Oil & Natural Gas Technology

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Quarterly Report

January 2009 to March 2009

Water-related Issues Affecting Conventional Oil and Gas Recovery and Potential Oil-Shale Development in the Uinta Basin, Utah

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EXECUTIVE SUMMARY

The second quarter of our saline water project (January to March 2009) was dominated by extensive data collection activities. We contacted several Uinta Basin oil and gas operators, including an in-person visit to Denver, to ask for water quality information, digitized geophysical logs, and formation tops data. Several companies responded favorably, generously offering large amounts of data as well as their support and advice. The effort of the past few months has set an excellent foundation for further collaborations.

Work also began on setting up a comprehensive database to store, organize, and manipulate the collected data. Thus far, we have received water quality information from roughly 1100 wells and formation tops information from about 3700 wells within the basin. For areas where water quality data is not available, we have begun looking at ways to calculate salinity from geophysical logs. These data collection efforts are expected to continue throughout the year, providing the necessary information for detailed mapping of the moderately saline aquifer within the Uinta Basin.

In addition to the regional aquifer study, we began our more detailed investigation of the Birds Nest aquifer. As a first step, we completed a detailed geologic description of the Utah State 1 core recovered from central Uintah County, which was drilled through the Birds Nest zone and into the underlying rich oil-shale deposits. This description will be used to correlate geophysical logs to lithology for help in understanding surrounding non-cored wells.

The analysis of the Utah State 1 core surprisingly revealed no saline mineral dissolution – it is the dissolution of saline minerals that creates the additional porosity and permeability needed for significant groundwater flow within the Birds Nest aquifer. It seems that there are zones where dissolution has not taken place, complicating the aquifer's overall flow regime. We plan to analyze several cores in the surrounding area to better define these zones of differing dissolution.

PROGRESS, RESULTS, AND DISCUSSION

Task 1.0: Project Management Plan

During the month of January, the Principal Investigator (PI) wrote and submitted the project's first quarterly report for October to December 2008. This report was subsequently sent via email to all interested parties and posted on the Utah Geological Survey (UGS) project Web site.

Task 2.0: Moderately Saline Aquifer Study

The first step toward completing this task, a digitized version of the old map published in the Utah Department of Natural Resources Technical Publication 92, is now complete. Well locations and the base of the moderately saline aquifer contours are available as ArcGIS shapefiles and will allow for comparisons with new mapping efforts.

The second, and one of the most important steps, is to collect as many water quality analyses as possible from wells in the Uinta Basin. We have contacted several oil and gas operators, most of which have been very willing to give us whatever water quality information they have available (figure 1). Through March 2009, we have received water quality data from Anadarko Petroleum Corporation (124 wells in the Natural Buttes field), Enduring Resources (4 wells in central Uintah County), Newfield Petroleum (194 wells in the Monument Butte area), and Questar E&P (164 wells in the Red Wash area, data is currently being processed and is not included in figure 1). We also have information from 659 wells obtained from the U.S. Geological Survey; the Utah Division of Oil, Gas, and Mining; and other governmental agencies. We will continue to contact other operators to try to obtain as much water quality information as possible.

In order to relate a newly mapped base of the moderately saline aquifer to Uinta Basin stratigraphy, we have also asked operators for formation top information. Through March 2009, we have received tops

