

Oil & Natural Gas Technology

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Research Performance Progress Report

Quarterly Report: July 2014 to September 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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EXECUTIVE SUMMARY

The fourth quarter of Budget Period 2 was dominated by Uteland Butte regional mapping and core examination, technology transfer activities, and setting up various collaborations. Several new regional maps of key Uteland Butte marker beds have been drafted and will be finalized over the coming months. These maps are vital in understanding the play's regional extent and the determination of potential drilling "sweet spots." This effort was aided by the detailed examination of two additional Uteland Butte cores, one in the paleo-depocenter of the basin and one farther south in more proximal lacustrine facies.

Considerable effort was spent during the past quarter arranging and negotiating agreements with various project collaborators. These collaborations will greatly enhance and augment research performed at UGS and help create a better understanding of the tight oil potential in the Uteland Butte and Cane Creek. In particular, project team members have begun analyzing Cane Creek cutting samples using epifluorescence microscopy techniques.

Several technology transfer activities took place this past quarter. Two presentations were made at the AAPG-RMS meeting in Denver, CO: an oral presentation on the Uteland Butte and a core poster presentation on the Cane Creek. In addition, the UGS hosted a RPSEA-sponsored conference and field trip that included several project related presentations and a field trip stop at Uteland Butte outcrop.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of July, the PI wrote and submitted the project's seventh quarterly report for April to June 2014. This report was subsequently sent via email to all interested parties and posted on the UGS project website.

The PI submitted a Continuation Application to NETL and presented a project overview via WebEx to NETL staff. The application was approved and the project will proceed into Budget Period 3.

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 seventh quarterly report and emailed it to all interested parties. It is also available on the project website.
- The PI presented on the Uteland Butte tight oil play in the Stratigraphy of Rocky Mountain Basins and Beyond session at the AAPG-RMS meeting in Denver, CO, in July 2014.
- Craig Morgan, project team member, presented on the Cane Creek shale tight oil play in the Exploration/Exploitation session at the AAPG-RMS meeting in Denver, CO, in July 2014.
- UGS hosted a RPSEA-sponsored conference and field trip on September 10-11, 2014. The agenda included presentations and core displays on the Uteland Butte and Cane Creek tight oil plays and the field trip included a stop in Nine Mile Canyon to view the Uteland Butte in outcrop.
- The PI helped organize a core workshop for an AAPG field course focusing on lacustrine rocks of the Green River Formation, including the Uteland Butte.
- Two abstracts were submitted to 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.

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

Uteland Butte Member: Two additional cores were described this past quarter, Newfield's newly drilled Cesspooch 15-21-3-3W and EOG's Petes Wash U 13-06 GR. The Cesspooch core is located in

the northern part of the play area, near the paleo-depocenter of the lake, and captures a complete section of Uteland Butte. The Petes Wash core is farther to the south and captures more proximal lacustrine facies. All cores have now been described and core descriptions drafted. The cores have been very important “ground-truth,” helping to better interpret the geophysical log signature and aiding in mapping the regional extent of various formation features.

The PI has established a collaboration with researchers at the U.S. Geological Survey (USGS) to study various aspects of the Uteland Butte tight oil play. Research from this project is being compared to similar research on the Cow Ridge Member (Uteland Butte equivalent) of the Green River Formation in the Piceance Basin in Colorado. In addition, the geochemistry of Uteland Butte oils is being studied. Uteland Butte oils are generally very waxy with API gravities between 30 and 40° and are low in sulfur (< 0.3 wt. %). Stable carbon isotope ratios ($\delta^{13}\text{C}$) of the saturate and aromatic fractions show the oil to be very isotopically light (-29 to -33 ‰). Molecular parameters, including ratios of pristane and phytane to relevant normal alkanes, show that the Uteland Butte oils are derived from similar organic material but are more thermally mature than oils produced from other Green River rocks in the Uinta Basin. Additional Uteland Butte oil samples will be collected and analyzed in the next quarter.

