Oil & Natural Gas Technology

DOE Award No.: DE-FE0010667

Research Performance Progress Report

Quarterly Report: July 2013 to September 2013

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

In August 2013, the Principal Investigator (PI) finished describing all available and useful Uteland Butte cores from the Uinta Basin, Utah. Efforts will now be shifted towards determining the play's regional extent, facies variations, and internal heterogeneity. Efforts are also underway to understand the geomechanical properties of the Uteland Butte in order to help determine optimum well completion strategies. The geomechanical portion of the project will involve two new graduate students at the University of Utah, slated to start in January 2014.

The project team has also made significant progress towards a better understanding of the Cane Creek shale play in the Paradox Basin. A detailed description of the Remington 21-1H Cane Creek core was completed and several geochemical analyses were performed. This core description will aid in the analysis of geophysical logs from wells without core, helping to create a regional geologic understanding of the play. In addition, negotiations are underway to acquire two or three more Cane Creek cores from both the southern, more prospective play area and from the northern, more established play area.

During the American Association of Petroleum Geologists (AAPG) Rocky Mountain Section meeting, held in Salt Lake City in September, project members presented two papers on the Cane Creek shale play. The first was an oral presentation that focused on the overall play, while the second was a poster presentation focused on the Remington 21-1H core. Both presentations were well received and generated significant interest in the project and its goals. The team also submitted an abstract on the Cane Creek shale to the 2014 AAPG annual meeting, to be held in April in Houston, Texas. If accepted, the team will present details and new information from the additional core material that should soon be available.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of July, the PI wrote and submitted the project's third quarterly report for April to June 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 third quarterly report and emailed it to all interested parties. It is also available on the project website.
- A project team member presented both a poster and oral presentation on the Cane Creek shale of the Paradox Formation at the AAPG-RMS convention in Salt Lake City in September. The Remington 21-1H Cane Creek core was displayed with the poster.
- An information panel, detailing the project's goals and objectives, was displayed at the UGS exhibit booth during the 2013 AAPG-RMS meeting in Salt Lake City.
- An abstract was submitted to the AAPG annual meeting, to be held in Houston in April 2014. The abstract focuses on the Cane Creek shale oil play in southeastern Utah.
- A project team member participated in an AAPG-RMS field trip to Nine Mile Canyon, which stopped at outcrops of the Uteland Butte Member of the lower Green River Formation.
- The PI contributed to an article on the tight oil potential of the Uteland Butte for the June 2013 issue of the AAPG Explorer (http://www.aapg.org/explorer/2013/06jun/utah0613.cfm).

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

The PI traveled to Denver in August to view and describe Newfield's Nickerson 6-28-3-2W and Ute Tribal 15-13-4-3 Uteland Butte cores and Anadarko's NBU 921-22M and NBU 921-18C4BS Uteland Butte cores (figure 1). Details of the descriptions are currently being drafted alongside geophysical logs and other available data. With the completed examination of nearly all useful Uteland Butte cores, focus will now shift towards understanding the regional geologic setting associated with this zone. For example, project team members have begun picking tops and mapping the individual marker beds and productive carbonate intervals within the Uteland Butte to determine lateral variations and heterogeneity. In addition, a north-south cross section (trace is displayed on figure 1) is currently 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.

Project members researching the Cane Creek shale in the Paradox Basin completed a detailed description of the Remington 21-1H core from the southern portion of the play area (figure 2, plate 1). The Cane Creek shale typically consists of three primary facies informally named from top to bottom, A, B, and C. Facies A and C commonly consist of carbonate, typically dolomite or silty dolomite with nodular anhydrite and scattered anhydrite-filled fractures. Facies B is the primary target for oil development, consisting of dolomite, dolomitic siltstone, and organic-rich shale with some open fractures. Facies B is identified on gamma ray logs with a very high gamma ray spike at the top of the facies and relatively high readings throughout the facies. Facies A and C have a highly variable gamma ray reading with numerous low readings in the anhydrite beds. In addition to the detailed description, several other analyses were performed including high-resolution x-ray fluorescence (XRF) data (137 analyses on 0.5 foot spacing, a selection of elemental data is plotted on plate 1), 10 RockEval geochemical analyses (figure 3), 19 x-ray diffraction (XRD) analyses, and 23 thin sections.

Total organic carbon (TOC) content was determined for the thin organic-rich shale intervals (plate 1) and ranges from a low of 2% to a high of 20%, with an average of 8.4%. The kerogen is mostly mixed Type II-III oil-gas prone with hydrogen index values between 200 and 350, with one sample as high as 487 (more typical of a Type II oil prone marine kerogen) (figure 3a). Nearly all samples are in the mature oil window, with T_{max} values between 435 and 450 (figure 3b).

The project team also made progress in locating additional Cane Creek core material. Arrangements are currently being made to analyze the Gibson Dome #1 and Cisco State 36-13 cores, also located in the southern portion of the study area, and the Skyline 1, Cane Creek #26-3, and Cane Creek Unit 7-1 cores from the actively producing Big Flat field (figure 2). More details on these cores will be available in the next quarterly report.

