Oil & Natural Gas Technology

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Research Performance Progress Report

Quarterly Report: January 2014 to March 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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Office of Fossil Energy

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EXECUTIVE SUMMARY

The second quarter of Budget Period 2 was dominated by Cane Creek core investigations, technology transfer activities, and setting up various collaborations. Three new Cane Creek cores were delivered to the Utah Geological Survey (UGS) for inclusion in our study, including two cores from the main productive field in the central portion of the play area. These cores will be vital in understanding the facies differences across the play area and their effect on potential production. In addition, significant time was spent preparing a presentation on the Cane Creek shale for the American Association of Petroleum Geologists (AAPG) annual meeting held in Houston, TX in early April 2014.

Two important collaborations were set up to help study the Uteland Butte member of the Green River Formation (GRF). First, the Principal Investigator (PI) met with researchers from the U.S. Geological Survey (USGS) who are interested in studying the origin of GRF oils and the thermal maturity of shales in the Uteland Butte; comparisons will be made with the equivalent Cow Ridge member of the basal GRF in Colorado's Piceance Basin. Second, the PI met with Dr. Hans Machel, geology professor at the University of Alberta and prominent dolomite researcher, to discuss a detailed study looking at the lacustrine dolomite of the Uteland Butte. Understanding the origin of the dolomite and subsequent diagenesis will be vital to understanding the productive potential of the play.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of January, the PI wrote and submitted the project's fifth quarterly report for October to December 2013. This report was subsequently sent via email to all interested parties and posted on the UGS 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 fifth 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 early April.
- 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.
- Two abstracts, one on the Cane Creek shale and one on the Uteland Butte tight oil play, were accepted for presentation at the AAPG Rocky Mountain Section meeting, which will be held in Denver, CO in July 2014.

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

Uteland Butte Member: All available Uteland Butte cores have been described (figure 1) and details of the descriptions are currently being drafted alongside geophysical logs and other available data. With the completed examination of the cores, focus has now shifted towards understanding the regional geologic setting of this zone. For example, project team members have begun picking tops on geophysical logs and mapping the individual marker beds and productive carbonate intervals within the Uteland Butte to determine their lateral variation and heterogeneity. In addition, a north-south cross section (trace is displayed on figure 1) is under construction (the west-east section is available on the 2013 AAPG poster).

This section will highlight facies changes from near shore to deep lake, including the pinching out of the Uteland Butte member to the north.

The UGS research team has set up a collaboration with the USGS to study the origin of oils produced from the GRF. Several samples have been collected from several GRF cores, over several intervals, for detailed thermal maturity and x-ray diffraction analysis. One goal will be to compare the basal Cow Ridge member of the GRF in Colorado's Piceance Basin with the basal Uteland Butte member in the Uinta Basin.

Since very little is known 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 study the origin of the Uteland Butte lacustrine dolomites. Understanding the origin and diagenesis of the dolomites will be key to understanding the overall production potential of the play.

Cane Creek Shale: The Cane Creek shale typically consists of three primary intervals (facies) informally named from top to bottom, A, B, and C (figure 2). Intervals A and C typically consist of carbonate (mostly dolomite) with nodular anhydrite and occasional anhydrite- or halite-filled fractures. Interval B is the primary target for oil development and consists of dolomite, dolomitic siltstone, and organic-rich shale with occasional open fractures. Interval B is identified on gamma-ray logs as typically having a high gamma-ray spike at the top of the interval and relatively high readings throughout the interval. Intervals A and C have highly variable gamma-ray readings with numerous low readings in the anhydrite beds.

The project team also made progress in locating additional Cane Creek core material. The Cisco State 36-13 core, located in the southern portion of the play area (figure 3), was delivered to UGS in December 2013 and described in January 2014. In addition, Fidelity E&P shipped the Cane Creek 26-3 and portions of the Cane Creek 7-1, both from the productive Big Flat field, to UGS for description and analysis. Information from the two Fidelity cores will be held confidential for at least one year.

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 4). To date, approximately 5.4 million barrels of oil have been produced from the Cane Creek. Figure 5 shows examples of production decline curves from two horizontal Cane Creek wells. The Kane Springs Fed 10-1 (figure 5a), completed in November 1992 in the Hell Roaring field, has produced a total of 644,309 barrels of oil from a ~700 foot lateral over the past 21 years. In contrast, the Cane Creek 12-1 (figure 5b), completed in November 2012 in the Big Flat field, has produced a total of 615,683 barrels of oil from a ~2400 foot lateral in only 1.5 years, demonstrating the recent success of new horizontal drilling.

Questions still remain as to why the central portion of the play area is more productive compared to areas in the south. Analysis of available RockEval data indicate 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 6). 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 contribute to a favorable fracture network. Further analysis of fractures and regional maps should shed light on how structure plays a role in production.

