RESERVOIR CHARACTERIZATION OF THE LOWER GREEN RIVER FORMATION, SOUTHWEST UINTA BASIN, UTAH

Biannual Technical Progress Report

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C. D. Morgan, Program Manager,
Utah Geological Survey

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Virginia Weyland, Contract Manager
U.S. Department of Energy
National Petroleum Technology Office
Tulsa, Oklahoma

Submitting Organization: Utah Geological Survey
1594 West North Temple, Suite 3110
P.O. Box 146100
Salt Lake City, Utah 84114-6100
(801) 537-3300

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ABSTRACT

Preliminary maps were constructed, and submitted to the DOE, of depositional cycles in the Middle and Lower Members of the Green River Formation, including boundaries, total sandstone, and total feet of porosity. Work on the stratigraphic sections in Nine Mile and Desolation Canyons is continuing in hope of defining more detail in the depositional interpretation and in the surface-to-subsurface correlations. Several miles of outcrop in Nine Mile Canyon was photographed and a series of continuous photomosaics were constructed. Correlations between measured sections were made using the photomosaics and later walking out several key beds between the sections. Future field work will concentrate on determining the south to north (proximal to distal) depositional pattern.

Numerous new wells have been added to the well database. Many of the correlations have been used by the Technical Advisory Board Members and as a result, the correlations in several key wells have been revised. A new set of maps will be constructed using the updated well database.

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EXECUTIVE SUMMARY

The objectives of the study are to increase both primary and secondary hydrocarbon recovery through improved characterization (at the regional, unit, interwell, well, and microscopic scale) and numerical simulation modeling of fluvial-deltaic lacustrine reservoirs, thereby preventing premature abandonment of producing wells. The study will encourage exploration and establishment of additional water-flood units throughout the southwest region of the Uinta Basin, and other areas with production from fluvial-deltaic reservoirs.

We established a log-based correlation scheme and nomenclature that reflect, as near as possible, time-correlative depositional cycles of the Middle and Lower Members of the Green River Formation. The cycles are at a scale that is easily recognizable on geophysical well logs and can be correlated throughout most of the southwest Uinta Basin. More than 1,300 wells have been correlated, and data on cycle boundaries, total sandstone, and total feet of porosity for each cycle have been entered into the well database and preliminary maps have been constructed.

Geological characterization of three oil fields, representing three reservoir types, was carried out. The three fields are: (1) Monument Butte Northeast, productive from the Middle Member of the Green River Formation; (2) Uteland Butte, productive from carbonates in the Lower Member; and (3) Brundage Canyon, productive from fractured sandstone in the Lower Member. Lithotypes were defined in the Monument Butte Northeast water-flood unit based on log-derived porosity values. Lithotypes were simulated over the unit using the appropriate variograms and the generated reservoir description is being used to simulate production from the unit. Numerical simulation models will be constructed for Uteland Butte and Brundage Canyon fields as well.

Numerous stratigraphic sections of the Middle Member of the Green River were measured and described in Willow Creek, Nine Mile, and Desolation Canyons. Spectral gamma-ray (GR) data were collected over four regional stratigraphic sections totaling 5,123 feet (1,561.5 m) in the Green River Formation: one in Willow Creek Canyon, and three in Nine Mile Canyon. Curves generated from the GR data have been correlated with GR curves from wells in the area.

A detailed study site was selected in Nine Mile Canyon, extending from Petes Canyon to Gate Canyon, which are tributaries to Nine Mile Canyon. The exposure is about 2,000 feet (600 m) in an east-west direction and about 500 feet (150 m) in a north-south direction. The stratigraphic interval studied is slightly more than 100 feet (30 m) thick, bounded above and below by carbonate beds. Six sections have been measured and described, and GR data gathered from five of the sections. To aid interpretation, the canyon walls of the site were photographed from the opposite side of the canyon, and photomosaics were compiled. The photomosaics have been annotated showing bed relationships, major bed forms, and fractures. The annotations were field checked and more detailed information added. Data from the study site provides significant information about the potential reservoir heterogeneity in the interwell environment.

Technology transfer consisted of a two-day field review in Willow Creek Canyon and Nine Mile Canyon. An evening program consisted of several presentations and a review of well core. The field review was attended by members of the Technical Advisory Board, geoscientists working the Uinta Basin, and representatives from the Bureau of Land Management. A home page for the project is maintained on the UGS web site.