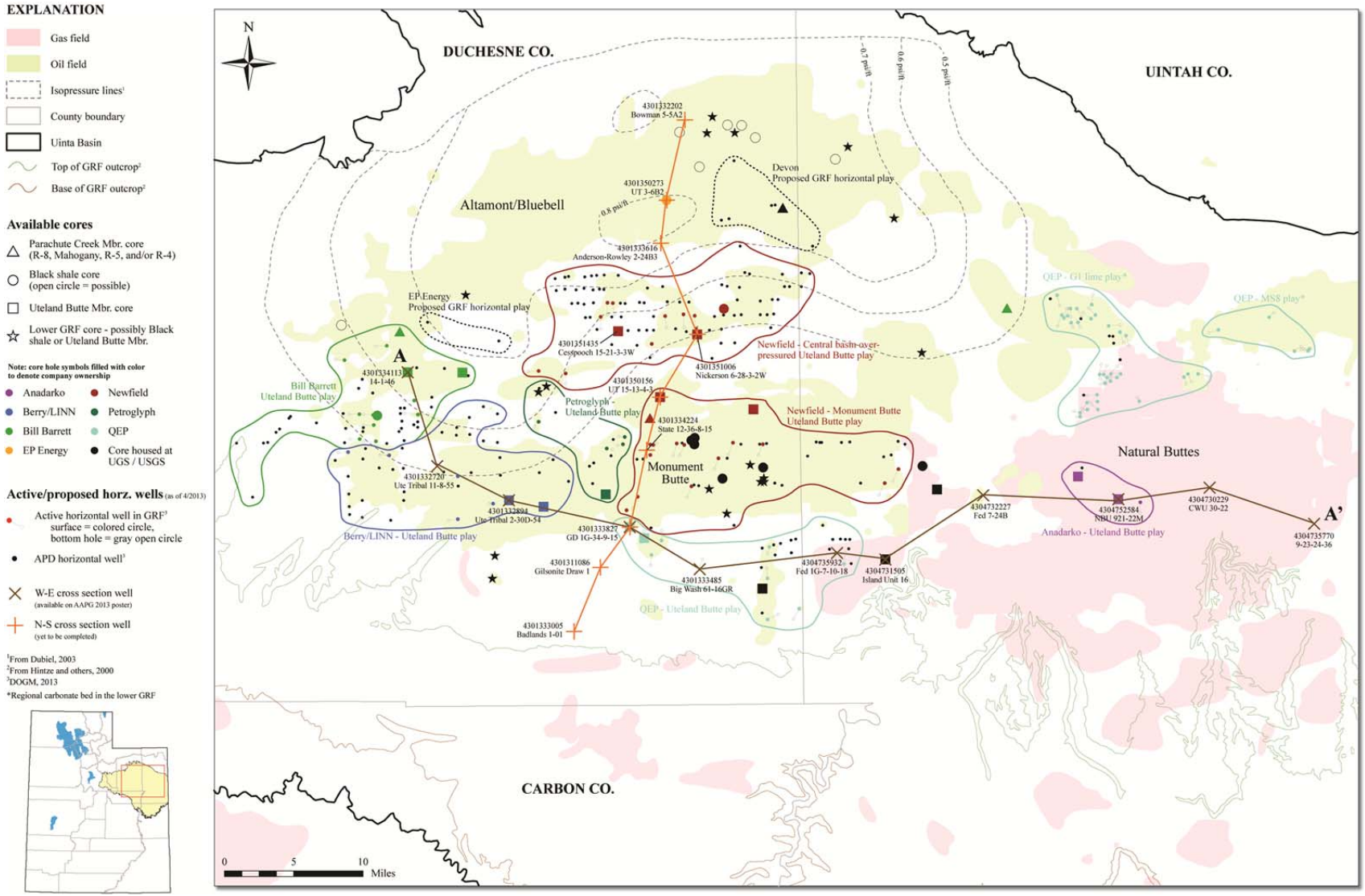


Figure 1. *Map of the Uinta Basin, Utah, showing the location of available GRF cores and horizontal wells.*

