SEISMICALLY-DETERMINED DISTRIBUTION OF TOTAL ORGANIC CARBON (TOC) IN THE WOODFORD SHALE, PAYNE COUNTY, OK

Lennon Infante and Dr. Roger Slatt
CPSGG, The University of Oklahoma

The University of Oklahoma
ConocoPhillips School of Geology and Geophysics

Introduction

Current market conditions place increased importance upon identifying "sweetspots" for producing shale resources more efficiently. Therefore a four phase modern workflow was developed in order to make a horizontal well proposal in the Woodford Shale, Cherokee Platform, Payne County Oklahoma.

Objectives and Scope

When dealing with mature shale resources there are three main factors in identifying "sweetspots". According to Wang (2014) these three factors are:

-Vertical distribution of Total Organic Carbon (TOC). Figure 4)
-Vertical variation in mineralogy . (Figure 3)
-Lateral stress direction (Figure 6)
We would add lateral distribution of TOC as another important factor (Figures 5 & 7).

Geological Model

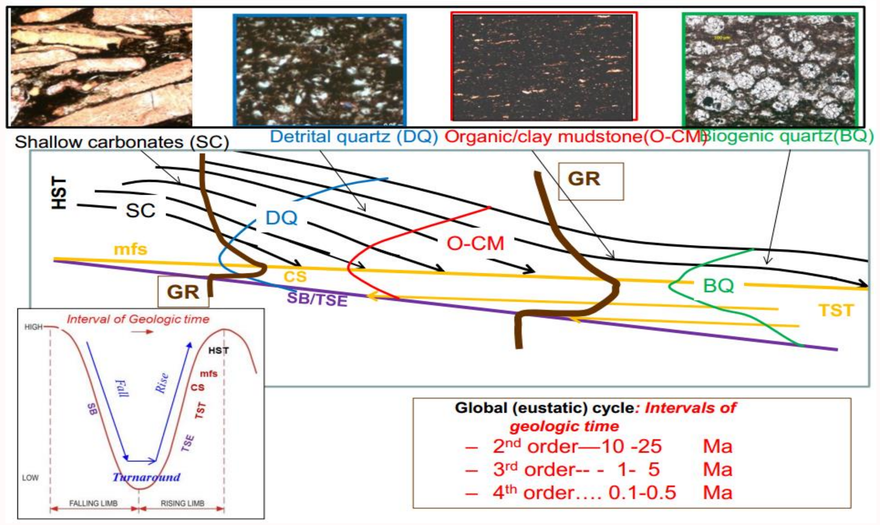


Fig 1. Depositional model for shale resources proposed by Slatt et al., (2012).

Woodford Shale Regional Correlation

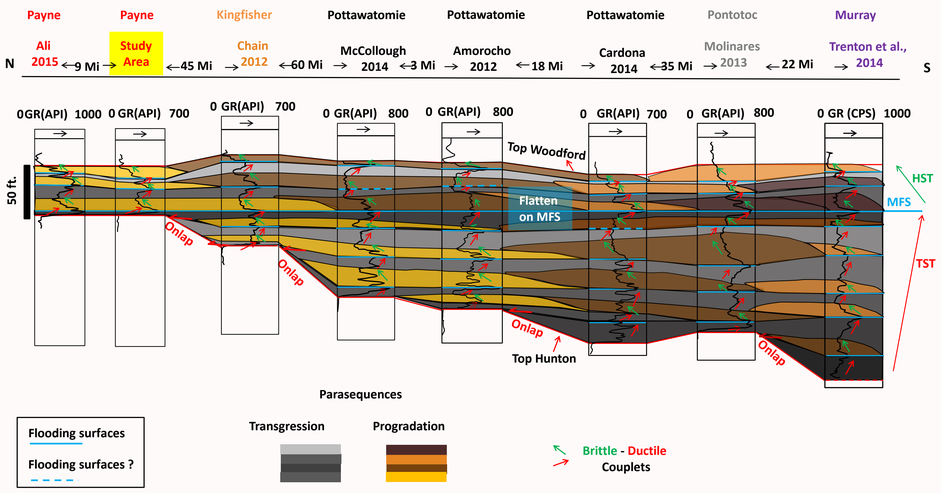


Fig 2. Regional Woodford correlation(approximately 200 miles) between study area and previous studies. Basin direction is to the South .The interpretation shows that some units of the Woodford are missing in this study area which is evidenced by onlap geometry.(Confidentiality of data prevents the display of the base map)

