

Oil & Natural Gas Technology

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Research Performance Progress Report

Quarterly Report: April 2014 to June 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

The third quarter of Budget Period 2 was dominated by Uteland Butte regional mapping and outcrop 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 revised 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 four Uteland Butte (or Uteland Butte equivalent) outcrop sections, two on the south side of the Uinta Basin near Nine Mile Canyon and two on the east side of the basin near Missouri Creek.

Considerable effort was spent during the past quarter arranging and negotiating agreements with various project collaborators. A major milestone was reached in May when a contract was finalized with TerraTek, A Schlumberger company, to perform innovative geomechanical testing on several Uteland Butte and Cane Creek cores. These data will provide the basis for geomechanical modeling and aid in determining best well completion strategies for each resource play, as outlined within the Task 6 objectives.

Several technology transfer activities took place this past quarter. The PI led several field trips through Nine Mile Canyon, stopping at Uteland Butte outcrop to talk about the project and the resource play. In addition, UGS ran several core workshops that included Uteland Butte and Cane Creek core. A presentation on the Cane Creek shale was given at the annual AAPG convention in Houston, TX in April. This presentation, as well as an article in the June AAPG Explorer magazine, greatly increased awareness of the Cane Creek tight oil play and the research being performed as part of this project.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of April, the PI wrote and submitted the project's sixth quarterly report for January to March 2014. This report was subsequently sent via email to all interested parties and posted on the UGS project website. The Project Summary was updated in May 2014 and the new version is available 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 sixth quarterly report and emailed it to all interested parties. It is also available on the project website.
- Stephanie Carney, project team member, presented on the Cane Creek tight oil play in the Unconventional Resources: Tight Oil Plays session at the AAPG annual meeting in Houston, TX in April 2014.
- Two presentations will be given at the upcoming AAPG-RMS meeting in Denver, CO (July 20-22, 2014). The PI will give an oral presentation on the Uteland Butte tight oil play and Craig Morgan, project team member, will present a poster on the Cane Creek shale tight oil play.
- An article summarizing the geology and current drilling and research activities of the Uteland Butte and Cane Creek tight oil plays was submitted for publication in the AAPG-EMD (Energy and Minerals Division) Shale Gas and Liquids Committee 2014 Annual Report, which will also be published as a Wiley Encyclopedia volume on shale gas/liquids.
- An AAPG Explorer article about the Cane Creek shale tight oil play was included in the June 2014 issue. The article can be downloaded from the project website.
- Two field trips and two core workshops were run in this past quarter, highlighting different aspects of the project (see below for more details).

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

Uteland Butte Member: As part of the article written for the AAPG-EMD Shale Gas and Liquids Committee 2014 Annual Report, the PI updated the Uteland Butte play map (figure 1). Of particular note, horizontal drilling in the play has slowed in the past year and a half (since the last map was made), but several APDs (applications for permit to drill) are still active. To date, horizontal wells have been drilled with 5000-foot laterals on average, but in December 2013, Newfield Exploration Company drilled the first 11,000-foot Uteland Butte lateral in the North Myton Bench field, part of the over-pressured area of the basin. Initial production from the well (Close 4-15-22-3-2-WH) was about 1300 barrels per day, and has since decreased to about 700 barrels per day (as of February 2014). This is much better than typical Uteland Butte wells outside the over-pressured zone (with 5000-foot laterals), whose initial production averages 200-300 barrels per day, then decreases to 25-80 barrels per day. Other wells in the North Myton Bench field, with 5000-foot laterals, have typical initial production of 600-800 barrels per day, which then decreases to 100-200 barrels per day over the course of 5 to 6 months. Since most Uteland Butte horizontal wells have been drilled in just the past few years, long-term production scenarios are still unclear.

With the majority of the available Uteland Butte cores described and analyzed (however, two additional cores will be described in August 2014), focus has shifted towards creating regional play maps using available geophysical log data. Formation tops were picked for several important Uteland Butte marker beds including the A, B, C, and D shales and the three most important dolomite intervals (dolomite 1, 2, and 3 or PZ-1, PZ-1', and PZ-2) between the C and D shales, as well as the top and base of the Uteland Butte (figure 2). Preliminary isopach and structure maps have been drafted and will be refined over the coming months.

Since very little has been published on the formation of lacustrine dolomites, the PI has reached out to Dr. Hans Machel, professor of geology at the University of Alberta and prominent dolomite researcher. Negotiations are underway to help fund a graduate student to investigate the origin of the Uteland Butte lacustrine dolomites. Understanding the origin and diagenesis of the dolomites will be key to understanding the overall reservoir potential of the play.

In addition, a collaboration has been set up with Dr. Rick Sarg, prominent carbonate geologist at the Colorado School of Mines. UGS plans to partially fund a CSM graduate student to research the Uteland Butte on the eastern side of the Uinta Basin. The student will measure several Wasatch-Green River-transition outcrop sections on the western flank of the Douglas Creek arch and compare them to the Anadarko Uteland Butte cores from the Natural Buttes gas field. While 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, 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 area is much more speculative.