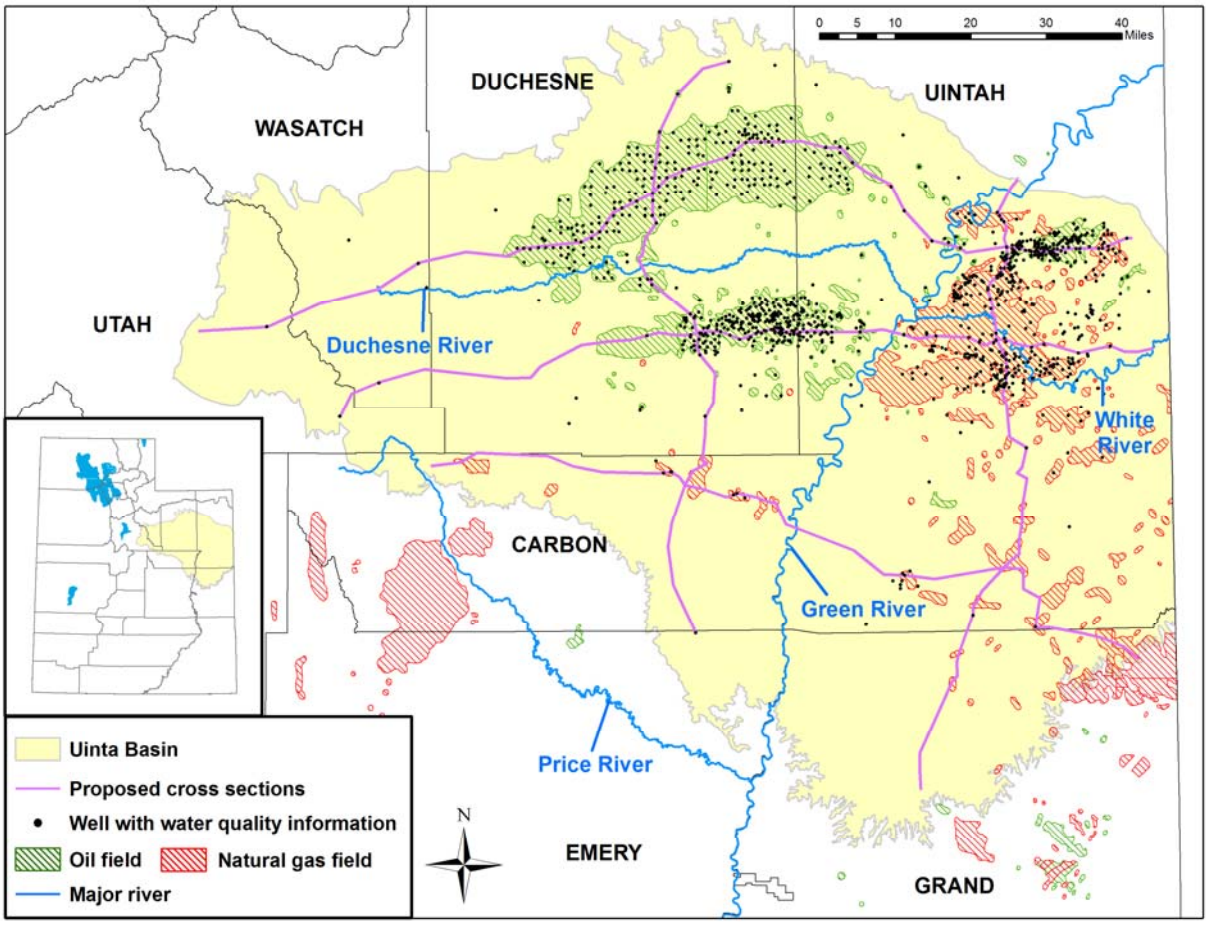

Figure 1. *Map of the Uinta Basin showing current number of wells with water quality information and proposed cross-section lines.*

information from Berry Petroleum (464 wells in the Brundage Canyon area), Enduring Resources (73 wells in central Uintah County), Newfield Petroleum (1842 wells in Monument Butte area), and Questar E&P (1314 wells in Red Wash area). Again, we will continue to communicate with operators to try to obtain as much data as possible. The formation top data will help create three east-west and two north-south cross sections relating water quality to basin stratigraphy. Traces of these yet-to-be-made cross sections are plotted in figure 1.

An Access database has been created to store and organize all the incoming data, as well as to facilitate its manipulation and retrieval. The database will continue to be updated as new data are acquired from operators or generated by project researchers.

Work has also begun on techniques that could be employed to determine the base of the moderately saline aquifer on geophysical logs. To facilitate this work, we have requested digitized log files (LAS files) from oil and gas operators, and we have received LAS files for roughly 100 wells. For logs where LAS files are not available (especially older wells), we have begun digitizing the logs in-house.

