The Integration of Key Petrophysical and Geomechanical Play Drivers into Geological Attribute Mapping: Getting Ahead of the Stampede*

Larry Brooks[1] and Randy Montalvo[1]

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Abstract

In unconventional and conventional plays alike, petrophysical attributes such as effective porosity (PHIE), permeability (k), brittleness, volume of clay (VCLAY), total organic carbon (TOC), adsorbed gas/original oil in place (OOIP), and water saturation (Sw) are key parameters that speak to the viability of entering into that play. Using abundantly available public well log data, high quality petrophysical attributes can be produced and subsequently mapped expeditiously. The ability to distribute these parameters in 2D mapping yields valuable insight to new and evolving plays.

In house data may be sparse and the ability for evaluating the play may not be recognized by conventional mapping (i.e. traditional structure, isopach maps, etc.). The power of using public data and proprietary petrophysical analysis gives the geoscientist an enviable suite of maps upon which critical decisions can be made. The final result is an accelerated advancement of learning and evaluation which will save time in the approval process, mobilization, leasing and E&P.

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In unconventional and conventional plays alike, petrophysical attributes such as effective porosity (PHIE), permeability (k), brittleness, volume of clay (VCLAY), total organic carbon (TOC), adsorbed gas/original oil in place (OOIP), and water saturation (Sw) are key parameters that speak to the viability of entering into that play. Using abundantly available public well log data, high quality petrophysical attributes can be produced and subsequently mapped expeditiously. The ability to distribute these parameters in 2D mapping yields valuable insight to new and evolving plays.

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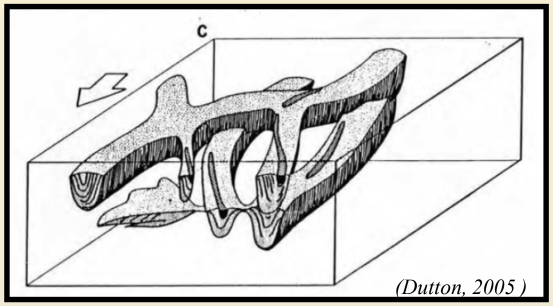
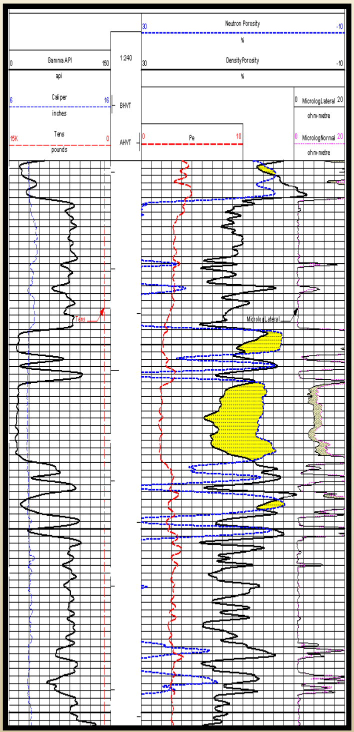
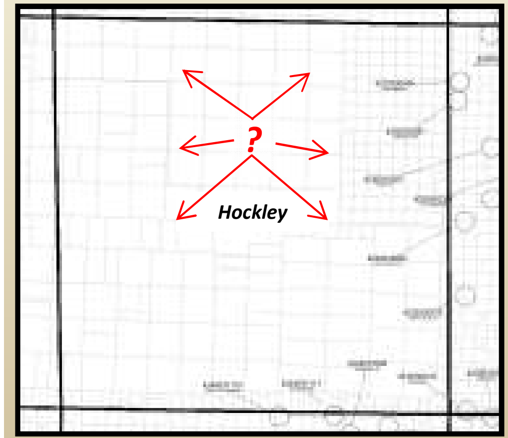
What are Some of the Initial Questions Before Entering into a Play?

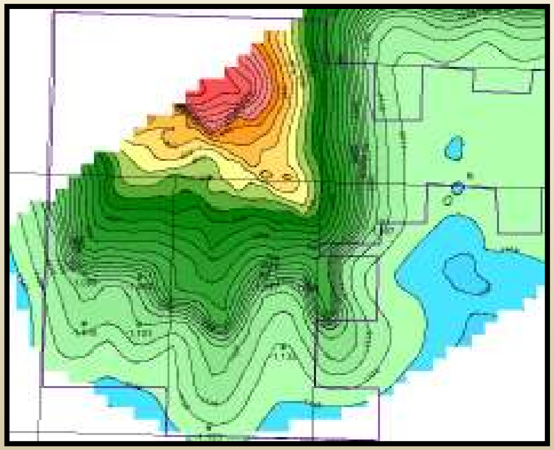
- ***"Where do I purchase acreage?***
- ***"I've drilled a well-what zones will produce?"***
- ***"How do I exploit the acreage I hold?"***
- ***"Where are the fluid contacts?***
- ***"What are the characteristics of the pore size distribution?"***
- ***"What are the reservoir volumes?"***
- ***"Connectivity-how continuous are the reservoirs?"***
- ***"Where are the sweet spots in the field?"***



(Dutton, 2005)