Cane Creek Shale: Oil production from the Cane Creek shale commenced in the 1960s from vertical wells. Starting in the 1990s, horizontal drilling began to improve the quality and production potential of Cane Creek wells. Currently, 18 wells produce from the Cane Creek in five different fields clustered in the central portion of the play area, with minor production from the Hatch Point field to the south (figure 3). To date, approximately 5.4 million barrels of oil have been produced from the Cane Creek.

Questions still remain as to why the central portion of the Cane Creek play area is more productive compared to areas in the south. Analysis of available RockEval data indicates that organic material in the Cane Creek in the south is within the early oil window, whereas areas farther north are within the peak to late window (figure 4). It is yet unclear how this might affect production; further analyses will be conducted to get a clearer picture of thermal maturity. The other main contributor to production could be

local structure. The central portion of the play area lies on top of the Cane Creek anticline, which might provide a structural trapping component and provide an enhanced fracture network. Further analysis of fractures and regional structure should shed light on how structure plays a role in reservoir productivity.

To understand the timing of Cane Creek oil generation and how it relates to fracture formation, UGS has contracted with Dr. Joe Moore from the Energy and Geoscience Institute at the University of Utah to help study fluid inclusions preserved in the fracture-fill of the Cane Creek shale. Samples from three cores will be analyzed: seven from the Remington 21-1H core and four from the Cisco State 36-13 core, both in the southern portion of the play area, and seven from the Cane Creek 26-3 core from the productive Big Flat field in the central portion of the play area (figure 5). Special double-sided thin sections will be made for the fluid inclusion analyses and will be paired with traditional thin sections. The traditional thin sections will be used to determine diagenetic changes and their relative timing.