INTRODUCTION

Geologic Setting

The Uinta Basin is a topographic and structural trough encompassing an area of more than 9,300 square miles (14,900 km^2) in northeast Utah (figure 1). The basin is sharply asymmetrical, with a steep north flank bounded by the east-west-trending Uinta Mountains, and a gently dipping south flank.

The Uinta Basin formed in Paleocene to Eocene time, creating a large area of internal drainage which was filled by ancestral Lake Uinta. Deposition in and around Lake Uinta consisted of open- to marginal-lacustrine sediments that make up the Green River Formation. Alluvial red-bed deposits that are laterally equivalent to, and intertongue with, the Green River make up the Colton Formation (Wasatch).

More than 450 million barrels of oil (63 MT) have been produced from the Green River and Colton Formations in the Uinta Basin. The Cedar Rim, Altamont, Bluebell, and Red Wash fields produce oil from the northern shoreline deposits of Lake Uinta, while the fields in the Monument Butte area produce from southern deltaic shoreline deposits as preserved in the Middle and Lower Members of the Green River. The southern shore of Lake Uinta was often very broad and flat, which allowed large transgressive and regressive shifts in the shoreline in response to climatic and tectonic-induced rise and fall of the lake. The cyclic nature of Green River deposition in the Monument Butte area resulted in numerous stacked deltaic deposits. Distributary-mouth bars, distributary channels, and nearshore bars are the primary producing sandstone reservoirs in the area.

Project Status

We are studying the Green River Formation on outcrop and in the subsurface to increase our knowledge of its reservoir characteristics, and to improve our ability to identify new play areas. We established a log-based correlation scheme and nomenclature that reflect, as near as possible, time-correlative depositional cycles of the Middle and Lower Members of the Green River Formation. The regional correlation nomenclature will help identify which intervals are productive in the southwest Uinta Basin. The cycles are at a scale that is easily recognizable on geophysical well logs and can be correlated throughout most of the southwest Uinta Basin. More than 1,300 wells have been correlated and entered into the geographic information system (GIS) database and preliminary maps have been constructed. New wells have been added to the database and some correlations have been revised after working with some of the Technical Advisory Board members. A new set of maps will be generated using the new wells and revised correlations.

Core from 32 wells in the project study area has been described and depositional environments interpreted. Editing of the core descriptions is complete and a final report is being prepared.

Geological characterization of three oil fields, (1) Monument Butte Northeast, (2) Uteland

Butte, and (3) Brundage Canyon, has been completed. Sandstone thickness, total feet of porous sandstone, and structural elevation of every productive bed in each of the three fields were determined and entered into the GIS database. Porosity and fluid saturation were also determined from the geophysical logs at a 1-foot (0.3 m) scale for each bed. This data is being used to construct a numerical simulation model of the Monument Butte Northeast water-flood unit and will be used to construct models for the Uteland Butte and Brundage Canyon oil fields.

Several stratigraphic sections had previously been measured and described, and spectral gamma-ray (GR) data were gathered in Willow Creek and Nine Mile Canyons. Curves were generated from the outcrop GR data and correlated to the geophysical logs of nearby wells. Additional sections were measured and described in Desolation Canyon and Trail Canyon, a tributary to Nine Mile Canyon. The Desolation Canyon section is the easternmost exposure studied. Gamma-ray data were gathered over the Trail Canyon section to help correlate it to well logs that lay directly north and south of the section. A few marker beds have been correlated between the stratigraphic sections, and using the GR curves these beds have been correlated to well logs. Detailed correlation between the various surface stratigraphic sections, and between the surface stratigraphic sections and the subsurface well logs was conducted during the spring 2001 field season.

A study site was selected to better understand the interwell-scale reservoir heterogeneity of one depositional cycle. The site, referred to as the Nutter's Ranch study site, lies along Nine Mile Canyon from Petes Canyon to Gate Canyon, both tributaries to Nine Mile Canyon. The exposures provide a three-dimensional perspective that, in the longest dimension, covers about the distance between two wells if drilled on 40-acre (16.2-ha) spacing. Seven stratigraphic sections have been measured and described, and GR data were gathered over six of the sections. Photomosaics were constructed and annotated. The annotations were field checked, and paleoflow and fracture data were gathered. A depositional interpretation of the strata studied was developed and was presented to the Technical Advisory Board during a fall field review.