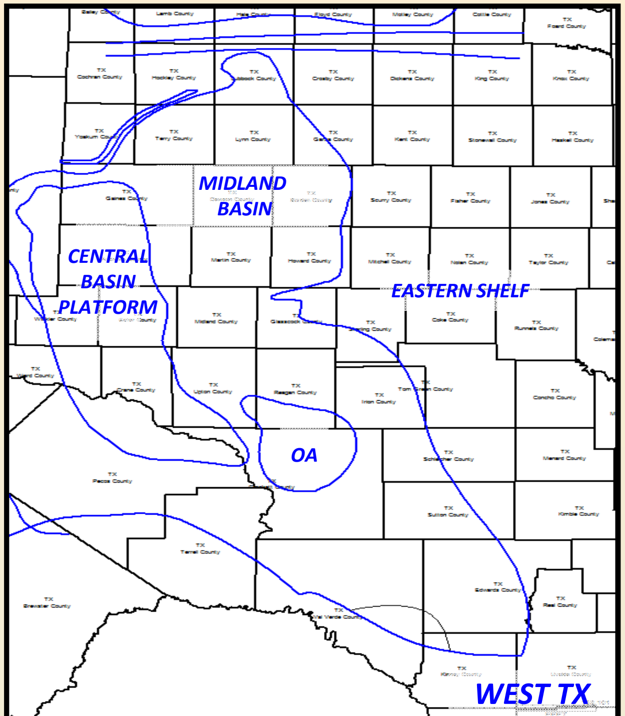




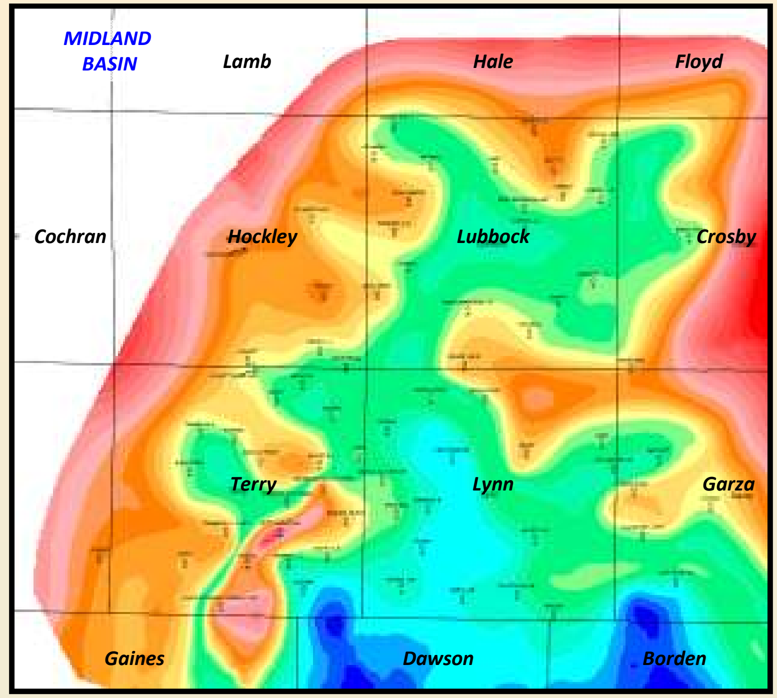


Answer: *Integration of Petrophysics with Geologic Attribute Mapping*

Where we start



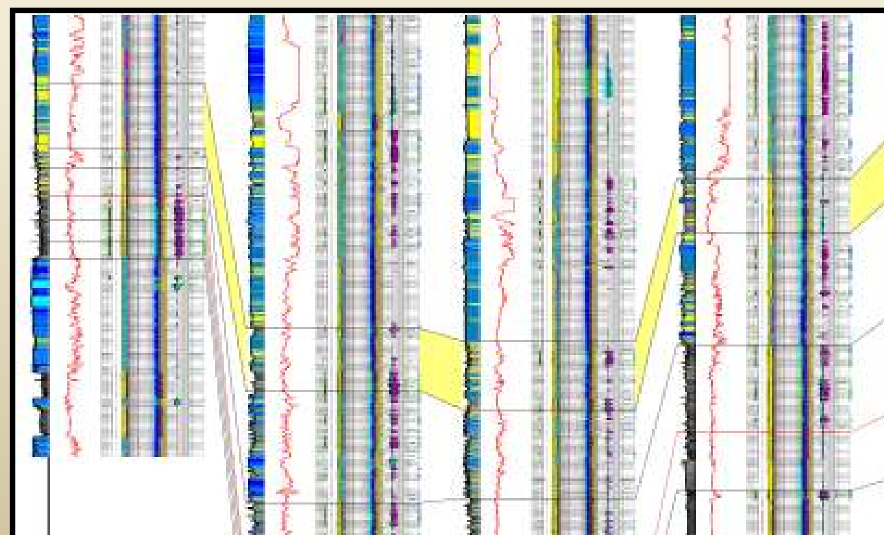
Mean Brittleness



Where we end

- ***define project objectives***
- ***data acquisition, screening, prepping***

- ***Petrophysical interpretation***
- ***Cross-Sections***

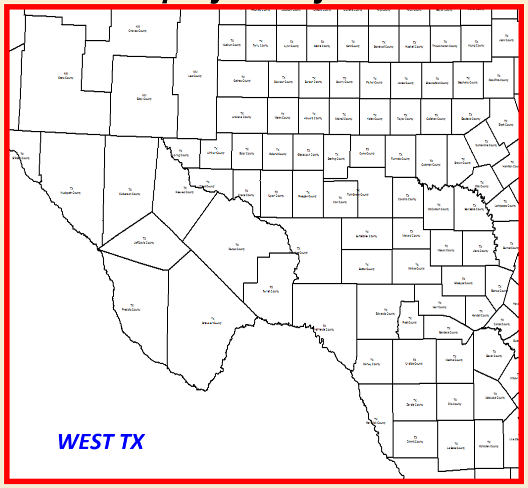


- ***Respect for paleogeography***
- ***Distribution of reservoir properties***

Data Acquisition & Preparation

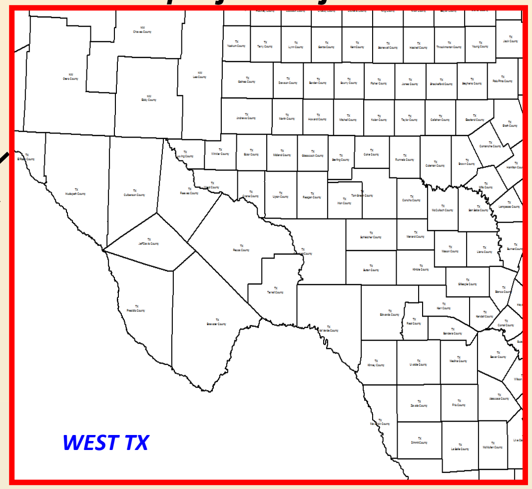
Define Project Objectives & Data Acquisition

Start with base map & define project objectives*



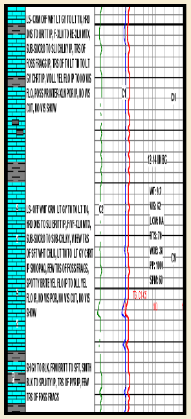
Define Project Objectives & Data Acquisition

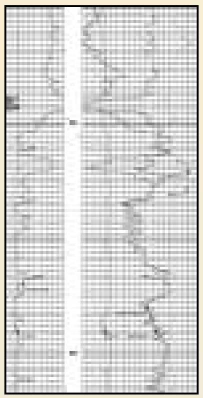
Start with base map & define project objectives*

