Petrophysics of the Greybull Sandstone: Old Log Foundation for Further Exploration*

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Abstract

This article considers some petrophysical characteristics of the Lower Cretaceous (Albian) Greybull Formation along the Nye-Bowler Lineament in south-central Montana, and studies the petrophysical characteristics of producing wells within this field. This field, along with the nearby Golden Dome Field, produces higher gravity low-sulfur crude, unlike the other fields along the lineament, which produce low gravity black oil from the Greybull. Since the oil from this field is a higher quality crude, the Greybull sand here is a higher quality objective and a better subject for further study. This study uses log, production and formation top data from the Montana Oil and Gas Commission to delineate the characteristics of a productive Greybull reservoir containing high-quality crude and furnish a guide to further exploration for other similar reservoirs. The logs used in this study range from very old Electric Surveys (ES), Induction-Electric Surveys (IES), and Dual Induction surveys (DIL) from a variety of service companies. These surveys provide the majority of the log data within the field and provide useful data despite their age.

Petrophysics of the Greybull sandstone in the Dry Creek Field, Carbon County, Montana: Old log foundation for further exploration

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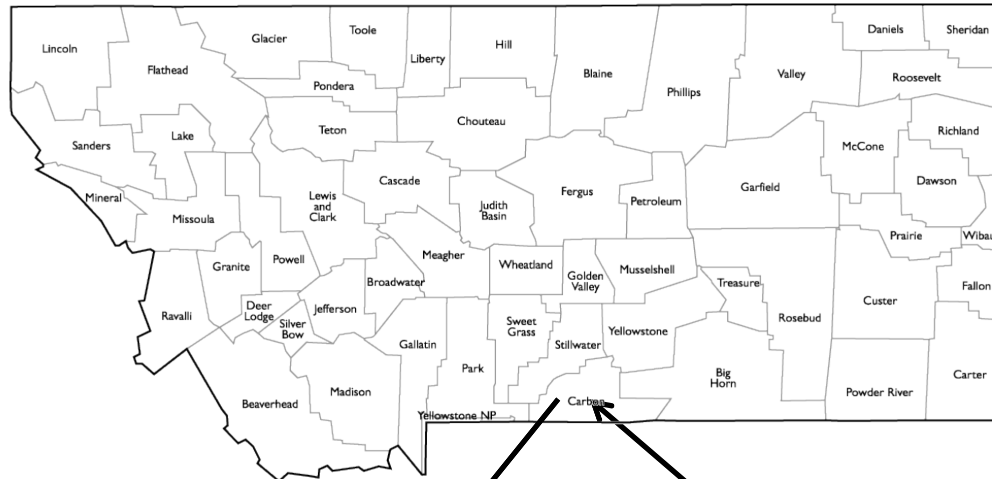
DRY CREEK FIELD LOCATION



Carbon County, MT

Dry Creek Field Topography

WHY STUDY THE DRY CREEK FIELD, GREYBULL SAND AND LAKOTA CONGLOMERATE?

It is the only field along the Nye-Bowler trend which produces high-gravity, low-sulfur oil and wet gas from the Greybull sand and it's companion the Lakota conglomerate.

These two objective formations are low-risk and low-cost objectives in SE Montana.

Dry creek field has had good oil and gas production from these two reservoirs, so this field should show us what "good" well logs look like.

PROJECT OBJECTIVES

Do “Old (Obsolete)” well logs have any ability to delineate production versus non-productive wells in these formations for wells drilled in other areas?

Are there qualitative or semi-quantitative criteria that can be used to indicate or “screen” which logs may indicate bypassed production in these formations?

REMEMBER: ***There are many old logs that may have bypassed pay for one reason or another when they were drilled originally.***

PROJECT SCOPE

At first, this study only considered the Greybull sand, but as work progressed, the Lakota/Pryor conglomerate was added, as they both were productive and are stratigraphically close. They occur in the same logs and it was efficient to consider both, rather than separate them into two studies.

Logs used in the study represent very early (~1950) technology up to the (~1975) technology, but BEFORE the rise of “triple combo-early computerized logging technology and the rise of modern digital well logging technology.