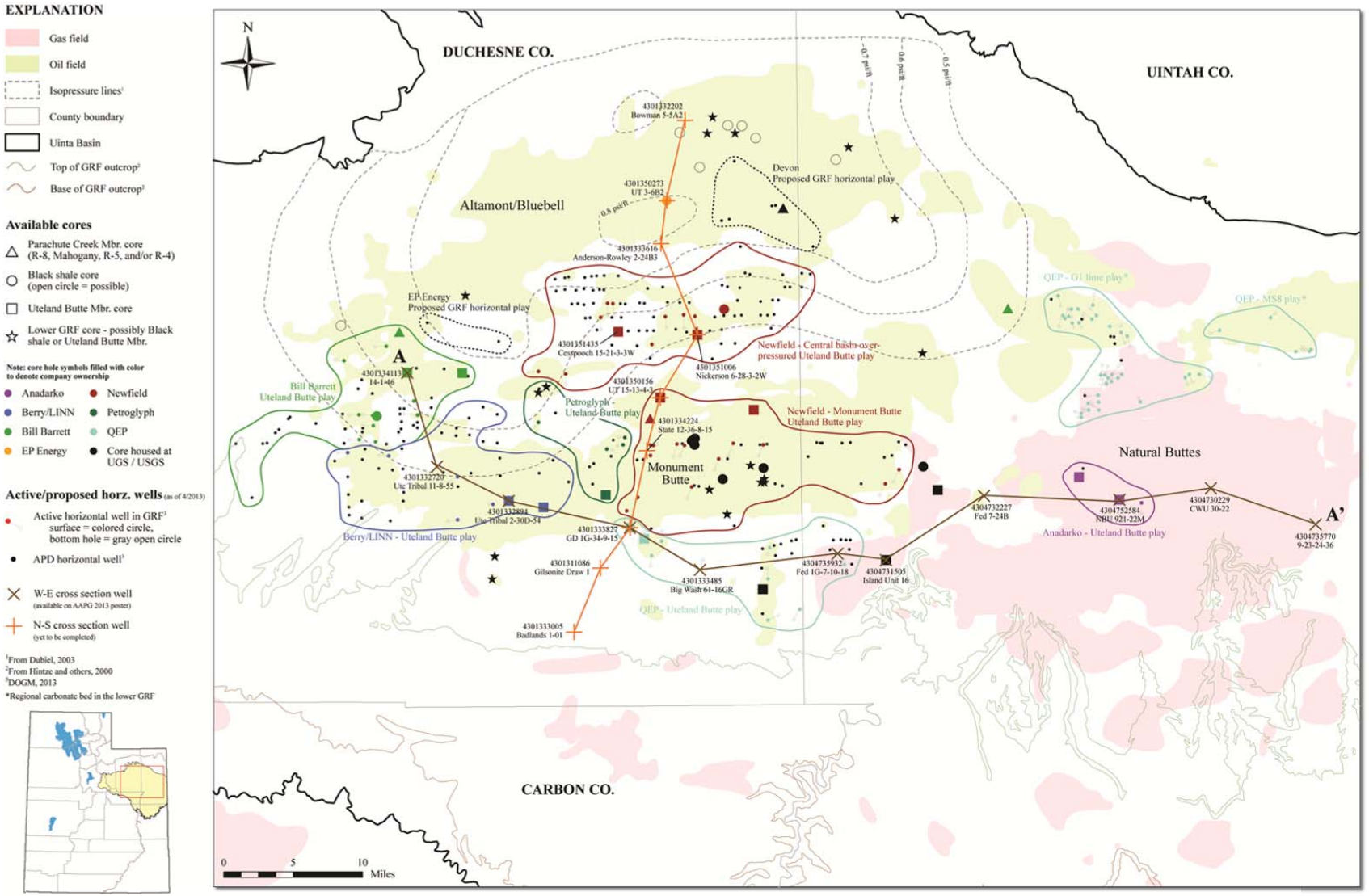


Figure 1. *Map of the Uinta Basin, Utah, showing the location of available Green River Formation cores, horizontal wells, and location of project cross sections.*