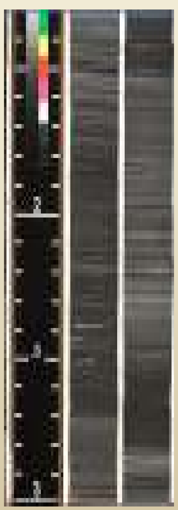


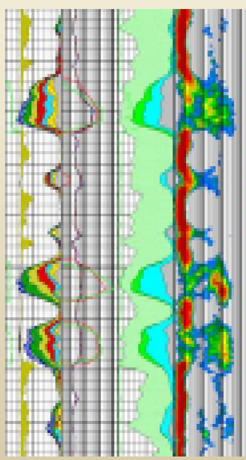
data acquisition

Proprietary log data provided









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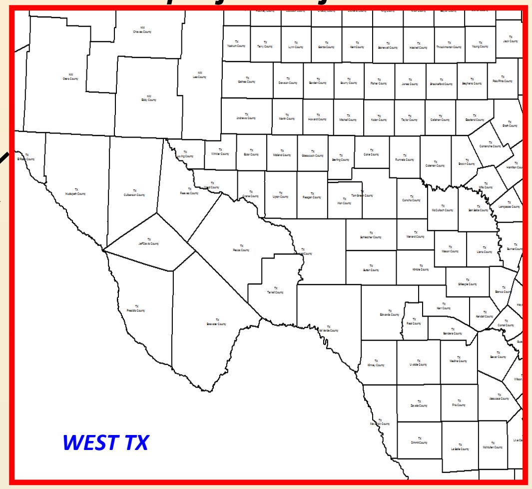

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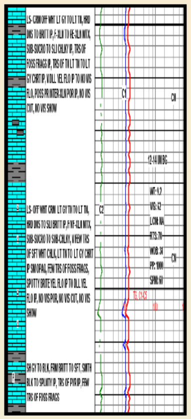
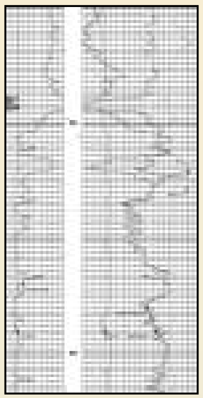
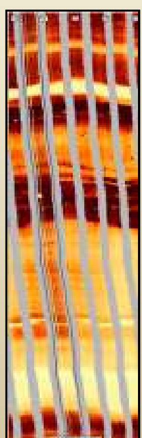
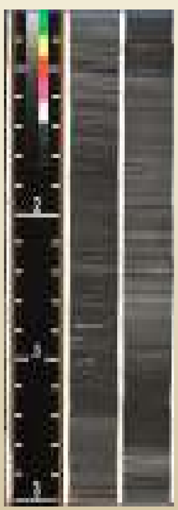
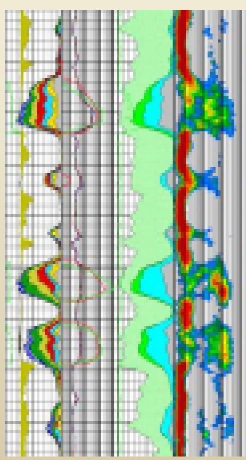






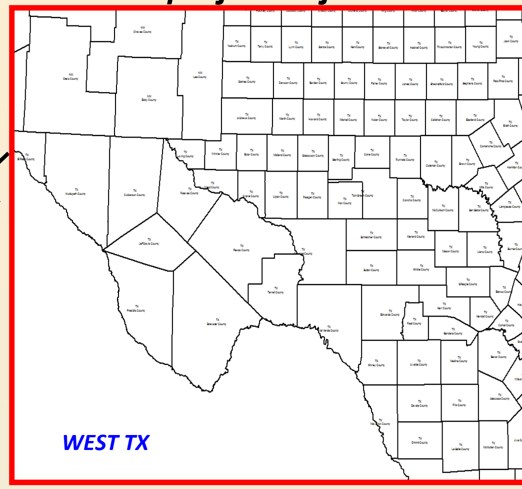




OR

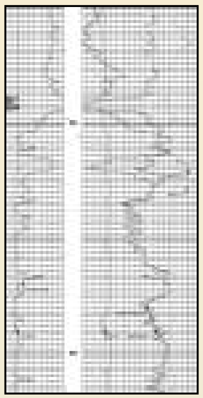
Define Project Objectives & Data Acquisition

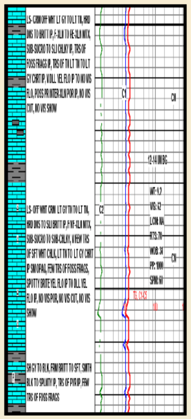
Start with base map & define project objectives*

