

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

***Biannual Technical Progress Report***

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## ABSTRACT

The +2000-foot-thick (600-m), Tertiary-aged lacustrine deposits of the Middle and Lower Members of the Green River Formation contain the primary oil-producing reservoirs in the southwest Uinta Basin, Utah. Currently, each oil and gas operator uses a different terminology to designate Green River stratigraphic units which makes it difficult to correlate and model productive intervals. We developed a log-based correlation scheme by identifying on gamma-ray and resistivity logs, what we interpret as depositional cycles. Regional cross sections were constructed and cycle boundaries revised as needed. The cycles typically range from 50 to 100 ft (15-30 m) thick. The regional correlation scheme will be used to improve our knowledge of the depositional patterns and distribution of productive intervals in the southwest Uinta Basin. A regional log-based correlation scheme based on depositional cycles will also aid in relating subsurface data to the outcrop where depositional environments and lateral continuity of the reservoir rocks can be studied in greater detail.

A Geographic Information System project file was created and well-log correlation data are being entered. Mapping and other analyses of the well data will be a significant part of the characterization study. Published measured sections have been entered into the database. Additional sections will be described, measured, and some gamma-ray data will be gathered to aid in correlating outcrop to well log data. The number and location of available well core and analyses take in the study area have been identified. Hydraulic fracture data from wells in the study area are being compiled and will be incorporated into a reservoir simulation model.

Technology transfer activities included a booth display of project material at the Interstate Oil and Gas Compact Commission annual meeting. Team members met with the Technical Advisory Board and reviewed the current status and future direction of the project. A home page for the project was developed on the Utah Geological Survey's web site.

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## EXECUTIVE SUMMARY

The objectives of the study are to increase both primary and secondary hydrocarbon recovery through improved characterization of fluvial-deltaic lacustrine reservoirs (at the regional, unit, interwell, well, and microscopic scale) and numerical simulation modeling, 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.

Geophysical logs from several wells in the Monument Butte area were selected to be used as type logs. Depositional cycles and packages were identified based on the character of the gamma-ray and resistivity curves. Regional cross sections were constructed and some cycles were redefined based on the regional correlation. A correlation scheme was developed using an alpha-numeric nomenclature avoiding local field or facies names that are difficult to use regionally. The nomenclature has three primary levels: (1) MGR or LGR for Middle or Lower Green River, (2) MGR1 through MGR18 and LGR1 through LGR3 for the different cycles in each member, and (3) MGR1a, MGR1b, and so on, for beds within each cycle. The third level of nomenclature is not intended to be applied regionally. The cycles (level 2) can be divided into smaller subcycles if necessary for detailed work within a field (MGR14A and MGR14B, for example). Cycles can be combined where depositional thinning or poor log quality does not allow correlation of all the individual cycles (MGR5-MGR9, for example). Some modifications may be made based on outcrop correlations to be investigated later in the study.

A project file was compiled using commercial Geographic Information System (GIS) software. Well correlations are being entered into the database for mapping and other analyses. Published measured sections were also entered into the database. Additional sections will be measured, described, and some gamma-ray data gathered for correlating outcrop sections to subsurface well data.

A catalog was compiled of publically available core and core data. The core will be described and additional analyses conducted. Hydraulic fracture data for wells in the study area are being compiled and will be used in the reservoir simulation model.

Project materials were displayed at the annual meeting of the Interstate Oil and Gas Compact Commission. The project team met with the Technical Advisory Board which consists of well operators from the study area, and discussed the project objectives, data needs, and additional research needs of the operators. A home page was developed containing information about the project.

## INTRODUCTION

The Uinta Basin is a topographic and structural trough encompassing an area of more than 9300 square miles (14,900 km<sup>2</sup>) in northeast Utah (Fig. 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. Cedar Rim, Altamont, Bluebell, and Red Wash fields produce from the north shoreline deposits of Lake Uinta while the fields in the Monument Butte area produce from deltaic southern shoreline deposits in the Middle and Lower Members of the Green River. The southern shore of Lake Uinta was very broad and flat resulting in large transgressive and regressive shifts in the shoreline with climate and tectonically induced rise and fall of the lake. The cyclic nature of the deposition of the Green River 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.