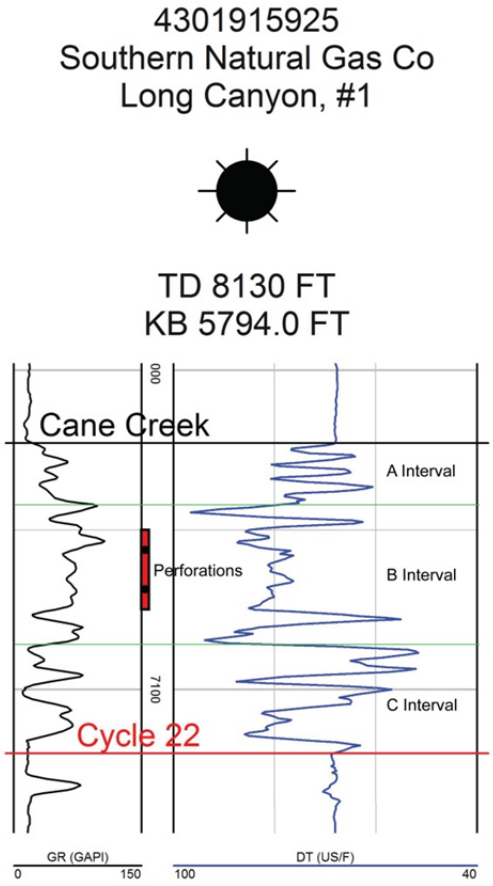


Figure 2. *Gamma-ray and sonic log from the Long Canyon 1 well showing the A, B, and C intervals of the Cane Creek shale in the Pennsylvanian Paradox Formation. More than 1.1 million barrels of oil have been produced from the vertically drilled Long Canyon 1 well since its completion in 1962. As of November 2013, the well is producing less than 10 barrels of oil per day.*

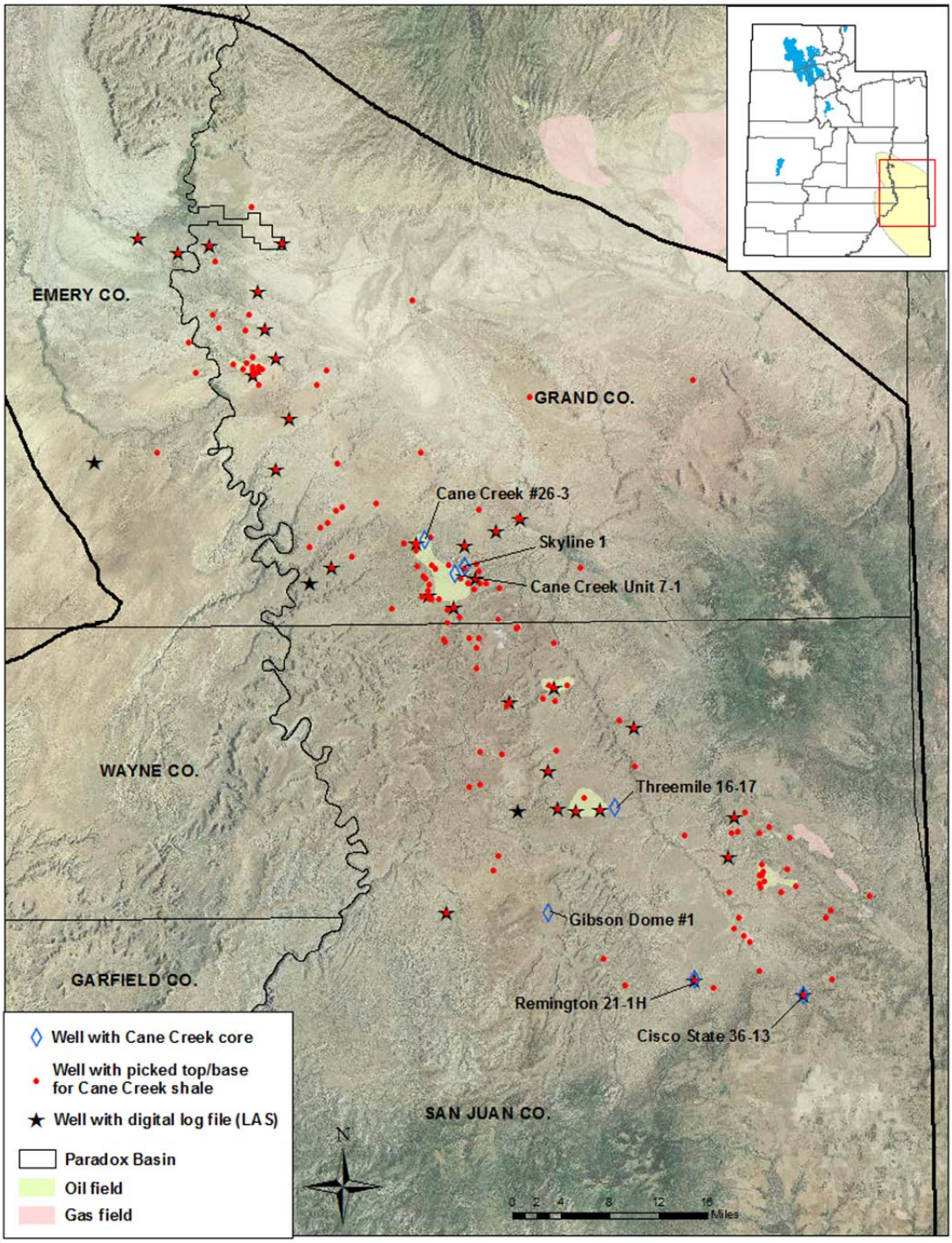


Figure 3. *Map of the Paradox Basin, Utah, showing the location of wells with Cane Creek core, picked Cane Creek top/base, and digitized log files (LAS files).*