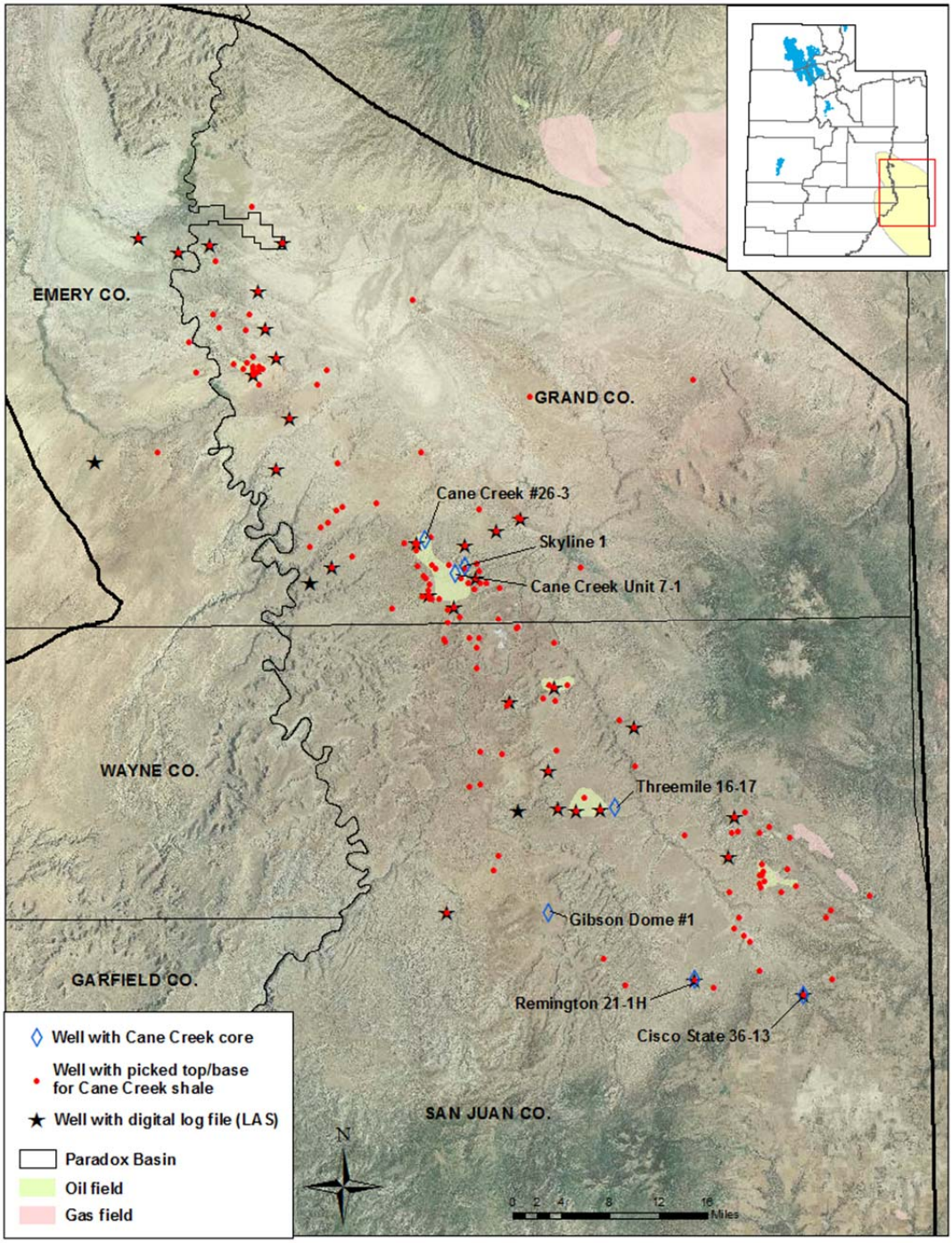
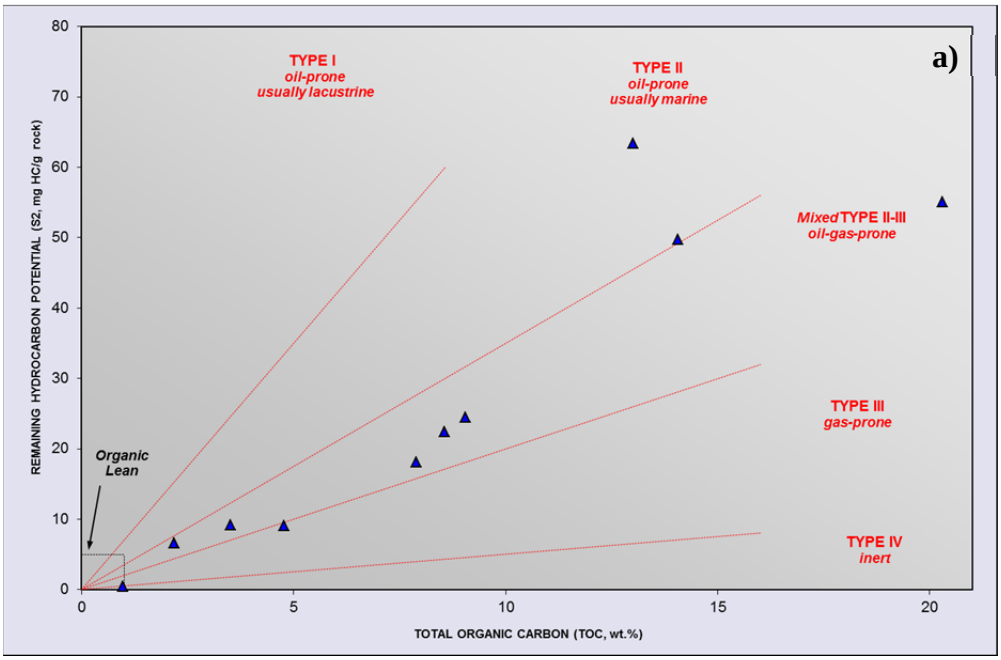


Figure 2. *Map of the Paradox Basin, Utah, showing the location of wells with Cane Creek core, picked Cane Creek top/base, and digitized log files (LAS files).*