To increase our knowledge of the reservoir characteristics of the oil-productive Green River Formation and to improve our ability to identify new play areas, we established a log-based correlation scheme and nomenclature that reflects, as near as possible, time correlative depositional cycles of the Middle and Lower Members of the Green River Formation. The regional correlation nomenclature will aid understanding of which intervals are productive in the southwest Uinta Basin. Currently, each operator uses a different terminology for many of the same intervals or beds. Regional log correlations based on depositional cycles will make it easier to relate subsurface data to the outcrop where the depositional environments and lateral continuity of the reservoir rocks can be studied in more detail. The cycles must be at a scale that is easily recognizable on geophysical well logs and can be correlated throughout most of the southwest Uinta Basin.

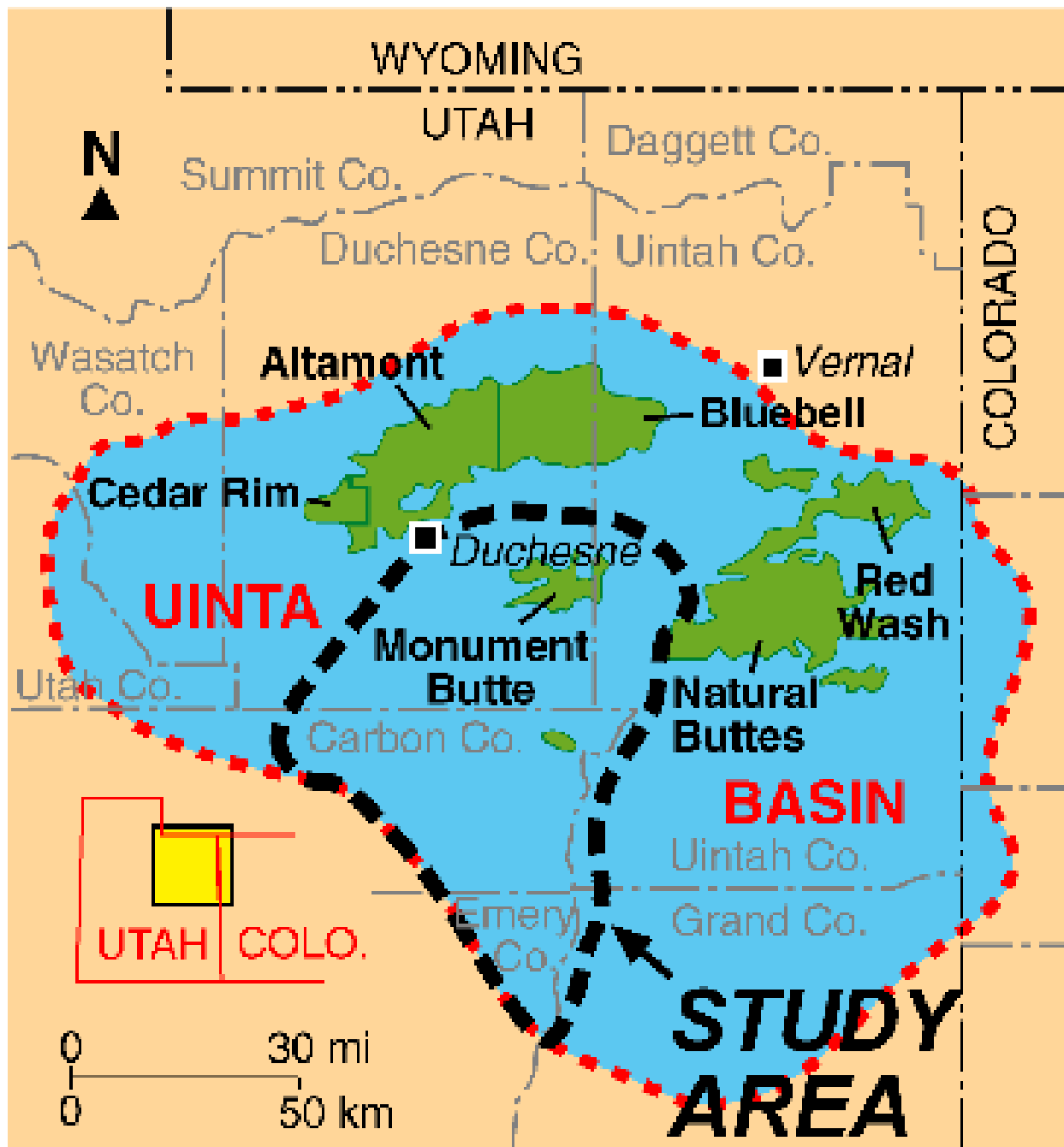


Fig. 1. Index map of the Uinta Basin, Utah showing study area and major oil and gas fields in the basin.

## RESULTS AND DISCUSSION

### Correlation Scheme and Nomenclature

We developed a correlation scheme and nomenclature based on geophysical well-log characteristics interpreted as depositional cycles (Figs. 2a-2c). The cycles are at a scale that can be correlated regionally, although smaller scale cycles can often be identified on the well logs.

#### First division: Members

Mappers divide the lower half of the Green River Formation in the southwest Uinta Basin region into the Middle Member from the base of the Mahogany oil shale to the top of the carbonate marker, and the Lower Member from the top of the carbonate marker to the top of the Colton Formation (Witkind, 1995). These two members are easily identifiable based on geophysical log character in the subsurface. Therefore, the first division in our correlation nomenclature is:

**MGR** for Middle Green River, and  
**LGR** for Lower Green River.

#### Second division: Cycles

The second division is the cycle, numbered from the base of the member upward. The cycles were defined by gamma-ray and resistivity log patterns. Log patterns that may represent coarsening-upward sequences overlain by a flooding event or a rise-to-fall sequence were identified in key wells. The correlations were then made on regional east-to-west and north-to-south well-log cross sections. Correlations that were