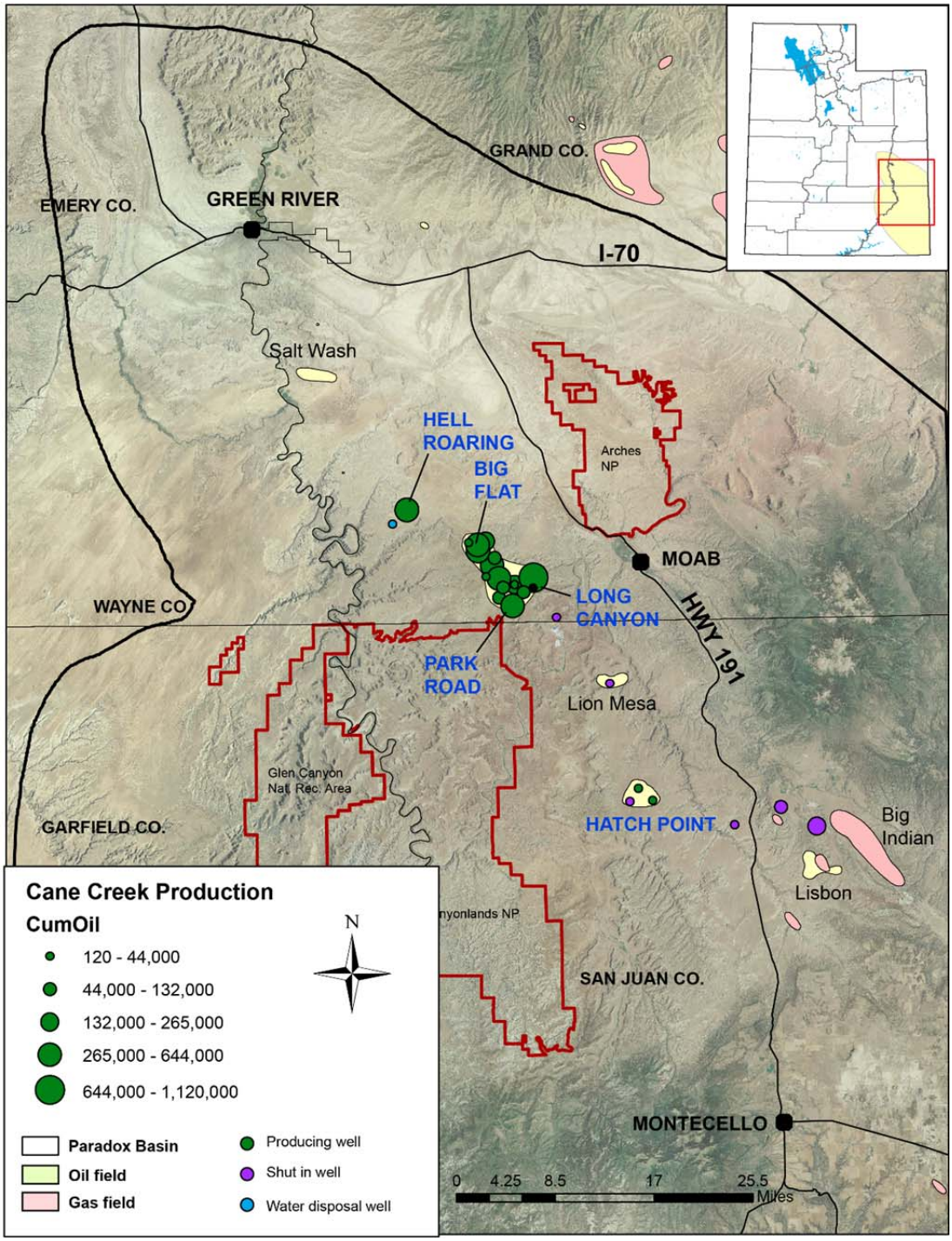
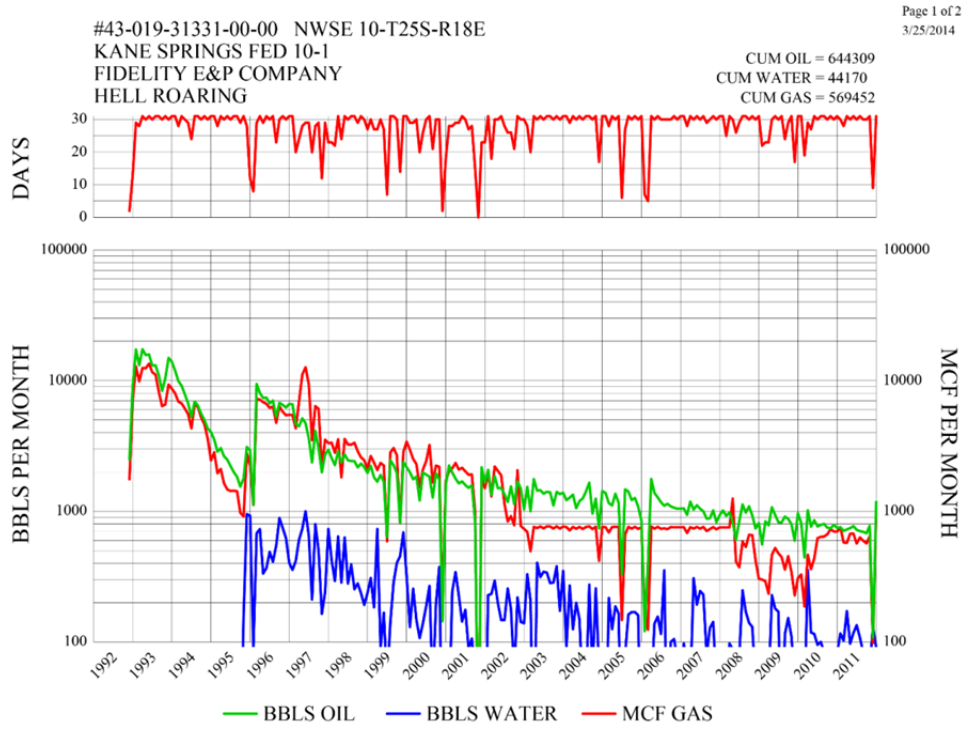


