AV Direct Method for Determining Organic Shale Potential from Porosity and Resistivity Logs to Identify Possible Resource Plays*

Thomas Bowman[1]

Search and Discovery Article #110128 (2010)
Posted June 14, 2010

*Adapted from oral presentation at session, Genesis of Shale Gas--Physicochemical and Geochemical Constraints Affecting Methane Adsorption and Desorption, at AAPG Annual Convention, New Orleans, LA, April 11-14, 2010

[1]Mantle Oil & Gas, LLC (tdbowman@aol.com)

Abstract

Today many geoscientists are faced with identifying possible resource plays throughout the world. Determination of potential organic content of the shale sections is one of the first estimations that is often made, and time and again there is a lack of information readily and inexpensively available to make these preliminary estimates. As Passey (AAPG, 1990) and others have shown, there are several methods that can be used to determine the organic content by interpretation of various electric logs. One such method, referred to as the Δ log R technique, used for identifying and calculating total organic carbon in organic-rich rocks can be quickly estimated by the improvement of cross-plotting sonic logs (DT) and log (natural logarithm) of resistivity data and determining the shale line that can then be used to calculate a pseudo-sonic log that is then displayed over the existing sonic logs to determine the organic shale potential for a zone in an individual well. In water-saturated, organic-lean rocks, the two curves parallel each other and allow the shale calculation line to be determined. However, in either hydrocarbon reservoir rocks or organic-rich shale sections a separation between the curves occur. Using the gamma-ray curve, reservoir intervals can be identified and eliminated from the analysis. The separation in organic-rich intervals results from two effects: the porosity curve responds to the presence of low-density, low-velocity kerogen, and the resistivity curve responds to the formation fluid. In mature source rocks the magnitude of the resistivity increases because of the presence of generated hydrocarbons. By cross-plotting multiple wells this technique can provide relative information for an area or entire shale section. This method requires little more than a simple cross-plot and log calculation mathematics to provide a geoscientist sufficient data to easily and quickly determine potential organic shale sections. Across an area, these log cross-plot displays support the correlation and mapping of organic-rich shale sections and allow the geoscientist to quickly determine high graded areas of focus for further study. This method allows organic richness to be assessed in a wide variety of lithologies and maturities using common well logs and has been applied to many of the North American shale plays, such as the Barnett, Woodford, Eagle Ford and Marcellus shales.

References

Meissner, F.F., 1978, Petroleum geology of the Bakken Formation, Williston Basin, North Dakota and Montana *in* Montana Geological Society, The Economic geology of the Williston Basin; Montana, North Dakota, South Dakota, Saskatchewan, Manitoba, p. 207-227.

Meyer, B.L., and M.H. Nederlof, 1984, Identification of source rocks on wireline logs by density/resistivity and sonic transit/resistivity crossplots: AAPG Bulletin, v. 68, p. 121-129.

Nixon, R.P., 1973, Oil Source Beds in Cretaceous Mowry Shale of Northwestern Interior United States: AAPG Bulletin, v. 57/1, p. 136-157.

Passey, Q.R., S. Creaney, J.B. Kulla, F.J. Moretti, and J.D. Stroud, 1990, A practical model for organic richness from porosity and resistivity logs: AAPG Bulletin, v. 74, p. 1777-1794.

Philippi, G. T., 1968, Essentials of the petroleum formation process are organic source material and a subsurface temperature controlled chemical reaction mechanism, *in* Advances in organic geochemistry: Oxford, Pergamon Press, p. 25-46.

Schmoker, J.W., 1981, Determination of organic-matter content of Appalachian Devonian shales from gamma-ray logs: AAPG Bulletin, v. 65/7, p. 1285-1298.

Direct Method for Determining Organic Shale Potential from Porosity and Resistivity Logs to Identify Possible Resource Plays

T. Bowman
Mantle Oil & Gas, LLC

AAPG
Annual Convention & Exhibition
New Orleans, April 2010

Theme VIII: Genesis of Shale Gas – Physicochemical and Geochemical Constraints Affecting Methane Adsorption and Desorption

Outline

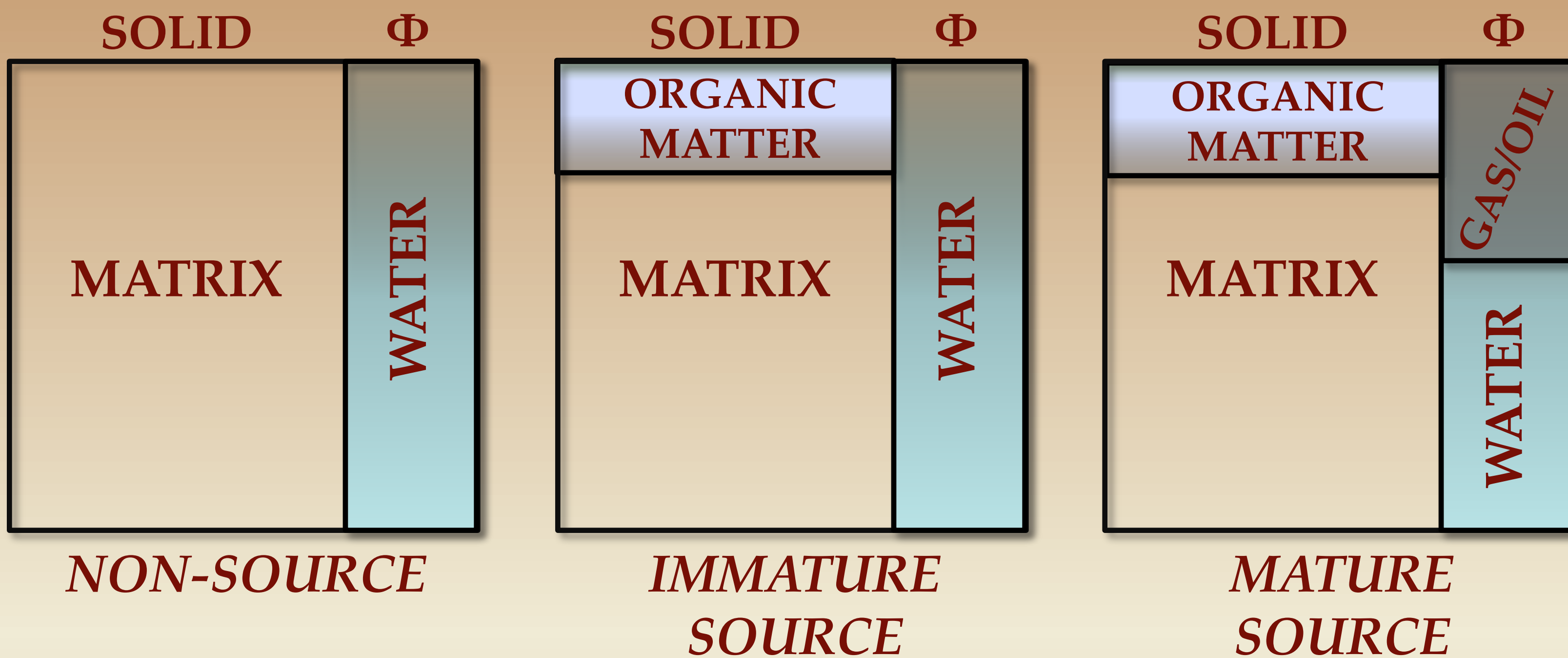
- ***Theory*** – *determine where potential TOC is located using a relatively simple calculation method.*
- ***Methods*** – *Modified ΔlogR Technique using Cross Plots*
- ***Examples*** – *Various US shale plays*
- ***Conclusion*** – *Observed information*

Methods - References

- ***Passey, Q. R.,*** *S. Creaney, J. B. Kulla, F. J. Moretti and J. D. Stroud,* ***1990, A practical model for organic richness from porosity and resistivity logs:*** *AAPG Bulletin, V. 74, P 1777-1794.*

- ***Meyer, B. L., and*** *M. H. Nederlof,* ***1984, Identification of source rocks on wireline logs by density/resistivity and sonic transit/resistivity crossplots:*** *AAPG Bulletin, V. 68, P 121-129.*

Source Rock Composition



***Mature Source Rocks** – As a Source Rock Matures, a portion of the solid organic matter is transformed to liquid or gaseous hydrocarbons which move into the pore space, displacing the formation water.**

**After Philippi (1968), Nixon (1973) and Meissner (1978)*

Hypothesis

- *Source Rocks - shales and lime-mudstones containing significant amounts of organic matter.*

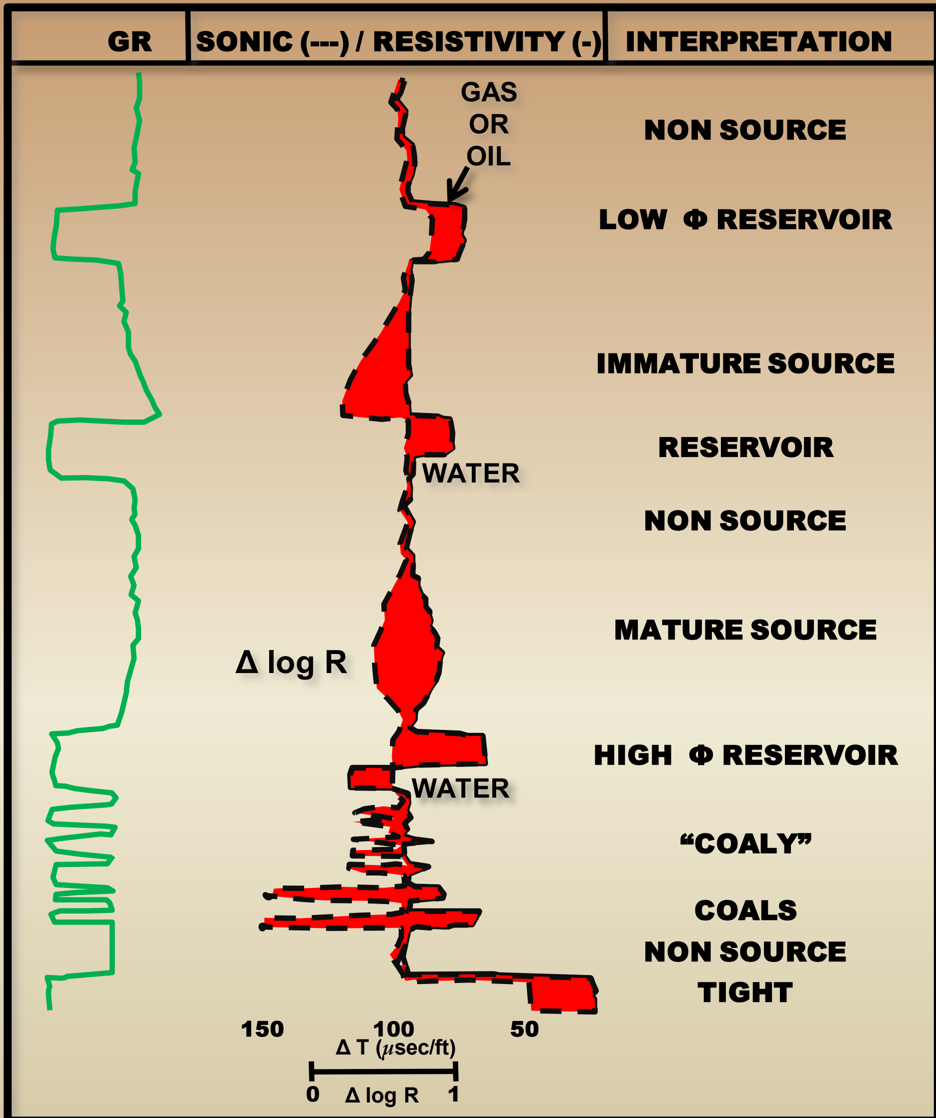
- *Non-Source Rocks - also contain small amounts of organic matter (< 1 wt. %).*

- *Organic-rich sediments have a higher resistivity than organic-lean sediments*

- *Organic-rich rocks - increase in sonic transit time and an increase in resistivity*

- *Organic-rich rocks can be relatively highly radioactive (higher gamma-ray reading than ordinary shales and limestones) Schmoker, 1981*

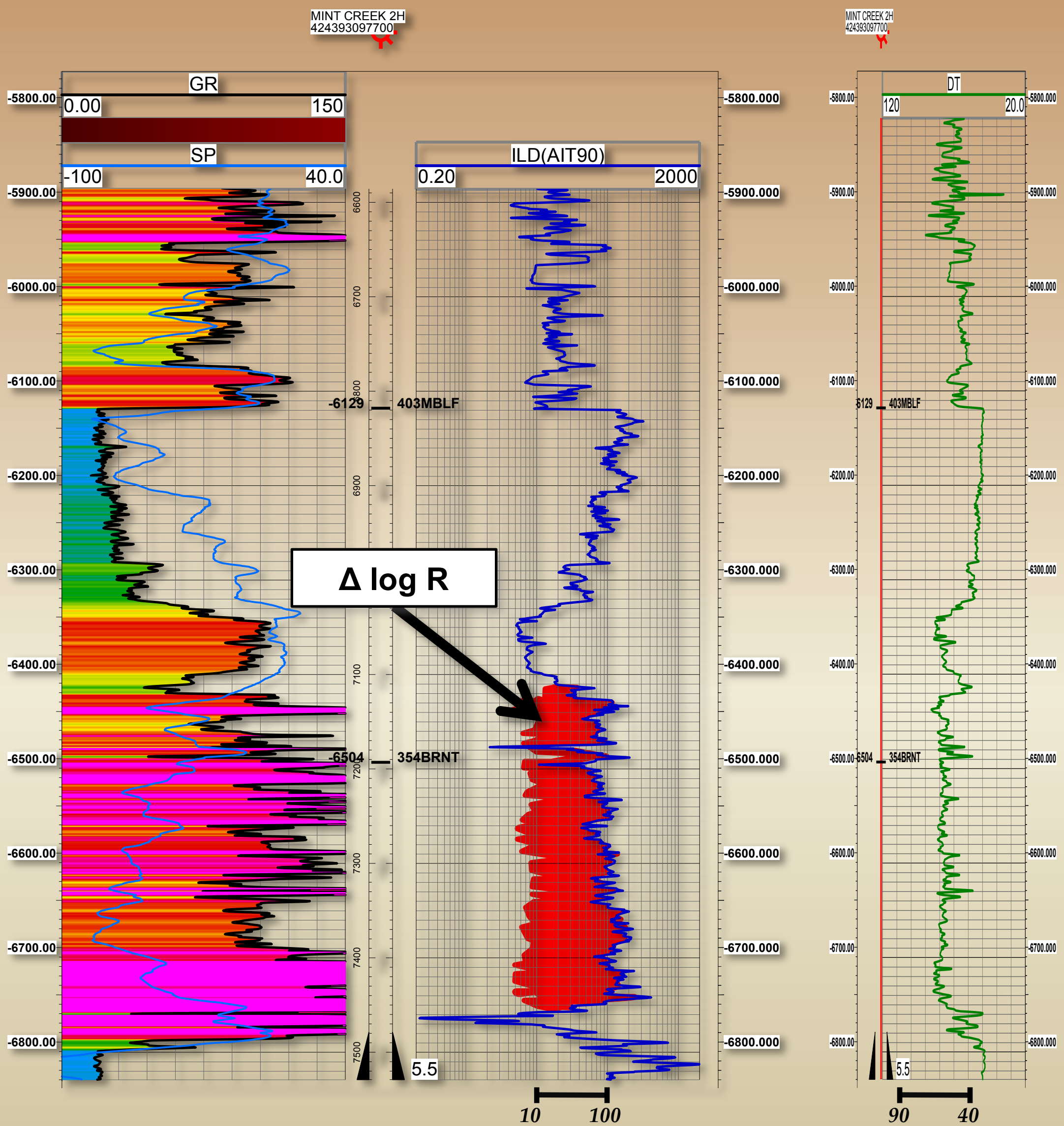
Schematic of Δ log R Response



Schematic guide for the interpretation of a wide variety of features observed on Δ log R overlays