difficult to make or appeared to have a limited extent were dropped. The correlations resulted in three cycles in the LGR plus the carbonate marker (not divided), and 18 cycles in the MGR. The top of the uppermost cycle (18) in the MGR is the middle marker. This is the top of the stratigraphic sequence that we will study. There are about 500 to 600 feet (150-180 m) of Middle Green River section from the top of the middle marker to the base of the Mahogany oil shale. The MGR numbering could be continued by other workers into the remaining overlying Middle Green River section. The second level divisions in descending order are:

**MGR18** middle marker  
**MGR17**  
**MGR16**  
.  
.  
.  
**MGR1**  
**CARBONATE MARKER** (may divide after further work, if not it will become LGR4)  
**LGR3**



**LGR2**  
**LGR1**

The LGR1-3 cycles are the basal Green River, Uteland Butte limestone, or the first lacustrine tongue of Bradley (1925). The three divisions are based on the work of Little (1988). Some cycles in the MGR do not have the typical cyclic log pattern but are packages underlain and overlain by cyclic sequences. These packages could represent a period of stable lake level or a period of high cyclicity resulting in a series of sequences at a scale smaller than what we are studying. Regardless, these packages can be correlated and mapped regionally. Another problematic sequence is MGR1-3, the lower Douglas Creek Member. This has been described in core by Lutz and others (1994) as turbidites and slump blocks and as a result, regional correlation may not be helpful. As a result, it could become necessary to combine one or more of these sequences.

**Combining or subdividing the second division**

Cycles can be combined if the correlation is questionable or if one or more cycles are not present. Cycles can be subdivided if other cycles are identified or if smaller, high frequency cycles are to be mapped locally in a field or unit. The second division of the nomenclature can be combined or subdivided as shown in the following examples.

To combine:

**MGR15, MGR14, and MGR13** could become **MGR15** and **MGR14-13**, or **MGR15-13**.

The cycle MGR14-13 is from the top of MGR14 to the top of MGR12. The cycle MGR15-13 is from the top of MGR15 to the top of MGR12.

To subdivide:

**MGR7** could be subdivided into **MGR7A, MGR7B, and MGR7C** and so on. Subdivisions within the cycles are defined by *Uppercase* letters in descending order.