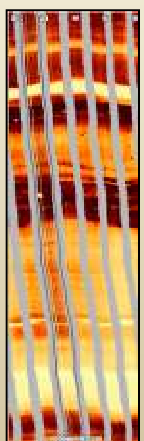


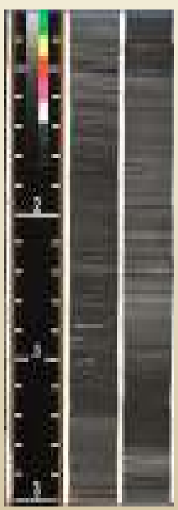
data acquisition

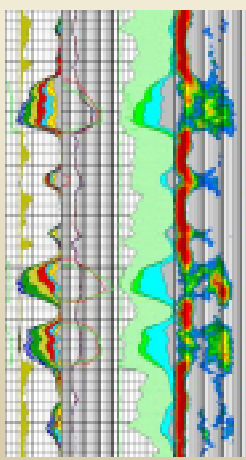
Proprietary log data provided





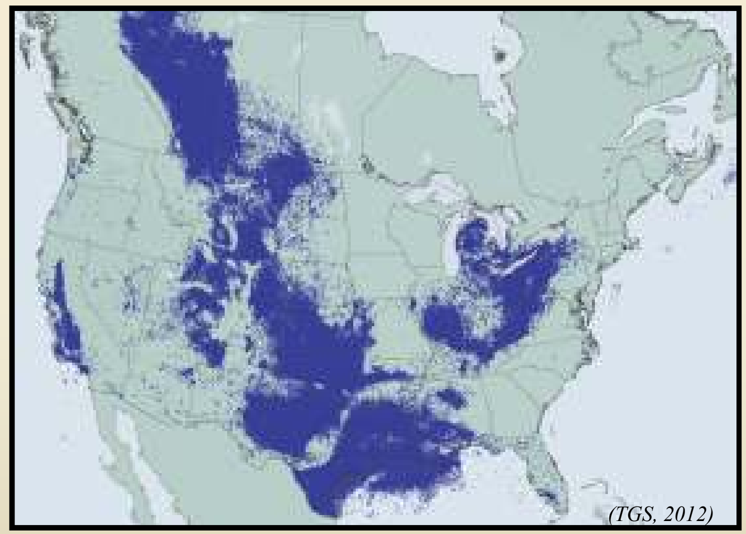






OR

Acquire public data



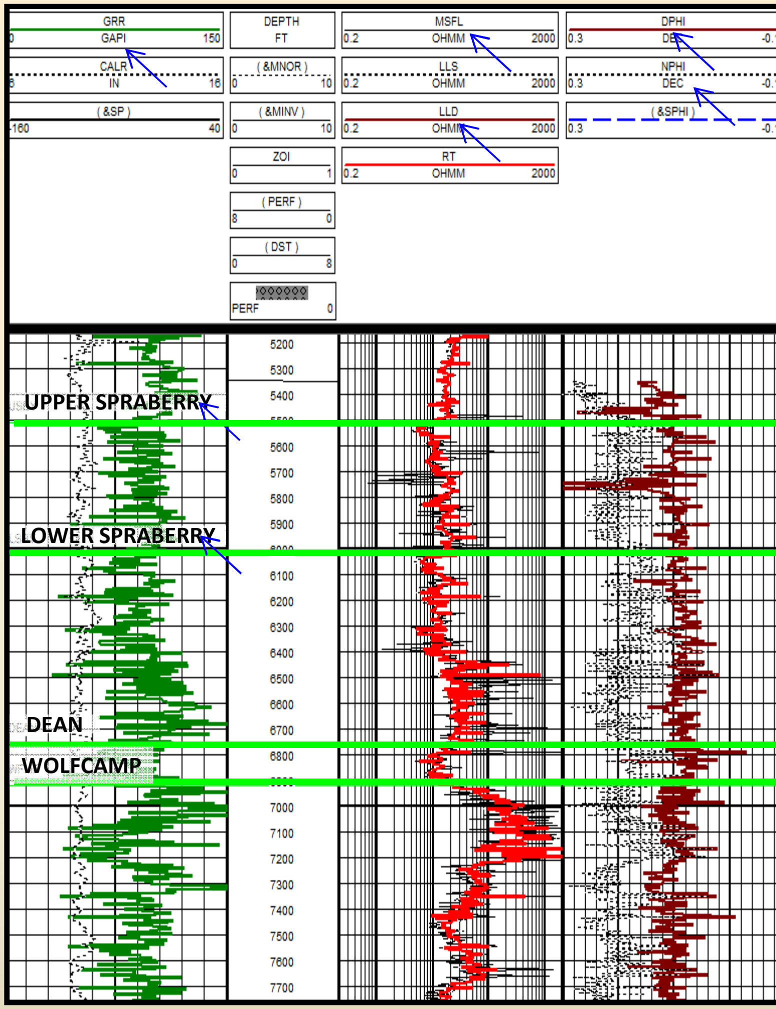
(TGS, 2012)

- ***TGS*** *(6 M wells worldwide)*
- ***MJ Systems*** *(2 M wells)*
- ***State Databases (ex: TX Railroad Commission)***
- ***IHS*** *(2.5 M wells)*
- ***International Databases***

Data Screening-Top Generation

After acquisition..

- *Log data is carefully screened by a team of technicians & Petrophysicists*
- *Geologist evaluate if the zone of interest is present*



System	Epoch/ Series/ Stage	Time (Ma)	Delaware basin	NW Shelf New Mexico	NW Shelf Texas	Central Basin Platform	Midland basin
PERMIAN			De Brushy Canyon				Brushy Canyon
			Cutoff *	Lower San Andres	Lower San Andres	Lower San Andres / Holt	*
	Leonardian		Bone Spring *	Glorieta	Glorieta	Glorieta	Spraberry
				Yeso: Paddock / Blinebry / Tubb / Drinkard	Clear Fork Group: Upper Clear Fork / Middle Clear Fork / Tubb / Lower Clear Fork	Clear Fork Group: Upper Clear Fork / Middle Clear Fork / Tubb / Lower Clear Fork	* Dean
				Abo	Abo	Abo/Wichita	
	Wolfcampian		Wolfcamp *	Wolfcamp	Wolfcamp	Wolfcamp	Wolfcamp *
PENNSYLVANIAN	Virgilian	302	Cisco	Cisco	Cisco	Cisco	Cisco
	Missourian		Canyon	Canyon	Canyon	Canyon	Canyon
	Desmoinesian		Strawn	Strawn	Strawn	Strawn	Strawn
	Atokan		Atoka	Atoka	Atoka	Atoka	Atoka/Bend
	Morrowan		Morrow	Morrow	Morrow		
MISSISSIPPIAN	Chesterian	323	Barnett	Barnett		Barnett	Barnett
	Meramecian		Mississippian	Mississippian	Mississippian	Mississippian	Mississippian
	Osagean						
	Kinderhookian	363					

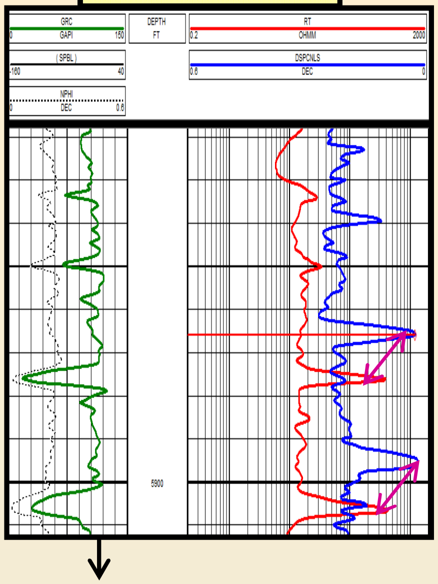
(Dutton & others 2005)