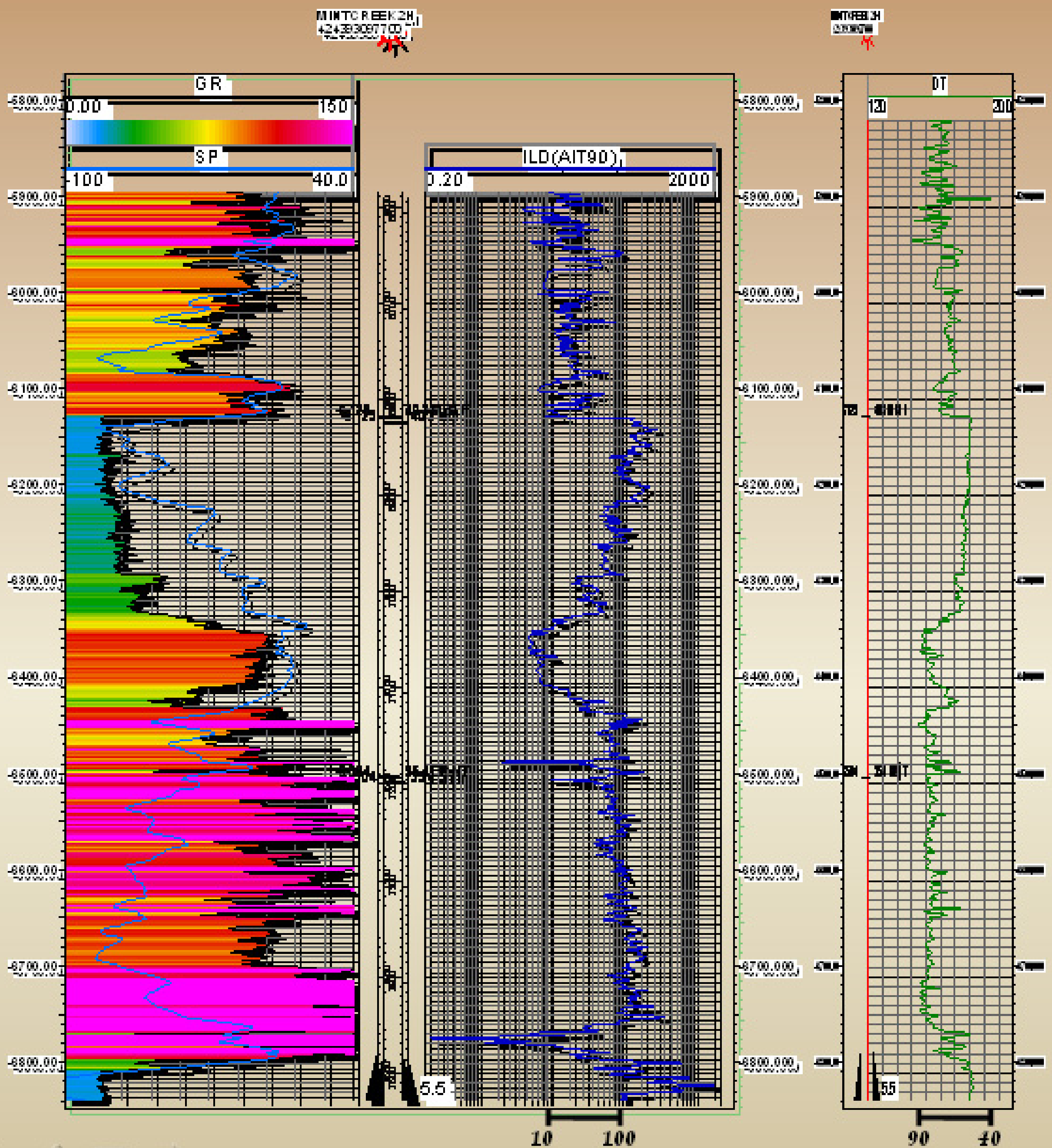
After Passey et al. (1990)

Passey Method In Practice



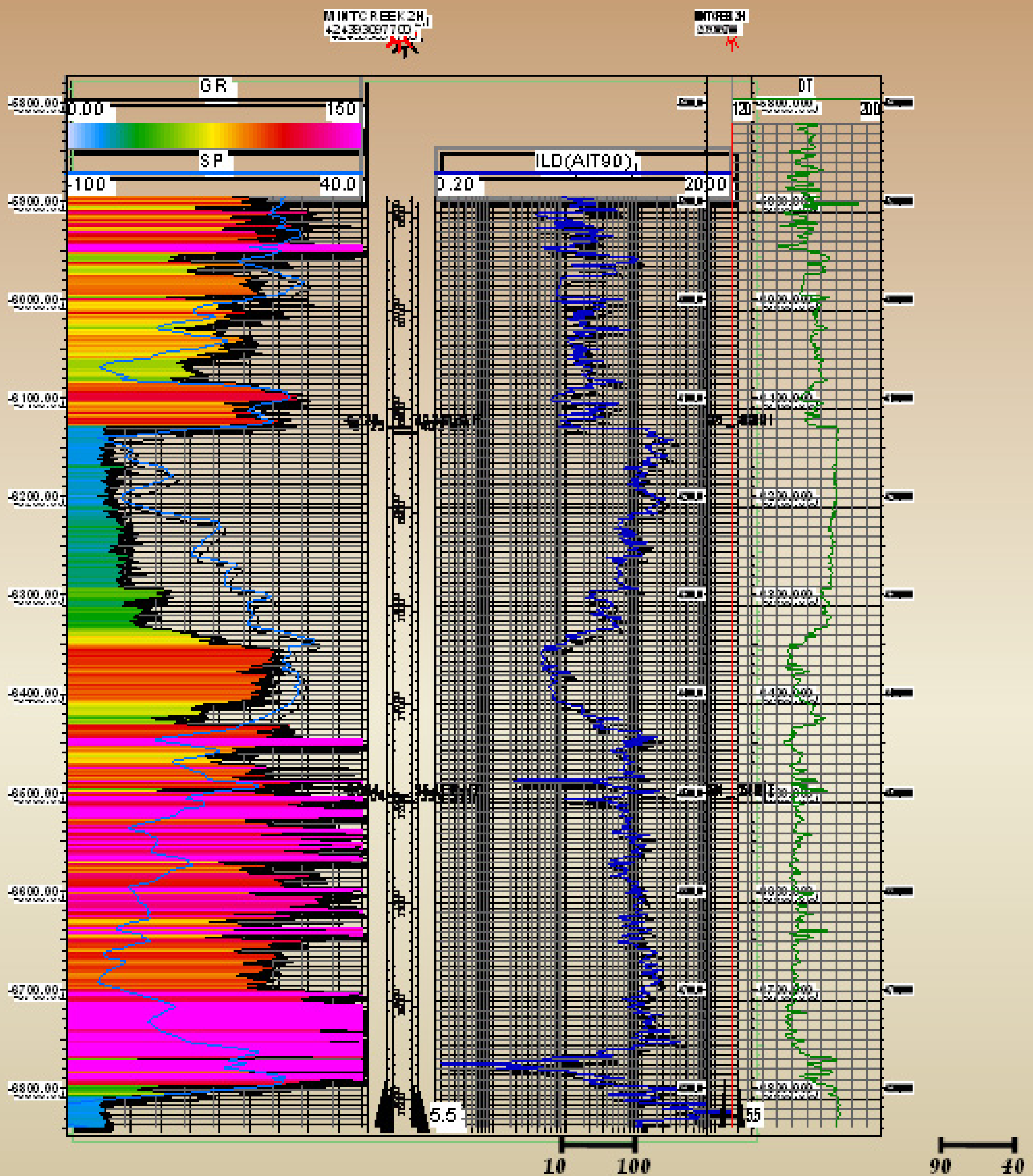
Scale Sonic and Resistivity where 50 μsec/ft equal to 1 decade Resistivity (ohm-m)

Passey Method In Practice



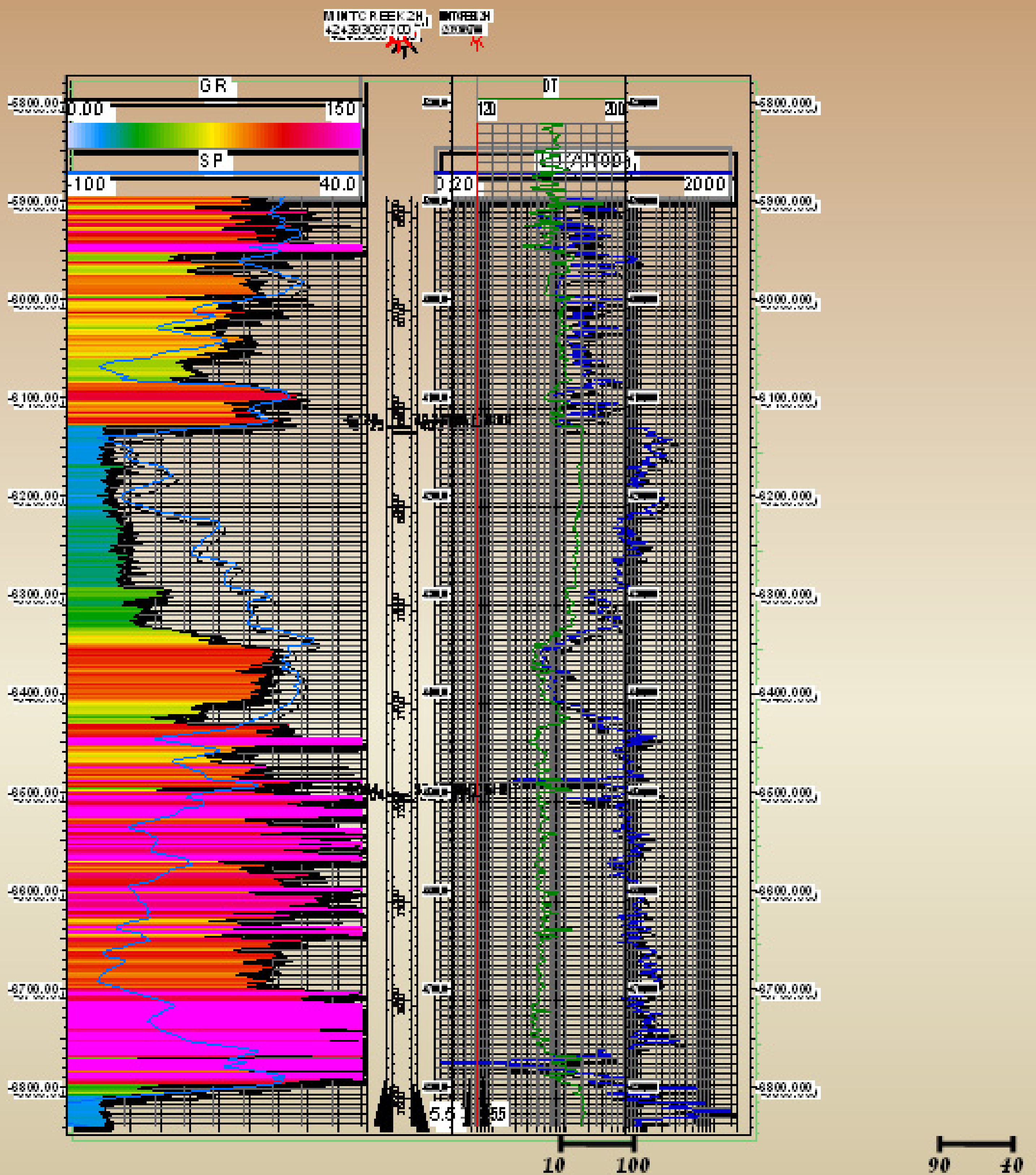
Scale Sonic and Resistivity where 50 μsec/ft equal to 1 decade Resistivity (ohm-m)

Passey Method In Practice



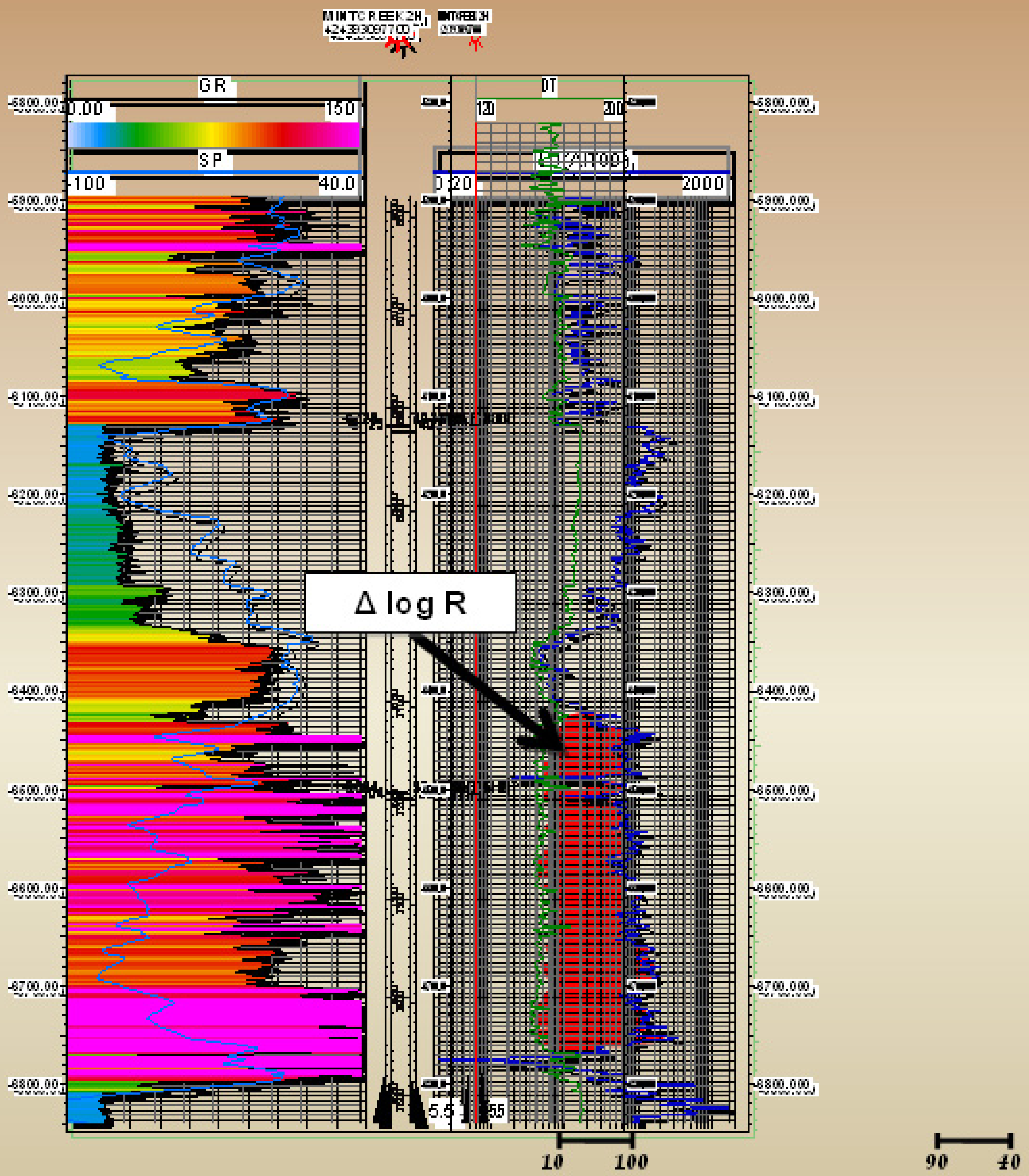
Scale Sonic and Resistivity where 50 μsec/ft equal to 1 decade Resistivity (ohm-m)

Passey Method In Practice



Scale Sonic and Resistivity where 50 µsec/ft equal to 1 decade Resistivity (ohm-m)

Passey Method In Practice



Scale Sonic and Resistivity where 50 µsec/ft equal to 1 decade Resistivity (ohm-m)