Both combined and subdivided cycles will typically have a local, not regional extent.

**Third division: Beds**

The third division is at the bed scale which, except for rare exceptions, will have a local extent. Beds will be labeled using *lowercase* letters in descending order within each cycle. For example:

Three beds in MGR12 would be **MGR12a, MGR12b, and MGR12c**.

If MGR8 was divided into three subcycles containing three beds, one bed, and two beds, they would be labeled as **MGR8Aa, MGR8Ab, MGR8Ac, MGR8Ba, MGR8Ca, and MGR8Cb**.

If cycles MGR7, MGR8, and MGR9 have been combined in an area, then the beds will be labeled the same way: **MGR7-9a**, **MGR7-9b**, **MGR7-9c** and so on, treating the combined cycles the same as an individual cycle.

MGR12a in Monument Butte field and MGR12a in Uteland Butte field may or may not be the same bed, but both are the uppermost bed in MGR12.

### **Geographic Information System**

A project file has been compiled using ArcView® GIS software. The coverages include: land grid and ownership, political subdivisions, water-flood unit and oil field boundaries, topographic data, and wells with extensive amounts of attribute data. The well data were exported to a spreadsheet table which contains columns for the drill depth, sandstone thickness, and sandstone thickness with 10% or more porosity, for all of the cycles defined in the correlation scheme. The table will be joined to the project file after the wells have been correlated and the data entered.

### **Data Gathering**

Relevant sections of the Middle Member of the Green River Formation measured and described by Remy (1992) have been entered into a graphics program. These and other published measured sections as well as sections and core described by the research team will be entered into the same graphics program. Two sections, one in Willow Creek Canyon and one in Nine Mile Canyon, have been selected where we will gather spectral gamma-ray data to use in correlating the surface sections to the subsurface well logs.

A catalog of available core taken in the study area is being compiled. The Utah Geological Survey Sample Library already has core from numerous wells in the study area. Additional core has been located at other research institutes, service companies, and field offices of operators. Also found during the search are numerous core analysis, thin sections, and core photos.

Halliburton Energy Services is compiling hydraulic fracture data from hundreds of wells in the study area. This data will be incorporated into the reservoir simulation model.

### **CONCLUSIONS**

Depositional cycles or packages can be correlated throughout the southwest Uinta Basin. The alpha-numeric correlation nomenclature can be modified to better meet the needs of the oil field operators and to better correlate with depositional events or cycles identified on outcrop.

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Fig. 2a-2b. Gamma-ray and resistivity log from the Monument Butte Federal 2-35 well (section 35, T. 8 S., R. 16 E., Salt Lake Base Line and Meridian) Duchesne County, Utah. Correlations for the Middle Member (MGR) and Lower Member (carbonate marker and LGR) of the Green River Formation are shown. Depths are shown in feet measured from the Kelly bushing (KB).

Well: Federal 2-35  
Field: Monument Butte  
KB: 5,531 ft.