Figure 4. *Map of Cane Creek production; five producing fields, 18 producing wells, cumulative oil production equals about 5.4 million barrels (as of January 2014).*

a.



b.

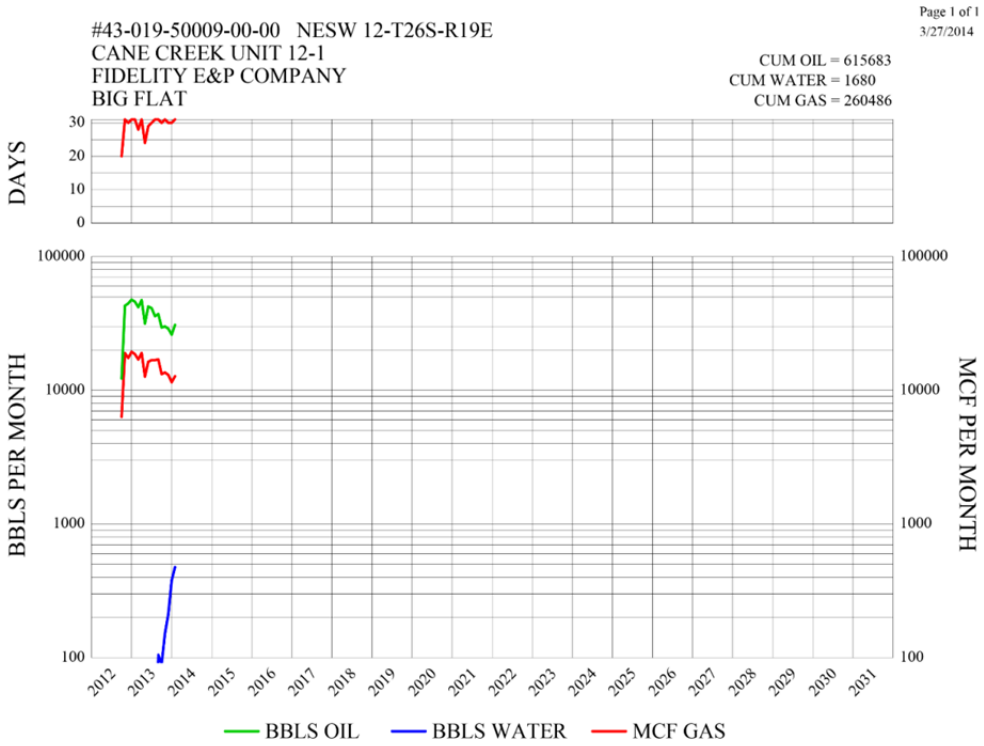


Figure 5. *Examples of production decline curves from two horizontal Cane Creek wells. a) Kane Springs Fed 10-1, Hell Roaring field, ~700 foot lateral, producing since November 1992, cumulative oil production over 21 years equals 644,309 barrels. b) Cane Creek 12-1, Big Flat field, ~2400 foot lateral, producing since November 2012, cumulative oil production over 1.5 years equals 615,683 barrels.*