Stratigraphic research & top generation by Geologists & Petrophysicist

Data Preparation

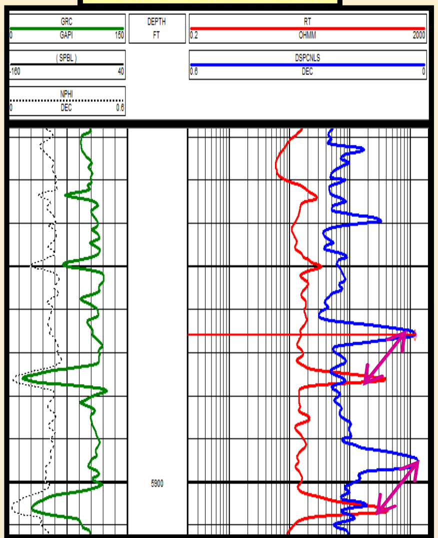
Data Preparation

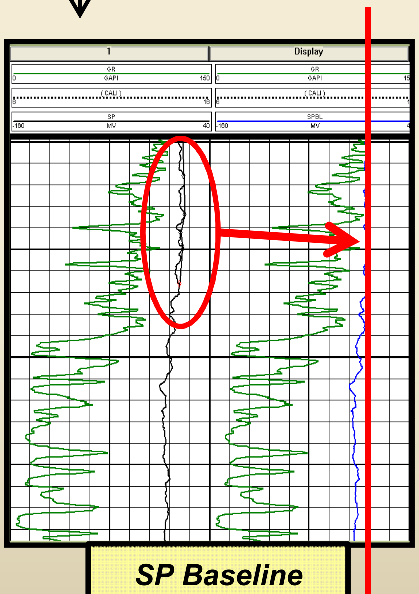
Depth shifting



Data Preparation

Depth shifting

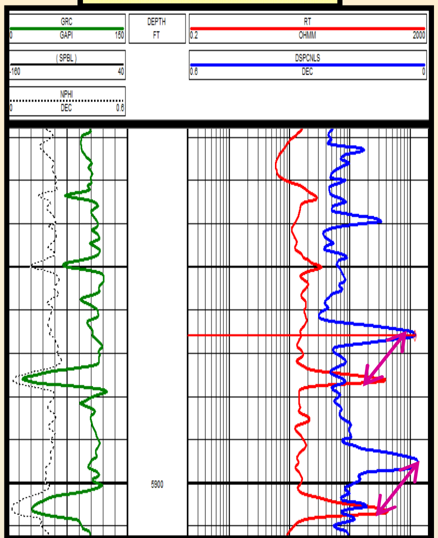


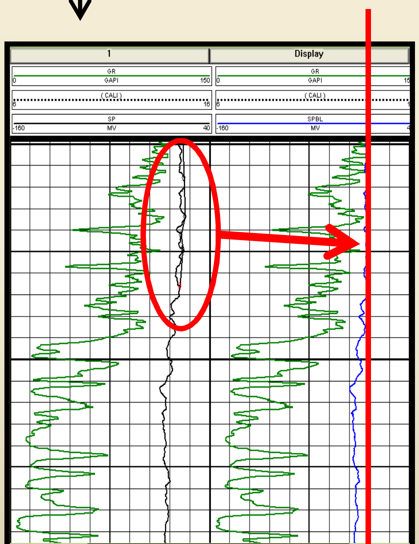


SP Baseline

Data Preparation

Depth shifting

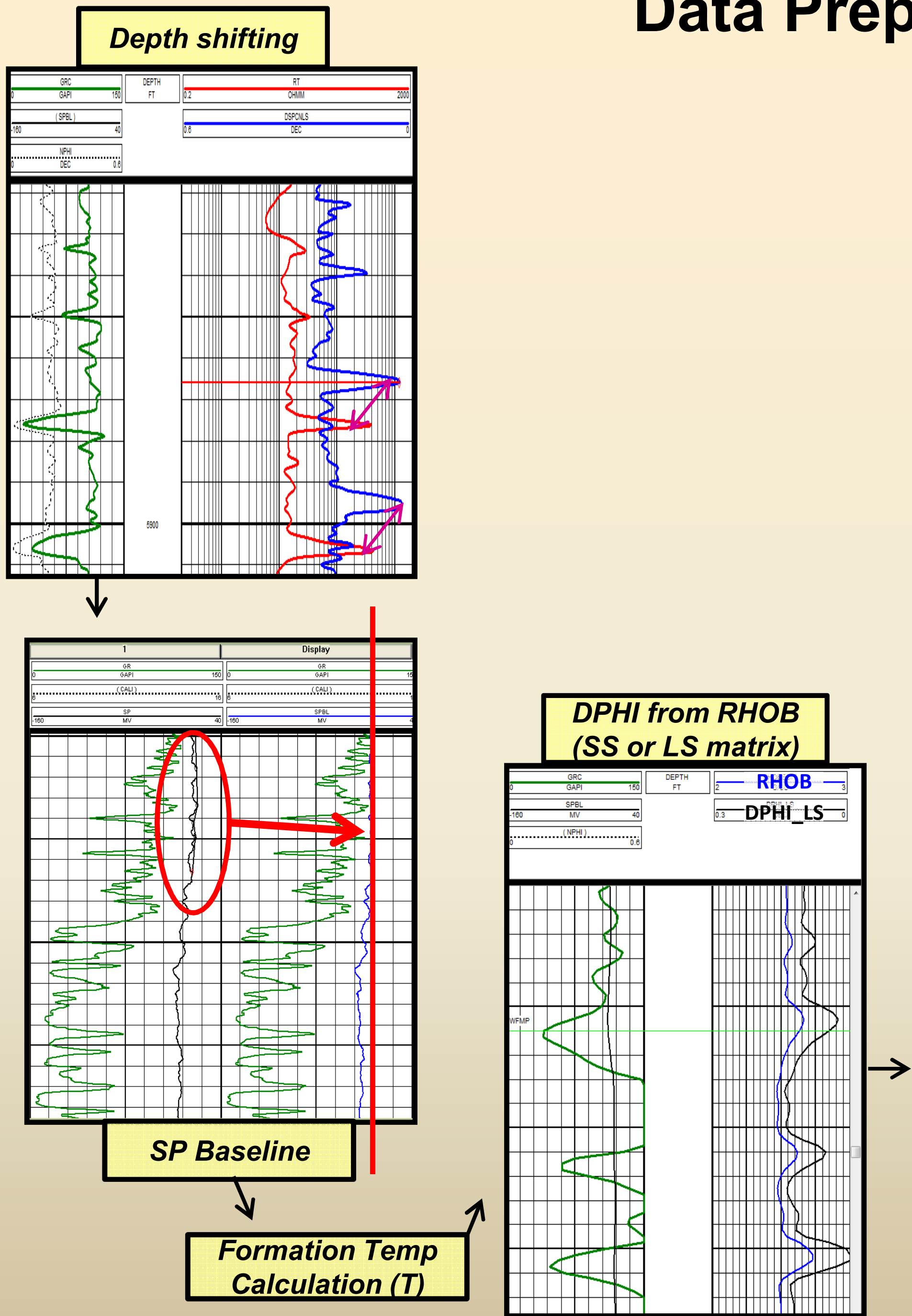




SP Baseline

Formation Temp Calculation (T)