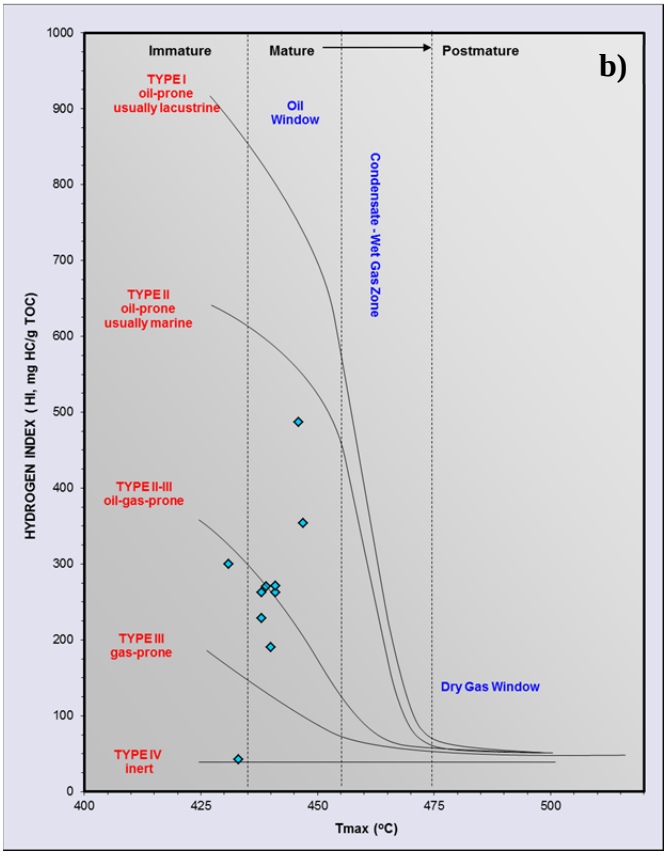


Figure 3. *Geochemical data showing kerogen type/quality (a) and kerogen type/maturity (b) from the Remington 21-1H core.*

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-pressure areas, with the goal of unlocking the economic potential of the more normal pressured areas.

Project team members are collaborating with Newfield in testing fresh core from the Uteland Butte in the play's over-pressure zone. Core from the Cesspooch 15-21-3-3W well was recovered in late July 2013 and the project covered expenses for "scratch" testing the core in selected lithologic regimes (figure 4). "Scratch" testing is a method where an indentor, under normal stress, is dragged along the external axis of a core sample or slab. The required shear force to scribe a groove on this surface is used in conjunction with the applied normal stress to infer a continuous measure of the friction angle, the unconfined compressive strength, and ideally other mechanical properties. Additional testing funded by Newfield will determine other petrophysical properties.

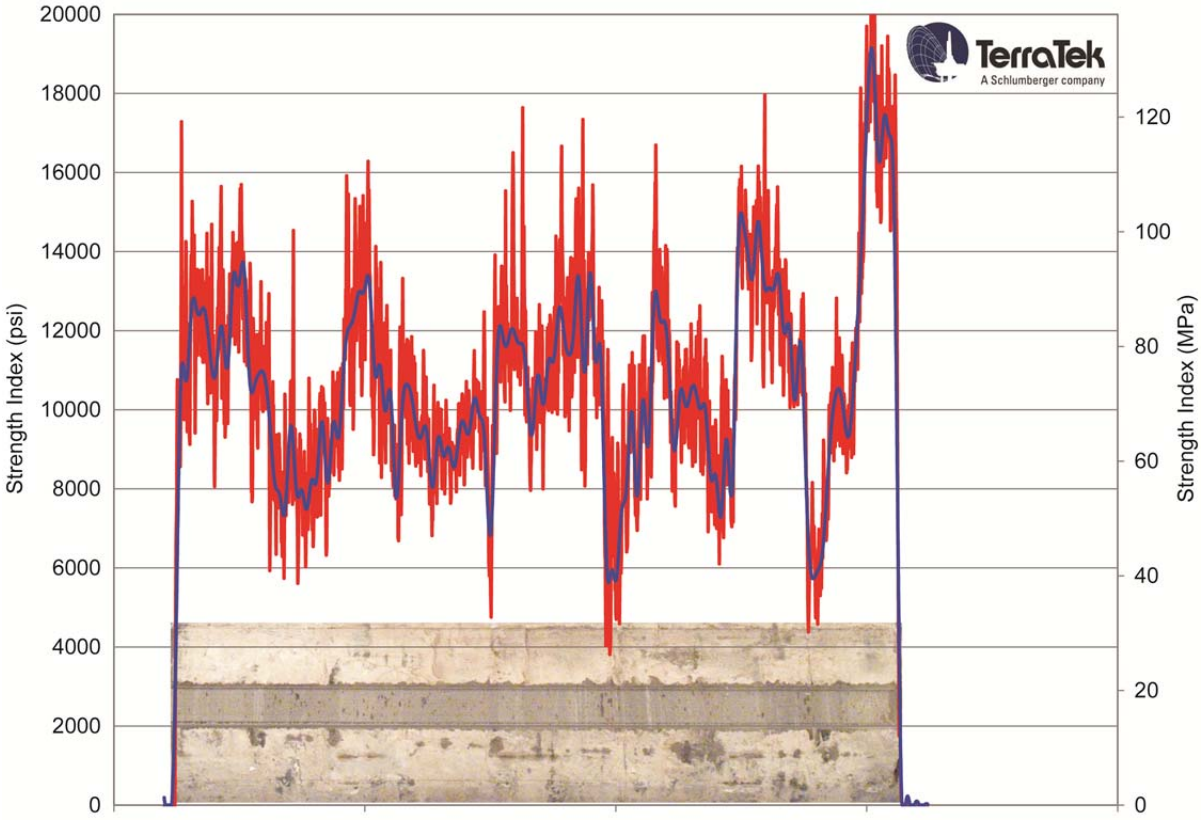


Figure 4. *An example of the "scratch" analysis on a section of Uteland Butte core from the Cesspooch 15-21-3-3W well. The lithologic heterogeneity of the core is reflected in the varying "strength" of the core segment.*

CONCLUSION

During this quarter, the remaining Uteland Butte core descriptions were completed and drafting of the core logs continued. The project team will continue to look for additional core material, but at this point the project's focus will shift towards integrating the core data into a regional geologic picture. The project team also finished description and analysis of the Remington 21-1H Cane Creek core. Addtional Cane Creek core is in the process of being acquired and analysis will commence in the next quarter. Details of a geomechanical program are still being finalized for both the Uteland Butte play in the Uinta Basin and the Cane Creek play in the Paradox Basin.