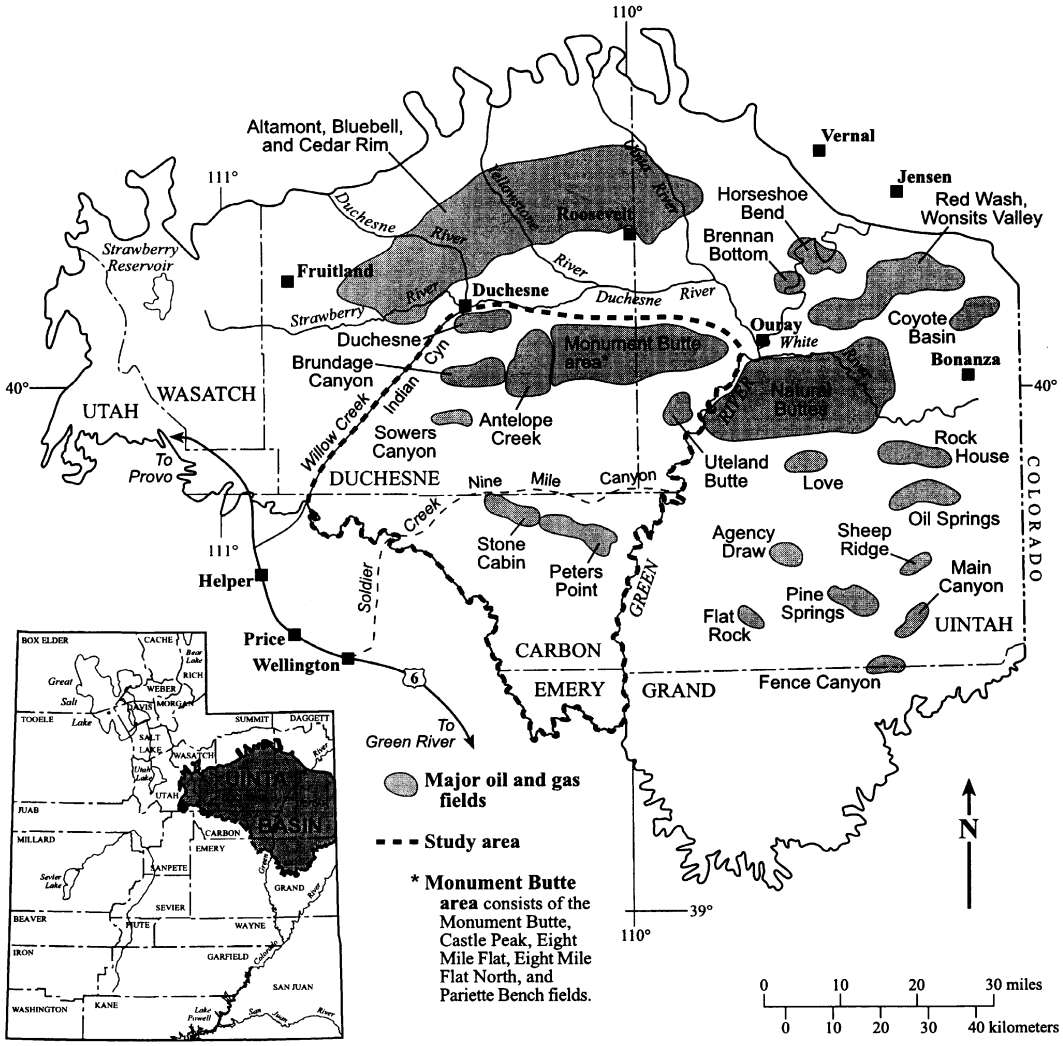

Figure 1. Index map of the Uinta Basin, Utah, showing study area and major oil and gas fields.