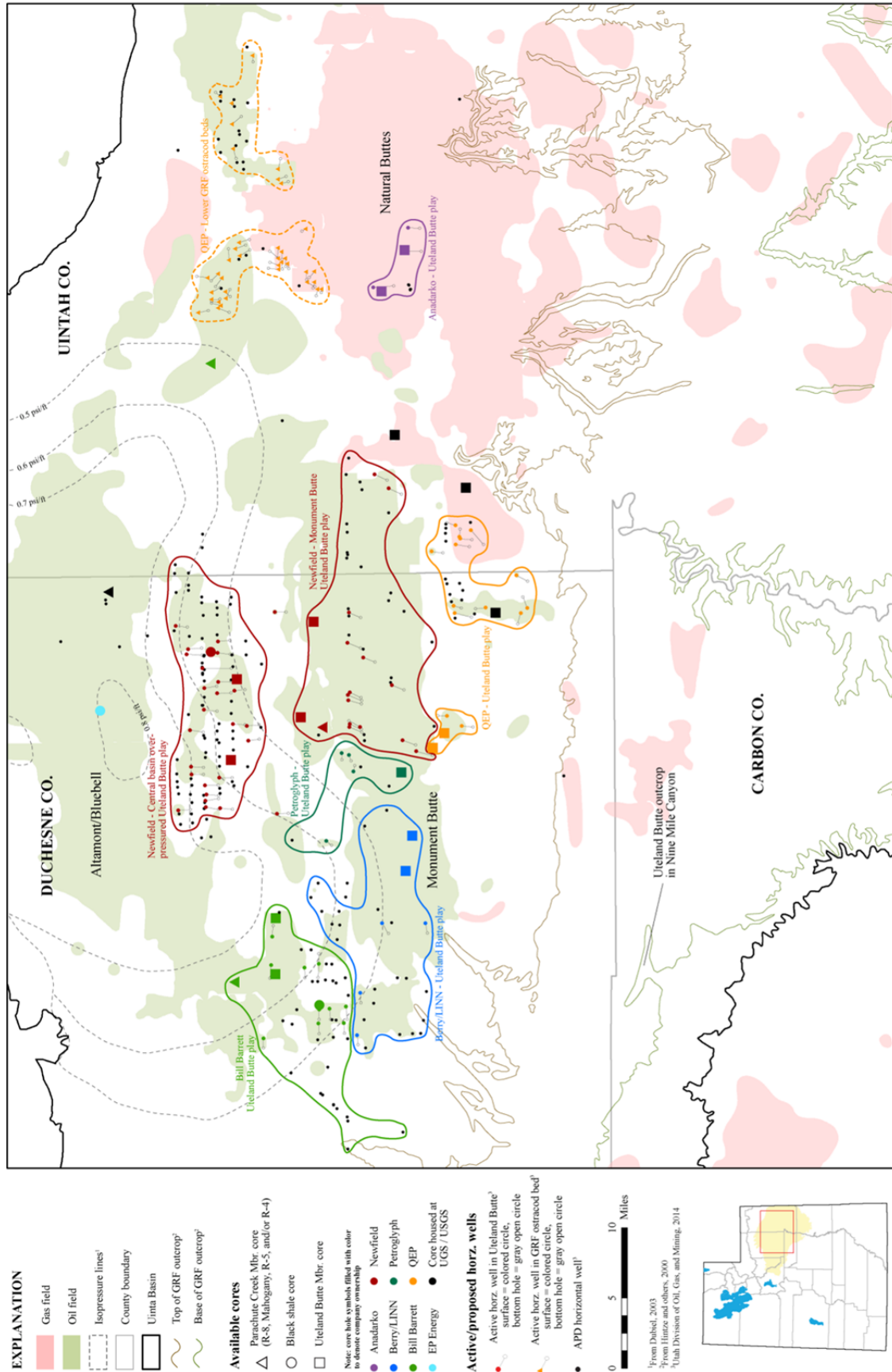


Figure 1. Map of the Uteland Butte play area in the Uinta Basin, Utah (updated June 2014).

Well name: Nickerson 6-28-3-2W
 Operator: Newfield Exploration Company

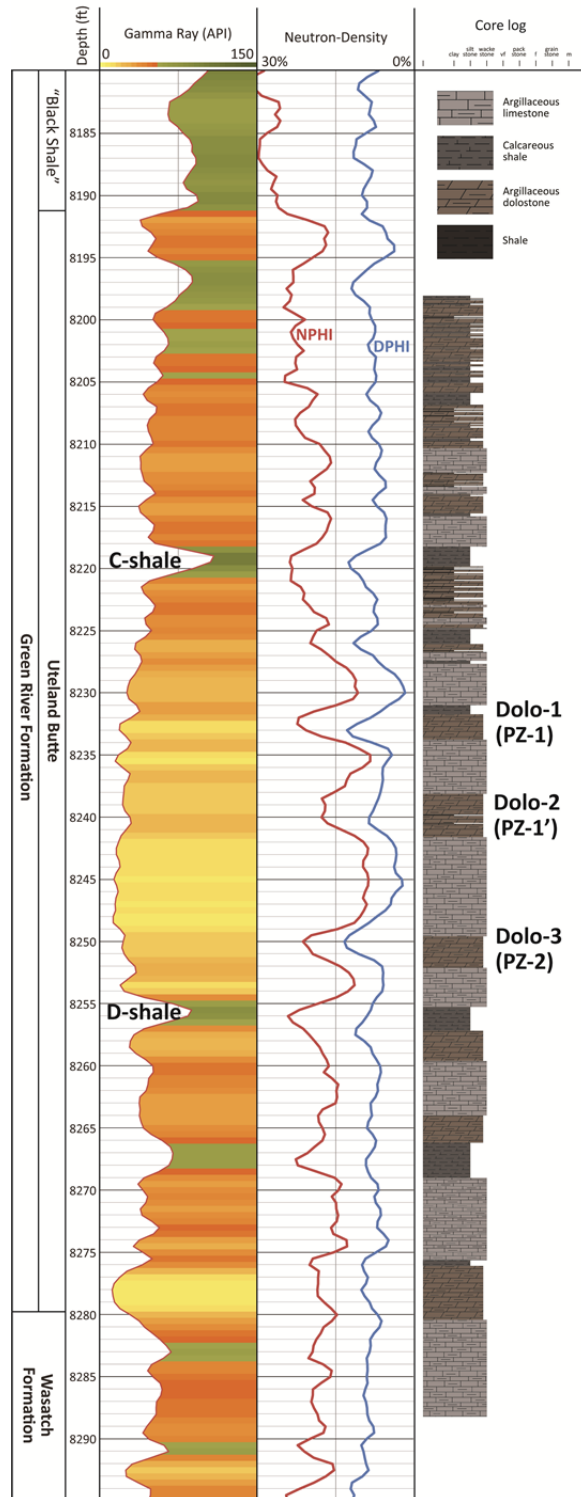


Figure 2. Uteland Butte stratigraphy as seen in the Nickerson 6-28-3-2W core. The main productive intervals are the three dolomites between the C- and D-shales.