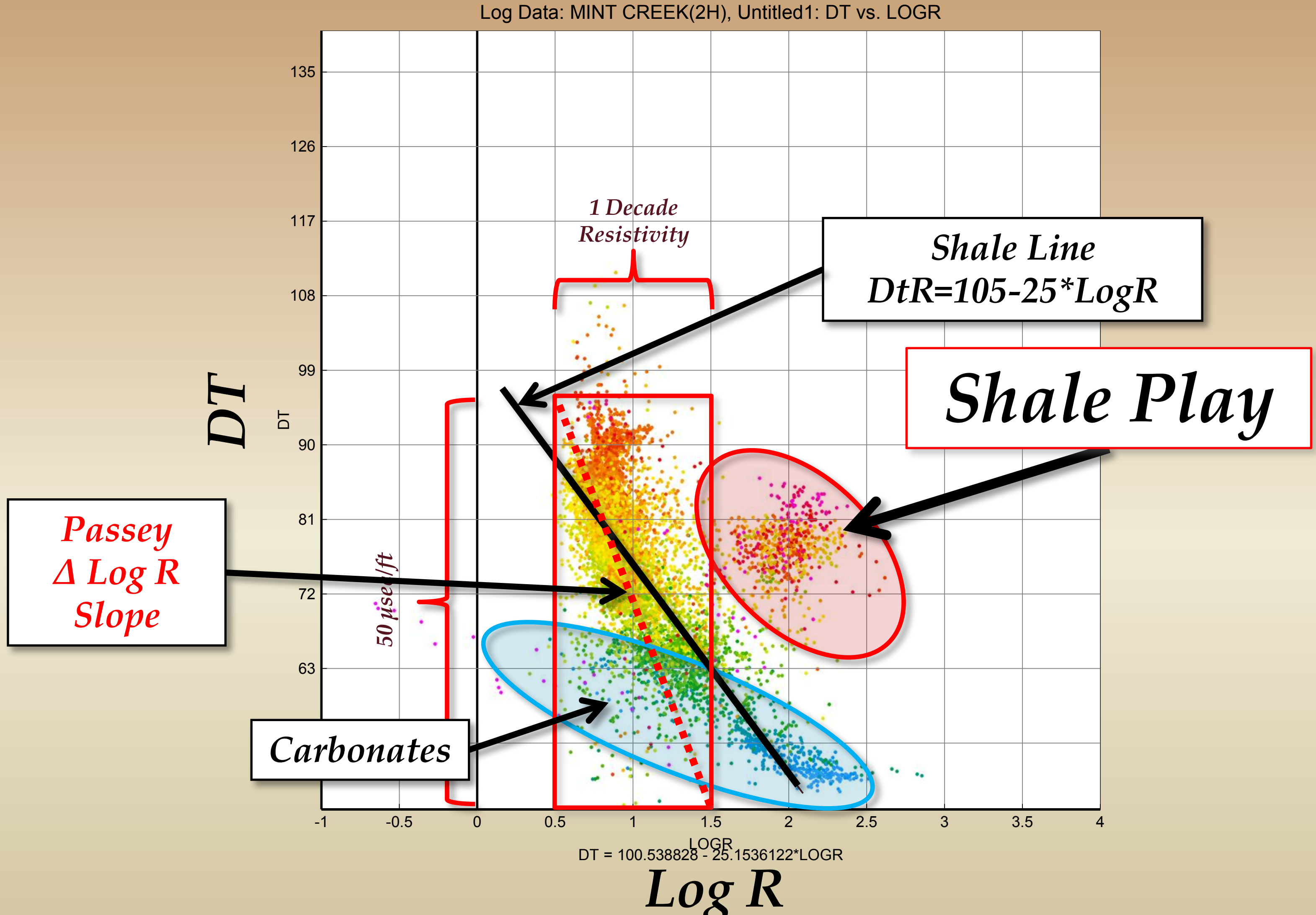
Modified Procedure

1. Calculate LogR of all Resistivity logs
2. Cross-Plot LogR vs Sonic (DT)*
3. Determine low Resistivity Shale line
4. Calculate new Sonic (pseudo-sonic DtR) from Shale line [DtR=b-m*LogR]
5. Overlay pseudo-sonic (DtR) over sonic
6. Highlight cross over of pseudo-sonic with DT
7. Interpret Organic shale section

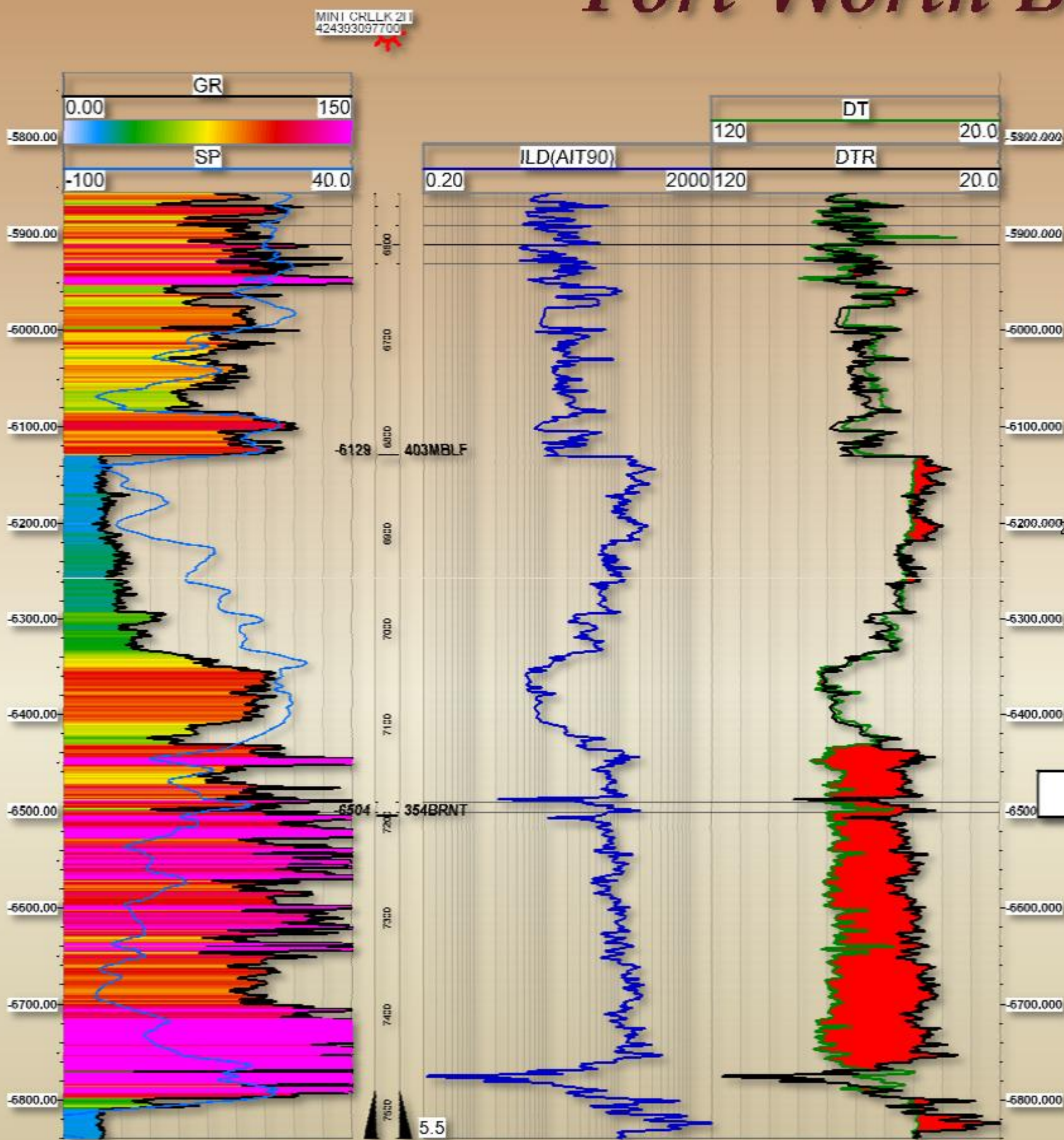
*Use Porosity log in place of DT

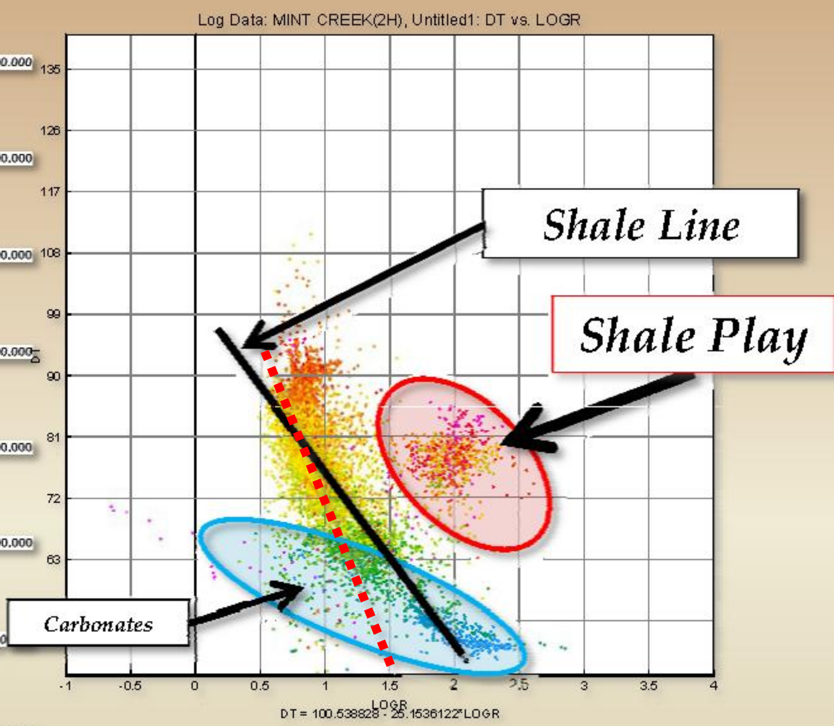
Cross Plot Analysis

Barnett Core (Mississippian)
Fort Worth Basin



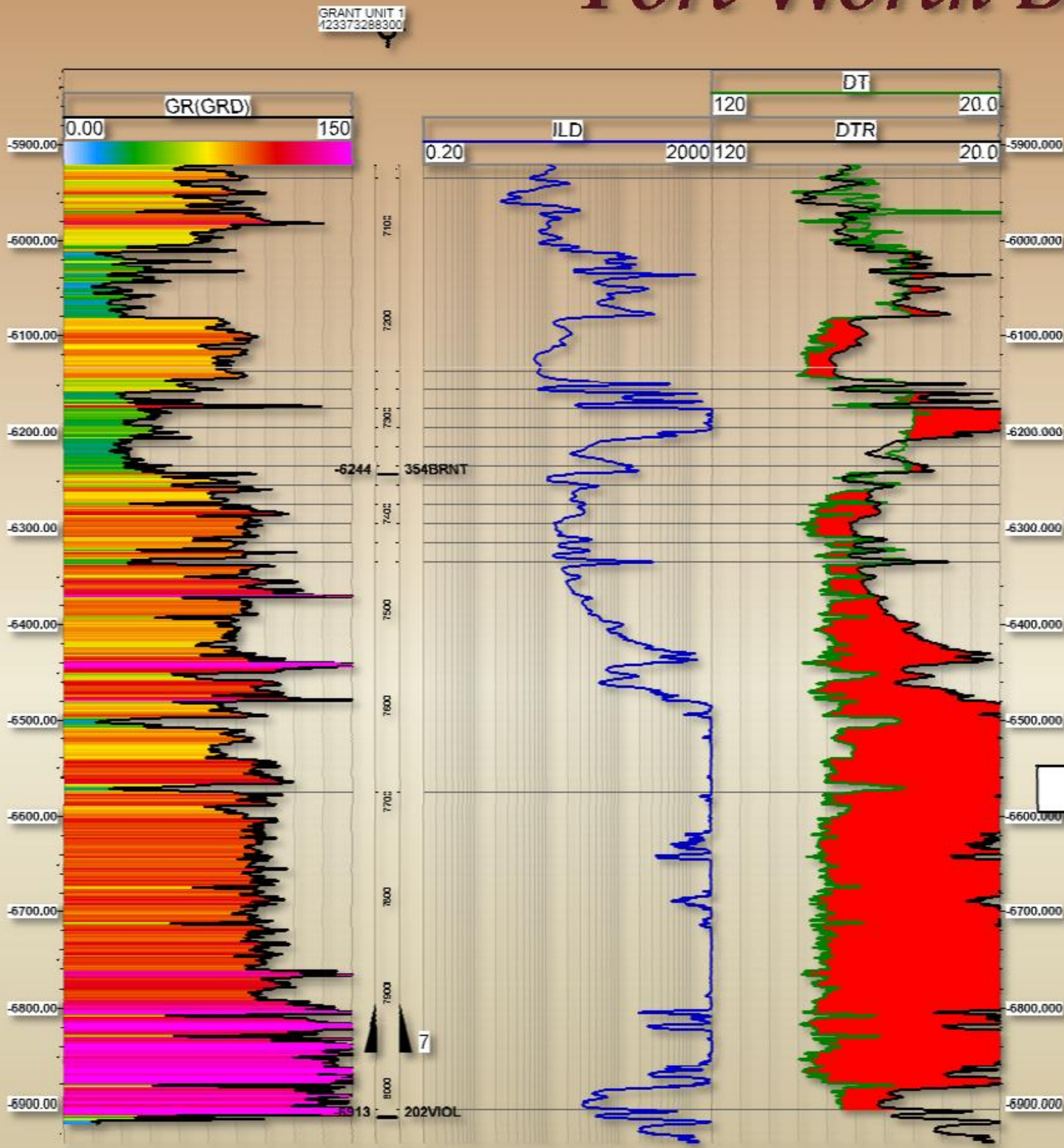
Barnett Core (Mississippian)
Fort Worth Basin

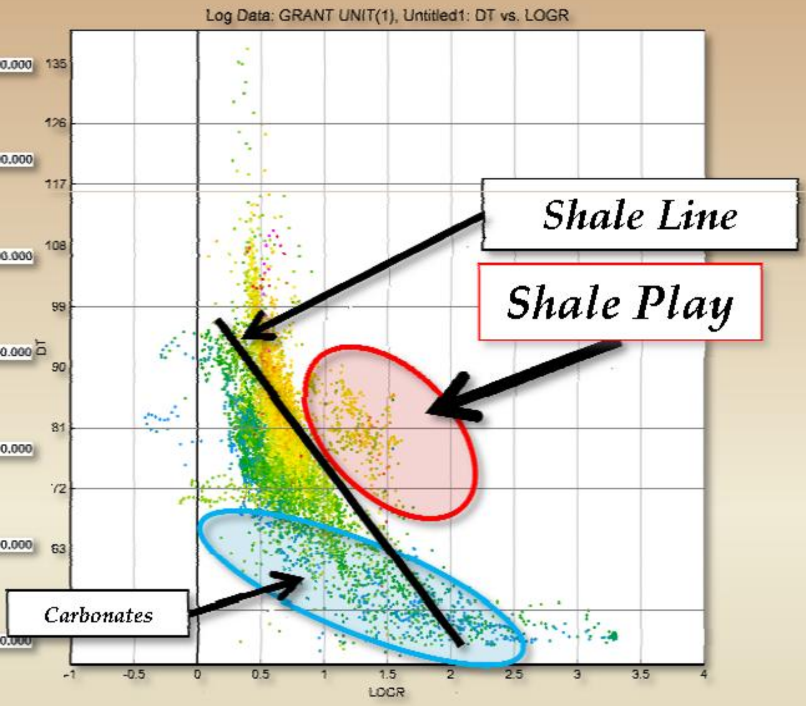




*DtR=105-25*LogR*

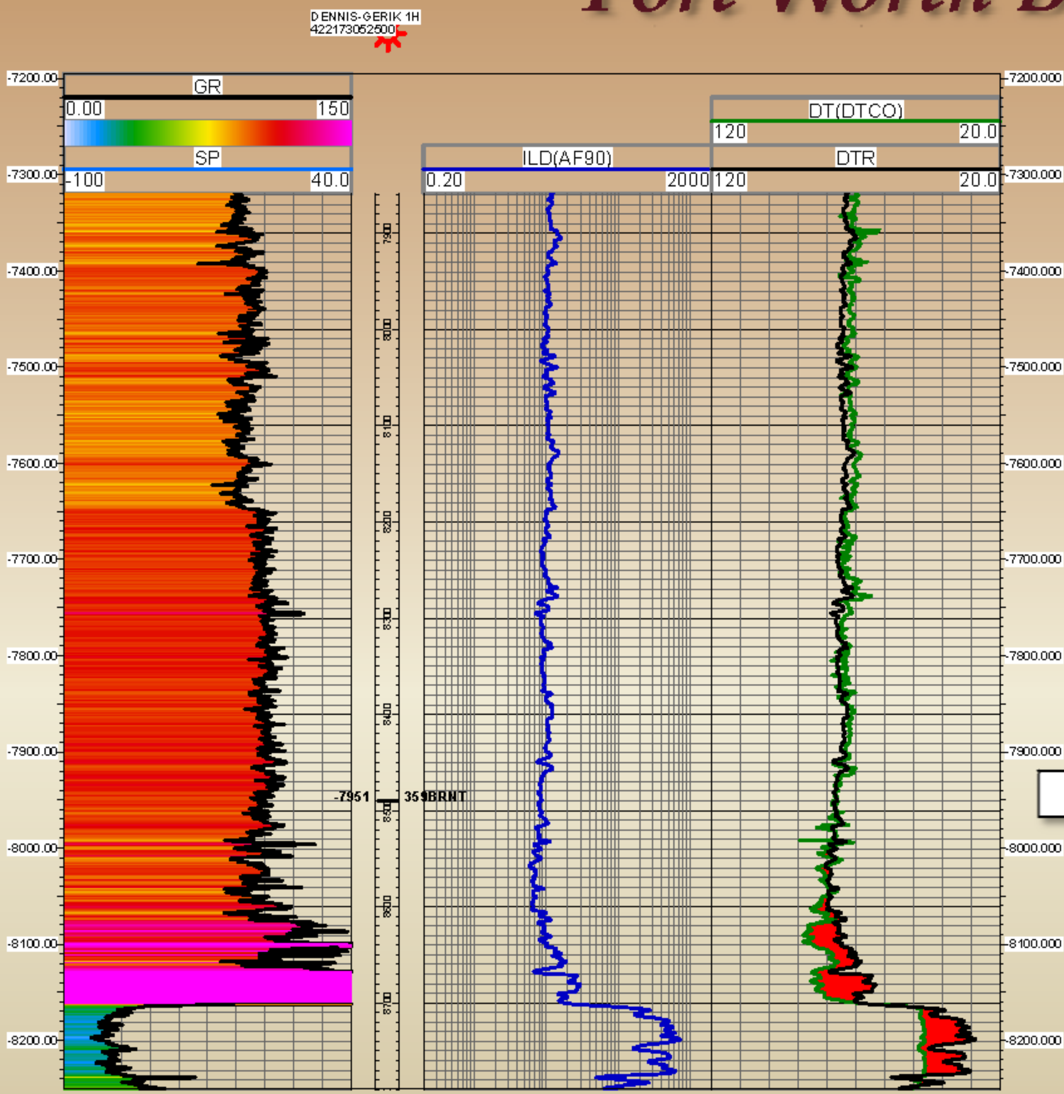
Barnett "Oil" (Mississippian) Fort Worth Basin