A second 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.

Cane Creek Shale: Potential oil-prone areas in the Cane Creek shale could be identified based on hydrocarbon shows recognized using low-cost epifluorescence (EF) techniques on cuttings and core. EF microscopy enables enhanced imaging of poorly preserved grains and textures. In addition, EF provides information on diagenesis, pore types, and organic matter (including “live” hydrocarbons) within sedimentary rocks (table 1). It is a rapid, non-destructive procedure that uses a petrographic microscope equipped with reflected-light capabilities, a Hg-vapor lamp, and appropriate filtering. Samples from cores (including producers and dry holes) will provide a template for selection of drill cuttings and calibration of EF shows.

Cutting samples will be evaluated from over 30 wells penetrating the Cane Creek shale throughout the region (figure 1). The dolomites in these cuttings (generally 10 representative samples per depth interval from each well) display intercrystalline porosity, microporosity, and microbial constructional pores. A qualitative visual rating (a range and average) based on EF evaluation was applied to the group of cuttings from each depth interval in each well (table 1). The highest average and maximum EF rating from each well will be plotted and mapped. Figure 2 displays images from three different wells showing the variations in EF intensity.

Table 1. *Key to the epifluorescence qualitative visual rating scale.*

Rating	Generalized Interpretation	Notes
0.0-1.0	No fluorescence	Not capable of oil production. May be wet, if not a gas-bearing zone.
1.0-2.0	Weak fluorescence	An "oil" show. Indicative of oil in the system, but not necessarily capable of production. Some dull or weak fluorescence may exist in a wet zone (especially if there is speckled fluorescence) or in a mixed oil/water zone.
2.0-3.0	Moderate fluorescence	A good indication of oil within this zone. Probably capable of some oil production if there is adequate porosity and permeability.
3.0-3.5	Bright fluorescence	A very good to excellent indication of oil within this zone. Should be capable of some oil production if there is adequate porosity and permeability.
3.5-4.0	Very bright, intense fluorescence	Also a very good to excellent indication of oil within this zone. However, some very bright fluorescence may indicate very tight oil-bearing rocks or mature, oil-generating source rocks.