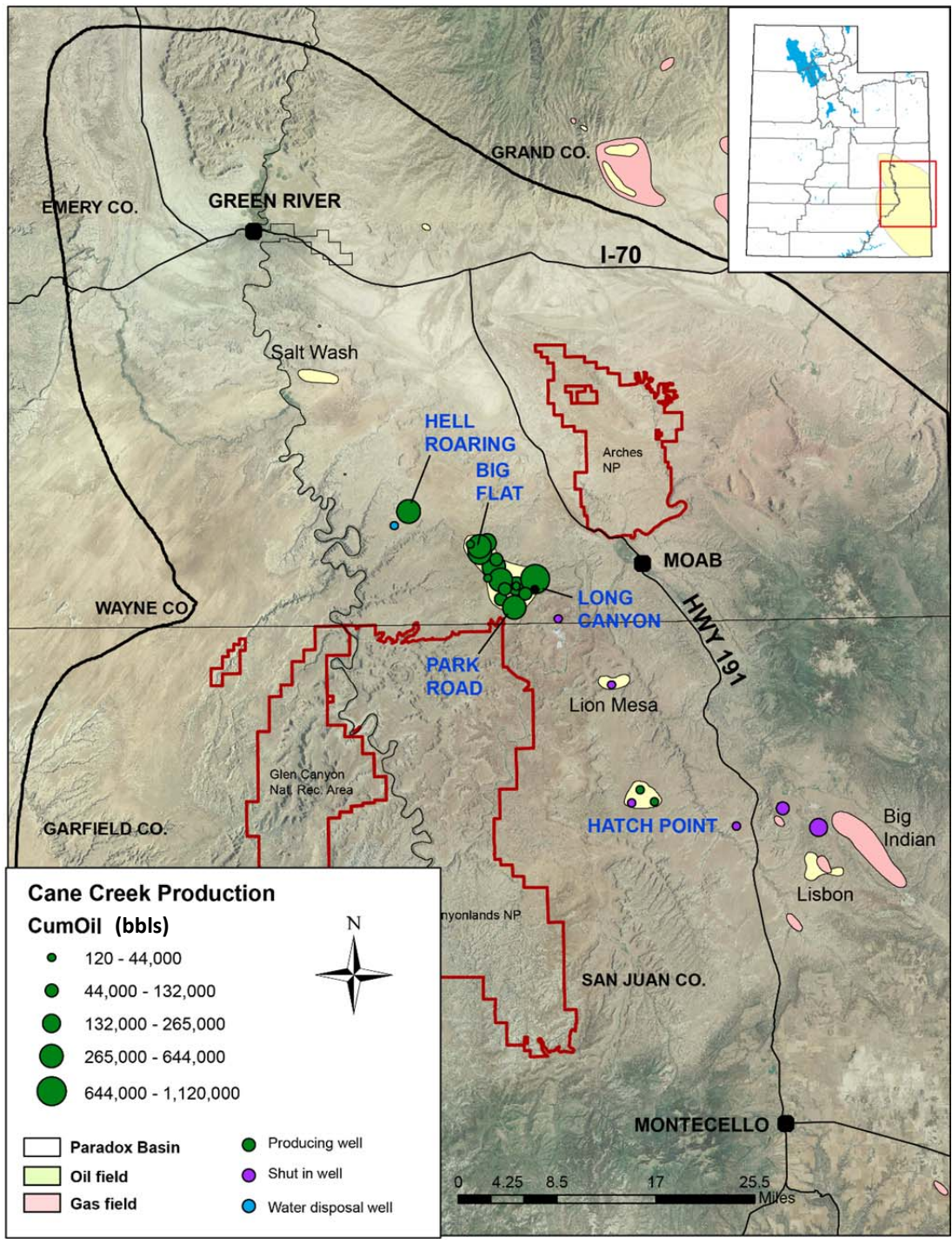


Figure 3. Map of Cane Creek production; five producing fields, 18 producing wells, cumulative oil production equals about 5.4 million barrels (as of January 2014).

