrography & Consulting, University of Alberta) were significantly delayed due to new, unanticipated, and exceedingly cumbersome State of Utah contract procedures; therefore the PI anticipates needing a one year, no-cost extension, pushing the project end date to September 30, 2016. Sufficient project funds are available for the extension as the project is currently only 75.5% of 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 2014
 - Completed late October and is available on the project website.
- Revised the Project Summary
 - Completed early December and is available on the project website.
- A delegation of Chinese energy scientists toured the Utah Core Research Center on October 2, 2014. On display were Uteland Butte and Cane Creek cores and the PI gave a presentation describing the project's goals and objectives.
- Abstracts (2) – 2015 AAPG Annual Meeting, Denver, CO, May 31-June 3, 2015
 - Two abstracts were submitted and accepted for presentation at the 2015 AAPG meeting in Denver.
 - Titles: “Analyzing Core from Two Emerging Tight Oil Plays in Utah: The Uteland Butte Member of the Green River Formation in the Uinta Basin and the Cane Creek Shale within the Paradox Formation in the Paradox Basin” and “Potential Oil-Prone Areas in the Cane Creek Shale Play, Paradox Basin, Utah, U.S.A., Identified by Epifluorescence Techniques.”
 - Both abstracts are available on the UGS project website.
- 2015 RMAG Source Rock Compendium volume
 - A paper idea (and abstract) detailing the Uteland Butte tight oil play was accepted by the editors of the upcoming 2015 Rocky Mountain Association of Geologists Source Rock Compendium volume. The PI, in collaboration with the U.S. Geological Survey, will submit the paper in late February and the volume is slated to be published in late 2015.

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