This study is confined to resistivity logs. Older sonic and nuclear tools were still under development and were generally not run, until the very late 1960’s and later, when their technology had matured.

PROJECT LIMITATIONS

The logs used in this study represent a small sample of reasonably high-quality logs from one service provider (SCHLUMBERGER).

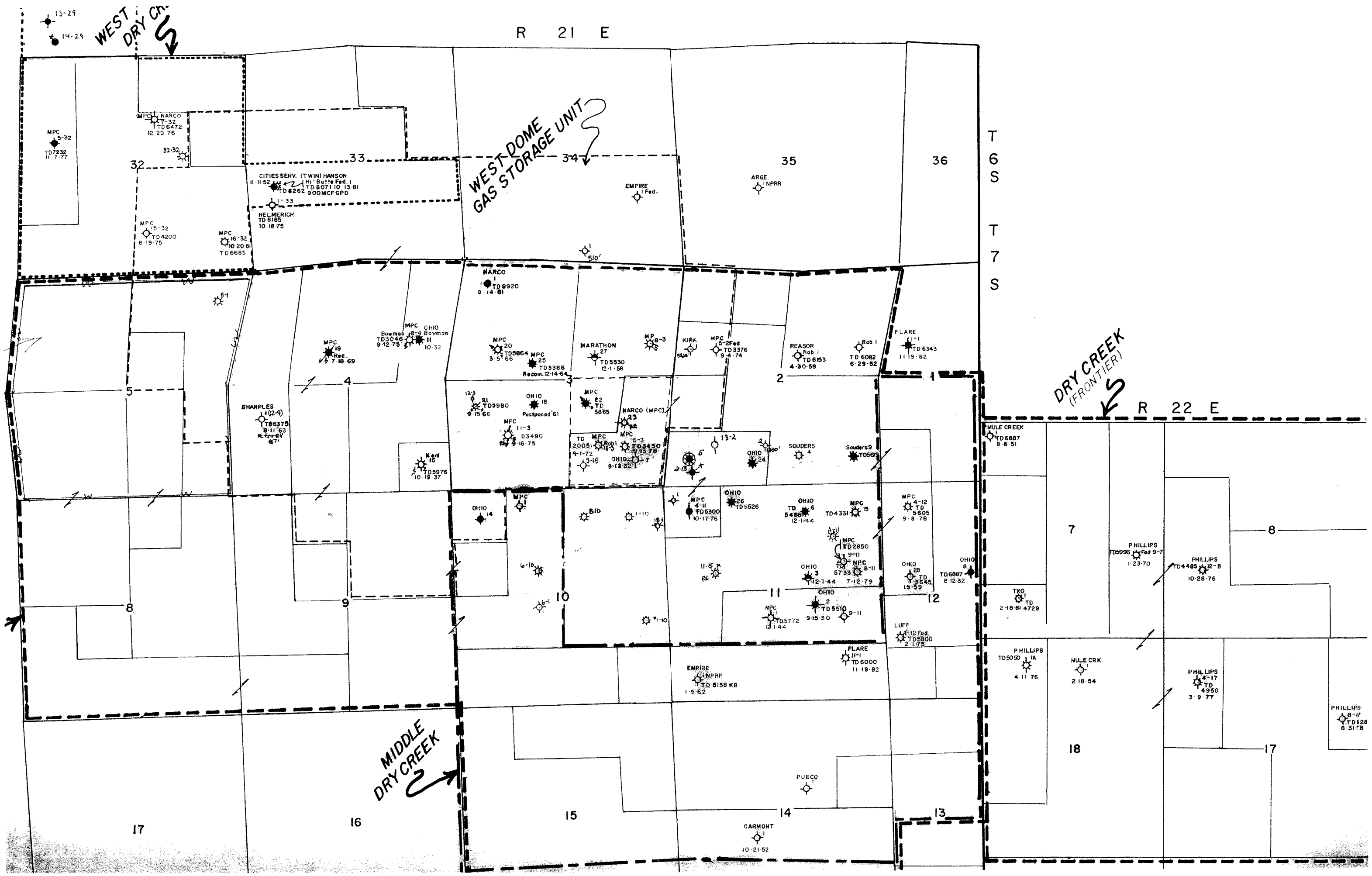
These logs were run using discrete transistor technology(*at best*), 6-strand cable, and by recording the data on camera. Considering the state of the technology, these engineers did a quite remarkable job of getting high-quality logs under difficult conditions.

