PSPetrophysical Analysis of the 3rd Bone Spring Formation*

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Abstract

The Permian Basin is very attractive to oil companies and researchers due to the fact that it has the biggest potential oil production in the nation by 29% for the future (e.g., Dutton et al., 2003; Root, Attanasi, Mast, and Gautier, 1995; Galloway et al., 1983). The area of the basin is roughly 86,000 square miles in Texas and New Mexico. The sub-basin of interest is situated to the west of the Central Platform in the Delaware Basin and covers approximately 10,000 square miles. The assigned formation for evaluation was the 3rd Bone Spring sitting immediately above the Wolfcamp and located in the Leonardian period. The 3rd Bone Spring Formation is predominantly shaly sand with intermittently interbedded carbonate layers.

A full well-log suite including geochemical data was presented in the assignment for analysis. A series of systematic calculations were performed in both software programs Microsoft Excel (2013) and Techlog by Schlumberger (2013). Assigned calculations included (1) thermal maturity using vitrinite reflectance, (2) total porosity, (3) effective porosity, (4) total organic carbon, (5) variable matrix analysis, (6) clay bound water, (7) OOIP using variable matrix analysis, (8) bitumen corrected OOIP, (9) T2 cutoff OOIP, (10) OOIP from rock evaluation data (S1), and finally (11) geo-mechanics. In addition, to generate rigorously defined conservative OOIP estimates and precise optimization of horizontal well placement, we developed new and creative methods.

As a result, it is found that the most conservative OOIP estimate using multiple stacked pay flags, MHI and Permeability combined, came from the Bitumen Corrected OOIP at 9700 ft and 0.9 MMstb. More precisely, the least conservative OOIP estimate using multiple stacked pay flags came from Variable Matrix Analysis using ECS data at 9698.5 ft and 4.1 MMstb. Finally, all optimized zones peaked within 5 ft of each other regardless of the method of OOIP calculation. Given this additional level of assurance we determined the optimal placement was at 9700 ft. This depth has a carbonate-dominated layer with a marked decrease in gamma ray count allowing for accurate geolocation and geo-steering of the well bore.

References Cited

Dutton, S.P., E.M. Kim, R.F. Broadhead, C.L. Breton, W.D. Raatz, S.C. Ruppel, and C. Kerans, 2003, Play analysis and digital portfolio of major oil reservoirs in the Permian Basin: Report of Investigations, University of Texas Bureau of Economic Geology, 271.

Galloway, W.E., T.E. Ewing, C.M. Garrett, N. Tyler, and D.G. Bebout, 1983, Atlas of major Texas oil reservoirs.