Data Preparation



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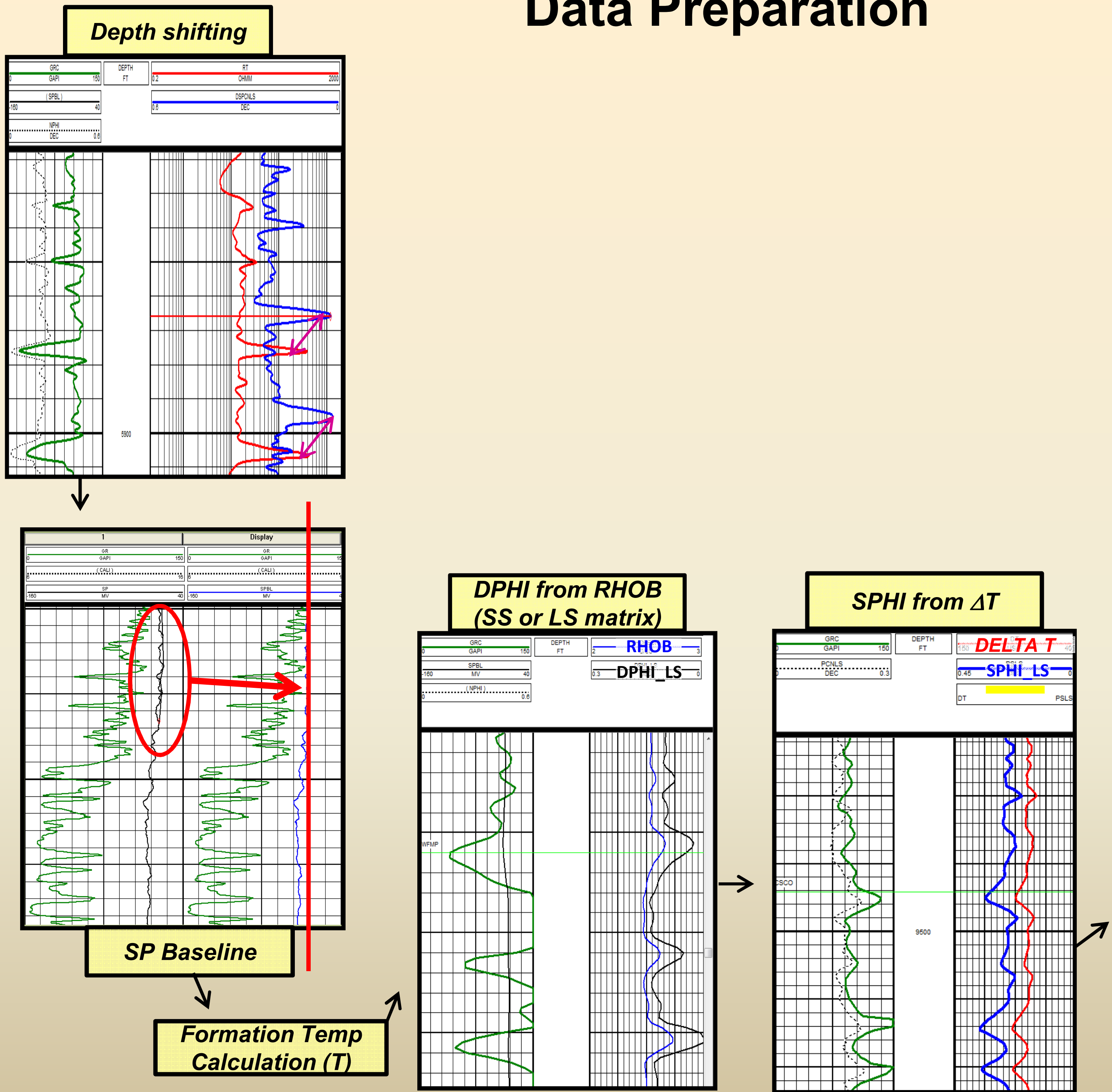

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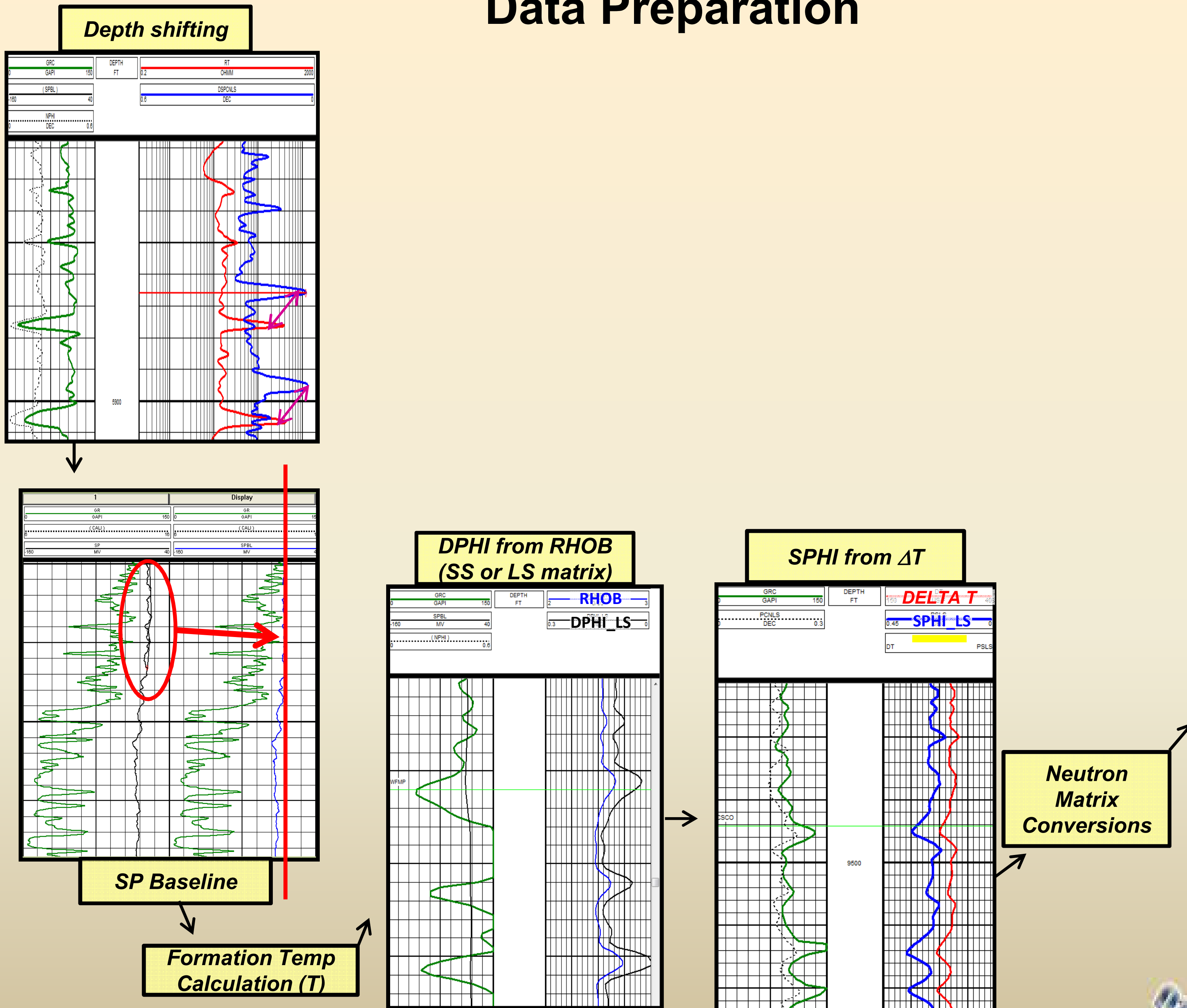