Mud-filtrate (Rmf) had to be estimated using the formula suggested by Overton and Lipson (1958), since ONLY the mud resistivity (Rm) was measured on the rig site when the earliest logs were run.

Log prints used in this poster session were reproduced from old prints (office) originally taken from field film. As such, curve quality is as good as can be reproduced. Resistivity values are as close as can be read from the print.

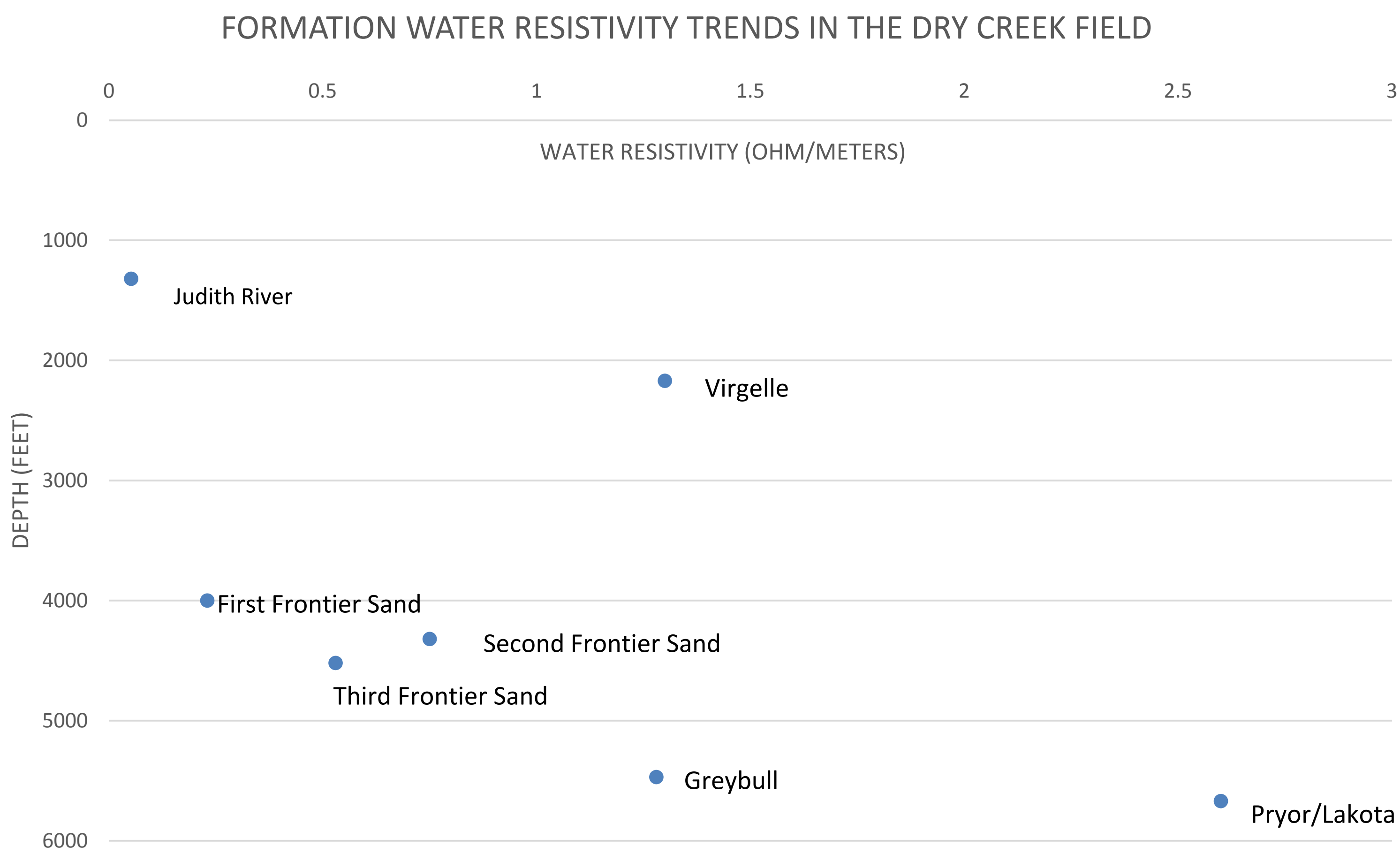
Although heuristic rules have been devised to interpret the lateral log curve within the Electric Log, this study did NOT consider them useful, but used the normal curves on the Log.