Task 3.0: Geologic Examination of the Birds Nest Aquifer

On February 23, 2009, Vanden Berg (PI and Task 3 leader) and Morgan (researcher) traveled to Denver for the day to meet with geologists from Questar E&P, Newfield Petroleum, and Anadarko. The goal of this trip was to further communications regarding this project and determine the extent of available data, especially in regard to the Birds Nest aquifer. Anadarko has mapped the Birds Nest (or what they refer to as the "zone of lost circulation") throughout the Natural Buttes field, including the

aquifer's salinity. Anadarko will allow us to use this extensive dataset as we develop our own comprehensive assessment of the Birds Nest aquifer.

The first subtask undertaken was a detailed description of core from a well drilled through the Birds Nest zone near Anadarko's recently approved disposal well and within an area of rich and thick oil shale. This core, recovered from the Utah State 1 well that was drilled by TOSCO Corporation in 1974, is housed at the UGS Core Research Center, and extends from 1570 to 2600 feet below the surface. The description of the core focused on lithology (especially the presence of porous sandstone), areas of saline deposition and any subsequent dissolution (the latter of which creates the porosity traditionally recognized as the Birds Nest aquifer), and zones of fracturing. To help with the lithologic identification (i.e., distinguishing clastic mudstone, calcareous mudstone, or dolomitic mudstone), 126 samples were analyzed with an x-ray fluorescence (XRF) spectrometer for major elements.

The most interesting discovery was the lack of any saline mineral dissolution. All the nahcolite in the form of nodules, beds, and fracture fill (as well as calcite fracture fill) showed no signs of dissolution from flowing ground water (figure 2). It was assumed that most or all of the nahcolite in the Birds Nest had been dissolved away, leaving behind the very high porosity and permeability of the "lost circulation zone" seen in many nearby natural gas wells. This core proves that there are isolated zones where the saline minerals are still present, complicating the overall areal extent of the aquifer. One possible explanation for the absence of dissolution would be that cross-cutting gilsonite veins are isolating and channeling ground water flow in this area. To develop this idea, we plan to look at several more surrounding cores to see if there are differences in the amount of dissolution.

Task 4.0: Baseline Water Quality and Quantity GIS Database

No work was performed on Task 4 during this quarter. Field sampling will begin spring 2009.

Task 5.0: Integration of Analysis of Produced Water from Simulated In-situ Oil Shale Extraction Technologies

This task is scheduled for Budget Period 3.

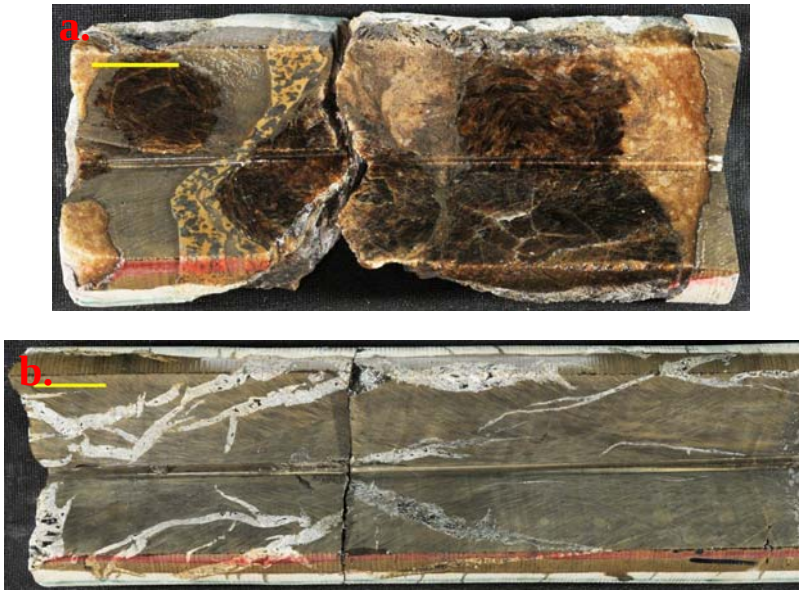

Figure 2. *a. Nahcolite nodules within the Utah State 1 core (depth - 1825.6 ft) (yellow bar equals one inch). b. Calcite-rich fracture fill (depth – 1753.6 ft). In surrounding areas, the dissolution of these saline minerals creates the porosity and permeability required for the Birds Nest aquifer.*