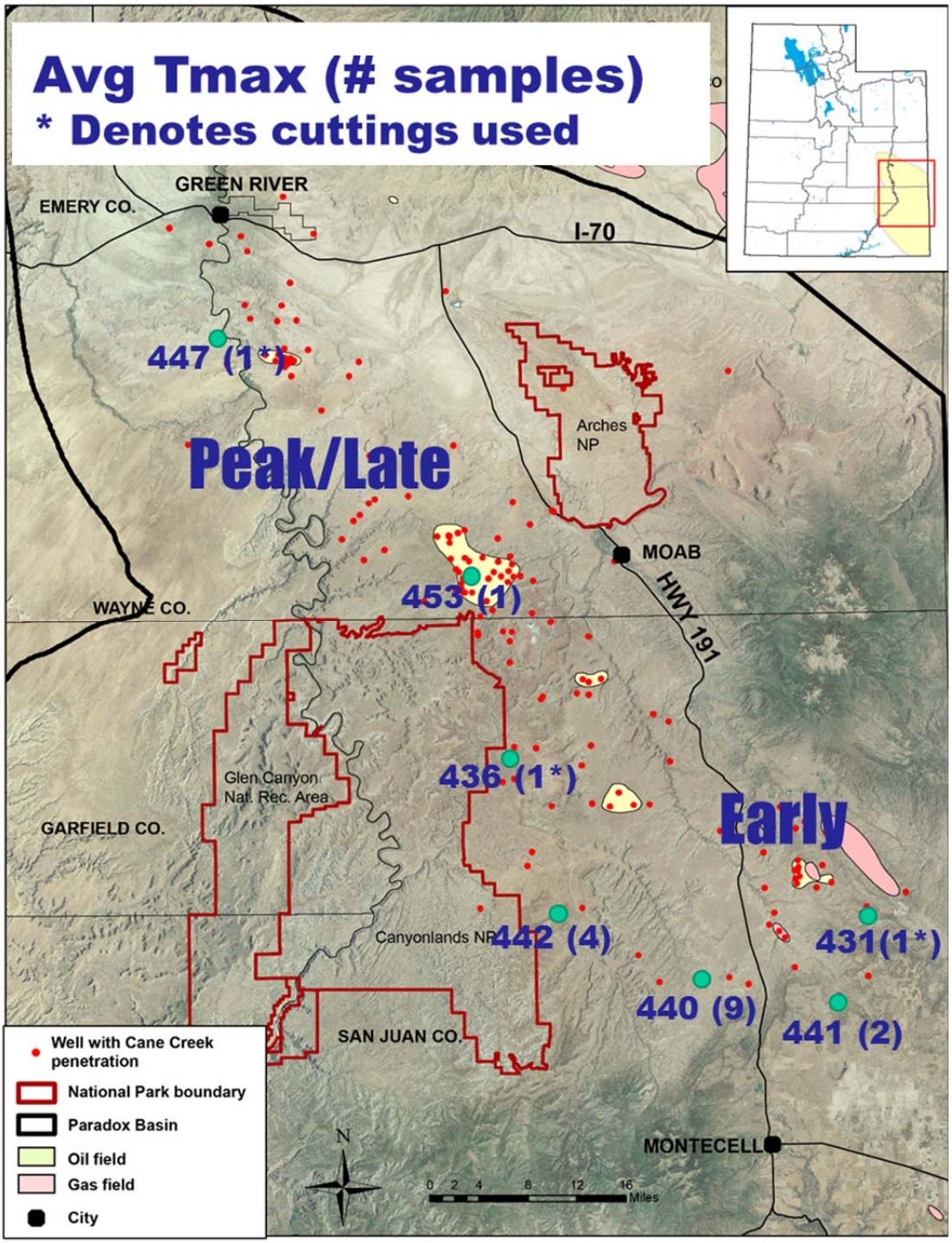


Figure 6. *Average Tmax values (°C) from Cane Creek cores and cuttings indicate that areas to the south might be in the early oil generation window, whereas areas further north are in the peak to late oil generation window. This may help explain why production in the central portion of the play has been more successful than in the southern areas.*

Task 6.0: Well Completion Optimization

Currently, production success in the Uteland Butte is most prevalent in the central, over-pressured portion of the Uinta Basin, where Newfield has a significant leasehold (figure 1). In areas farther to the south, east, and west, the Uteland Bute is under normal to only slight over-pressure, making economic production from such target areas more challenging. Goals for Task 6 will be to conduct a comprehensive geomechanical program on cores from normal and over-pressured areas, with the goal of unlocking the economic potential of the more normal pressured areas. Sample intervals from the Bill Barrett 14-1-46 Uteland Butte core, located outside the main over-pressured productive area, were determined for a comprehensive geomechanics testing program.