COST STATUS

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

	Jul 2013		Aug 2013		Sep 2013	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	$7,607	$6,850	$7,607	$15,003	$7,607	$9,542
Travel Expenses[1]	$1,970			$1,069	$2,326	
Analyses[2]				$499		$930
Miscellaneous[3]		$1,255		$583		$400
SUBTOTALS	$9,577	$8,105	$7,607	$17,155	$9,933	$10,872
UGS OVERHEAD (34.44%)	$3,298	$2,791	$2,620	$5,908	$3,421	$3,744
SUBCONTRACTS						
EGI	$6,771	$0	$6,771	$0	$6,771	$0
Eby						
GRAND TOTALS	$19,646	$10,896	$16,997	$23,063	$20,124	$17,176

[1]Aug – Travel to Denver to look at core
[2]Aug – Remington 21-1H core thin sections, Sep – RockEval analyses on Remington 21-1H core
[3]Jul – Registration for RMS-AAPG, computer software license; Aug – Core shipping and supplies; Sep – exhibit booth for 2014 AAPG

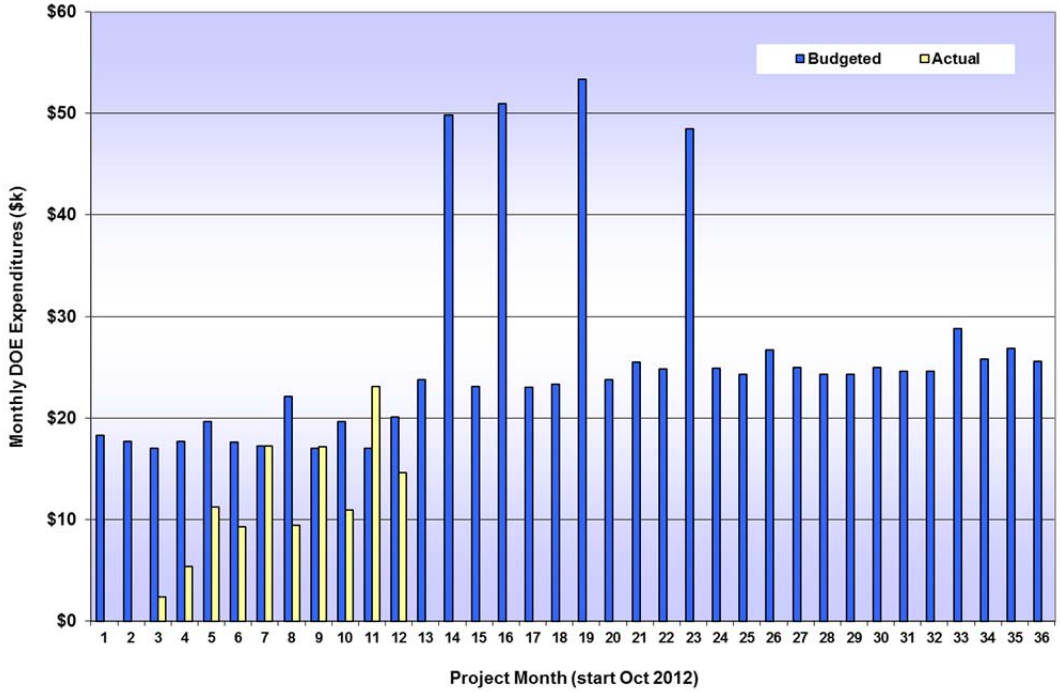


Figure 5. *Project costing profile.*

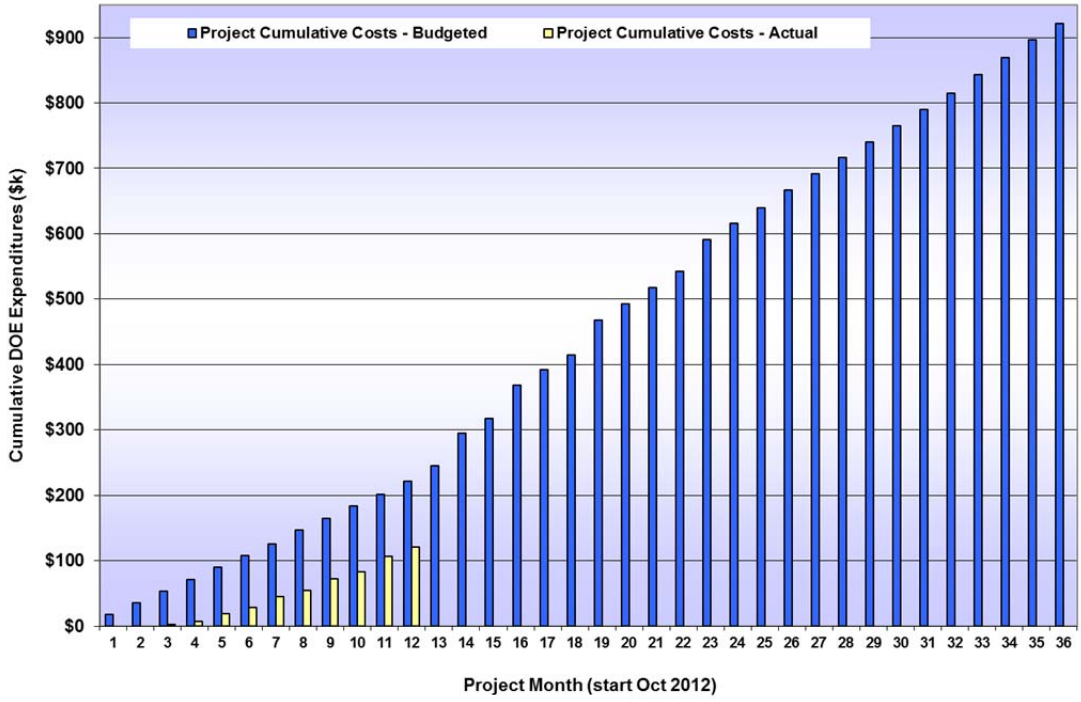


Figure 6. *Project cumulative costs.*

MILESTONE STATUS

Table 2. *Milestone log for Budget Period 1.*

	Title	Related task or subtask	Completion Date	Update/comments
Milestone 1	Project Management Plan	Task 1	12/21/2012	Completed and approved by DOE
Milestone 2	Establish project website	Subtask 2.1	12/31/2012	Website is up and running
Milestone 3	Quarterly website updates	Subtask 2.1	Quarterly	Ongoing
Milestone 4	Quarterly reports	Subtask 2.2	Quarterly	Ongoing
Milestone 5	Select bibliography	Subtask 3.1	3/31/2013	Completed
Milestone 6	Prelim. Well database – cores/cuttings info	Subtask 3.2	3/31/2013	Completed
Milestone 7	Technical presentations at National AAPG	Subtask 2.4, 2.5	5/20/2013	Poster on Uteland Butte was presented at the National AAPG in Pittsburgh (May 2013)
Milestone 8	Updated select bibliography	Subtask 3.1	9/30/2013	Completed, but will be updated throughout the project
Milestone 9	Final well database	Subtask 3.2	9/30/2013	Completed, but will be updated throughout the project
Milestone 10	Core descriptions	Subtask 4.1	9/30/2013	12 core descriptions completed, drafting is underway
Milestone 11	First debriefing meeting	Subtask 2.3	9/2013	Cancelled, personally talked with all participating companies, presented update on Cane Creek at AAPG-RMS meeting
Milestone 12	Technical presentations at Regional AAPG	Subtask 2.4, 2.5	9/2013	Two presentations on Cane Creek were made at AAPG-RMS in Salt Lake City (Sept 2013)
Milestone 13	BP 1 decision point	Task 1	9/30/2013	Completed Continuation Application which was approved by DOE

ACCOMPLISHMENTS

- Presented two papers on the Cane Creek shale at the 2013 AAPG-RMS meeting in Salt Lake City in September.
- Submitted an abstract on the Cane Creek shale to the 2014 AAPG annual meeting, to be held in Houston, Texas, in April.
- Completed four additional Uteland Butte core descriptions.
- Completed a detailed description of the Remington 21-1H Cane Creek core, including the collection of high-resolution XRF data (137 analyses on 0.5 foot spacing), 10 RockEval geochemical analyses, 19 XRD analyses, and 23 thin sections.