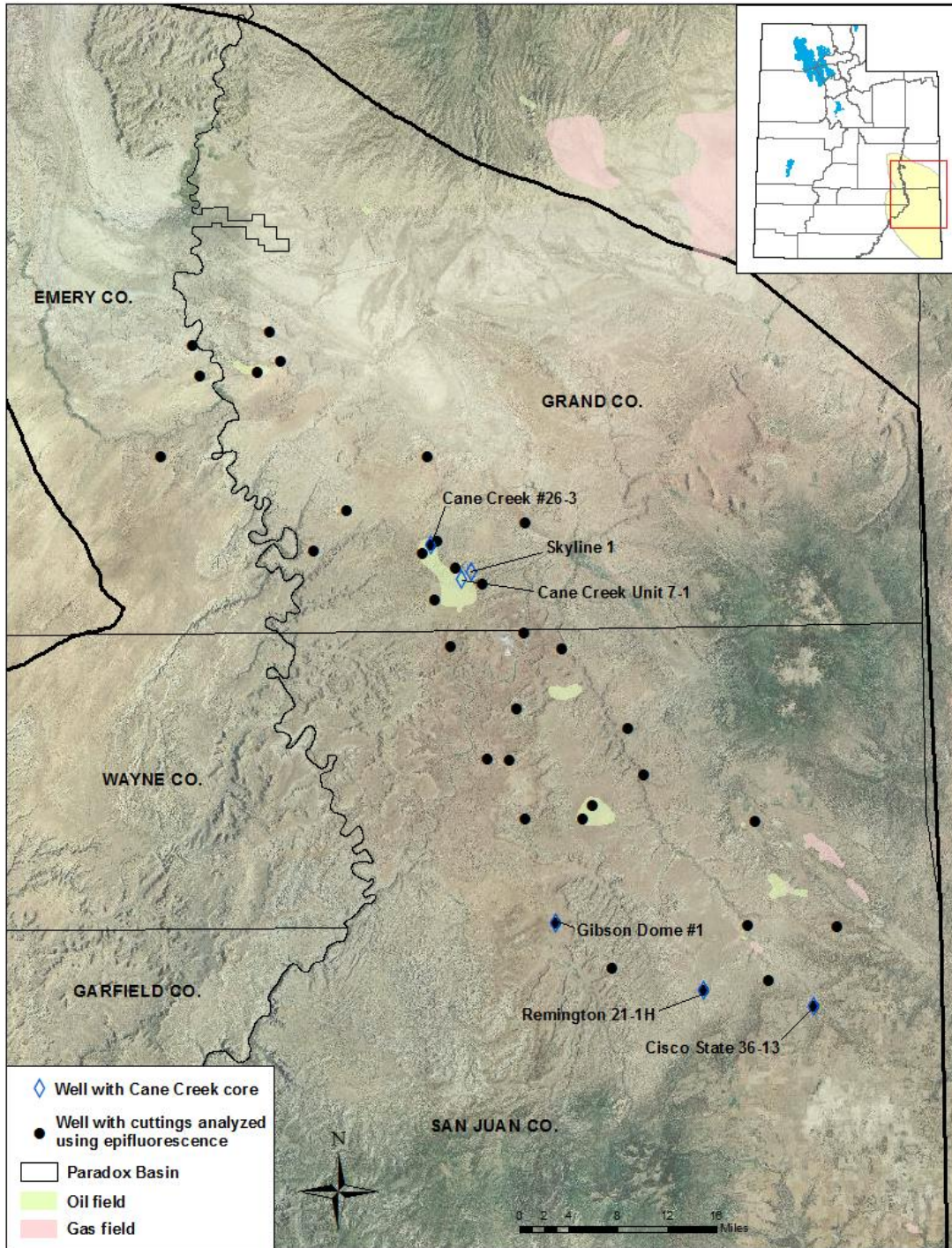


Figure 1. Map showing the location of Cane Creek cores and wells with Cane Creek cuttings that will be analyzed using epifluorescence.