In addition to studying the geomechanics of the Uteland Butte, a sampling and testing program was determined for three Cane Creek shale cores (Cisco State 36-13, Cane Creek 26-3, and Cane Creek 7-1) (figure 2). A contract with TerraTek, A Schlumberger company, was initiated and negotiations are underway on the terms and conditions. The contract is expected to be approved in May 2014, followed shortly by the start of testing.

CONCLUSION

Two important collaborations were set up to help research the Uteland Butte tight oil play, one with the USGS focusing on the origin of oils and thermal maturity of organic matter, and the other with Dr. Hans Machel, University of Alberta, to study the origin of lacustrine dolomite and its diagenesis. Two additional Cane Creek shale cores were described, the Cane Creek 26-3 core in the productive, central portion of the play area, and Cisco State 36-13 core in the southern, nonproductive area. These cores greatly aid our understanding of the regional changes in facies that could impact production. A contract for a detailed geomechanical testing program is still being finalized for both the Uteland Butte cores from the Uinta Basin and the Cane Creek cores from the Paradox Basin.

COST STATUS

Table 1. *Project costing profile for Budget Period 2.*

	Jan 2014		Feb 2014		Mar 2014	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	$9,930	$12,600	$9,930	$11,604	$9,930	$4,336
Travel Expenses[1]	$1,876			$3,021		$422
Analyses	$19,364					
Miscellaneous[2]		$948	$450	$293	$700	$609
SUBTOTALS	$31,170	$13,549	$10,380	$14,918	$10,630	$5,367
UGS OVERHEAD (34.44%)	$10,735	$4,666	$3,575	$5,138	$3,661	$1,848
SUBCONTRACTS						
EGI	$6,771	$0	$6,771	$0	$6,771	$0
Eby	$2,287	$0	$2,287	$0	$2,287	$0
GRAND TOTALS	$50,962	$18,215	$23,012	$20,056	$23,348	$7,215

[1]February and March – travel and registration for AAPG in Houston

[2]January – Core shipping, exhibit booth fee for AAPG-RMS 2014, software; February – core shipping; March – exhibit booth expenses, software, poster lamination