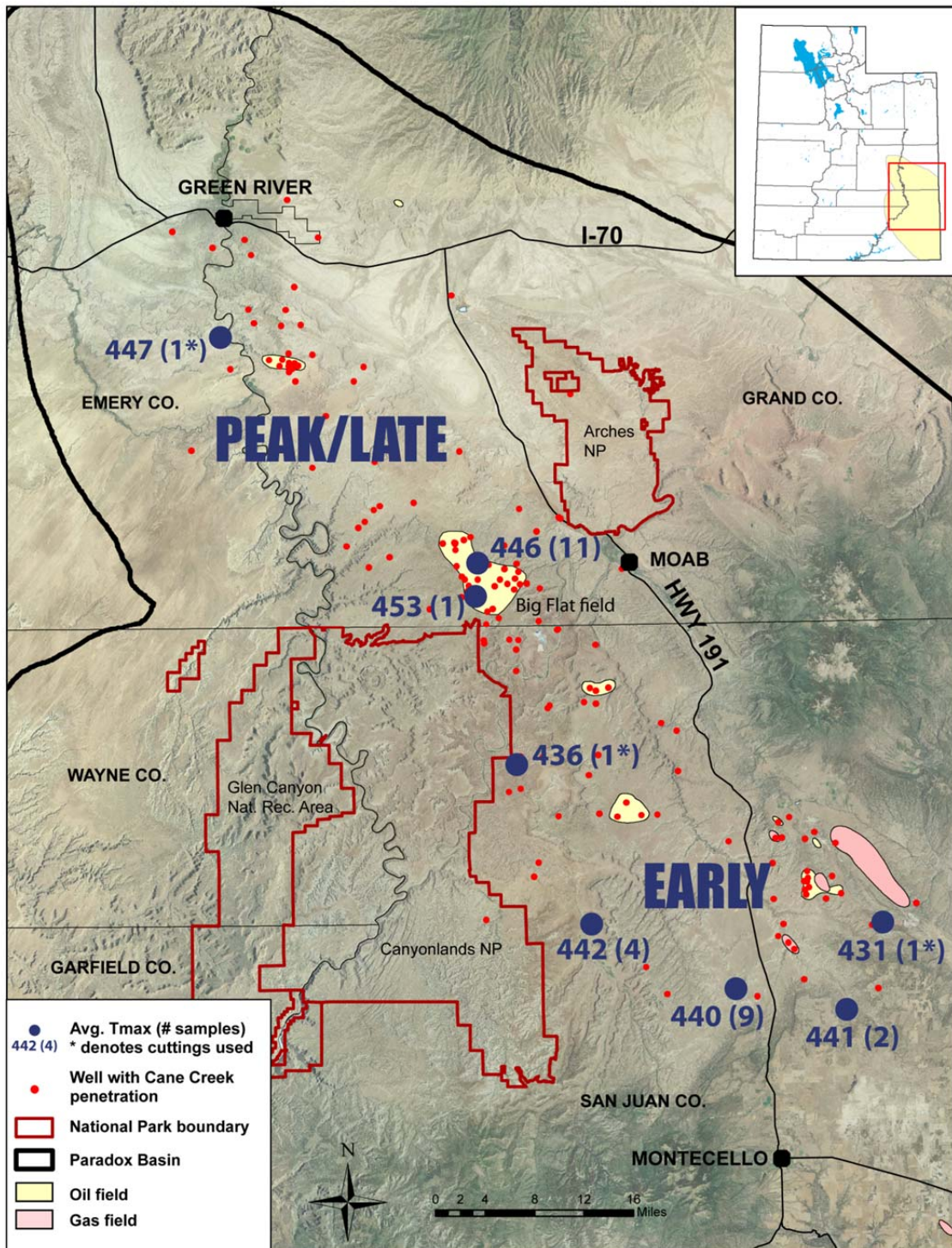


Figure 4. Average Tmax values (°C) from Cane Creek cores and cuttings indicate that areas to the south might be in the early oil generation window, whereas areas further north are in the peak to late oil generation window. This may help explain why production in the central portion of the play has been more successful than in the southern areas.