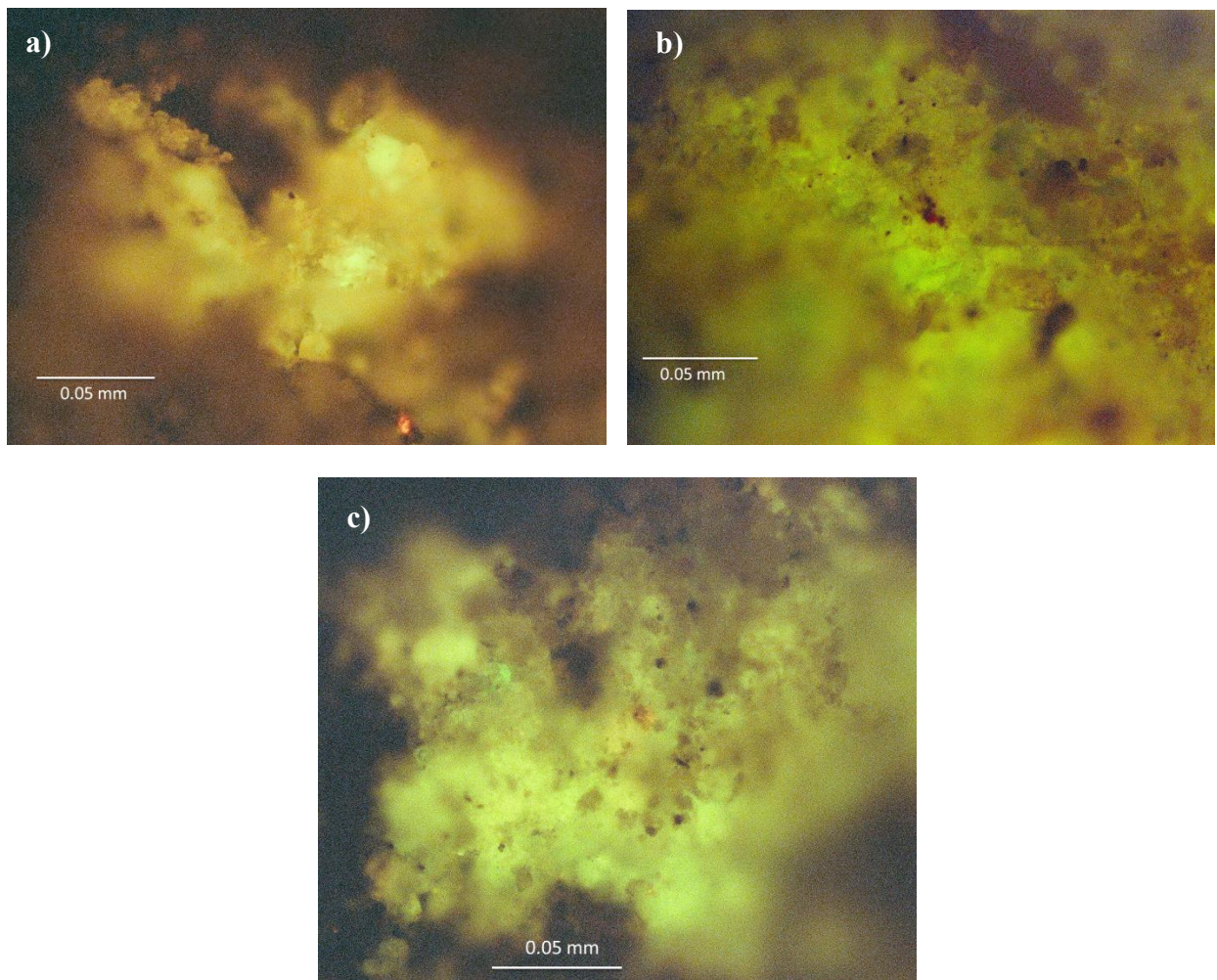


Figure 2. *Examples of varying epifluorescence intensities on Cane Creek cuttings. a) Pure Horsehead #1, 6290-6300 ft, rating = 1.4 (spotty, weak oil show). b) Lockheart Federal #1, 4785-4790 ft, rating = 2.4 (good, continuous oil show). c) Texaco Gulf Federal #1, 6940-6950 ft, rating = 2.7 (good, continuous oil show).*

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.

Task 6.0: Well Completion Optimization

After months of negotiations between the State of Utah and Schlumberger, a contract was approved and signed in late May 2014 for a geomechanical testing program to be performed by TerraTek, A Schlumberger company. Portions of five cores were delivered to TerraTek in early June, two Uteland Butte cores and three Cane Creek cores. The PI and Dr. John McLennan, geomechanics task leader, met with TerraTek staff to finalize sampling and testing procedures. In addition, McLennan provided estimates of effective confining pressure to be used during the testing. To date, the test samples have been drilled from the cores and testing is currently underway. Final results should be available in December 2014. These data will provide the basis for the objectives of Task 6.

Well summary files have been created for each producing Uteland Butte and Cane Creek well. This database includes general well information (bottom hole depth, bottom hole temperature, mud properties, bit size, producing formation), completion information (zones perforated, fracture gradient, perforation diameter), drilling information (well bore direction and orientation), geology/mineralogy (formation tops, XRD data), lateral length, and available analyses (source rock analysis, triaxial data). These data will be used to help develop information for fracture simulations.