Task 6.0: Technology Transfer

The project Web site (http://geology.utah.gov/emp/UBwater_study) was updated with available reports and newly submitted abstracts. In addition to updating the website, the project was announced/discussed at the quarterly Uinta Basin Oil and Gas Collaborative Group meeting held in January 2009 in Vernal, Utah.

An abstract detailing the project objectives was accepted for the American Association of Petroleum Geologist (AAPG) annual meeting to be held in Denver, Colorado. The UGS will deliver a poster presentation in the Groundwater and Site Remediation session to be held from 8:30 am to 12:00 pm on June 9, 2009. Another presentation on oil-shale resources in Utah and Colorado, somewhat related to this project, will be delivered at the Geological Society of America – Rocky Mountain Section (GSA-RMS) meeting in Orem, Utah, on the morning of May 13, 2009. We also submitted an abstract to the Water/Energy Sustainability Symposium which will be held at the Ground Water Protection Council's annual forum in Salt Lake City in September 2009. The abstract details the project objectives, with particular emphasis on the Birds Nest aquifer and its relationship to oil and gas development. We are waiting to hear if it was accepted.

CONCLUSION

This quarter was dominated by data gathering activities, including contacting several oil and gas operators and setting up databases to organize incoming information. Initial efforts have been very successful and dialogues will continue until we have collected as much data as possible. Acquiring digitized log traces from operators is especially important since in-house log digitization is one of the most time consuming tasks.

Initial studies related to the Birds Nest aquifer are proving that much is still unknown about this potential disposal zone. Work will continue on defining differing zones of dissolution and how these areas could affect future saline water disposal and possible oil-shale development.

COST STATUS

Table 1. Project costing profile for Budget Period 1.

	Jan 2009		Feb 2009		Mar 2009	
	Plan	Actual	Plan	Actual	Plan	Actual
UGS-personnel	$10,027	$12,122	$8,276	$8,138	$9,630	$7,663
Travel Expenses[1]				$45		$124
Water Chemistry						
Miscellaneous[2]						$817
SUBTOTALS	$10,027	$12,122	$8,276	$8,183	$9,630	$8,604
UGS OVERHEAD (32.40%)	$3,249	$3,927	$2,681	$2,651	$3,120	$2,788
SUBCONTRACTS						
P. Anderson[3]	$8,132		$8,132		$8,132	$20,780
GRAND TOTALS	$21,408	$16,049	$19,090	$10,835	$20,882	$32,172

[1]February travel – Day trip to Denver to meet with operators (per diem billed in Feb, plane ticket billed in March)
[2]March – AAPG annual meeting poster exhibit charges (tables for core display)
[3]March – Three months of Anderson billing