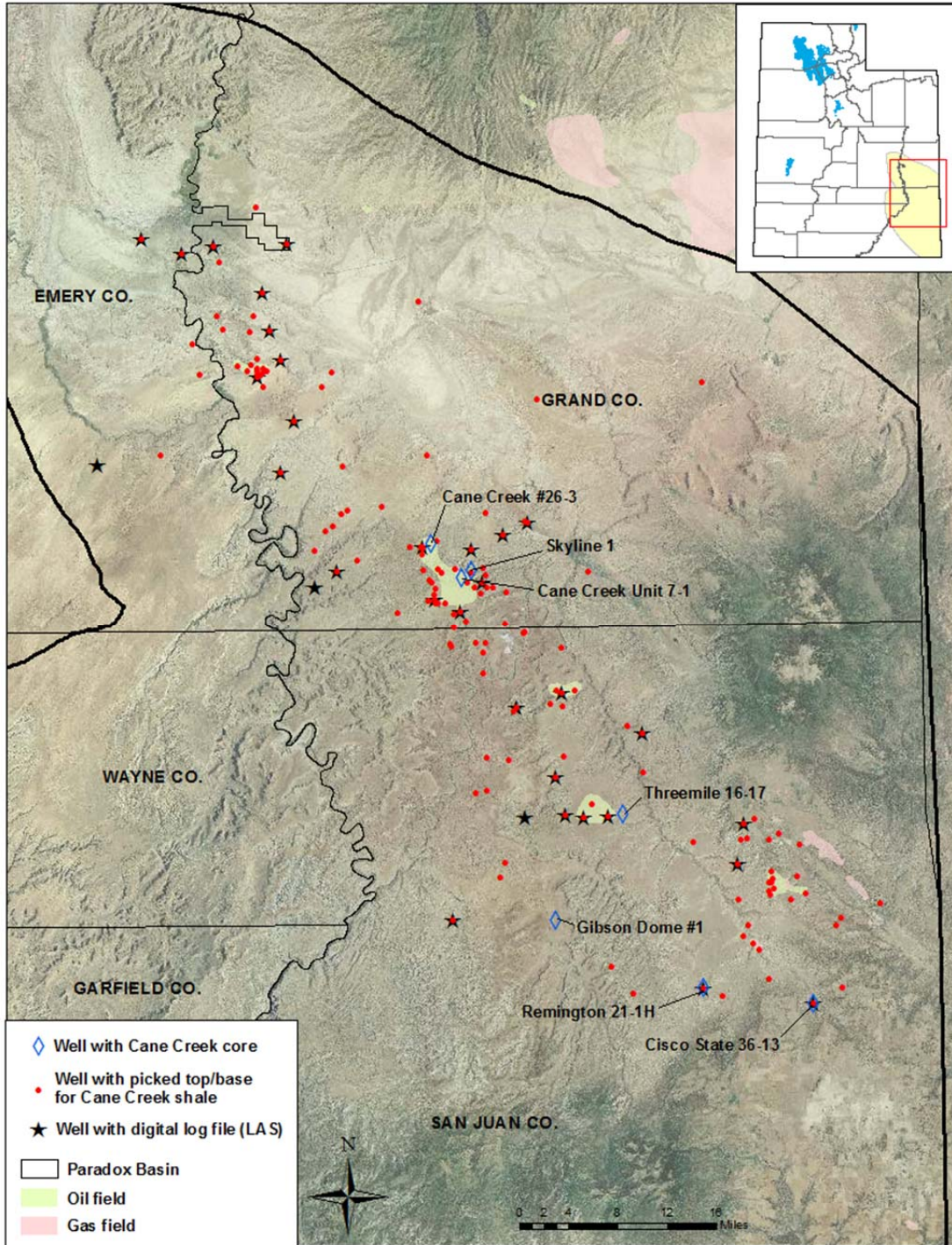


Figure 5. Map of the Paradox Basin, Utah, showing the location of wells with Cane Creek core, picked Cane Creek top/base, and digitized log files (LAS files).

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. Testing will begin in late July and continue into August. Final results should be available in September 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 is starting 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. A large milestone was reached when a contract was finalized for geomechanical testing at TerraTek, A Schlumberger company. 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 1. Project costing profile for Budget Period 2.

	Apr 2014		May 2014		Jun 2014	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	\$9,930	\$14,221	\$9,930	\$11,945	\$9,930	\$16,867
Travel Expenses ¹	\$3,634	\$2,133	\$1,020	\$354	\$2,290	\$380
Analyses	\$19,364					
Miscellaneous ²		\$609		\$644		\$1,215
SUBTOTALS	\$32,928	\$16,786	\$10,950	\$12,943	\$12,220	\$18,462
UGS OVERHEAD (34.44%)	\$11,340	\$5,781	\$3,771	\$4,458	\$4,208	\$6,358
SUBCONTRACTS						
EGI	\$6,771	\$0	\$6,771	\$3,329	\$6,771	\$9,189
Eby	\$2,287	\$0	\$2,287	\$0	\$2,287	\$0
GRAND TOTALS	\$53,325	\$22,568	\$23,778	\$20,730	\$25,486	\$34,009

¹April – travel to AAPG in Houston; May – travel to Uinta Basin for outcrop description; June – travel to Uinta Basin for outcrop description, registration for RMS

²April – Exhibit booth expenses for AAPG; May – exhibit booth expenses, software

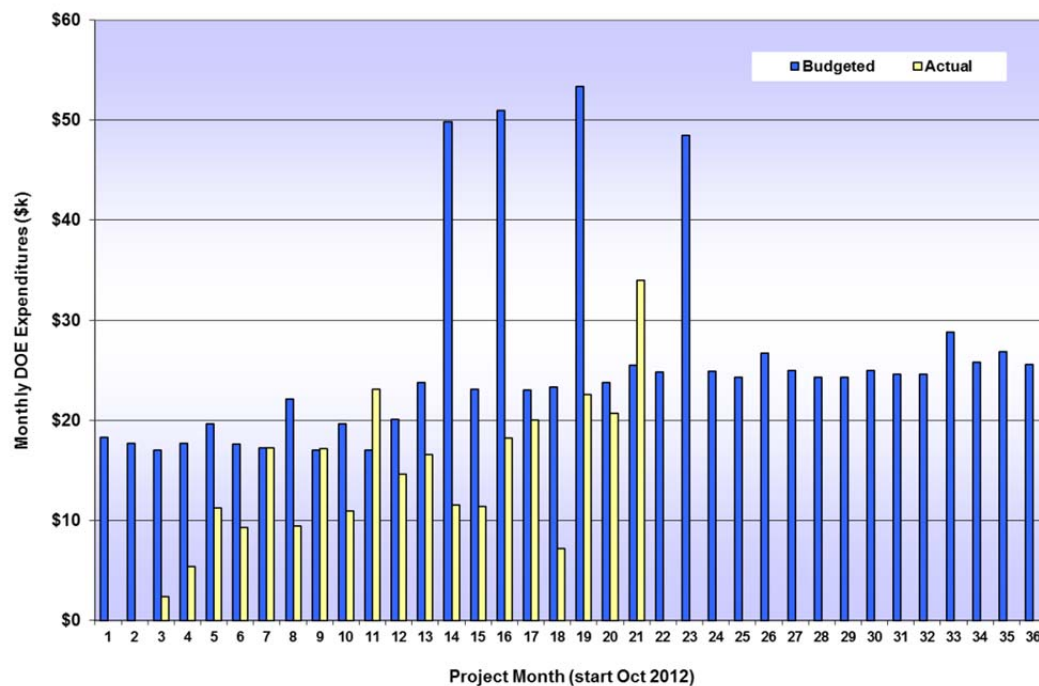


Figure 6. Project costing profile.