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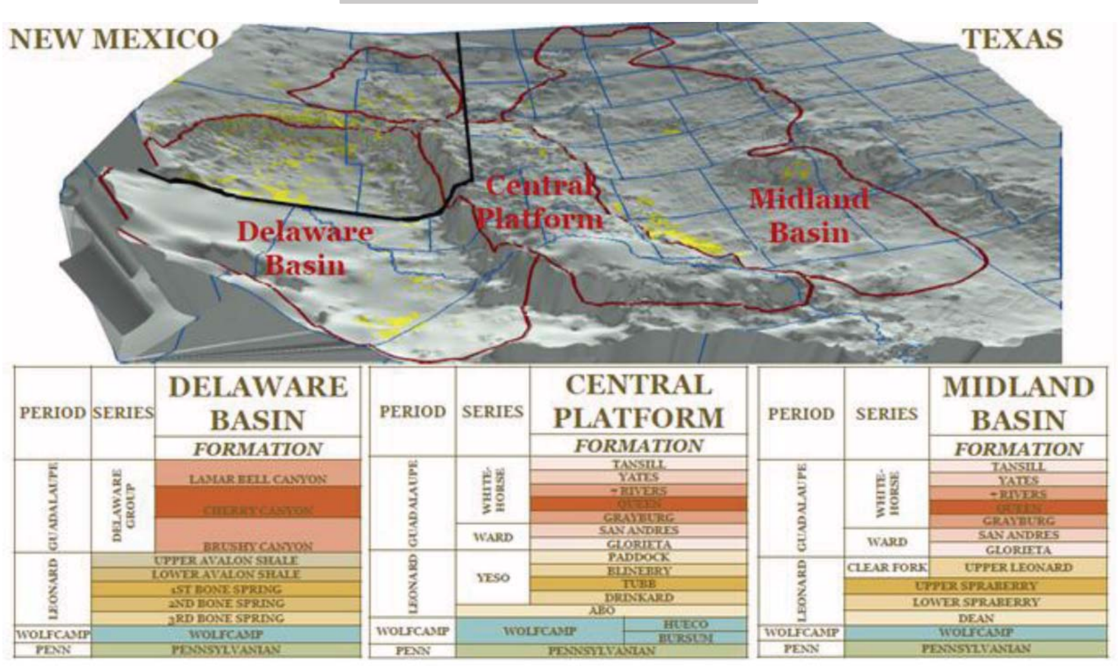
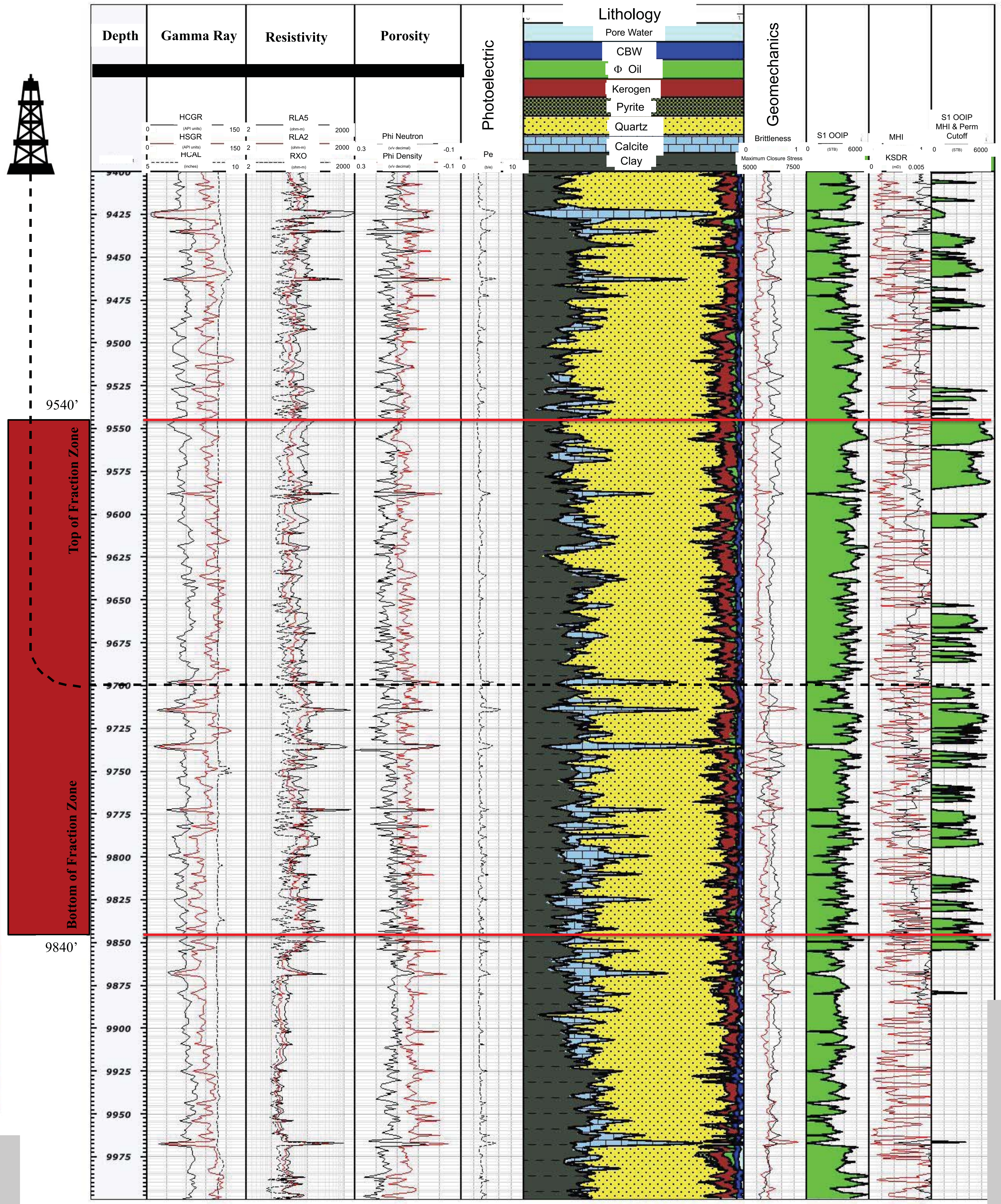
Permian Basin