WELL LOCATIONS



FORMATION WATER RESISTIVITY (R_W)

Formation water resistivity for the Dry Creek Field Reservoirs were published in a field description paper by T. Culley (1984) measured at 68ºF.



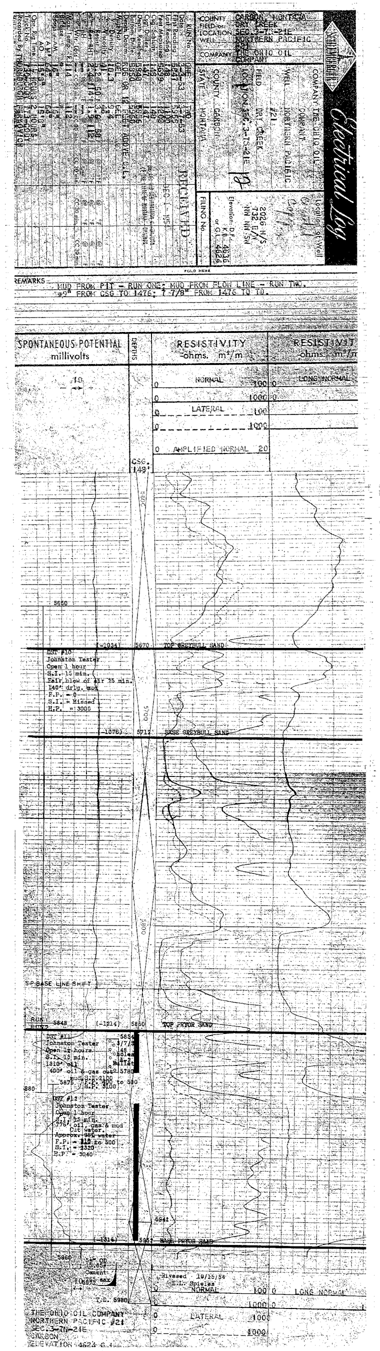
ELECTRIC LOGS

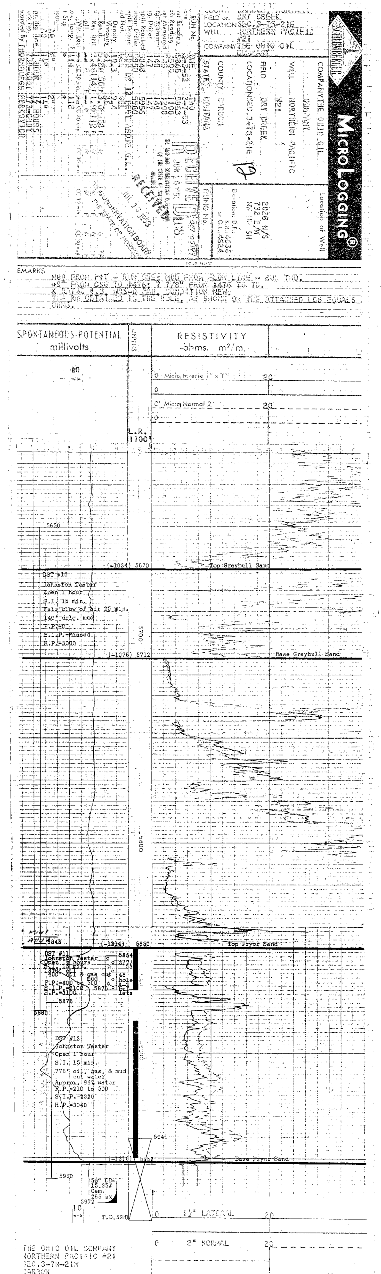
The earliest logs used in this study are Ohio Oil Company H.T. Bowman #25 (drilled 5-23-1954) and the Ohio Oil Company Northern Pacific #21 (drilled 3-3-1953). Both were electric surveys comprised of an SP, short normal (*16" spacing*), long normal*(64 " spacing*) and a lateral (*8'-18" spacing*).