- Initiated a geomechanical testing program with Newfield on a recently drilled Uteland Butte core, including performing “scratch” test analysis (continuous unconfined compressive strength measurements).
- Completed a Continuation Application, which was approved by DOE, allowing the project to move into Budget Period 2.

PROBLEMS OR DELAYS

A contract has been set up with the Energy and Geoscience Institute (EGI), University of Utah, and two incoming Masters level students, both starting January 2014, will be funded to perform research on this project. As a result of the delay in finding students, the overall project will be under-billed until research begins at EGI.

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 2013
  - Completed late July and is available on the project website.
- Poster presentation at AAPG-RMS meeting in Salt Lake City, UT, September 22-24, 2013.
  - A project member presented a poster titled "Detailed Sedimentology and Stratigraphy of the Remington 21-1H Cane Creek Shale Core, Pennsylvanian Paradox Formation, Southeastern Utah: Implications for Unconventional Hydrocarbon Recovery." The Remington 21-1H core was displayed along with the poster.
  - The poster will soon be available on the UGS project website.
- Oral presentation at AAPG-RMS meeting in Salt Lake City, UT, September 22-24, 2013.
  - A project member presented a paper titled "Current Understanding of the Sedimentology, Stratigraphy, and Liquid-Oil Potential of the Pennsylvanian Cane Creek Shale of the Paradox Formation, Southeastern Utah."
  - The presentation will soon be available on the UGS project website.
- Exhibit booth panel displayed at AAPG-RMS meeting.
  - A panel detailing the project's goals and objectives was displayed at the UGS exhibit booth during the 2013 AAPG-RMS meeting in Salt Lake City, UT. In addition, flyers containing the Project Summary were available for those interested.
- AAPG-RMS field trip to Nine Mile Canyon.
  - During the Nine Mile Canyon field trip, held September 25, 2013, the group stopped at outcrops of the Uteland Butte Member of the lower Green River Formation. Project team members were on hand to talk about the Uteland Butte and give an overview of the project.
- AAPG Explorer article about the Uteland Butte (June 2013).
  - The PI contributed to an article on the tight oil potential of the Uteland Butte in the June 2013 issue of the AAPG Explorer.
  - http://www.aapg.org/explorer/2013/06jun/utah0613.cfm
- Abstract – 2014 AAPG annual meeting, Houston, TX, April 6-9, 2014.
  - An abstract titled "Geological Evaluation of the Cane Creek Shale, Pennsylvanian Paradox Formation, Paradox Basin, Southeastern Utah" was submitted to the 2014 AAPG annual meeting, to be held in Houston in April.
  - The abstract will soon be available on the UGS project website.