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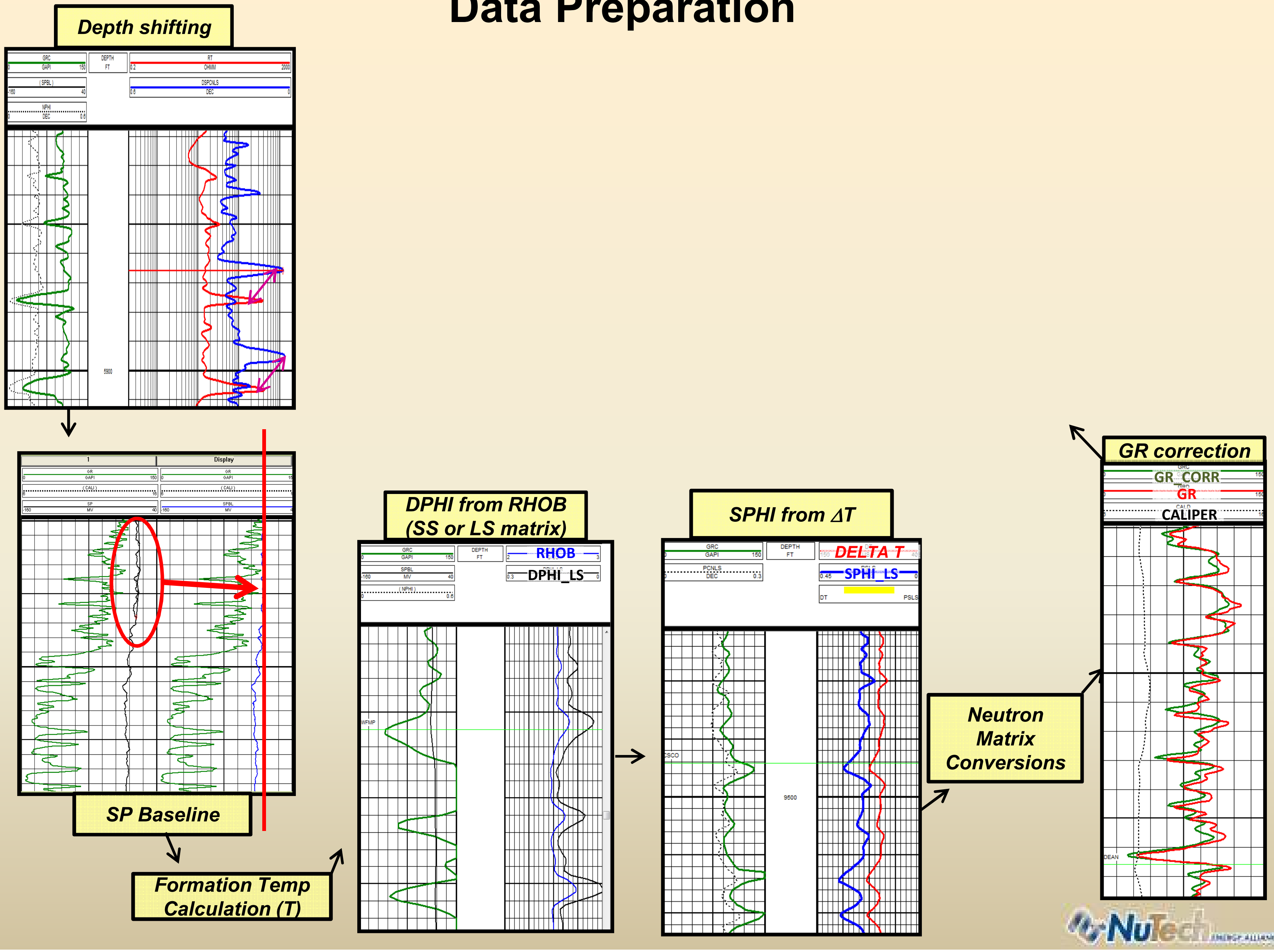

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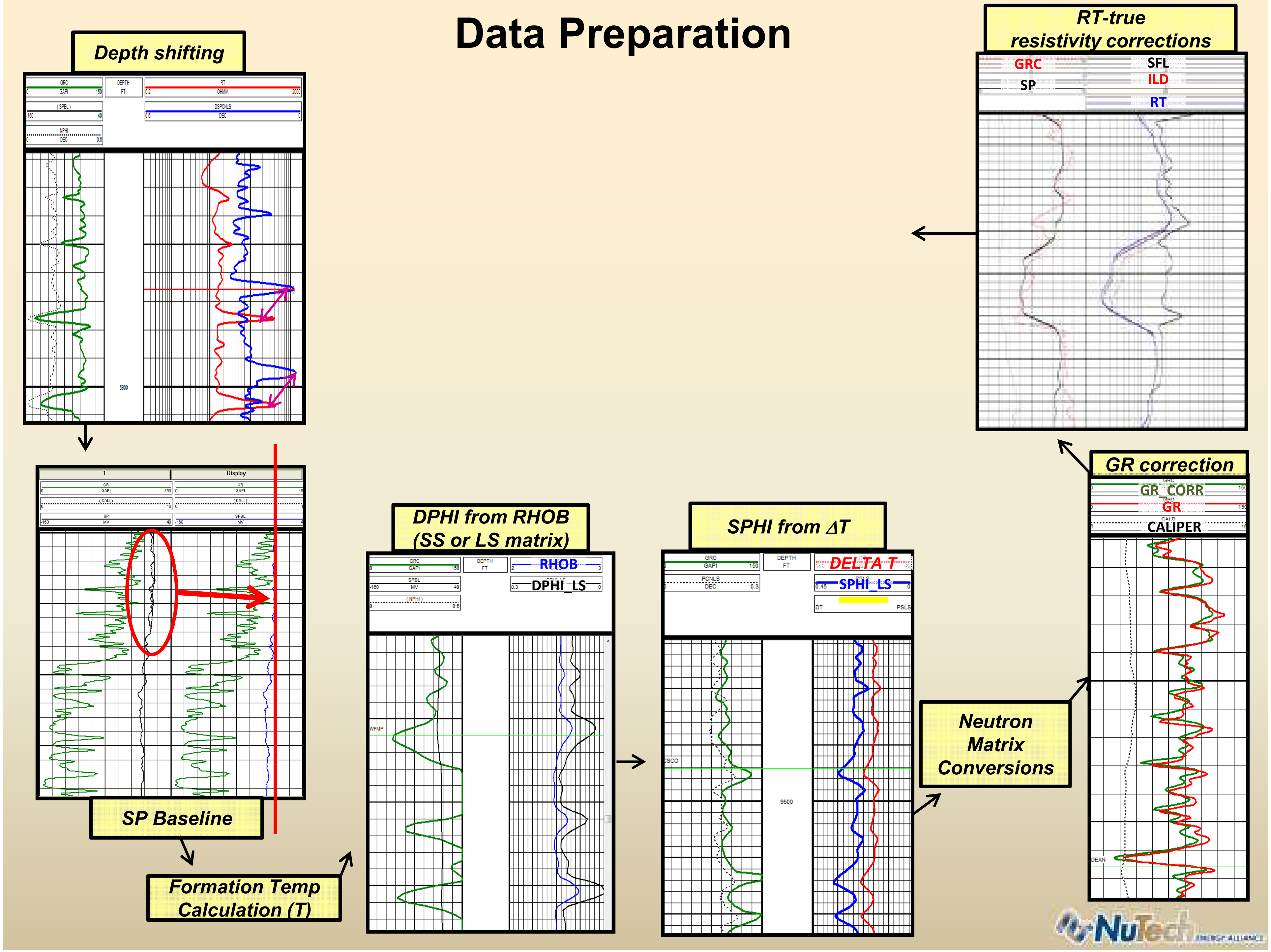