Source: Concho Resources Company Presentation

Method

1. Calculate hydrocarbon maturity using an average from vitrinite reflectance and then select a value for the shrinkage factor.
2. Calculate total porosity, effective porosity, total organic carbon, clay bound water, matrix density using variable matrix analysis, and fluid density.
3. Calculate OOIP (160 acre spacing) using variable matrix analysis, oil porosity, water saturation, and oil porosity.
4. Calculate OOIP (160 acre spacing) using a bitumen correction.
5. Calculate OOIP (160 acre spacing) using T2 relaxation greater than 10ms.
6. Calculate OOIP (160 acre spacing) using pyrolysis S1 from rock evaluation data.
7. Calculate geomechanics.
8. Apply MHI and permeability cutoff to each OOIP.
9. Determine optimal well placement using 300ft scrolling window.



Selected References

Dutton, S. P., Kim, E. M., Broadhead, R. F., Breton, C. L., Raatz, W. D., Ruppel, S. C., & Kerans, C. (2003). Play analysis and digital portfolio of major oil reservoirs in the Permian Basin. *Report of Investigations-University of Texas Bureau of Economic Geology, 271*.

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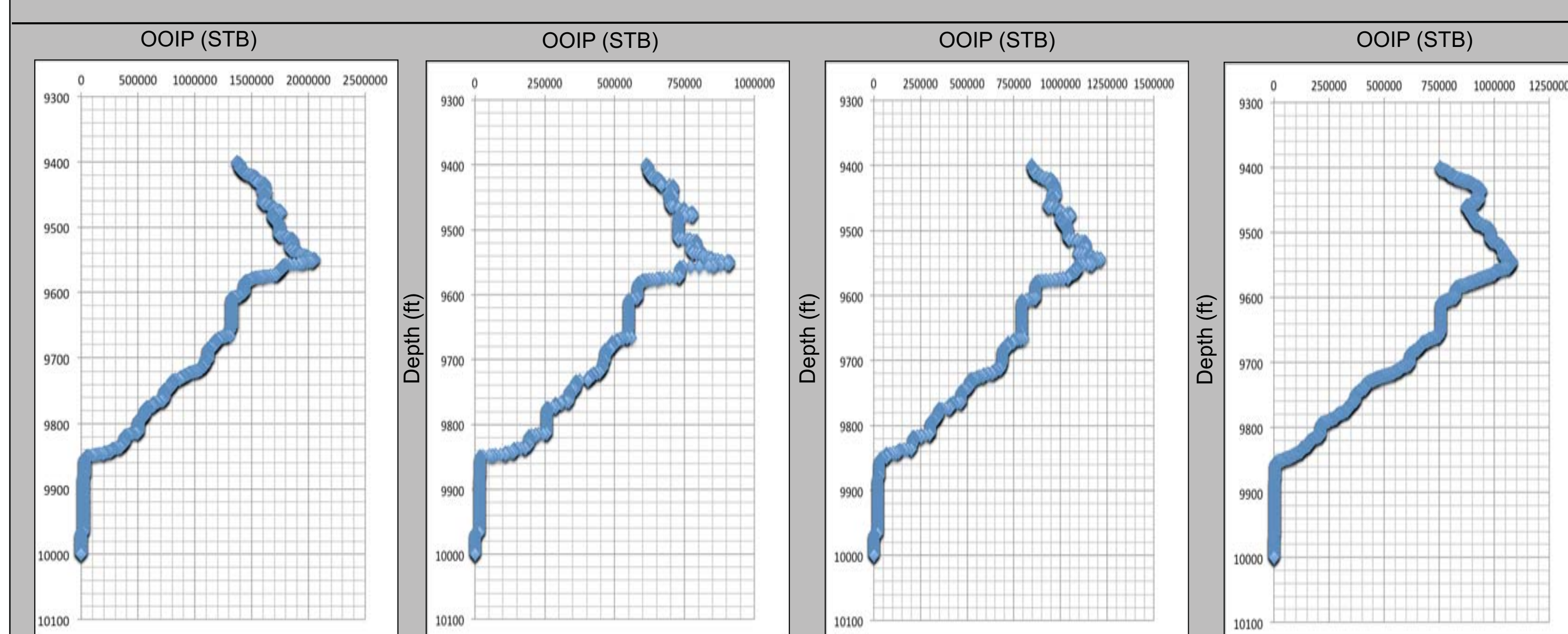
Horizontal Well Placement Optimization