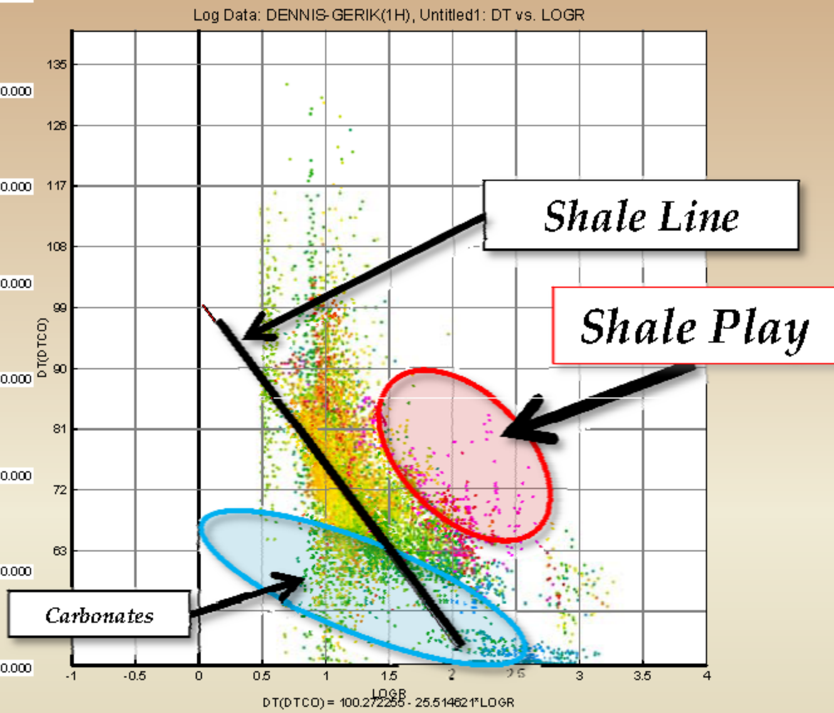




*DtR=105-25*LogR*

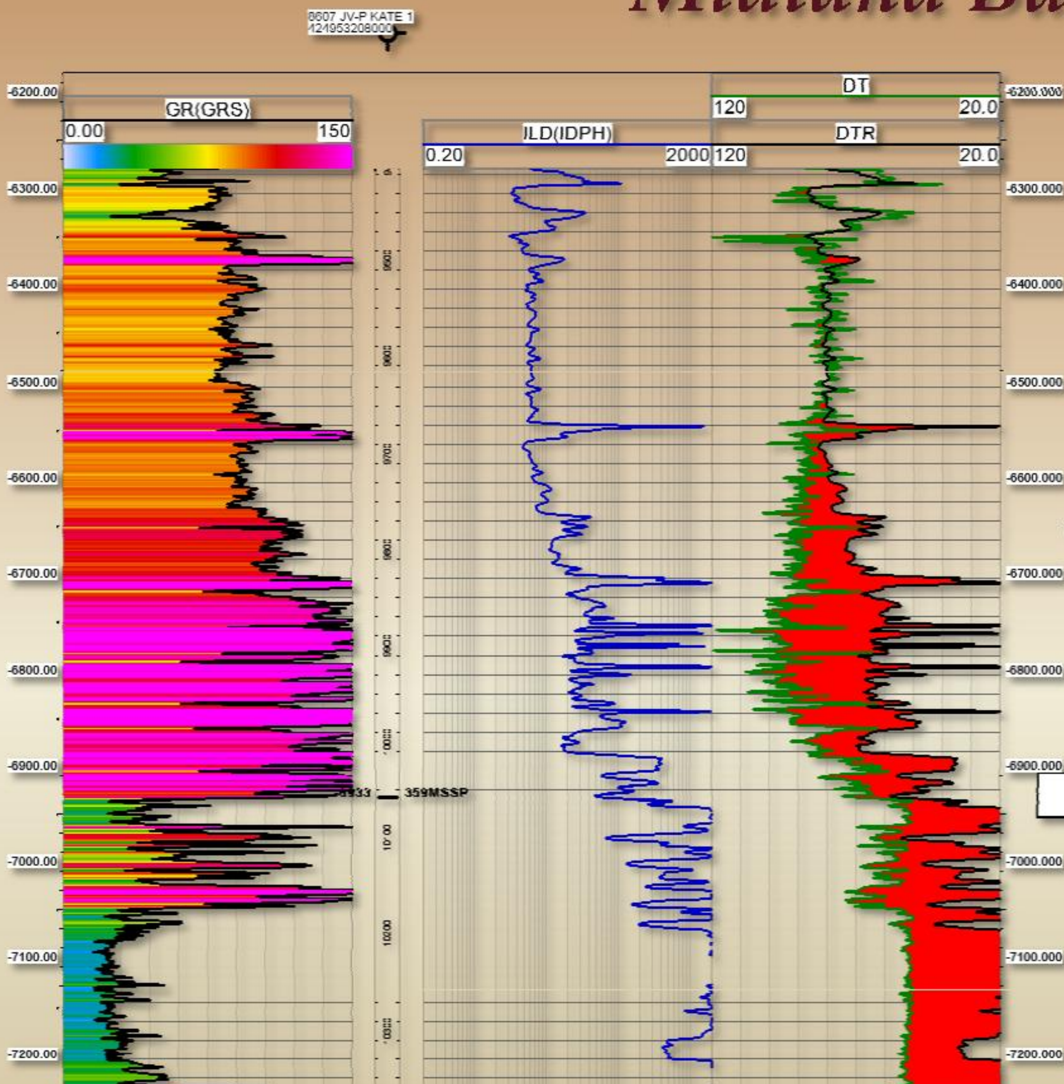
Barnett South (Mississippian)
Fort Worth Basin

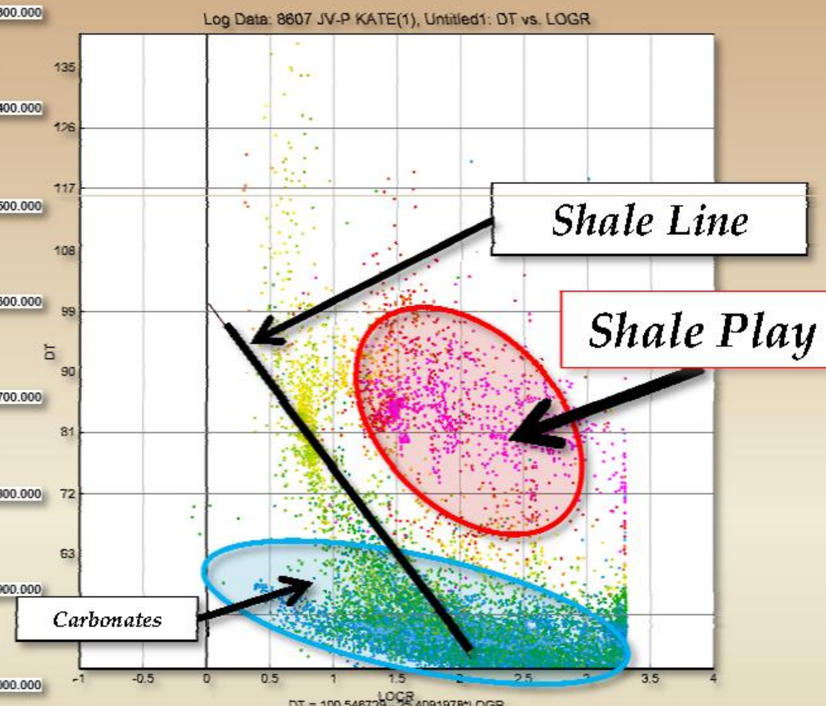




*DtR=105-25*LogR*

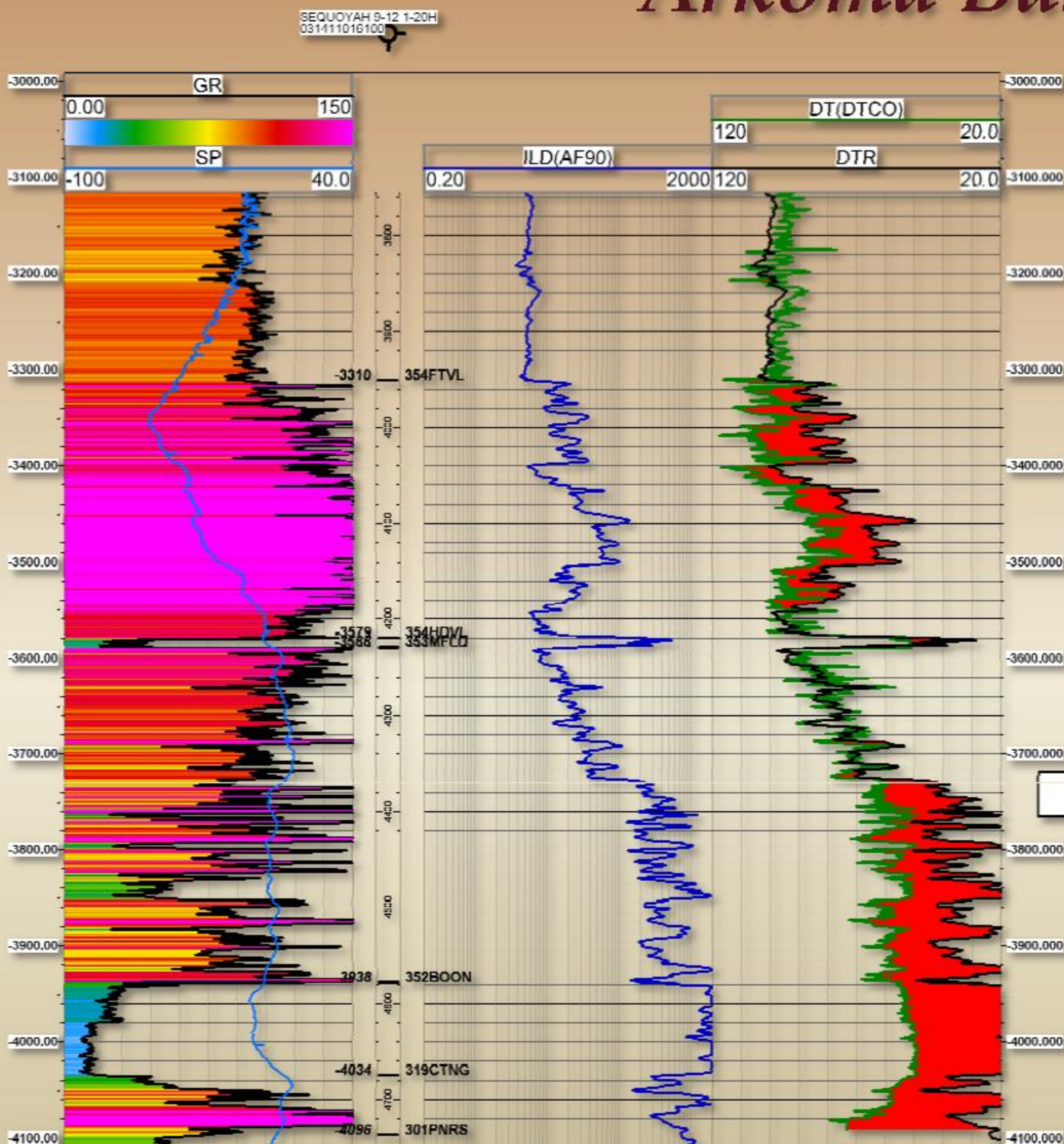
Barnett (Mississippian)
Midland Basin

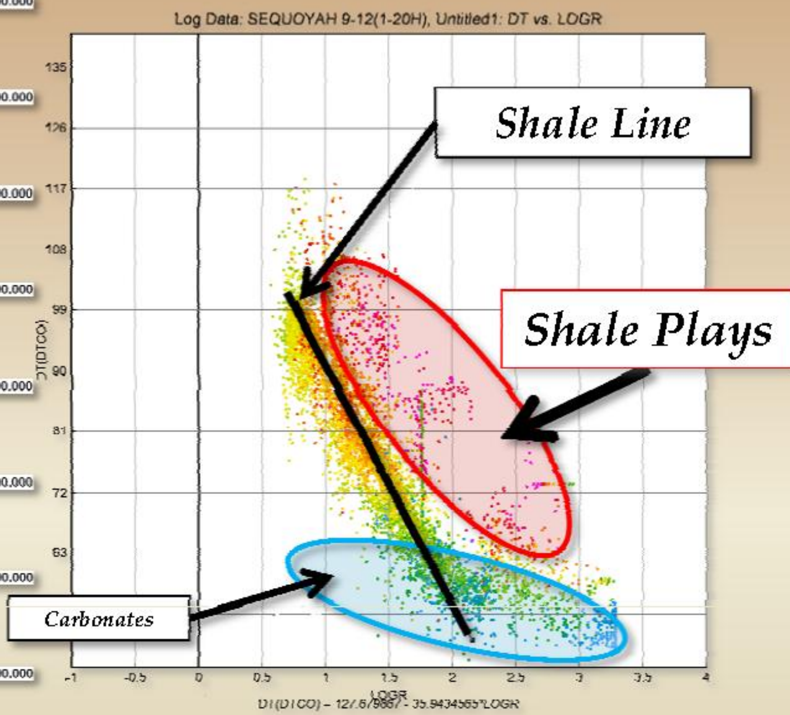




*DtR=100-25*LogR*

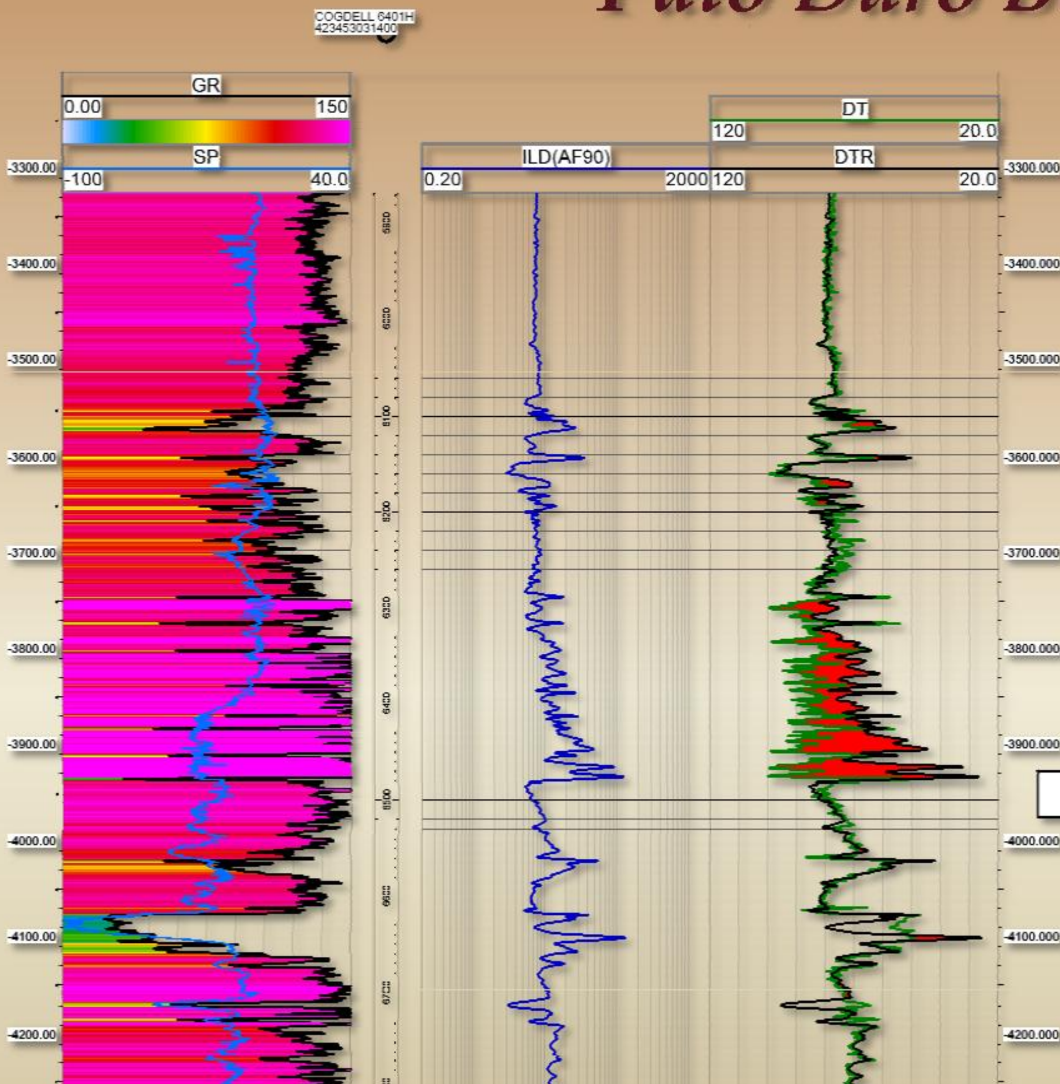
Fayetteville (Mississippian) Arkoma Basin