Cuttings and XRD Analysis

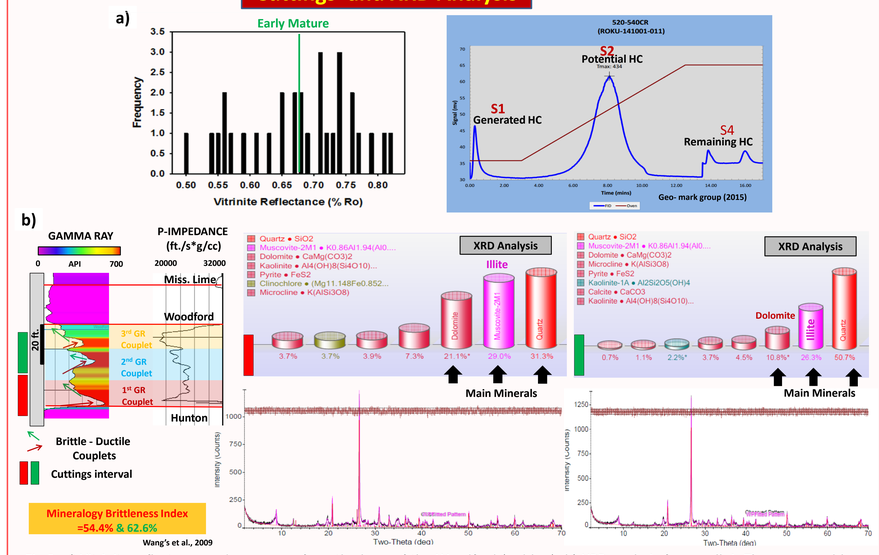


Fig 3. a) Vitrinite reflectance and pyrogram from the base of the Woodford (red bar) b) XRD analysis from well *A*. The green-red bars represent the interval where the cuttings were taken. Main minerals for this interval are quartz, illite and dolomite. BI for brittle-ductile interval are 62.6 and 54.4 % respectively.

Vertical Distribution of TOC ($\Delta LogR$ Method)

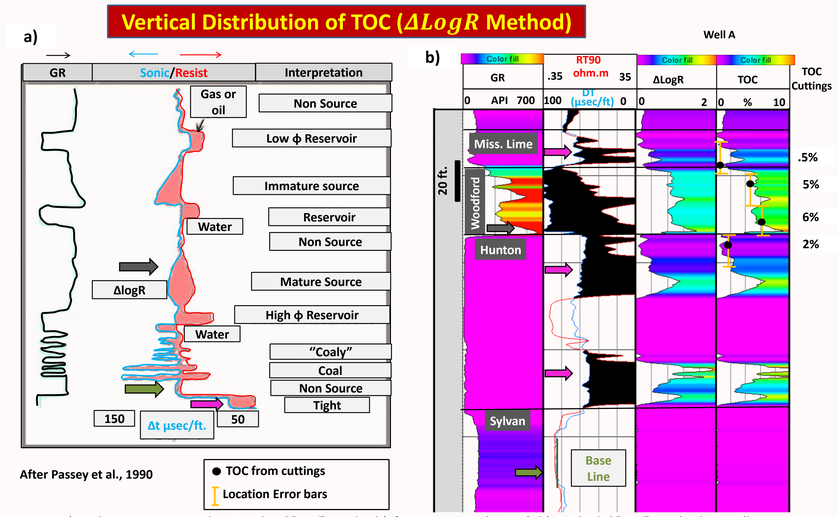


Fig 4. a) Explanatory cartoon showing the $\Delta LogR$ method (after Passey et al.,1990). b) Applied $\Delta LogR$ method on well A.