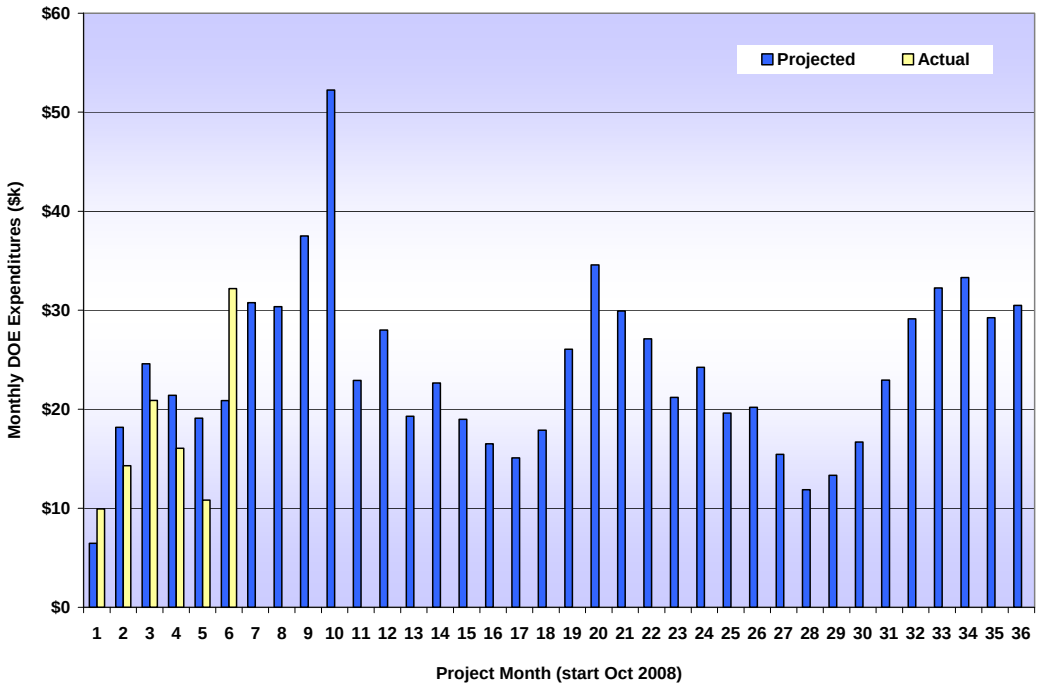

Figure 3. Project costing profile.

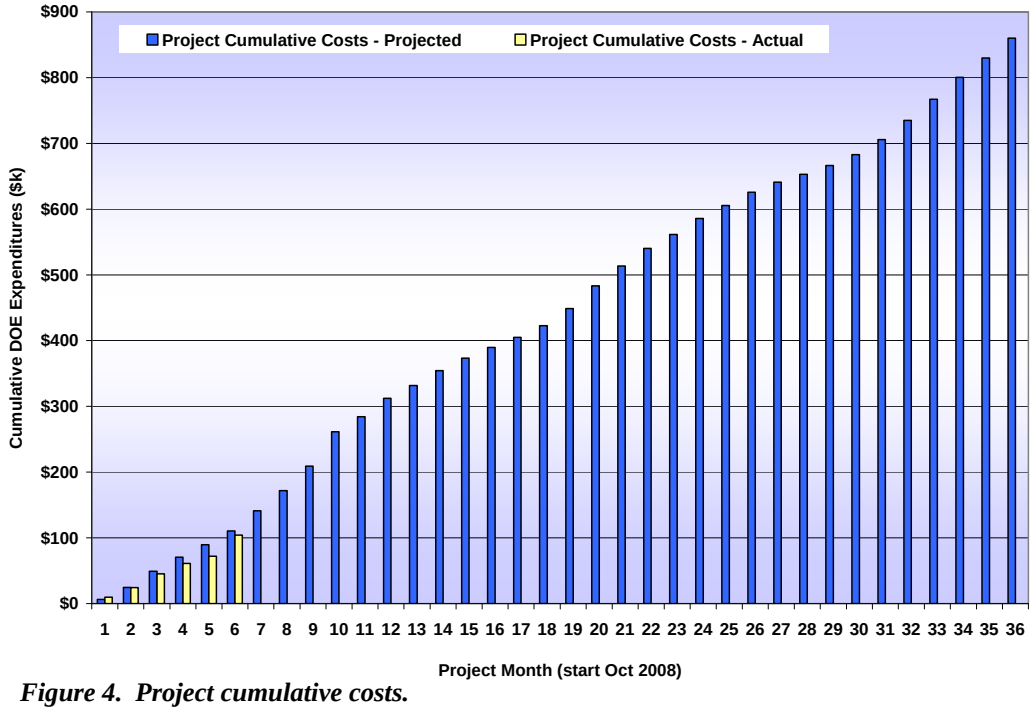

Figure 4. Project cumulative costs.