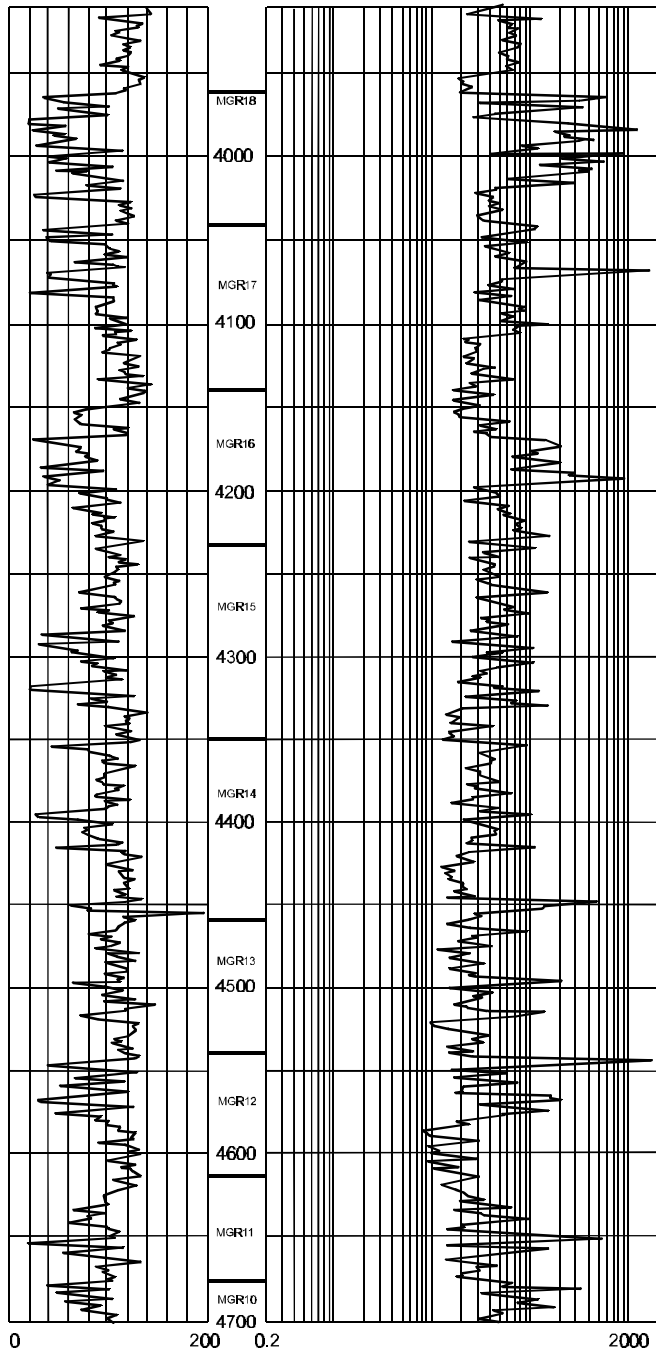


Fig. 2a

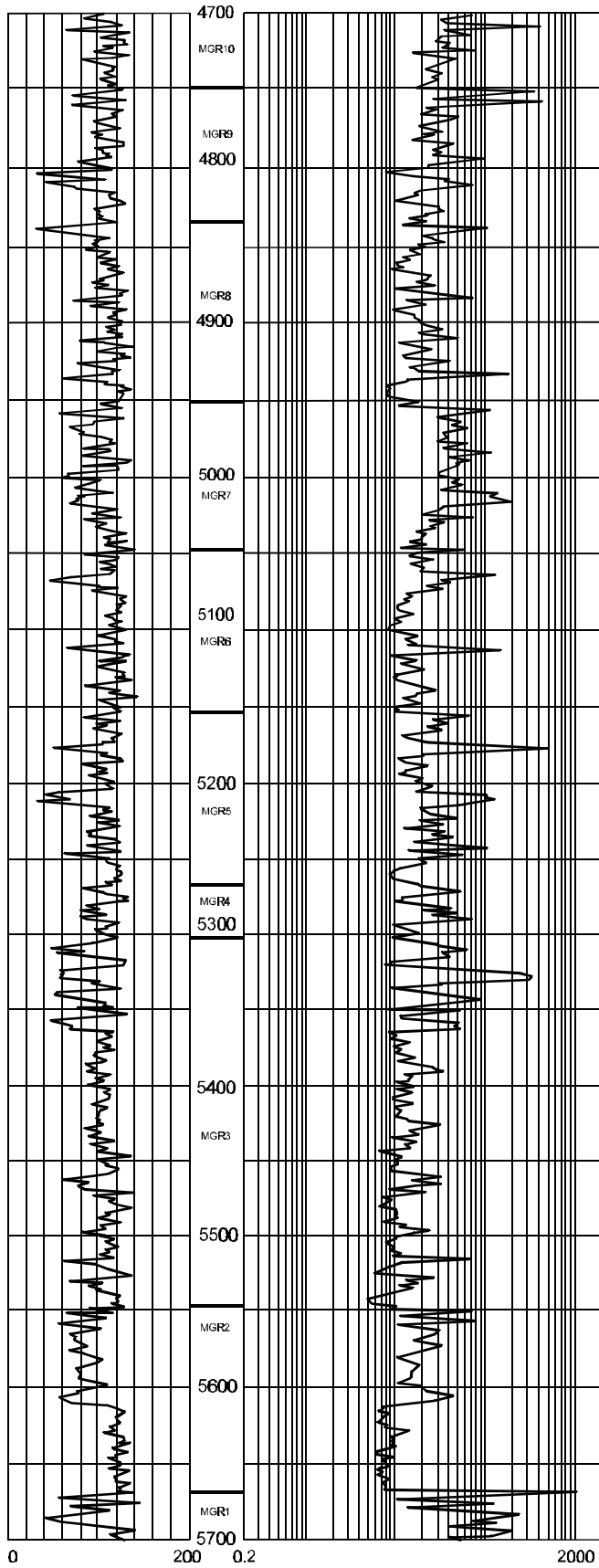
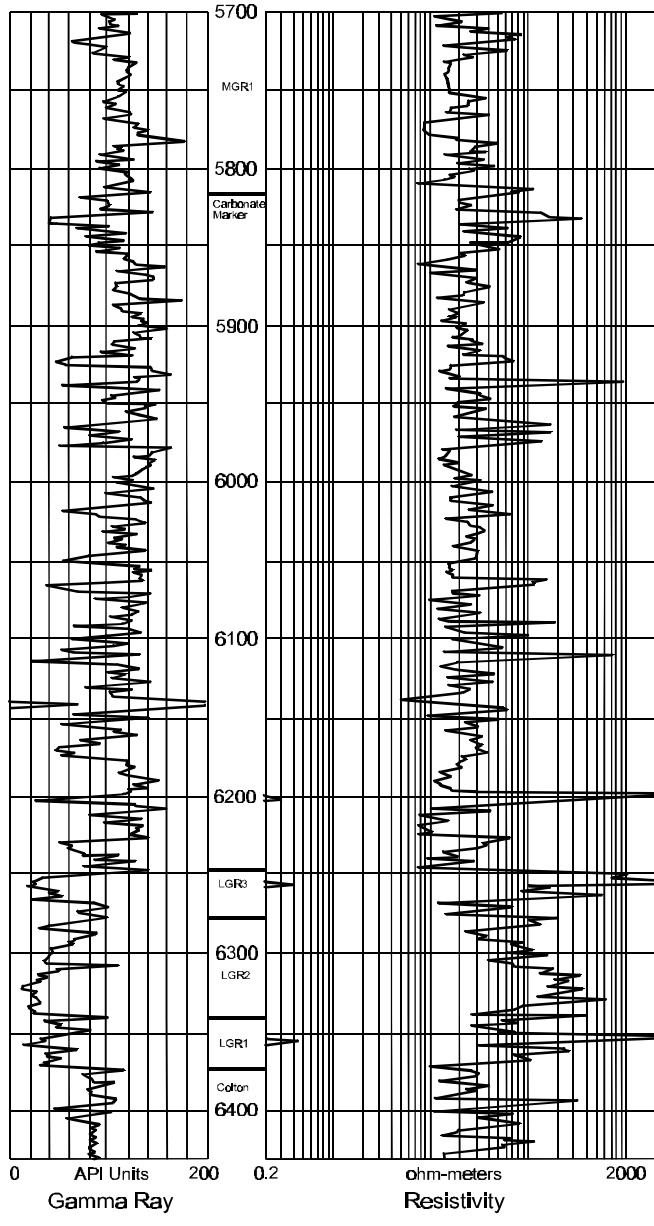


Fig. 2b



Total Depth 6,440 ft.

Fig. 2c

## TECHNOLOGY TRANSFER

The Utah Geological Survey displayed an overview about the project at the Interstate Oil and Gas Compact Commission annual meeting held in Salt Lake City, Utah, from December 6 - 8, 1998.

Members of the research team met with the Technical Advisory Board March 3, 1999 at the office of Inland Resources Inc., in Denver, Colorado. Seven individuals representing five companies that operate wells in the study area attended the meeting. The objectives, contract requirements, and data needed from the operators were discussed. Additional research topics not specified in the contract but within the scope of the objectives were suggested by the Board.

The Utah Geological Survey 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>

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