Seismic Inversion Results

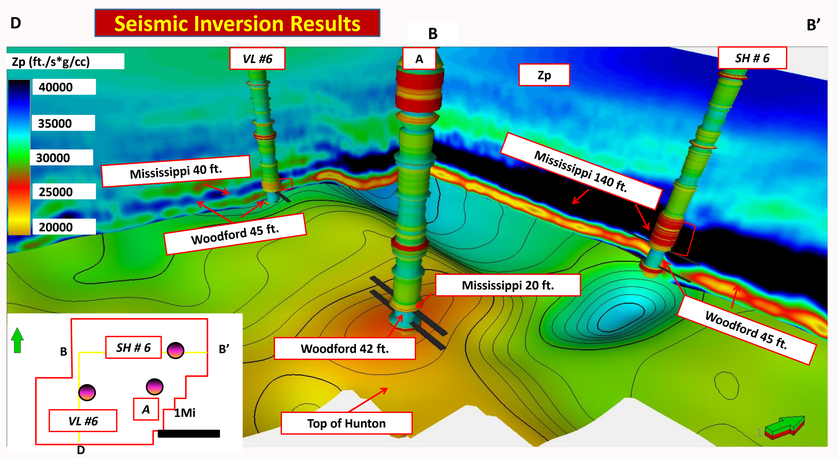


Fig 5 . 3D view of time structure map of top Hunton and vertical slices of acoustic impedance (Zp).Wells *VL #6*, *SH #6* and A display Woodford and Mississippi thicknesses. Zp shows the drastic increase in thickness within the Mississippi Lime in the northern part.

Stress Direction Based on Curvature

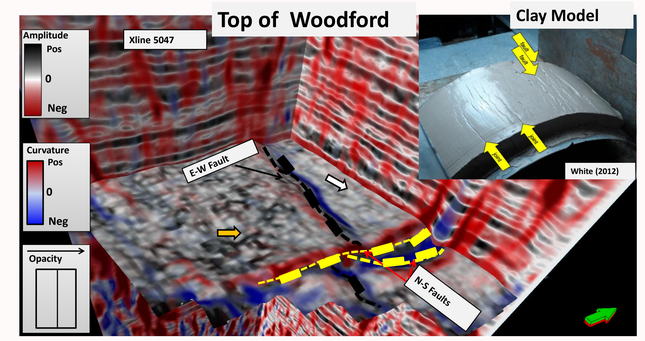
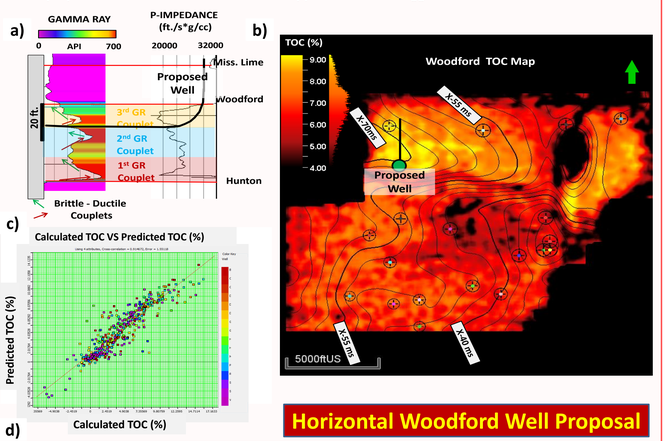


Fig 6. Most positive and most negative curvature co-rendered with amplitude in vertical seismic sections and co-rendered with energy ratio similarity on top of the Woodford. Clay model shows fractures and faults perpendicular to the direction of stress applied. Vertical exaggeration is about 50 times.



Horizontal Woodford Well Proposal

Fig 7. Horizontal Woodford well proposal. Location based on a) Brittle-ductile couplets and b) TOC map c) calculated TOC and predicted TOC correlation using a Neural Network. d) 3D view of propose well.

Summary & Conclusions

This study used seismic inversion techniques and seismic attributes fed into an Artificial Neural Network to generate a 3D volume of TOC. This allowed the identification of areas with high(10 %) TOC within the Woodford Shale.

The vertical zone chosen to induce horizontal fracking was selected based on the BI and P-impedance log and brittle-ductile pattern of the GR log. As evidenced by the curvature attributes horizontal drilling should be performed in the North-South direction in order to drill perpendicular to maximum stress and produce hydrocarbons more efficiently.

The workflow we propose is: first identify areas with higher TOC (using seismic inversion techniques to predict a 3D volume of TOC from the $\Delta LogR$ Method) second, choose the vertical zone to induce horizontal fracking based on mineralogical variation (B) and third, determine the direction of the horizontal well based on regional stress (curvature, AVZ).

References

-Slatt, R. M., and N. Rodriguez, 2012, Comparative sequence stratigraphy and organic geochemistry of gas shales: Commonality or coincidence? : Journal of Natural Gas Science and Engineering, v. 8, p. 68-84.
-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, 74, p. 1777-1794.
-Wang, J., 2014, Revisiting Reservoir Quality Issues in Unconventional and Conventional Resources: Techniques, Technologies and Case Studies: AAPG workshop, Houston TX.