Even these earliest Electric Logs were supplemented by the "new" Microlog (introduced ~1949), which was used to delineate permeable zones in the sand. This survey consisted of the SP, 1"x1" Micro Inverse, and a 2" micro Normal curves.

Porosity had to be measured from cores or estimated from estimates of the formation factor (F).

ELECTRICAL LOGS
<1950 to ~1952

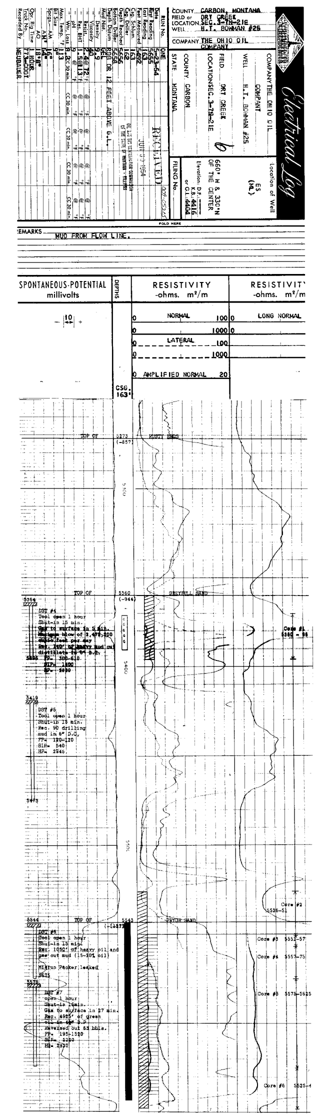




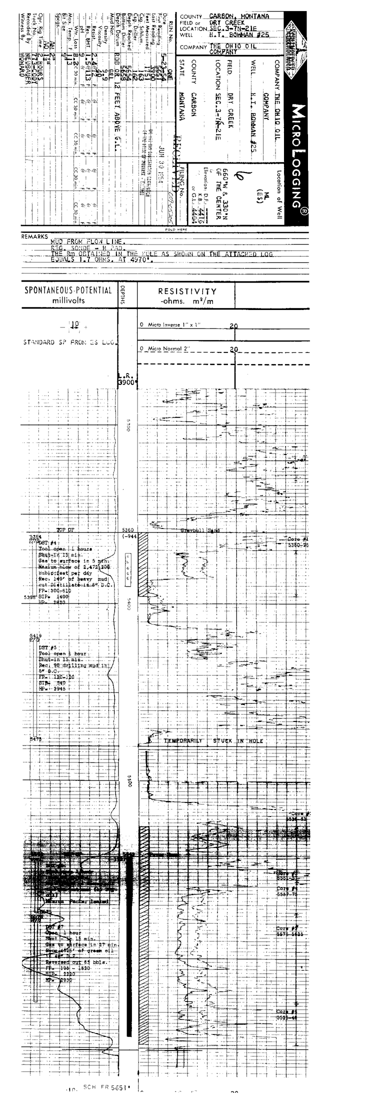
MUD PROPRETIES BOWMAN #25
R_m= 2.4@ 72°F
R_m= 1.5@ 113°F
R_{mf}= 1.31@ 113°F
BHT = 113 °F

R_w = 0.91 at BHT

OHIO OIL COMPANY
H.T. BOWMAN #25
3-7S-21E (DRY CREEK)
ELECTRICAL LOG (5-23-1954)



OHIO OIL COMPANY
H.T. BOWMAN #25
3-7S-21E (DRY CREEK)
MICROLOGGING (5-23-1954)



THE LATERLOG (FOCUSED ELECTRODE)

In 1955, the Laterlog (LL7) focused electrode tool was run in the Dry Creek field. Two examples provided are the Ohio Oil Company Montana Industrial #26 (drilled 7-19-1955) and the Ohio Oil Company Souders #4 (drilled 5-28-1955). Both wells were also logged using the Microlog, similarly to the older Electric Logs.