MILESTONE STATUS

Table 2. Milestone log for Budget Period 1.

	Title	Description	Related task or subtask	Completion Date	Update/comments
Milestone 1.1	Water chemistry data collection (part 1)	Collect at least half of the required 1 well per township	Subtask 2.1	9/30/2009	Data collection is in progress; currently have data for 1134 wells, still communicating with several operators to get more data, began analyzing well logs in areas where no chemistry data exists
Milestone 1.2	Evaluation of the Birds Nest in core and outcrop	Examine the Birds Nest in core and find at least five outcrop exposures to describe	Subtask 3.2, 3.3	6/30/2009	Evaluated Utah State 1 core, plans to look at more core in June 2009, plans to look at outcrop in Fall 2009
Milestone 1.3	Completion of the Quality Assurance Project Plan	Locate 50 sites suitable for water chemistry analyses	Subtask 4.2	12/15/2008	Completed

ACCOMPLISHMENTS

- An abstract was accepted for the AAPG Annual meeting in Denver, CO.
  - Title: Saline water disposal in the Uinta Basin, Utah: The single most pressing issue with regard to increasing petroleum production and protecting freshwater aquifers
  - Poster presentation
  - Session: Groundwater and Site Remediation
  - Tuesday, June 9, 2009, 8:30 am to 12:00 pm
- An abstract was accepted for the GSA-RMS Annual Conference in Orem, UT.
  - Title: Comparing the depositional characteristics of the oil-shale-rich Mahogany and R-6 zones of the Uinta and Piceance Creek Basins
  - Oral presentation
  - Session: Economic Geology of the Rocky Mountain Region
  - Monday, May 11, 2009, 9:40 am
- Detailed description of the Utah State 1 core
  - Detailed lithologic description of the Birds Nest aquifer and underlying rich oil-shale deposits
  - XRF analysis on 126 samples
  - Results will be presented at the AAPG Annual meeting in June 2009

PROBLEMS OR DELAYS

We have decided to focus our efforts this spring on describing the Birds Nest aquifer in core, both at the UGS and USGS Core Research Centers. This will push back planned fieldwork to look at the Birds Nest aquifer in outcrop until late summer or early fall 2009.

PRODUCTS AND TECHNOLOGY TRANSFER ACTIVITIES

- Completed first quarterly report
  - October 2008 to December 2008 – available on the UGS project Web site
- Updated project Web site
  - Posted various reports and abstracts
  - http://geology.utah.gov/emp/UBwater_study
- Abstract – AAPG Annual meeting – Denver, CO – June 7-10, 2009
  - An abstract was submitted and accepted for the AAPG 2009 annual meeting detailing the project objectives, with particular emphasis on the Birds Nest aquifer and its relationship to oil and gas development.
  - The abstract is available on the UGS project Web site
- Abstract – GSA-RMS – Orem, UT – May 11-13, 2009
  - An abstract was submitted and accepted for the Economic Geology of the Rocky Mountain Region session at the GSA-RMS conference. The abstract details work related to mapping specific oil-shale horizons within the Uinta Basin, Utah.
  - The abstract is available on the UGS project Web site.
- Abstract – Ground Water Protection Council – Salt Lake City, UT – September 13-17, 2009
  - An abstract was submitted to the Water/Energy Sustainability Symposium at the Ground Water Protection Council's annual forum. The abstract details the project objectives, with particular emphasis on the Birds Nest aquifer and its relationship to oil and gas development. We are waiting to hear if it was accepted.
  - The abstract is available on the UGS project Web site.
- Uinta Basin Oil and Gas Collaborative Group meeting - Vernal, UT – convened January 8, 2009
  - This is a group of state and federal officials and Uinta Basin oil and gas operators that meets quarterly to discuss latest activities in the basin.
  - Members of the research team attended the meeting and networked about the project (talked with EOG Resources, U.S. BLM, and U.S. EPA).

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