GEOLOGIC INVESTIGATION OF THE GREEN RIVER FORMATION IN THE SUBSURFACE

Regional Characterization

Geophysical well logs were used to define 22 log cycles for the Middle and Lower Members of the Green River Formation. The logs were correlated using an alpha-numeric bed numbering scheme described in the first biannual technical report (Morgan and others, 1999a). The drill-depth top of each log cycle, total feet of sandstone, and total feet of sandstone with 10 percent or more porosity were entered into the GIS database. The GIS database is being used to map and interpret regional trends and depositional environments of each of the 22 log cycles. Logs from more than 1,300 wells have been correlated and entered into the database. Regional correlations are currently being interpreted using a sequence stratigraphy approach. The final product will be an interactive GIS project in which the user can view maps within the GIS project or use the data files to construct their own maps.

Field-Scale Characterization

Geological characterization, consisting of correlating and mapping all perforated beds, was carried out on portions of three oil fields: (1) Monument Butte Northeast, (2) Uteland Butte, and (3) Brundage Canyon (Morgan and others 2001). The fields are examples of three different reservoir types found in the southwest Uinta Basin. The geological characterizations will be used for reservoir numerical simulation modeling.

GENERATION OF RESERVOIR MODELS

numerical simulation models have been constructed for the monument Butte Northeast water-flood unit. These models will be presented to the Technical Advisory Board in June 2001. Numerical simulation models will be constructed for Uteland Butte and Brundage Canyon fields following review of the monument Butte Northeast water-flood models.

GEOLOGIC INVESTIGATION OF THE OUTCROP OF THE GREEN RIVER FORMATION

Regional Outcrop Study

The UGS measured and described four stratigraphic sections ranging in total thickness from 1,064 to 1,935 feet (324.3 to 589.8 m) in Willow Creek, Nine Mile, and Desolation Canyons. Gamma-ray data were gathered over three of the UGS sections and over one section by Remy (1992). The primary marker beds, Remy D and C (Remy, 1992) have been correlated

between the stratigraphic sections and to geophysical logs from neighboring drill holes. Work is continuing to better define individual depositional cycles in the surface stratigraphic sections and correlate them to the log cycles (Morgan and others, 1999a) that have been mapped throughout the region. During the 2001 field season we photographed the outcrop and in many areas, walked key correlation beds between measured sections, to ensure good correlation between each of the measured sections.

Nutter's Ranch Study Site

A study site was selected to better understand the interwell-scale reservoir heterogeneity that exists in one depositional cycle that is bounded above and below by carbonate beds. The study site, referred to as the Nutter's Ranch study site, was described in Morgan and others (1999b). The Nutter's Ranch study site was photographed and digitally joined into mosaics that were used to correlate the beds along the entire length of the exposure. The correlations were checked in the field and modified as needed, by walking out each of the bed boundaries.

A preliminary interpretation of the depositional sequence and the potential effects of the heterogeneity on oil production, was presented by Morgan and others, (2001), and during the field review.

TECHNOLOGY TRANSFER

A Copy of the Biannual Technical Report for the period from April 1, 2000 to September 30, 2000, was sent to everyone on the project mailing list and then posted on the Green River Study home page where it can be downloaded.

A two day field review was conducted in Willow Creek Canyon and Nine Mile Canyon. More than 20 people attended who were Technical Advisory Board Members, scientists who work in other parts of the Uinta Basin, and representatives from the Bureau of Land Management.

The UGS maintains a Green River Study home page on its web site containing the following information: (1) an index map of the study area, (2) a copy of the proposal and statement of work, (3) each of the Biannual Technical Progress Reports, and (4) an extensive selected reference list for the Uinta Basin and lacustrine deposits worldwide. The home page address is ***http://www.ugs.state.ut.us/greenriv.htm***

FUTURE ACTIVITIES

The following work is planned for the period of April 1, 2001 through September 30, 2001:

(1) A field review will be held May 2001 to show the Technical Advisory Board and DOE representatives, the work being done in Desolation Canyon.

(2) The biannual technical report will be sent to all interested parties and posted on the project web site.

(3) A poster with core will be presented at the AAPG National Convention in Denver, Colorado.

(4) New maps will be constructed using the revised well database.

(5) Correlation between the stratigraphic sections and correlation of the surface-to-subsurface will continue.

(6) The petrophysical report will be written.

(7) Paleoflow and fracture data were gathered from the Nutter's Ranch study site. The data will be mapped and interpreted.

(8) The geological characterization of the Uteland Butte and Brundage Canyon fields will be incorporated into the numerical reservoir simulation models for each of the fields.

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