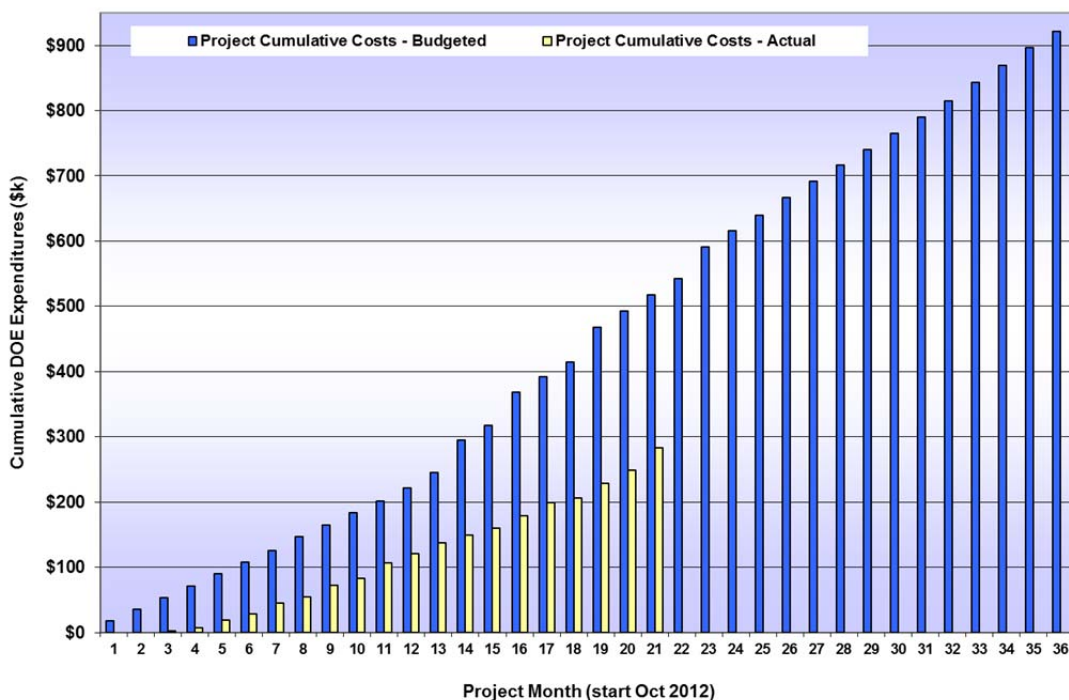


Figure 7. Project cumulative costs.

MILESTONE STATUS

Table 2. 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) will be given at AAPG-RMS 2014, July 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 planned for August 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 should be finished early Aug 2014, analyses planned for fall 2014
Milestone 25	Rock mechanics testing	Subtask 4.6	30-Sep-14	Testing at TerraTek scheduled to begin late July 2014
Milestone 26	Lab analyses of samples	Subtask 5.4	30-Sep-14	
Milestone 27	Methodologies for brittle behavior	Subtask 6.1	30-Sep-14	
Milestone 28	Methodologies for fracture growth	Subtask 6.2	30-Sep-14	
Milestone 29	Identify algorithms	Subtask 6.3	30-Sep-14	
Milestone 30	Second debriefing meeting	Subtask 2.3	Sep-14	Scheduled for Sept. 10 as part of a RPSEA sponsored conference, hosted by the UGS in Salt Lake City
Milestone 31	BP 2 Decision Point	Task 1	30-Sep-14	

ACCOMPLISHMENTS

- Delivered an oral presentation at the AAPG annual conference in Houston, TX in April 2014 on the Cane Creek shale. The presentation was very well received and generated significant interest in the project and the play area.
- Completed contract for geomechanical testing with TerraTek, A Schlumberger company. Testing will commence in late July 2014.
- Formed a collaboration with the Colorado School of Mines and Dr. Rick Sarg. UGS will help fund a graduate student to research the eastern extent of the Uteland Butte member of the GRF, studying several outcrop locations and one core.
- Finalized a contract with Dr. Joe Moore at the Energy and Geoscience Institute, University of Utah, for help with fluid inclusion analysis on the Cane Creek shale.
- Measured four stragraphic sections, including gamma ray profiles; two in Nine Mile Canyon, south-central Uinta Basin, and two near Missouri Creek, far eastern Uinta Basin.
- Initiated contract with Dr. David Eby for epifluorescence analysis on Cane Creek cuttings samples.