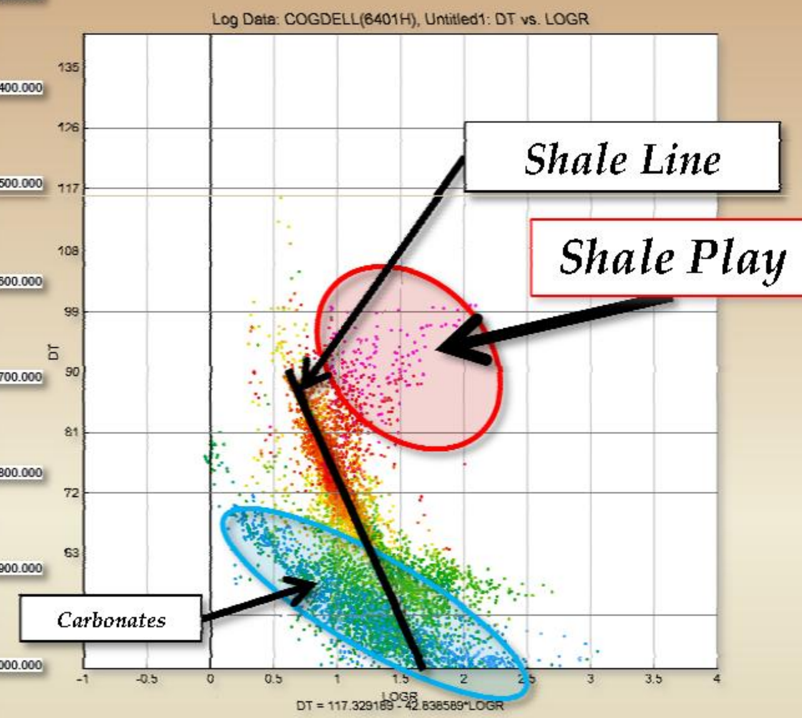




DtR=127-35*LogR

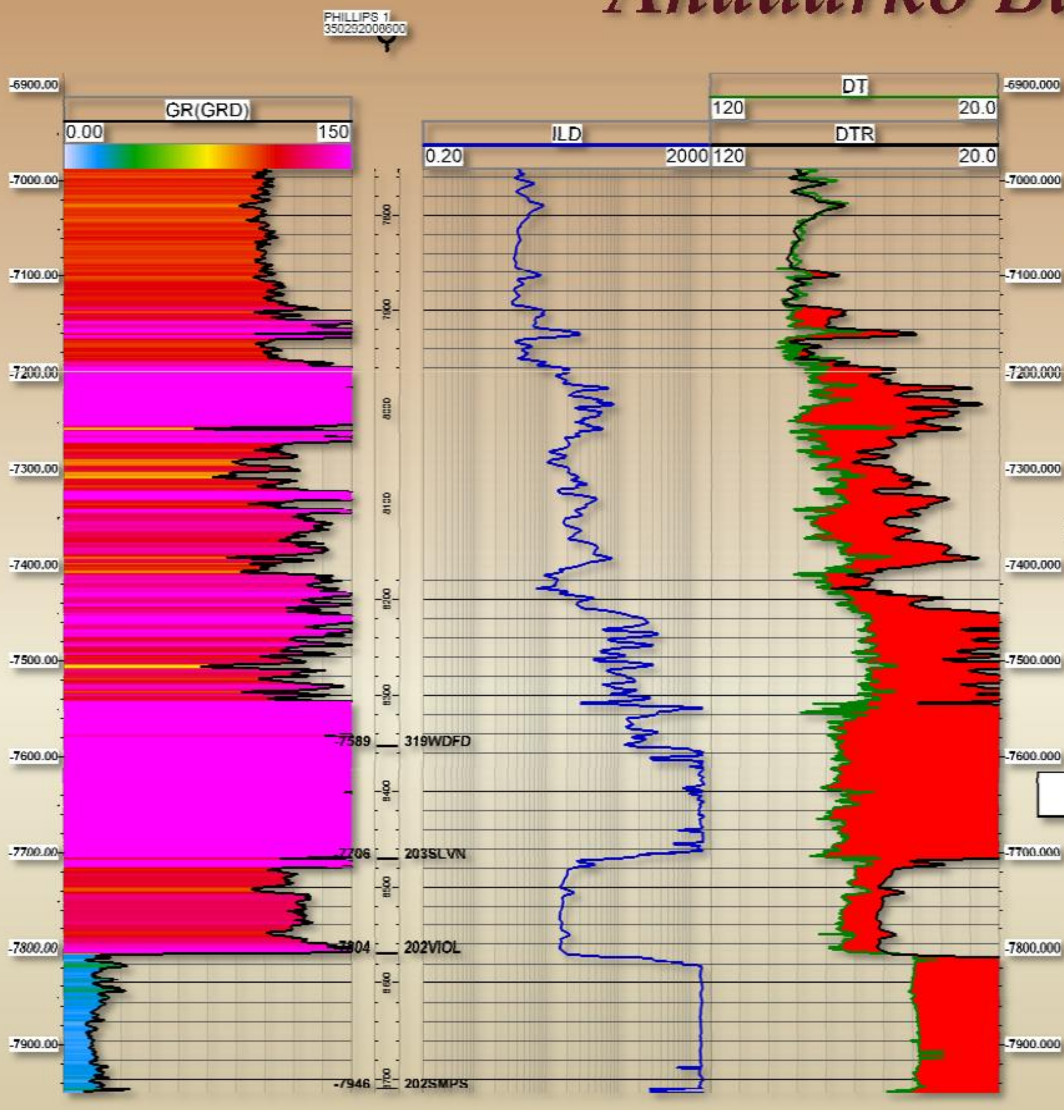
Bend – (Pennsylvanian)
Palo Duro Basin

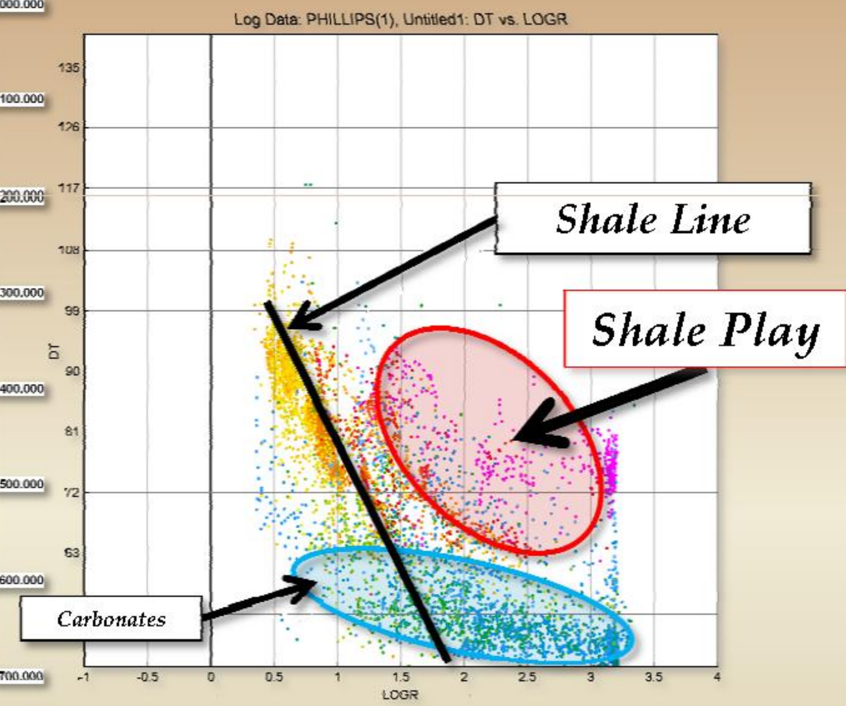




*DtR=117-43*LogR*

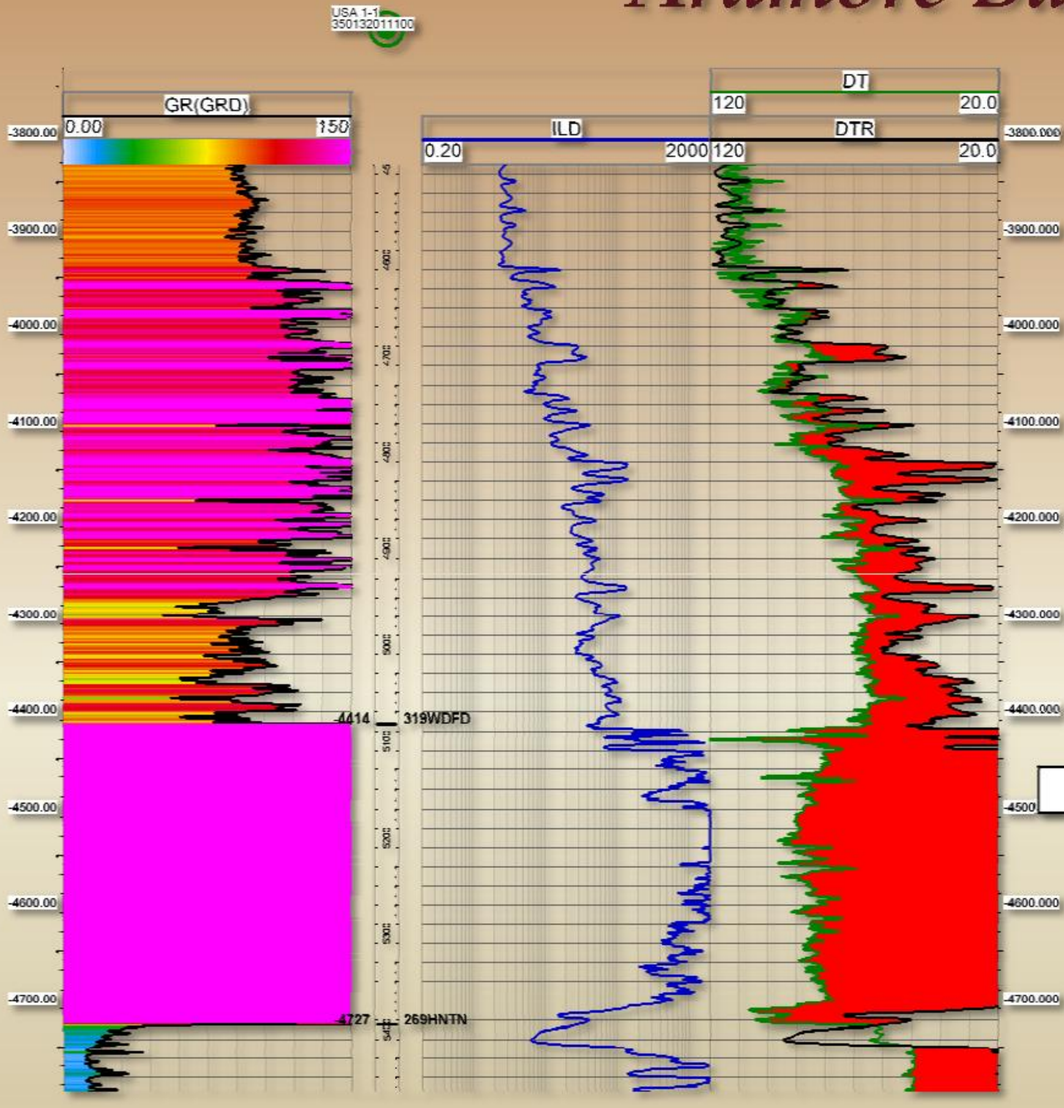
Woodford (Miss-Devonian)
Anadarko Basin

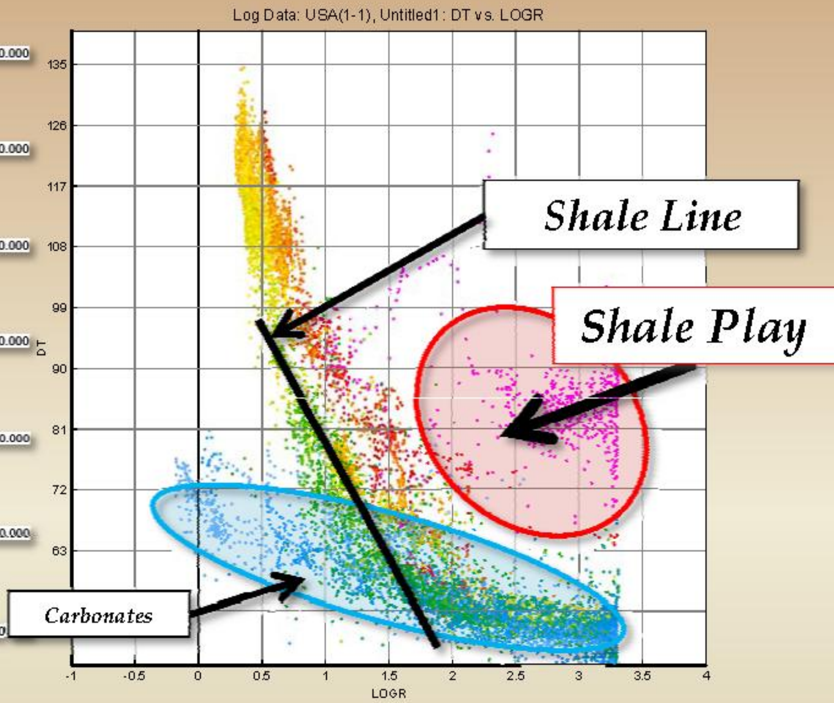




*DtR=121-49*LogR*