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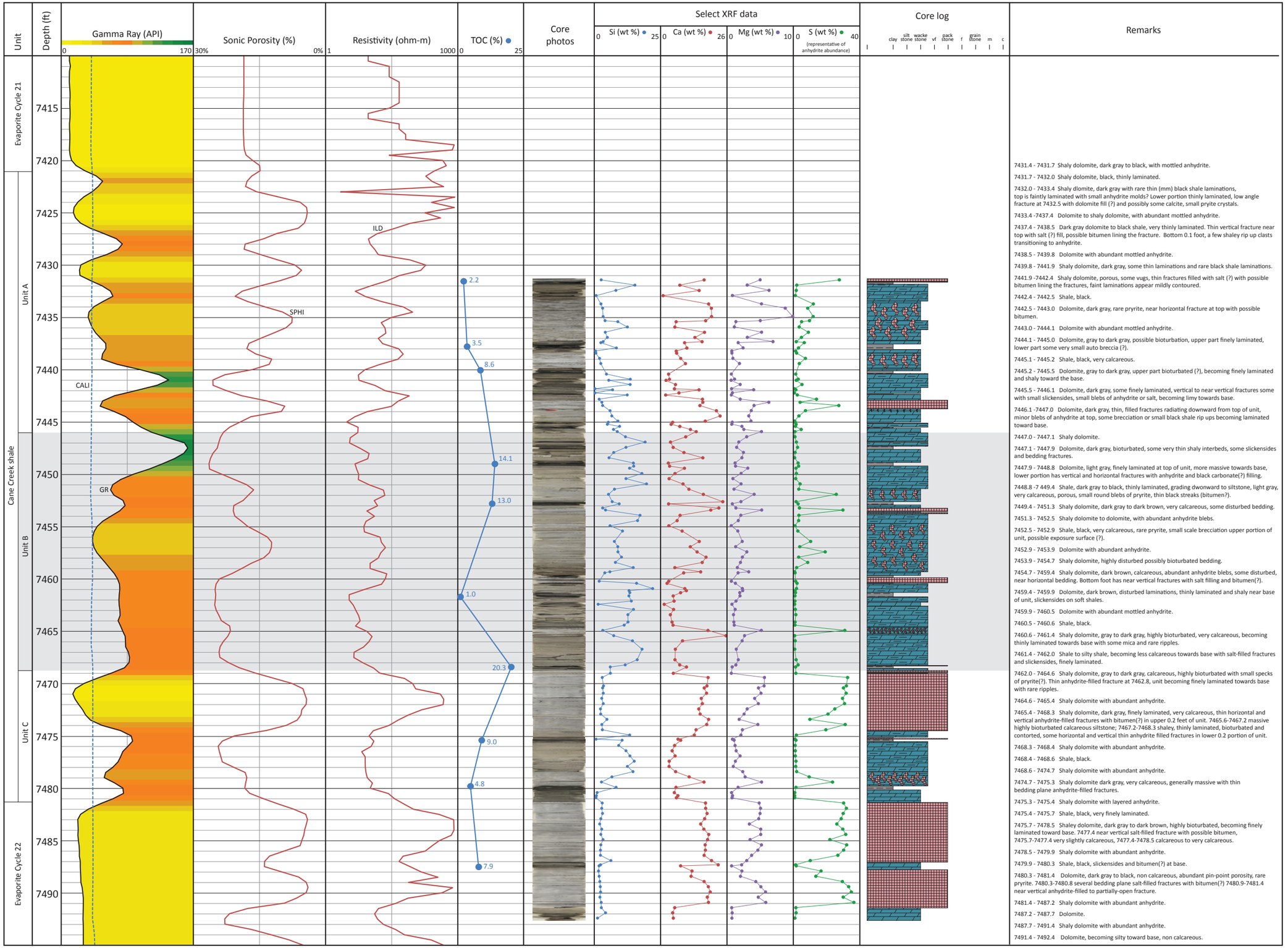
Customer Service:
1-800-553-7681

Plate 1
Well name: Remington 21-1H (4303731742)

Operator: Union Pacific Resources Co.
Location: T31S, R23E, Sec. 21, San Juan County, UTM E 640628, UTM N 4214975

Cored interval: 7435-7496.3 ft (core shifted up 3.6 ft to match logs)
Core location: Utah Core Research Center



7431.4 - 7431.7 Shaly dolomite, dark gray to black, with mottled anhydrite.

7431.7 - 7432.0 Shaly dolomite, black, thinly laminated.

7432.0 - 7433.4 Shaly dlomite, dark gray with rare thin (mm) black shale laminations, top is faintly laminated with small anhydrite molds? Lower portion thinly laminated, low angle fracture at 7432.5 with dolomite fill (?) and possibly some calcite, small pryite crystals.

7433.4 -7437.4 Dolomite to shaly dolomite, with abundant mottled anhydrite.

7437.4 - 7438.5 Dark gray dolomite to black shale, very thinly laminated. Thin vertical fracture near top with salt (?) fill, possible bitumen lining the fracture. Bottom 0.1 foot, a few shaley rip up clasts transitioning to anhydrite.

7438.5 - 7439.8 Dolomite with abundant mottled anhydrite.