The assigned calculated OOIP data was further adapted by our team to optimize horizontal well placement by stacking pay flags and comparing calculation methods. We set and stacked cutoffs for the movable hydrocarbon index at 0.7 and at 300 nD for permeability and applied them to each calculated OOIP. To determine what depth the horizontal well would capture the greatest amount of hydrocarbons we iteratively calculated at half-foot intervals the optimal well placement using a fracturing total vertical distance of 300 feet. This is equivalent to a 300ft scrolling window moving down the data in half-foot increments allowing us to mathematically maximize OOIP through well placement. The points shown to have the highest OOIPs over the four calculated OOIP methods with stacked cutoffs were plotted and horizontal well placement was selected based on these peaks.

Our best assurance was given by the fact that irrespective of which method of OOIP calculation used the optimized zones all occurred within 5ft of each other. The best assurance is reflected in the graphs below displaying peaks in approximately the same area. The optimum placement is derived by looking at the peak then moving down hole 150ft. This accounts for the fact that window goes from 0ft to 300ft and the fracture distance is considered to be 150ft above and below the horizontal well placement.

300 ft Interval Optimization with Stacked MHI and Permeability Cutoffs

Volumetric (ECS Data) Variable Matrix Analysis	Volumetric (ECS Data) Variable Matrix Analysis Bitumen Corrected	Volumetric (ECS Data) Variable Matrix Analysis T2 Cutoff 10 ms	Pyrolysis S1 Using Rock Evaluation Data



Economics

Combining the conservative estimate from the bitumen corrected OOIP with the most expensive drilling data from Concho resources in the area, we have a total cost of $6.5MM.

Delaware Basin HZ Bone Spring Type Curves			
Metric	W. TX 3rd B.S.	Eddy/Lea NM	State Line
EUR (MBoe)	1,000	630	1,000
30-day IP (Boe/d)	1,000	670	850
% Oil	80%	84%	58%
Cost ($mm)	$6.5	$6.4	$5.4
Spacing (acre)	160	160	160
TVD (ft)	10,000-11,000'	8,000-9,000'	<8,000'
Lateral (ft)	4,500'	4,500'	4,500'
Frac Stages	5-8	5-8	5-8
IRR	87%	73%	61%

Source: Concho Company Presentation & Howard Weil

EUR of 818714 stock tank barrels. Excluding the time value of money and an assumed oil price of WTI $60 we have $49MM. Given the information available this is the best first order estimate.

OOIP Method	Variable Matrix Analysis (VMA)	Bitumen Corrected (VMA)	T2 Corrected (VMA)	S1 Pyrolysis
OOIP for 300ft section (9540ft-9840ft)	4108354.595	1876360.642	2487073.843	2257327.227
OOIP for 300ft section after cut off applied (9540ft-9840ft)	1922913.789	818714.3424	1159975.476	1059930.907

Conclusion

Based on the results of this study, we make three primary conclusions.

1. The best zone is from 9540ft to 9840ft.

2. Horizontal well placement is optimized at 9700ft.

3. Excluding TVM we have a cost of $6.5mm and revenue of $49MM at $60 BOE WTI.

Using the carbonate layer at 9700ft would allow accurate geolocation and well steering assuming the layer is continuous. In addition, hydraulic fracturing can be initiated using an acid frac to initially increase permeability in the relatively thin carbonate layer followed by hydraulic fracturing using a fluid suitable for shaly-sands.