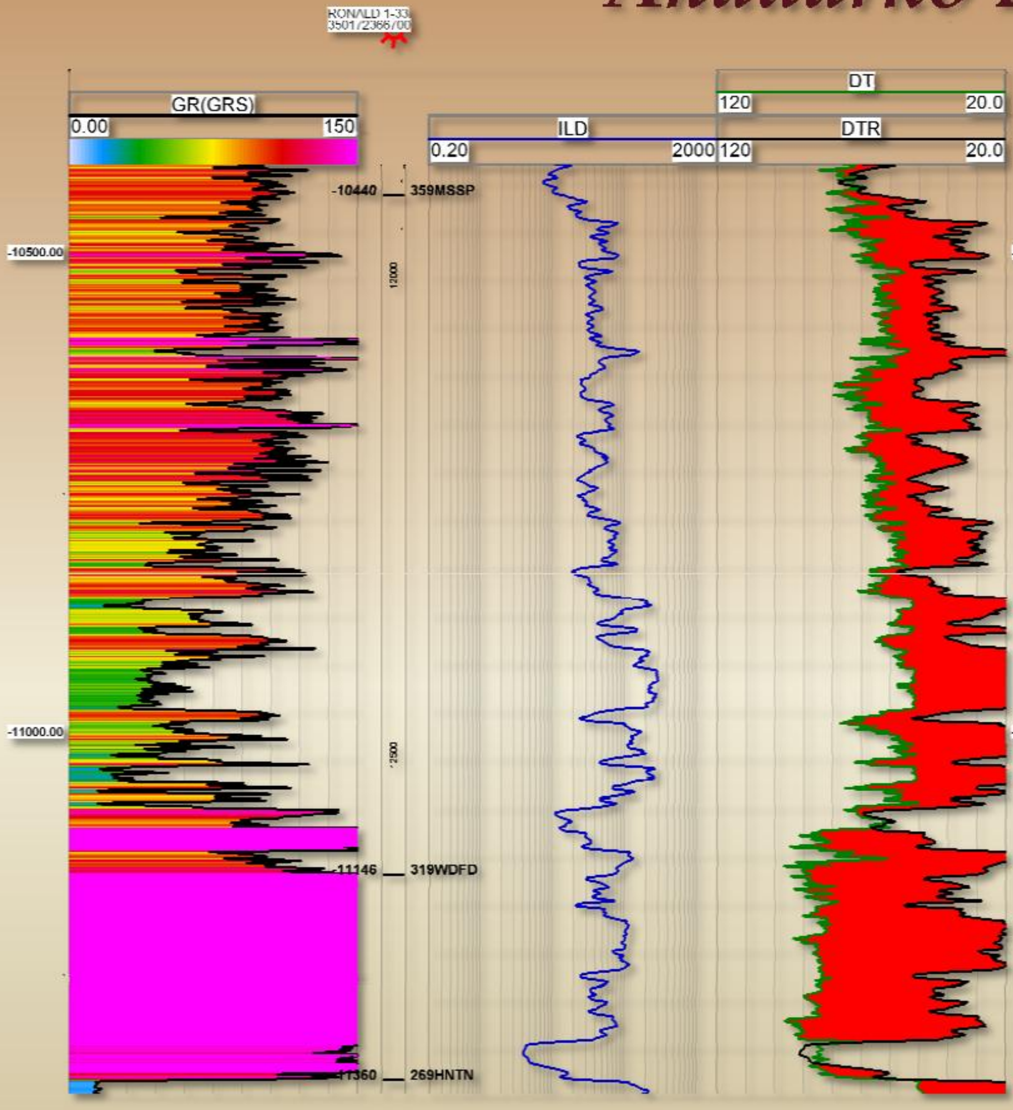
Woodford (Miss-Devonian) Ardmore Basin

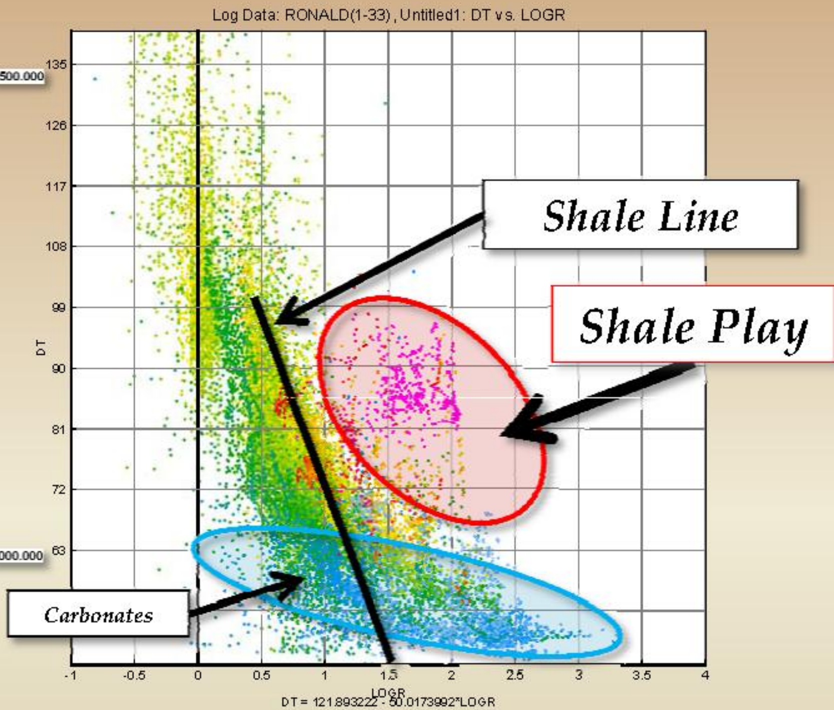




*DtR=139-55*LogR*

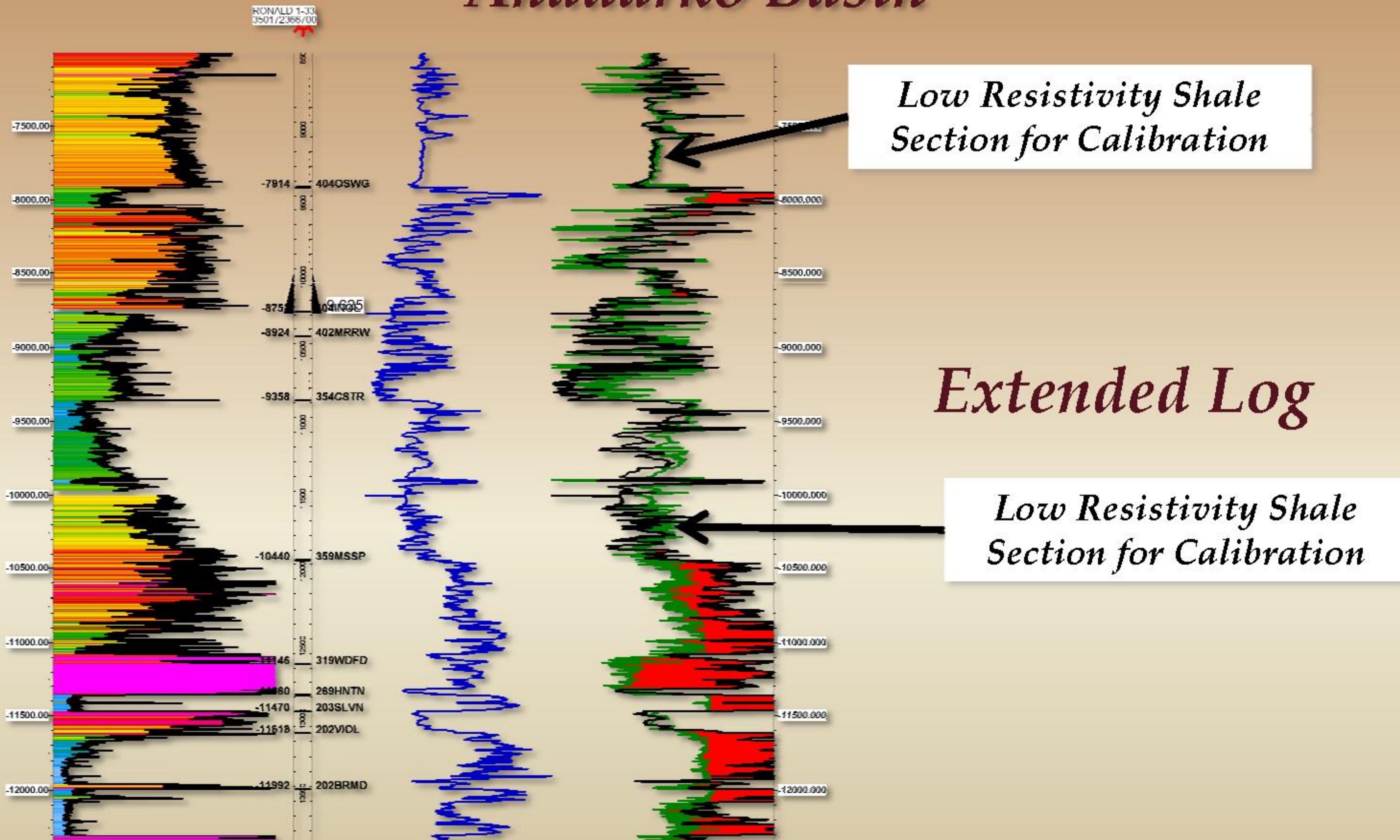
Examples – Woodford (Cana) Anadarko Basin





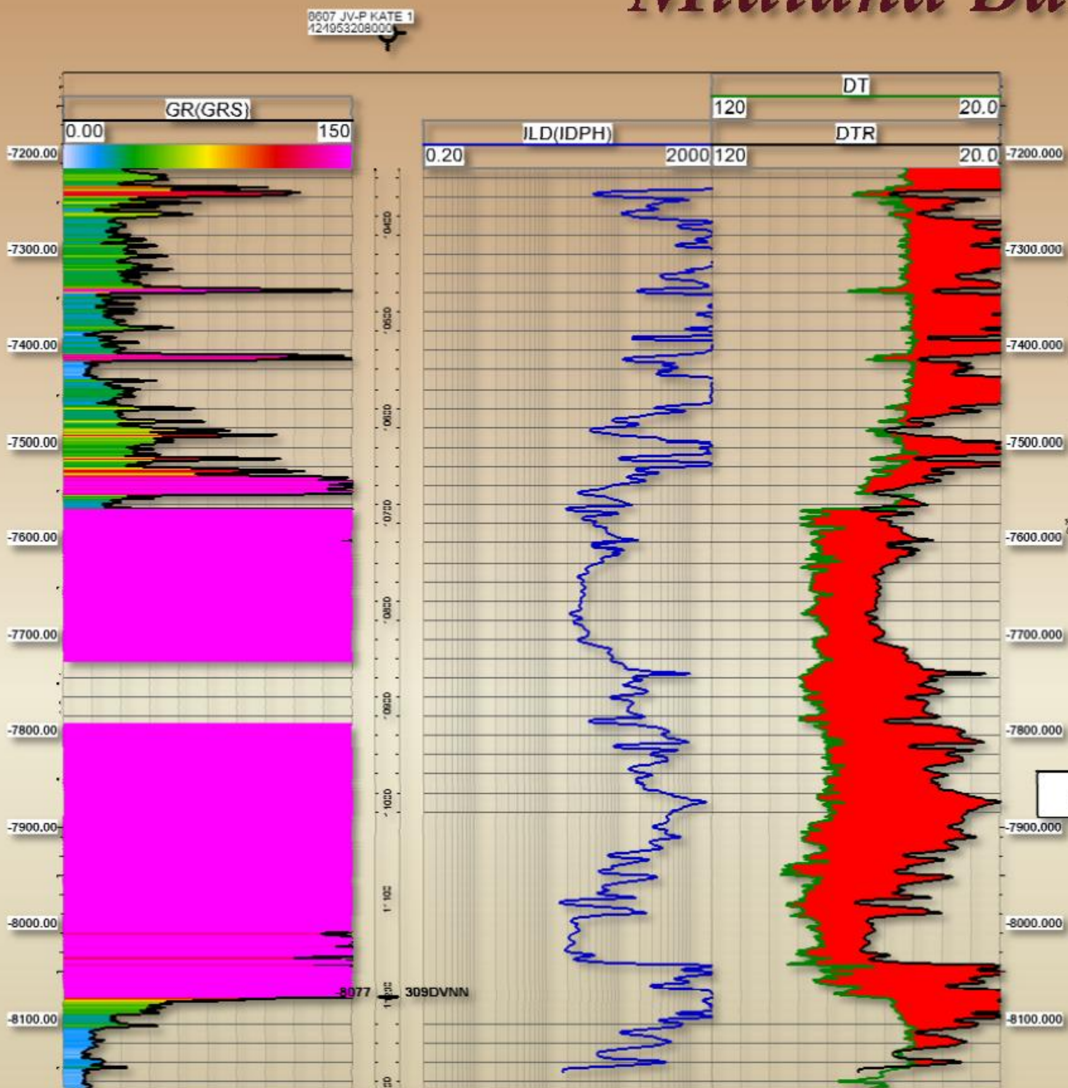
*DtR=121-49*LogR*

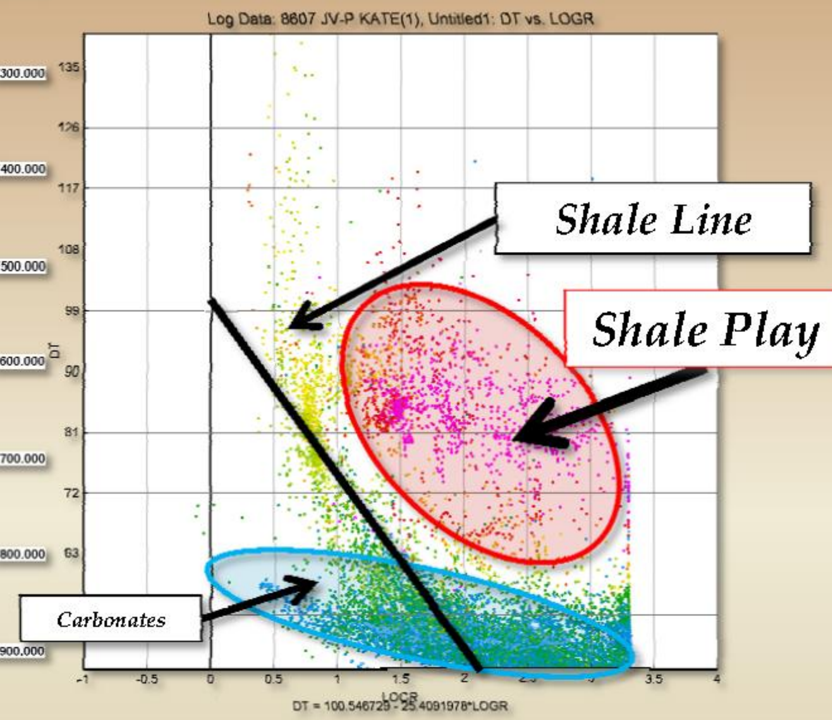
Woodford (Cana) (Miss-Devonian) Anadarko Basin