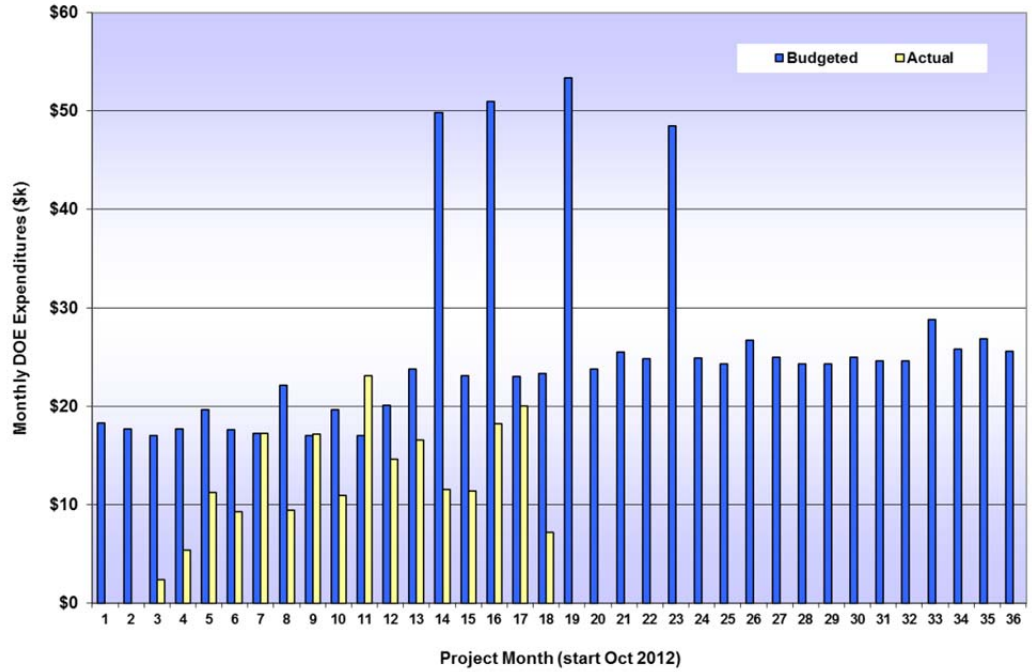


Figure 7. *Project costing profile.*

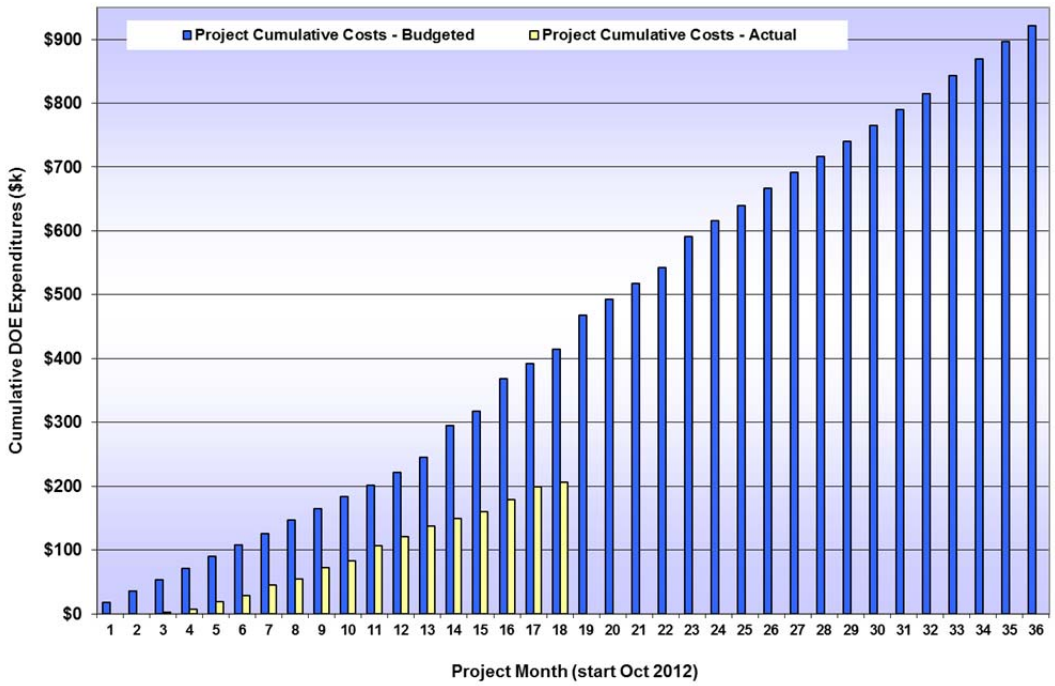


Figure 8. *Project cumulative costs.*

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 abstracts (one on Cane Creek and one on Uteland Butte) accepted for AAPG-RMS 2014
Milestone 18	Measure & describe key outcrops	Subtask 5.1	30-Jun-14	Started April 2014
Milestone 19	Outcrop sample collection	Subtask 5.2	30-Jun-14	Started April 2014
Milestone 20	Fracture analyses of outcrop	Subtask 5.3	30-Jun-14	Started April 2014
Milestone 21	Sample analyses from core	Subtask 4.2	30-Sep-14	Ongoing
Milestone 22	Epifluorescent measurements on cuttings	Subtask 4.3	30-Sep-14	Completed sample collection, analysis planned for Summer 2014
Milestone 23	Organic geochemical analyses	Subtask 4.4	30-Sep-14	Ongoing
Milestone 24	Fracture analyses of core	Subtask 4.5	30-Sep-14	Ongoing
Milestone 25	Rock mechanics testing	Subtask 4.6	30-Sep-14	Contract pending with TerraTek
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	
Milestone 31	BP 2 Decision Point	Task 1	30-Sep-14	

ACCOMPLISHMENTS

- Described two new Cane Creek cores, the Cisco State 36-13 and the Cane Creek 26-3.
- Initiated a contract for geomechanical testing with TerraTek, A Schlumberger company.
- Formed a collaboration with the USGS to study the origin of oils in the GRF, as well as study the thermal maturity of GRF shales.
- Initiated a collaboration with the Dr. Hans Machel, University of Alberta, to study the origin of Uteland Butte lacustrine dolomites and diagenesis.

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. EGI will bill the project quarterly; the first invoice will be for January-March 2014 (this billing will show up in the next quarterly report). In addition, the Eby contract has been delayed until the third quarter of BP 2.

The contract with TerraTek, A Schlumberger company, for geomechanical testing has been initiated. Negotiations on terms and conditions between the State of Utah and TerraTek are underway. Approval of the contract and the commencement of testing should occur in the next quarter.

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 January 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 will soon be available on the UGS project website.
- Article for the AAPG-EMD (Energy and Minerals Division) Shale Gas and Liquids Committee 2014 Annual Report
  - 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 will soon be available on the UGS project website.
- Abstracts (2) – 2014 AAPG Rocky Mountain Section meeting, Denver, CO, July 20-22, 2014
  - Two abstracts were accepted for presentation at the AAPG-RMS meeting in Denver.
  - Titles: "Play Analysis of the Cane Creek Shale, Pennsylvanian Paradox Formation, Paradox Basin, Southeast Utah" and "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"
  - Both abstracts are available on the UGS project website.

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