CONCLUSION

Significant effort was made this past quarter on the regional mapping of key stratigraphic marker beds in the Uteland Butte. As maps are drafted, a clearer picture of production potential has started to emerge. To help fill in details of facies changes, diagenesis, and geomechanics, several collaborations have been set up to enhance the research being performed by the UGS. Epifluorescence analysis on Cane Creek cuttings has commenced, fluid inclusion analyses on the Cane Creek are underway, rock mechanics testing at TerraTek has started, as well as several other activities. In addition to significant progress in research, several technology transfer activities occurred this past quarter to help inform industry and the public. During technology transfer activities, the UGS received encouraging feedback from industry about progress made on this project, both on the Uteland Butte and the Cane Creek tight oil plays.

COST STATUS

Table 2. Project costing profile for Budget Period 2.

	Jul 2014		Aug 2014		Sep 2014	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	\$9,930	\$852	\$9,930	\$20,308	\$9,930	\$17,392
Travel Expenses ¹	\$1,790	\$472		\$2,227	\$1,876	\$1,177
Analyses ²			\$19,364			\$5,916
Miscellaneous ³		\$364		\$127		\$29
SUBTOTALS	\$11,720	\$1,688	\$29,294	\$22,662	\$11,806	\$24,514
UGS OVERHEAD (34.44%)	\$4,036	\$581	\$10,089	\$7,805	\$4,066	\$8,443
SUBCONTRACTS						
EGI	\$6,771	\$0	\$6,771	\$0	\$6,771	\$12,945
Eby	\$2,287	\$0	\$2,287	\$0	\$2,287	\$0
GRAND TOTALS	\$24,813	\$2,269	\$48,440	\$30,467	\$24,929	\$45,901

¹July – travel to AAPG-RMS in Denver; August – travel to Denver for core description and epifluorescence analysis, travel to Austin, TX for core description; September – additional costs associated with August trips

²September – thin sections from Cane Creek core, RockEval analysis from Cane Creek core

³July – Exhibit booth expenses and poster lamination for AAPG-RMS; August – core layout fees; September – miscellaneous office supplies

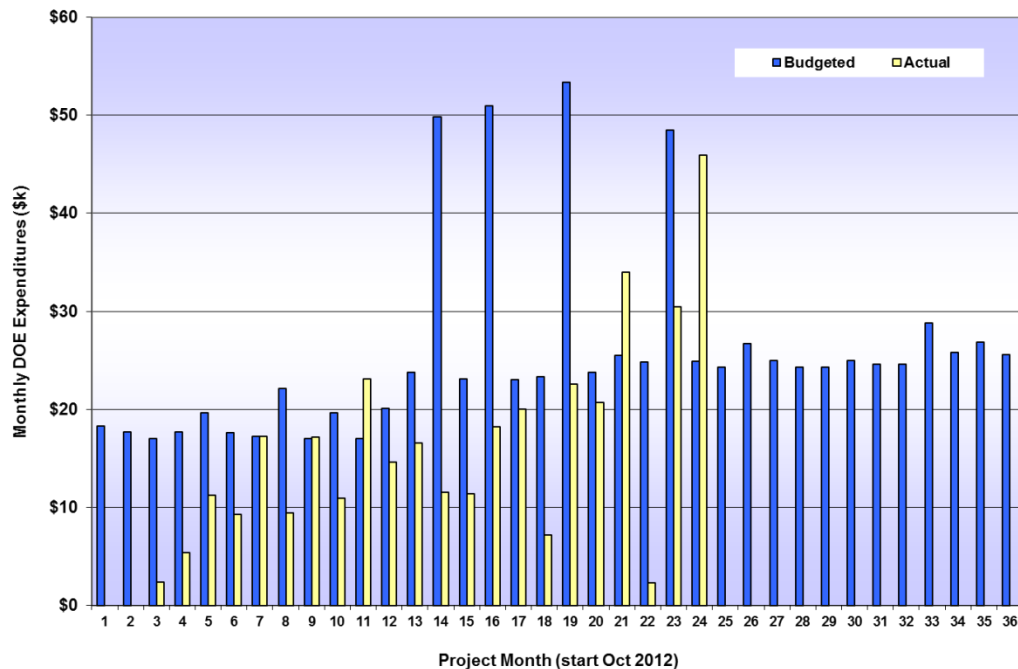


Figure 3. Project costing profile.