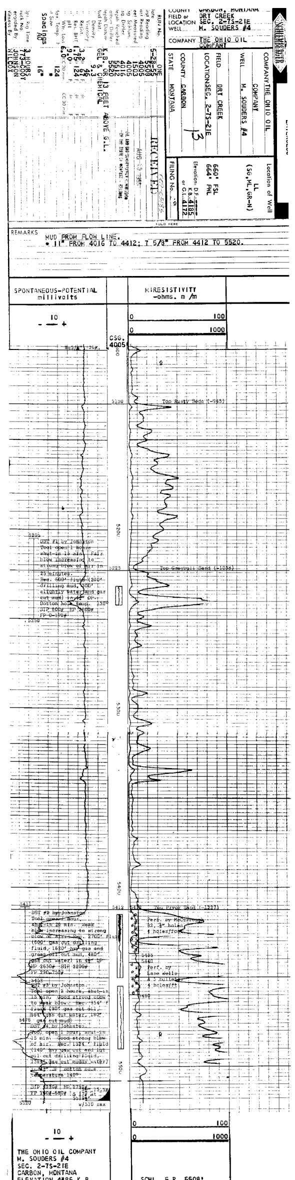
Both logs used for this session seem to have the LL7 curve run with traces showing both the “on-scale” AND the “off-scale” instead of the “off-scale” trace being used when the LL7 values exceeded the maximum resistivity. This seems to be a local practice in this area.

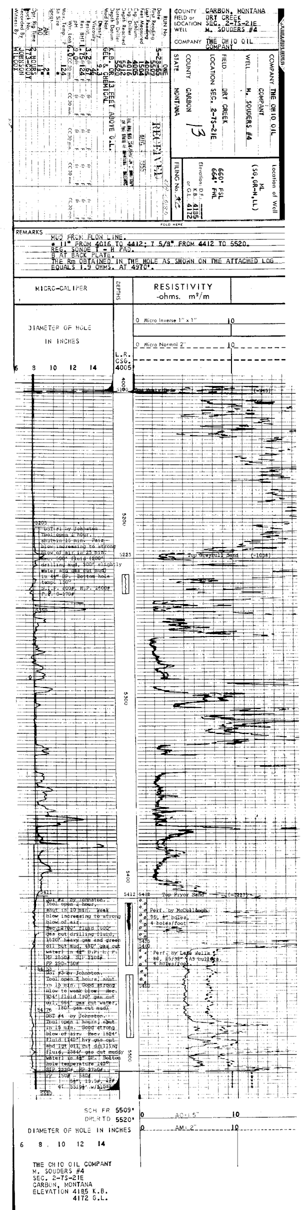
LATEROLOGS (LL7)
~1954 to ~ 1960

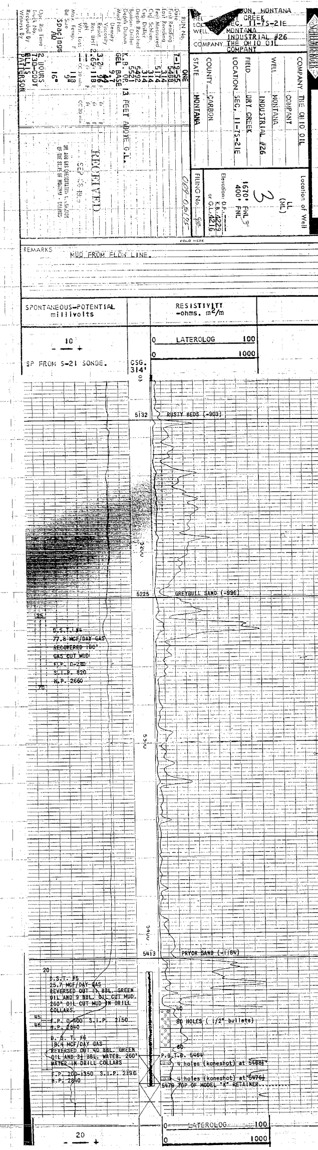
OHIO OIL COMPANY
H. SOUDERS #4
2-7S-21E (DRY CREEK)
LATEROLOG (5-28-1955)