PROBLEMS OR DELAYS

A contract has been set up with the Energy and Geoscience Institute (EGI), University of Utah, and a PhD-level student started working on this project in January 2014. Due to personal issues, the student has been slow to start, resulting in lower than expected billing from the first and second quarters of 2014. Now that a contract has been finalized with TerraTek, rock mechanics testing will soon commence and the student will spend much more time dedicated to the project. EGI has also elicited the help of an additional researcher to work on the project, which should increase the amount billed each quarter.

A contract with Dr. David Eby has been initiated and will be completed by the end of July 2014. Eby will begin analyzing Cane Creek cuttings samples in August 2014, and billing on his contract will occur in the first quarter of BP 3 (Oct-Dec 2014).

After several months of contract negotiations between the State of Utah and Schlumberger, the contract with TerraTek for geomechanical testing was completed in May 2014 and core was delivered for testing in June. Testing is scheduled to begin in late July 2014 and continue into August. An invoice for the testing (~\$75,000) will be billed to the project in September or October 2014.

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 – January to March 2014
 - Completed late April and is available on the project website.
- Oral presentation – 2014 AAPG annual meeting, Houston, TX, April 6-9, 2014
 - Stephanie Carney, project team member, presented “Geological Evaluation of the Cane Creek Shale, Pennsylvanian Paradox Formation, Paradox Basin, Southeastern Utah” in the Unconventional Resources: Tight Oil Plays session, Wednesday morning, April 9, 2014.
 - The presentation is available on the UGS project website.
- Upcoming oral presentation – 2014 AAPG-RMS annual meeting, Denver, CO, July 20-22, 2014
 - The PI will present on the Uteland Butte tight oil play in the “Stratigraphy of the Rocky Mountains Basins and Beyond” session on Tuesday, July 22, 2014.
- Upcoming poster presentation – 2014 AAPG-RMS annual meeting, Denver, CO, July 20-22, 2014
 - Craig Morgan, project team member, will present a poster on the Cane Creek tight oil play in the “Exploration/Exploitation” session on Monday, July 21, 2014.
- Article for the AAPG-EMD (Energy and Minerals Division) Shale Gas and Liquids Committee 2014 Annual Report, which will be published as part of a Wiley Encyclopedia volume on shale gas/liquids and renewable energy.
 - Project team member Tom Chidsey wrote an article summarizing the geology and current drilling and research activities of the Uteland Butte and Cane Creek tight oil plays.
 - The article is available on the UGS project website.
- AAPG Explorer article about the Cane Creek shale tight oil play (June 2014).
 - The PI contributed to an article on the tight oil potential of the Cane Creek shale in the June 2014 issue of the AAPG Explorer.
 - <http://www.aapg.org/publications/news/explorer/2014/06jun>
 - The article is also available on the UGS project website.
- Pertamina field trip and core workshop, April 16-21, 2014
 - The PI and other project team members led a 6-day field trip for Pertamina EP, the national oil company of Indonesia, which included a stop in Nine Mile Canyon at the Uteland Butte outcrop where we discussed the project and the play’s oil production potential. The trip also included a stop near Dead Horse Point and the Big Flat Cane Creek oil field in Grand County, Utah, where we discussed the Cane Creek tight oil play. The core workshop included Uteland Butte and Cane Creek core.
- UGS-sponsored field trip, May 21-22, 2014
 - The PI and other project team members led a UGS-sponsored field trip through the San Rafael Swell and the Uinta Basin to highlight ongoing research on several UGS projects. The field trip included a stop in Nine Mile Canyon to view the Uteland Butte and discuss this project. The field trip included several UGS geologists, as well as representatives from industry; Utah Division of Oil, Gas, and Mining; and the EPA.

- Core workshop for Shell Oil Company, June 3, 2014
 - The PI led a lacustrine systems core workshop for Shell Oil Company that included Uteland Butte core and a discussion of our project.
- Core workshop for the 3rd Annual Utah Governor's Energy Development Summit, June 4, 2014
 - The PI led a core workshop for attendees of the 3rd Annual Utah Governor's Energy Development Summit. The workshop included several cores from several different producing fields in Utah, including the Cane Creek and the Uteland Butte tight oil plays.
- RPSEA-sponsored conference and field trip, Salt Lake City, Utah, September 10-11, 2014
 - The PI worked with RPSEA to plan a UGS-hosted conference and field trip for September 10-11, 2014. The agenda includes presentations on the Uteland Butte and Cane Creek tight oil plays and the field trip will include a stop in Nine Mile Canyon to view the Uteland Butte in outcrop. This conference will serve as our year-two debriefing meeting.
 - Information about the conference and field trip can be found on RPSEA's website: <http://www.rpsea.org/events/451/>

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