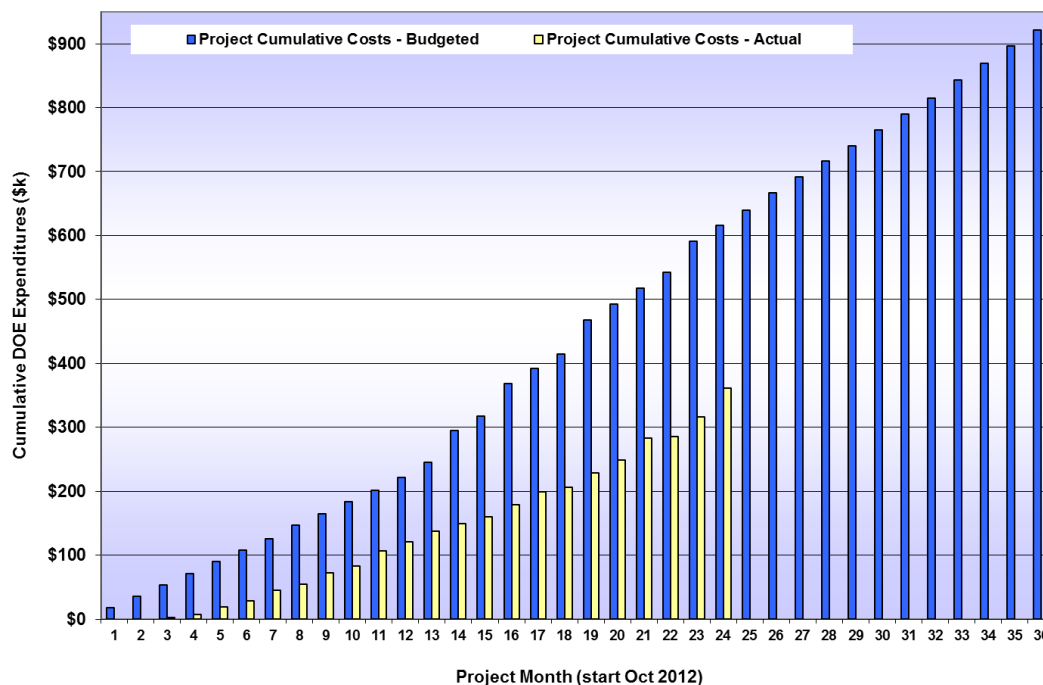


Figure 4. Project cumulative costs.

MILESTONE STATUS

Table 3. Milestone log for Budget Period 2.

	Title	Related task or subtask	Completion Date	Update/comments
Milestone 14	Quarterly updates of website	Subtask 2.1	Quarterly	Ongoing
Milestone 15	Quarterly reports	Subtask 2.2	Quarterly	Ongoing
Milestone 16	Technical presentations at National AAPG	Subtask 2.4 & 5	Apr-14	Oral presentation on Cane Creek delivered at AAPG 2014
Milestone 17	Technical presentations at Regional AAPG	Subtask 2.4 & 5	Jun-14	Two presentations (one on Cane Creek and one on Uteland Butte) given at AAPG-RMS 2014
Milestone 18	Measure & describe key outcrops	Subtask 5.1	30-Jun-14	Measured 4 outcrop sections, 2 in Nine Mile Canyon and 2 near Texas Creek, eastern Uinta Basin
Milestone 19	Outcrop sample collection	Subtask 5.2	30-Jun-14	Sampled as needed during outcrop field work
Milestone 20	Fracture analyses of outcrop	Subtask 5.3	30-Jun-14	Completed as part of the outcrop field work
Milestone 21	Sample analyses from core	Subtask 4.2	30-Sep-14	Ongoing, filling in data gaps as needed
Milestone 22	Epifluorescent measurements on cuttings	Subtask 4.3	30-Sep-14	Completed sample collection, analysis started in August 2014 and will continue into fall 2014