Extended Log

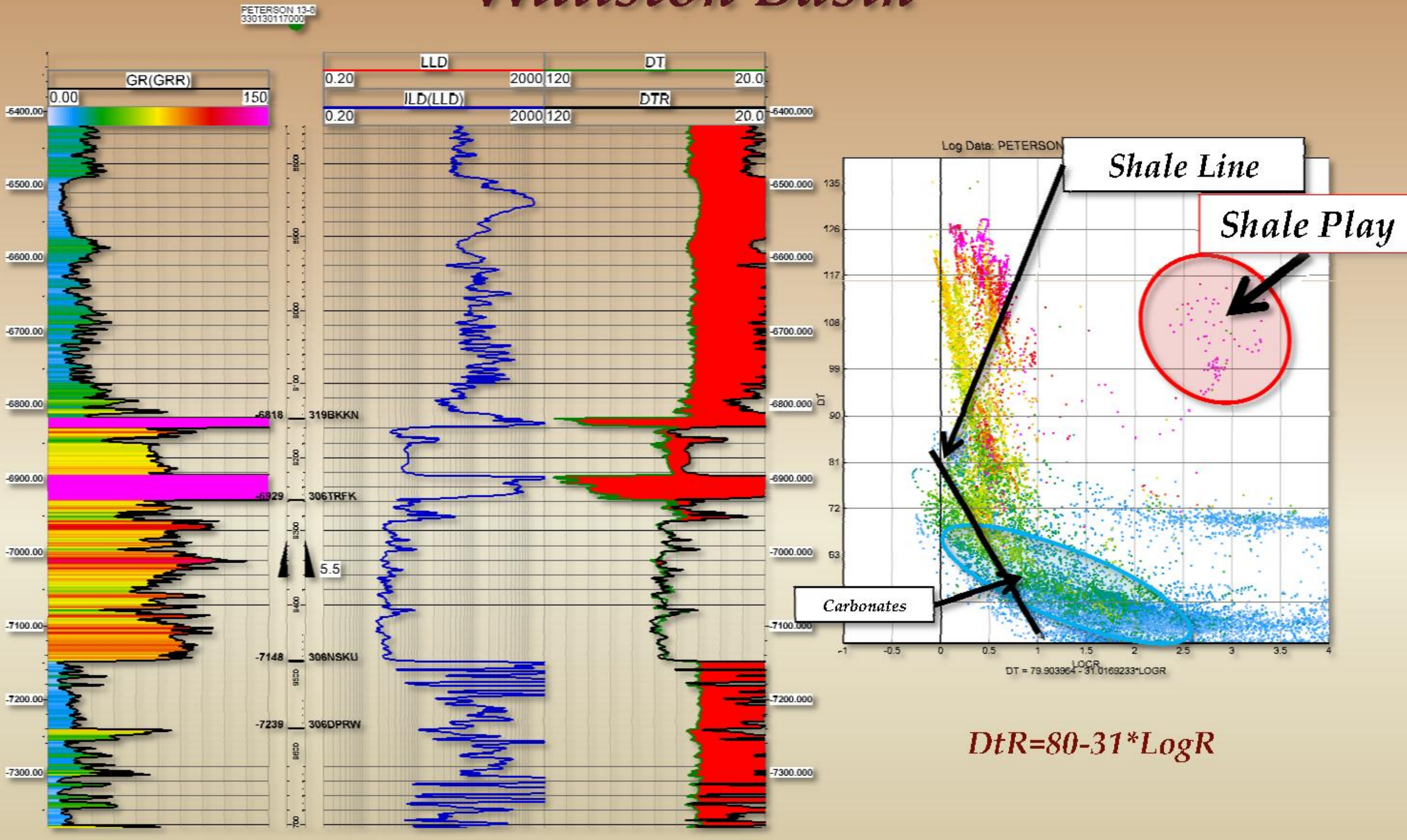
Woodford (Miss-Devonian)
Midland Basin





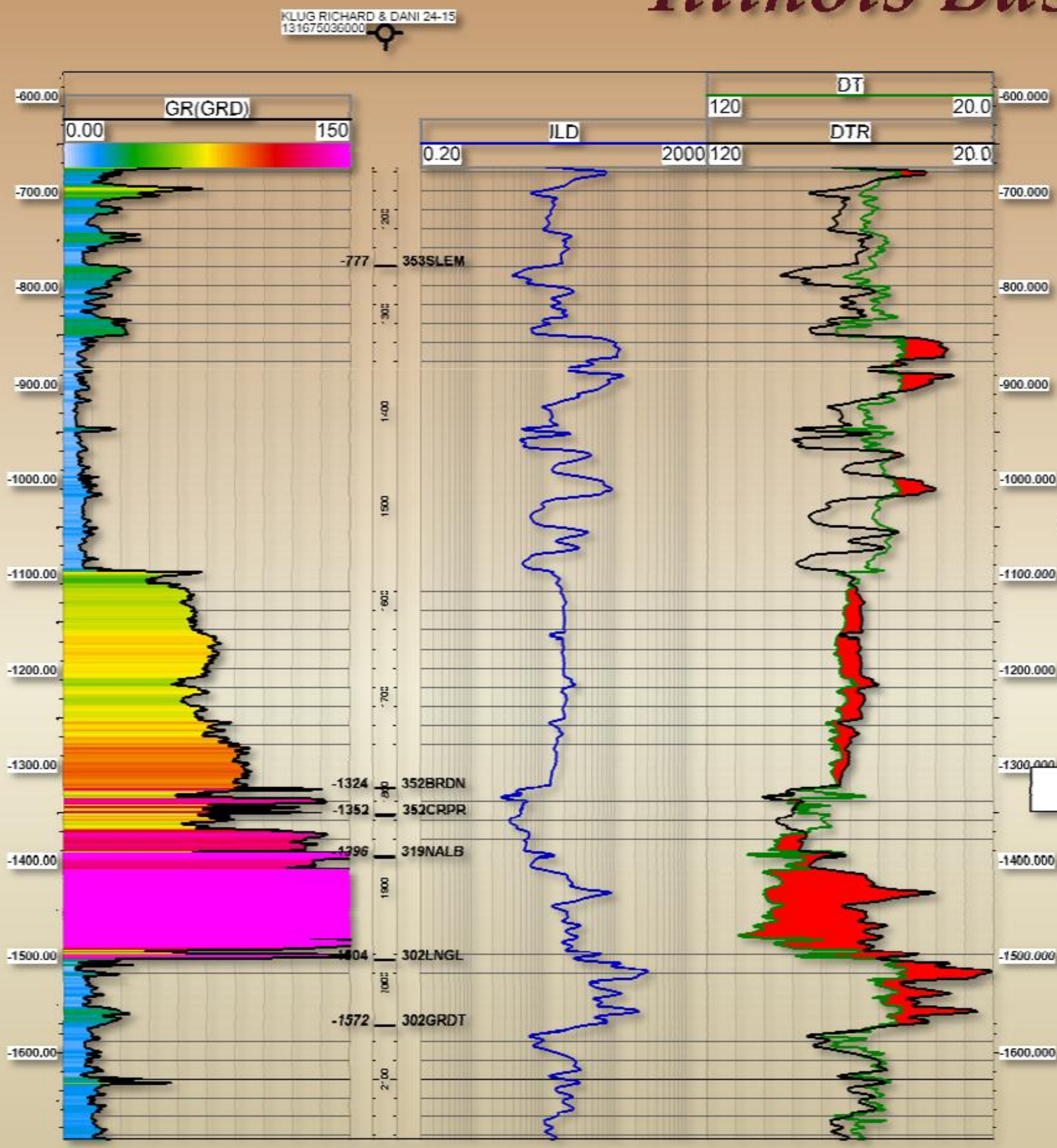
*DtR=100-25*LogR*

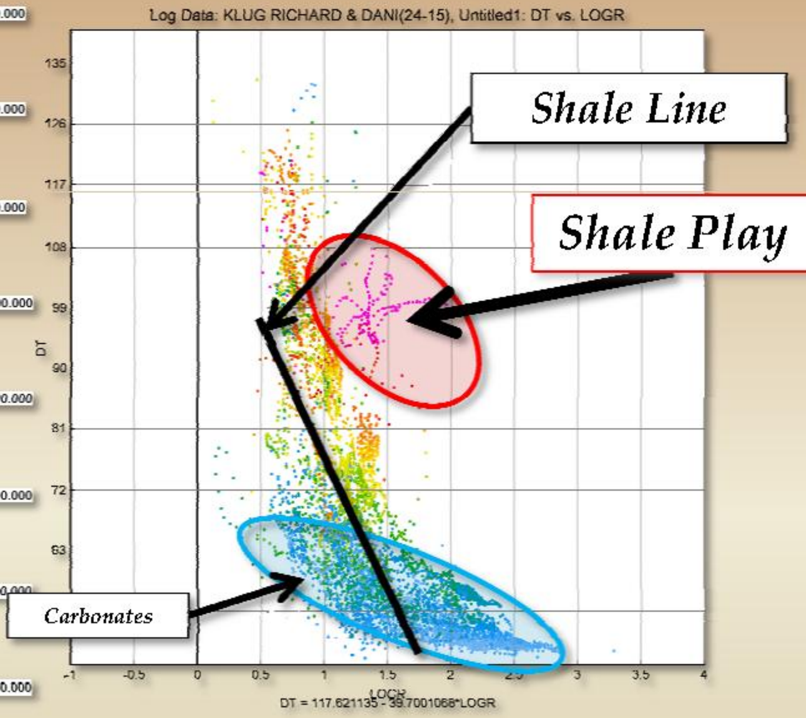
Bakken – (Miss-Devonian) Williston Basin