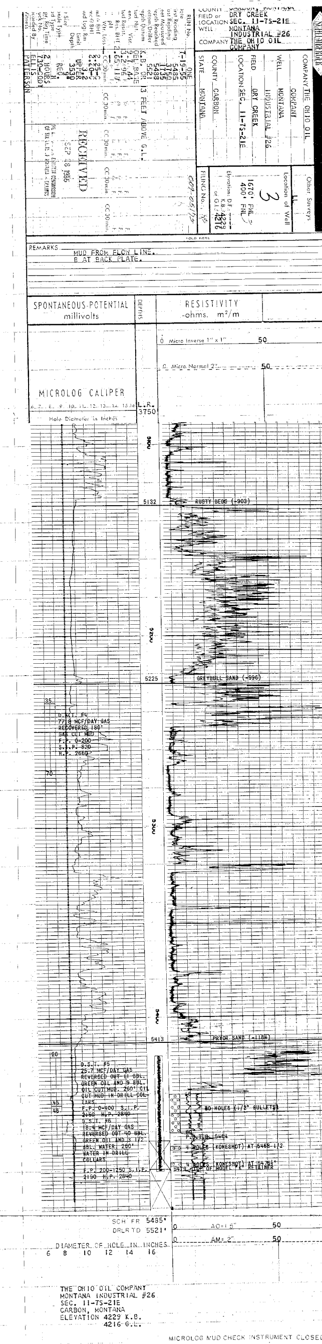
MUD PROPRETIES H. SOUDERS #4
R_m= 3.2@ 67°F
R_m= 1.75@ 124°F
R_{mf}= 999@ 124°F
BHT = 124 °F R_w = 0.84 at BHT

OHIO OIL COMPANY
H. SOUDERS #4
2-7S-21E (DRY CREEK)
MICROLOGGING (5-28-1955)









EARLY INDUCTION LOGS

By 1970, the first Induction logs were run in the Dry Creek field. The first example is the Cardinal Petroleum/Jerry Chambers #9-7 wildcat (drilled 1-21-1970). The tool consisted of an early version of the 6FF40 induction tool, but retained the short normal (16”) curve from the older logs.

The second early induction log example is the Montana Power Company Industrial #1-10 (drilled 11-11-1976). This log used a 6FF40 deep induction tool, like the # 9-7 well, but replaced the short normal with a laterolog 8 (LL8) tool. Neither well ran a “medium” induction tool, found on the later dual-induction logs.

Both the Federal #9-7 and the Industrial #1-10 produced gas from the Frontier formation, rather than the Greybull or the Pryor/Lakota.

RESULTS TO DATE

POTENTIAL HYDROCARBON PRODUCTION MAY BE INDICATED BY THE FOLLOWING CHARACTERISTICS:

Electric and Laterologs with Microlog:

(1) Look for strong SP deflection (> 70 mv) with a typical fresh-water mud and check that the resistivity should also be high (> 80 ohms).
(2) Check the same interval on the Microlog for pronounced positive separation (> 2mv) over a discrete interval. Discount "patchy" separation and look for separation over significant intervals (>10').

Induction Logs:

(1) Look for strong SP deflection (> 70 mv) with a typical fresh-water mud and check that the shallow resistivity should also be high (> 80 ohms).
(2) Check any associated porosity log for evidence of porosity.

ACKNOWLEGEMENTS

Cully, Timothy G. (1984) Dry Creek Field, Carbon County, MT, Montana Geological Society (MGS)

Hilchie, Douglas (1982). Applied Open Hole Log Interpretation for Geologists and Engineers. Douglas Hilchie Inc.

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