Milestone 23	Organic geochemical analyses	Subtask 4.4	30-Sep-14	Ongoing, filling in data gaps as needed
Milestone 24	Fracture analyses of core	Subtask 4.5	30-Sep-14	Cane Creek – fluid inclusion analyses, thin section analyses planned for fall 2014
Milestone 25	Rock mechanics testing	Subtask 4.6	30-Sep-14	Testing at TerraTek underway
Milestone 26	Lab analyses of samples	Subtask 5.4	30-Sep-14	Ongoing, filling in data gaps as needed
Milestone 27	Methodologies for brittle behavior	Subtask 6.1	30-Sep-14	Waiting for rock mechanics data
Milestone 28	Methodologies for fracture growth	Subtask 6.2	30-Sep-14	Waiting for rock mechanics data
Milestone 29	Identify algorithms	Subtask 6.3	30-Sep-14	Waiting for rock mechanics data
Milestone 30	Second debriefing meeting	Subtask 2.3	Sep-14	Hosted RPSEA-sponsored conference September 10, 2014
Milestone 31	BP 2 Decision Point	Task 1	30-Sep-14	CA completed and approved, ready to move into BP 3

ACCOMPLISHMENTS

- Delivered an oral presentation at the AAPG-RMS meeting in Denver, CO, in July 2014 on the Uteland Butte tight oil play. The presentation was very well received and generated significant interest in the project and the play area.
- Presented a poster at the AAPG-RMS meeting in Denver, CO, in July 2014 on the Cane Creek shale tight oil play. The presentation was very well received and generated significant interest in the project and the play area.
- Submitted a Continuation Application to NETL to move from Budget Period 2 to Budget Period 3. The application was approved and research will continue as scheduled.
- Described two additional Uteland Butte cores and one additional Cane Creek core.
- Commenced epifluorescence analysis on cuttings from the Cane Creek shale with Dr. David Eby.
- Hosted a RPSEA-sponsored conference and field trip. The PI and other project team members presented research updates, displayed Uteland Butte and Cane Creek core, and visited Uteland Butte outcrop.

PROBLEMS OR DELAYS

None at this time

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 – April to June 2014
 - Completed late July and is available on the project website.
- Oral presentation – 2014 AAPG-RMS annual meeting, Denver, CO, July 20-22, 2014

- The PI presented “Geological Characterization of the Uteland Butte Member of the Eocene Green River Formation: An Emerging Unconventional Carbonate Tight Oil Play in the Uinta Basin, Utah” in the Stratigraphy of Rocky Mountain Basins and Beyond session, Tuesday morning, July 22, 2014.
- The presentation is available on the UGS project website.
- Poster presentation – 2014 AAPG-RMS annual meeting, Denver, CO, July 20-22, 2014
 - Craig Morgan, project team member, presented “Play Analysis of the Cane Creek Shale, Pennsylvanian Paradox Formation, Paradox Basin, Southeast Utah” in the Exploration/Exploitation session, Monday, July 21, 2014.
 - The presentation is available on the UGS project website.
- RPSEA-sponsored conference and field trip, hosted by the Utah Geological Survey, September 10-11, 2014
 - The UGS hosted a RPSEA-sponsored conference and field trip on September 10-11, 2014. The agenda included presentations on the Uteland Butte and Cane Creek tight oil plays and the field trip included a stop in Nine Mile Canyon to view the Uteland Butte in outcrop. The conference was attended by over 70 individuals from the private sector, academia, and state and federal government agencies. The conference also included Uteland Butte and Cane Creek core displays.
- Core workshop – AAPG Lacustrine Basin Exploration field course – September 16, 2014
 - The PI helped organize a core workshop for an AAPG field course focusing on lacustrine rocks of the Green River Formation, including the Uteland Butte.
- Abstracts (2) – 2015 AAPG annual meeting, Denver, CO, May 31-June 3, 2015
 - Two abstracts were submitted 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.

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