*DtR=80-31*LogR*

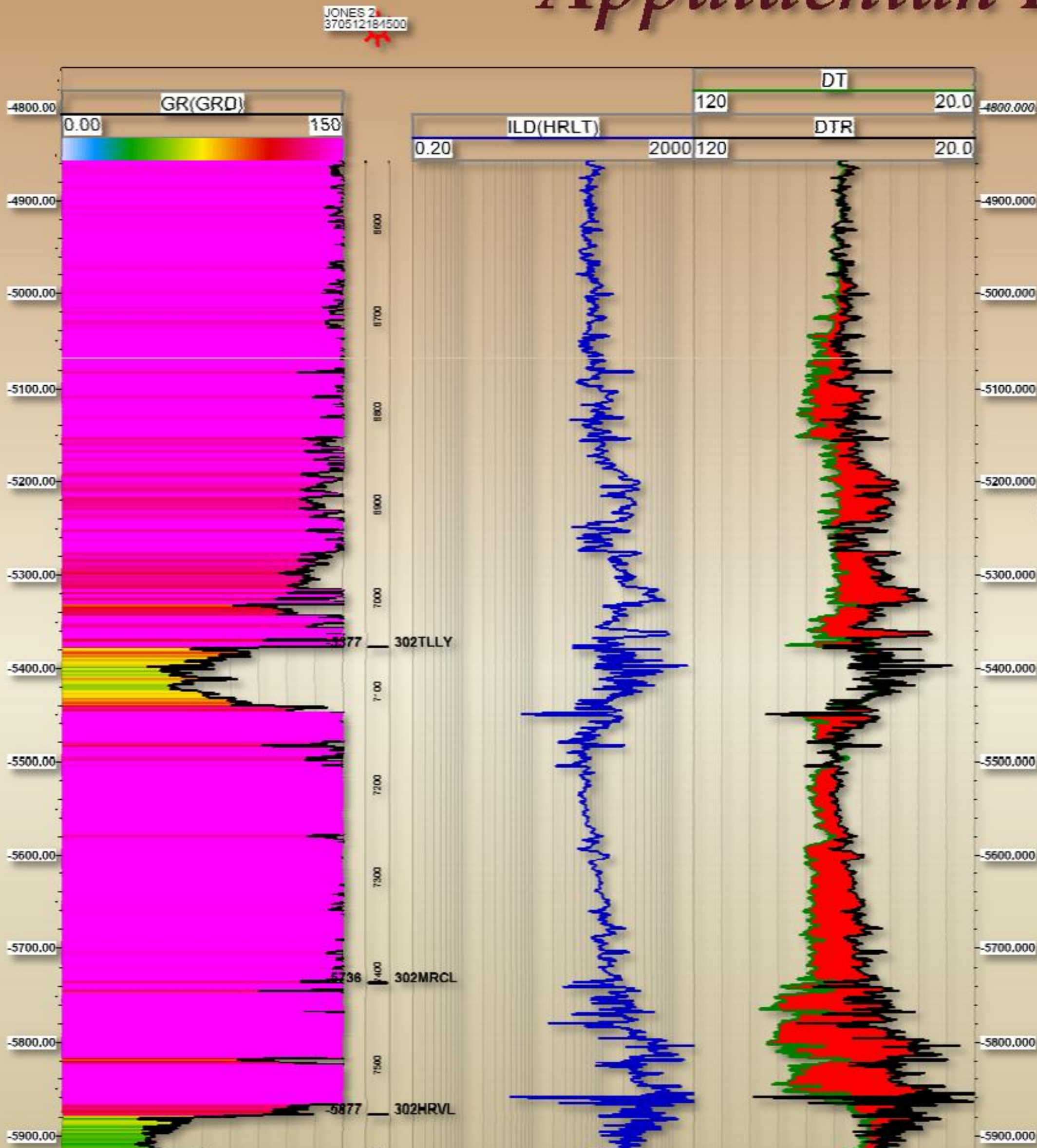
New Albany (Devonian) Illinois Basin

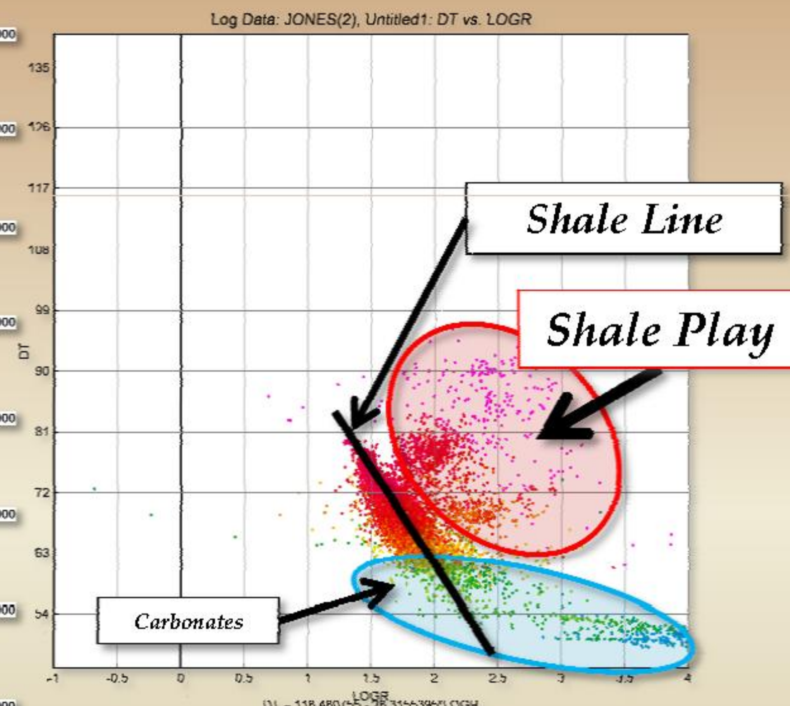




*DtR=117-39*LogR*

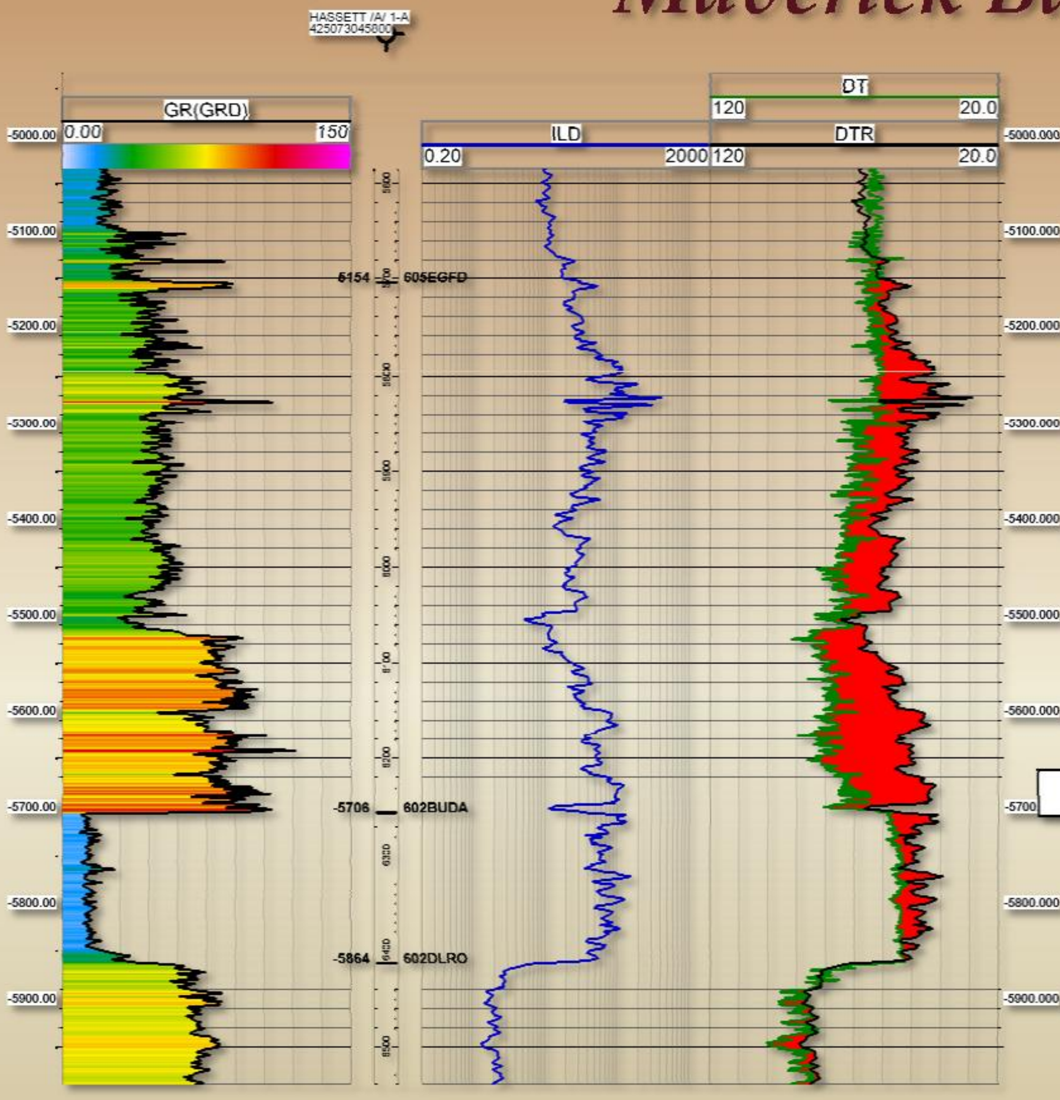
Marcellus (Devonian)
Appalachian Basin

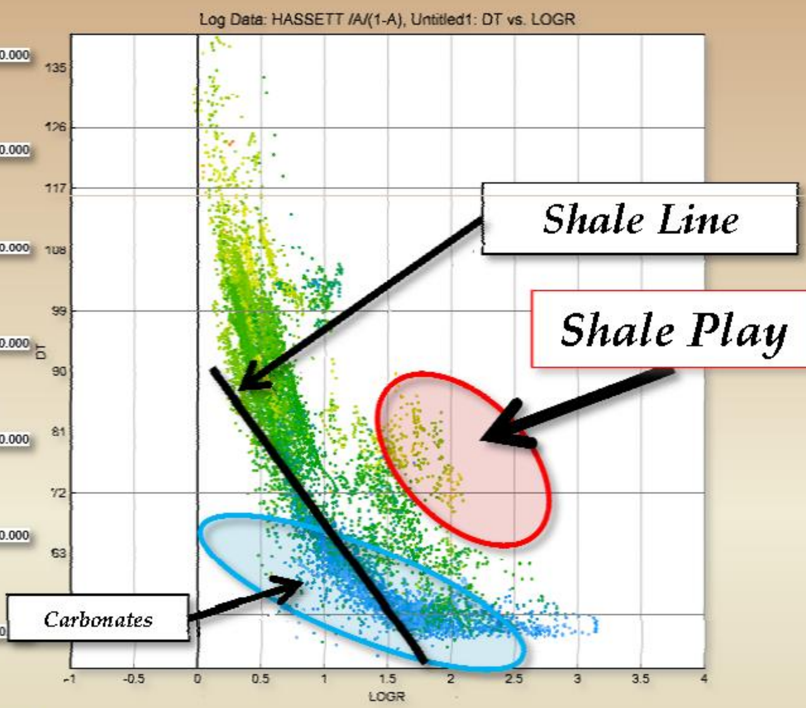




*DtR=118-28*LogR*

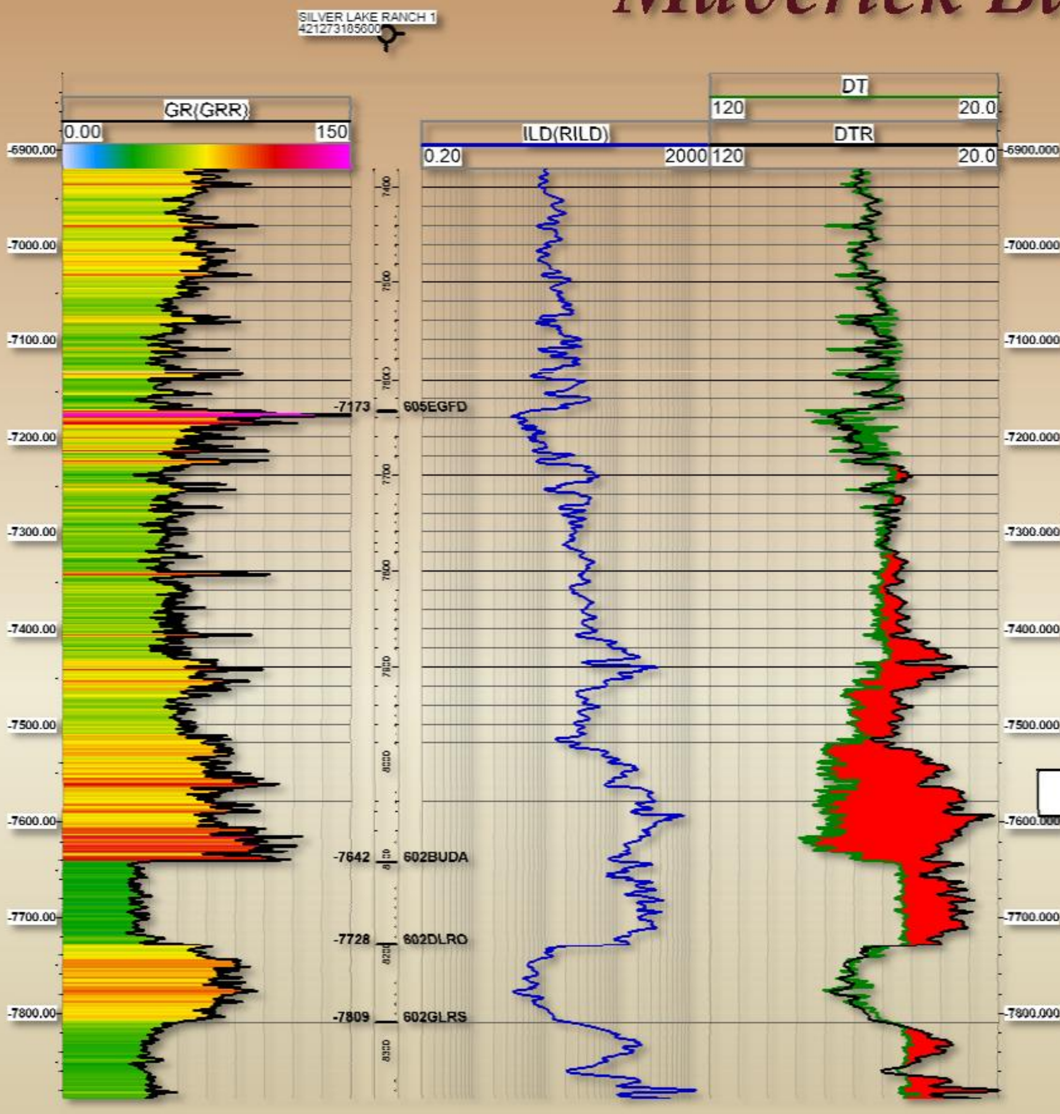
Eagle Ford – Oil (Cretaceous)
Maverick Basin

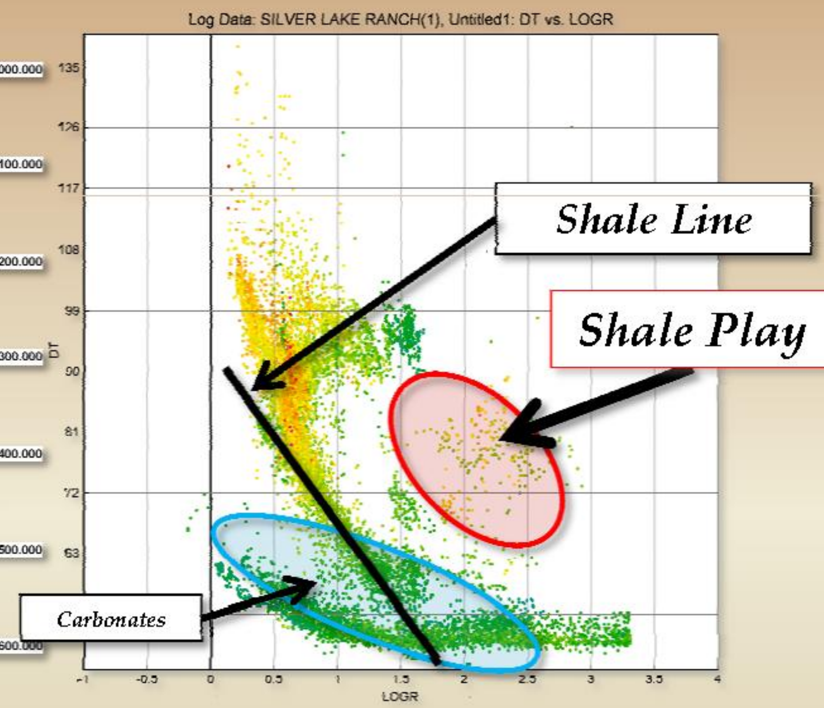




*DtR=92-24*LogR*

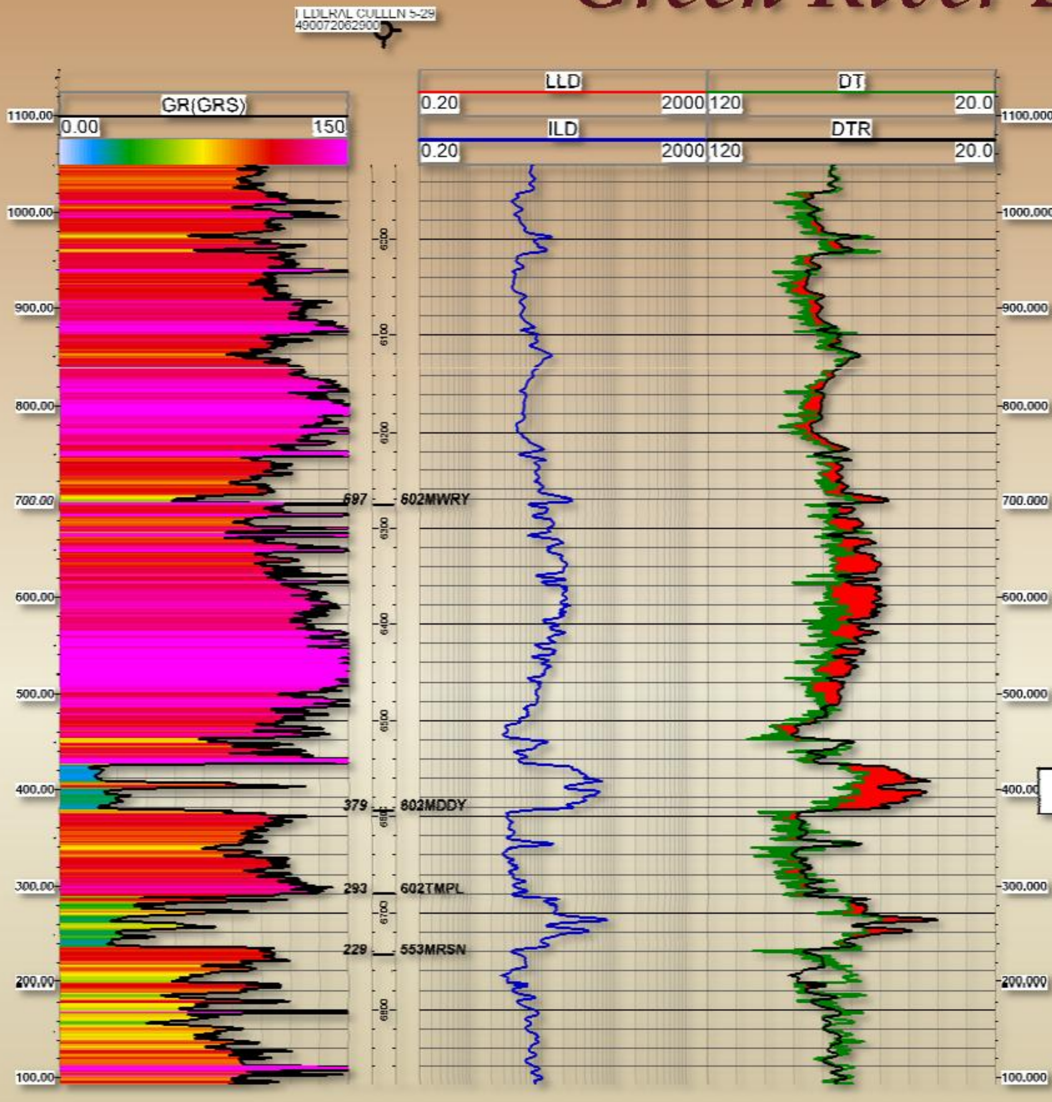
Eagle Ford - Gas/Condensate (Cretaceous)
Maverick Basin

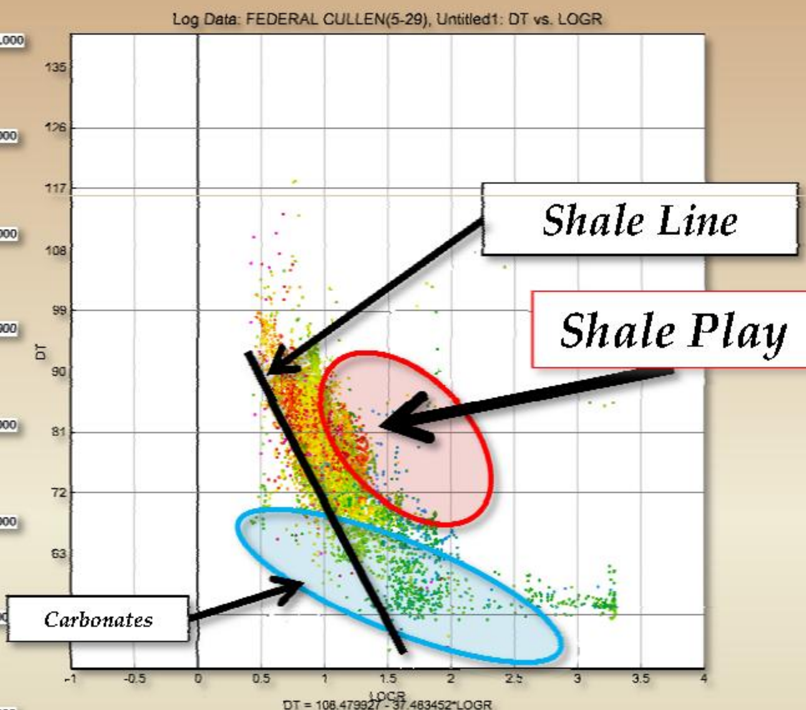




*DtR=92-24*LogR*

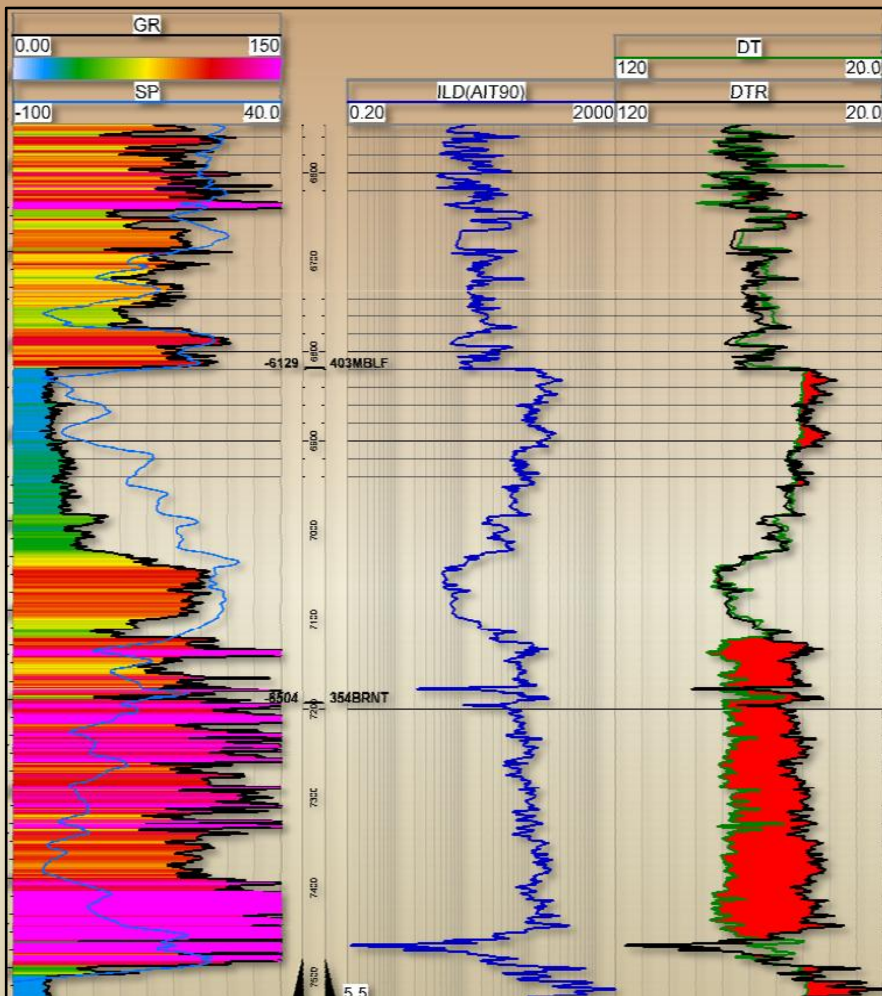
Mowry - Cretaceous
Green River Basin





DtR=108-37*LogR

Conclusions



1. *Organic-rich sediments have a higher resistivity than organic-lean sediments*
2. *Organic-rich rocks - increase in sonic transit time and an increase in resistivity*
3. *Organic-rich rocks can be relatively highly radioactive (higher gamma-ray reading than ordinary shales and limestones)*
4. *The ΔLogR cross plot is a quick and easy determination of resource*
5. *Word of Warning*

Thank You