7439.8 - 7441.9 Shaly dolomite, dark gray, some thin laminations and rare black shale laminations.

7441.9 -7442.4 Shaly dolomite, porous, some vugs, thin fractures filled with salt (?) with possible bitumen lining the fractures, faint laminations appear mildly contoured.

7442.4 - 7442.5 Shale, black.

7442.5 - 7443.0 Dolomite, dark gray, rare pryrite, near horizontal fracture at top with possible bitumen.

7443.0 - 7444.1 Dolomite with abundant mottled anhydrite.

7444.1 - 7445.0 Dolomite, gray to dark gray, possible bioturbation, upper part finely laminated, lower part some very small auto breccia (?).

7445.1 - 7445.2 Shale, black, very calcareous.

7445.2 - 7445.5 Dolomite, gray to dark gray, upper part bioturbated (?), becoming finely laminated and shaly toward the base.

7445.5 - 7446.1 Dolomite, dark gray, some finely laminated, vertical to near vertical fractures some with small slickensides, small blebs of anhydrite or salt, becoming limy towards base.

7446.1 -7447.0 Dolomite, dark gray, thin, filled fractures radiating downward from top of unit, minor blebs of anhydrite at top, some brecciation or small black shale rip ups becoming laminated toward base.

7447.0 - 7447.1 Shaly dolomite.

7447.1 - 7447.9 Dolomite, dark gray, bioturbated, some very thin shaly interbeds, some slickensides and bedding fractures.

7447.9 - 7448.8 Dolomite, light gray, finely laminated at top of unit, more massive towards base, lower portion has vertical and horizontal fractures with anhydrite and black carbonate(?) filling.

7448.8 -7 449.4 Shale, dark gray to black, thinly laminated, grading dwonward to siltstone, light gray, very calcareous, porous, small round blebs of pyrite, thin black streaks (bitumen?).

7449.4 - 7451.3 Shaly dolomite, dark gray to dark brown, very calcareous, some disturbed bedding.

7451.3 - 7452.5 Shaly dolomite to dolomite, with abundant anhydrite blebs.

7452.5 - 7452.9 Shale, black, very calcareous, rare pryrite, small scale brecciation upper portion of unit, possible exposure surface (?).

7452.9 - 7453.9 Dolomite with abundant anhydrite.

7453.9 - 7454.7 Shaly dolomite, highly disturbed possibly bioturbated bedding.

7454.7 - 7459.4 Shaly dolomite, dark brown, calcareous, abundant anhydrite blebs, some disturbed, near horizontal bedding. Bottom foot has near vertical fractures with salt filling and bitumen(?).

7459.4 - 7459.9 Dolomite, dark brown, disturbed laminations, thinly laminated and shaly near base of unit, slickensides on soft shales.

7459.9 - 7460.5 Dolomite with abundant mottled anhydrite.

7460.5 - 7460.6 Shale, black.

7460.6 - 7461.4 Shaly dolomite, gray to dark gray, highly bioturbated, very calcareous, becoming thinly laminated towards base with some mica and rare ripples.

7461.4 - 7462.0 Shale to silty shale, becoming less calcareous towards base with salt-filled fractures and slickensides, finely laminated.

7462.0 - 7464.6 Shaly dolomite, gray to dark gray, calcareous, highly bioturbated with small specks of pyrite(?). Thin anhydrite-filled fracture at 7462.8, unit becoming finely laminated towards base with rare ripples.

7464.6 - 7465.4 Shaly dolomite with abundant anhydrite.

7465.4 - 7468.3 Shaly dolomite, dark gray, finely laminated, very calcareous, thin horizontal and vertical anhydrite-filled fractures with bitumen(?) in upper 0.2 feet of unit. 7465.6-7467.2 massive highly bioturbated calcareous siltstone; 7467.2-7468.3 shaley, thinly laminated, bioturbated and contorted, some horizontal and vertical thin anhydrite filled fractures in lower 0.2 portion of unit.

7468.3 - 7468.4 Shaly dolomite with abundant anhydrite.

7468.4 - 7468.6 Shale, black.

7468.6 - 7474.7 Shaly dolomite with abundant anhydrite.

7474.7 - 7475.3 Shaly dolomite dark gray, very calcareous, generally massive with thin bedding plane anhydrite-filled fractures.

7475.3 - 7475.4 Shaly dolomite with layered anhydrite.

7475.4 - 7475.7 Shale, black, very finely laminated.

7475.7 - 7478.5 Shaley dolomite, dark gray to dark brown, highly bioturbated, becoming finely laminated toward base. 7477.4 near vertical salt-filled fracture with possible bitumen, 7475.7-7477.4 very slightly calcareous, 7477.4-7478.5 calcareous to very calcareous.

7478.5 - 7479.9 Shaly dolomite with abundant anhydrite.

7479.9 - 7480.3 Shale, black, slickensides and bitumen(?) at base.

7480.3 - 7481.4 Dolomite, dark gray to black, non calcareous, abundant pin-point porosity, rare pryrite. 7480.3-7480.8 several bedding plane salt-filled fractures with bitumen(?) 7480.9-7481.4 near vertical anhydrite-filled to partially-open fracture.

7481.4 - 7487.2 Shaly dolomite with abundant anhydrite.

7487.2 - 7487.7 Dolomite.

7487.7 - 7491.4 Shaly dolomite with abundant anhydrite.

7491.4 - 7492.4 Dolomite, becoming silty toward base, non calcareous.