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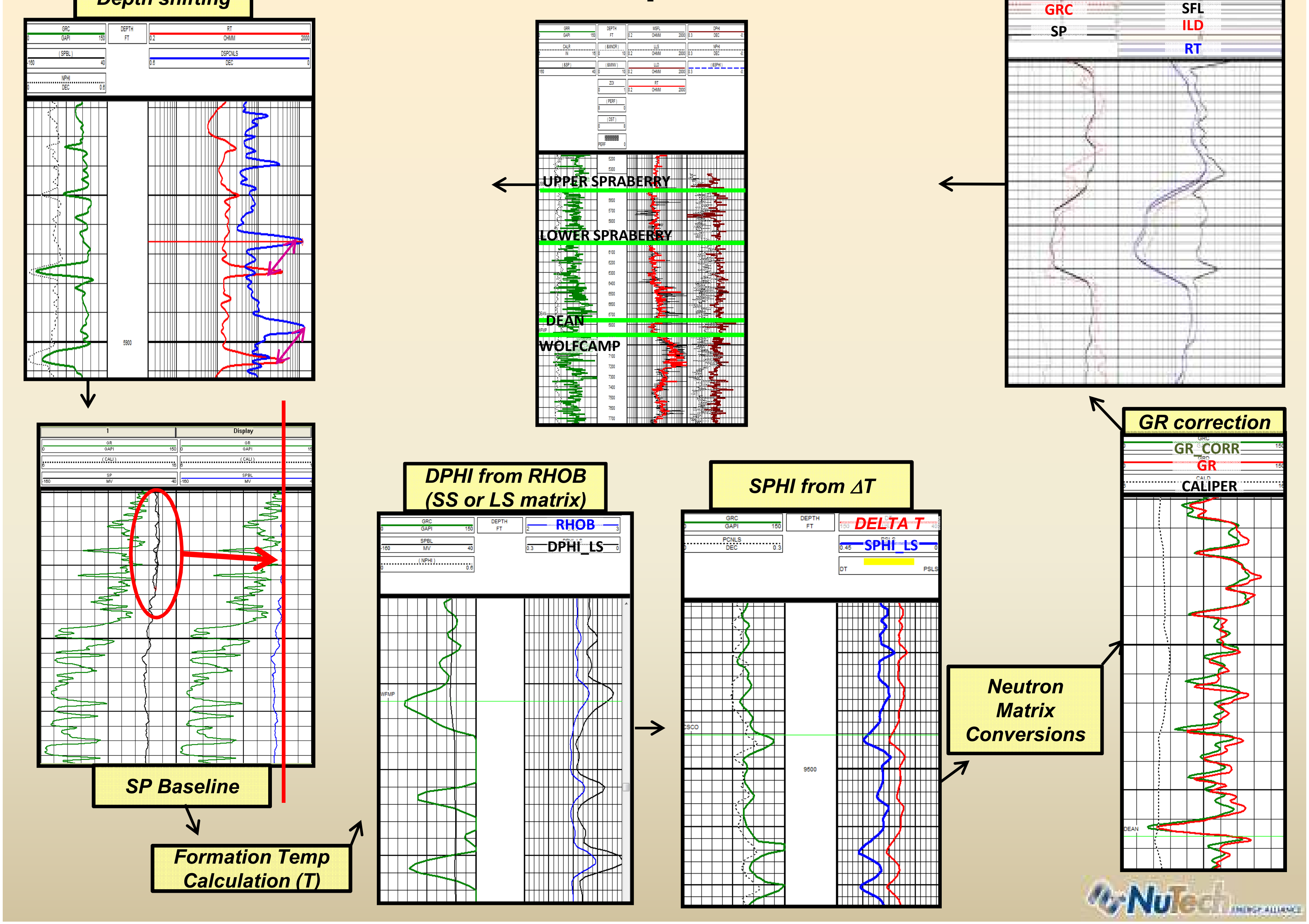
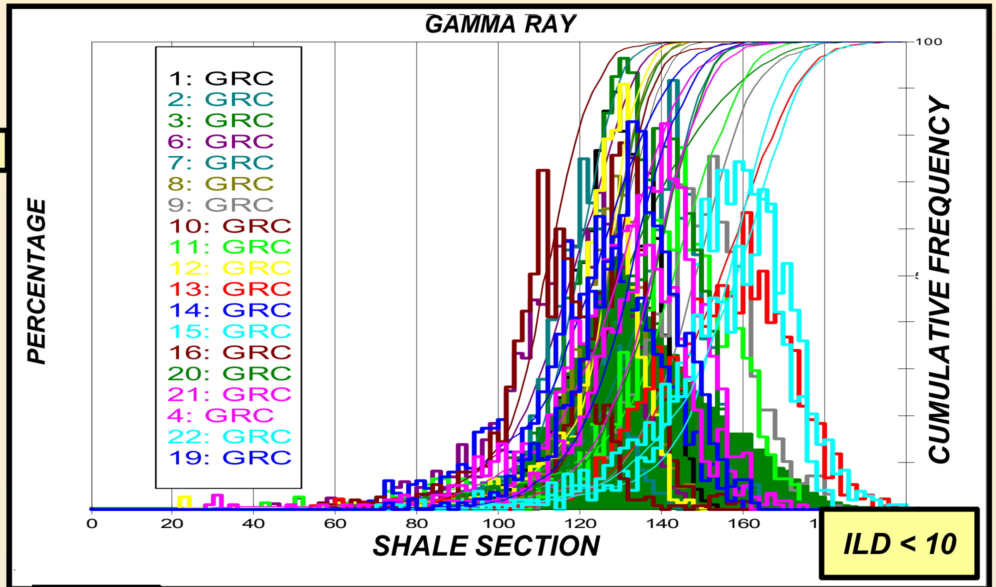


Log Data Normalization

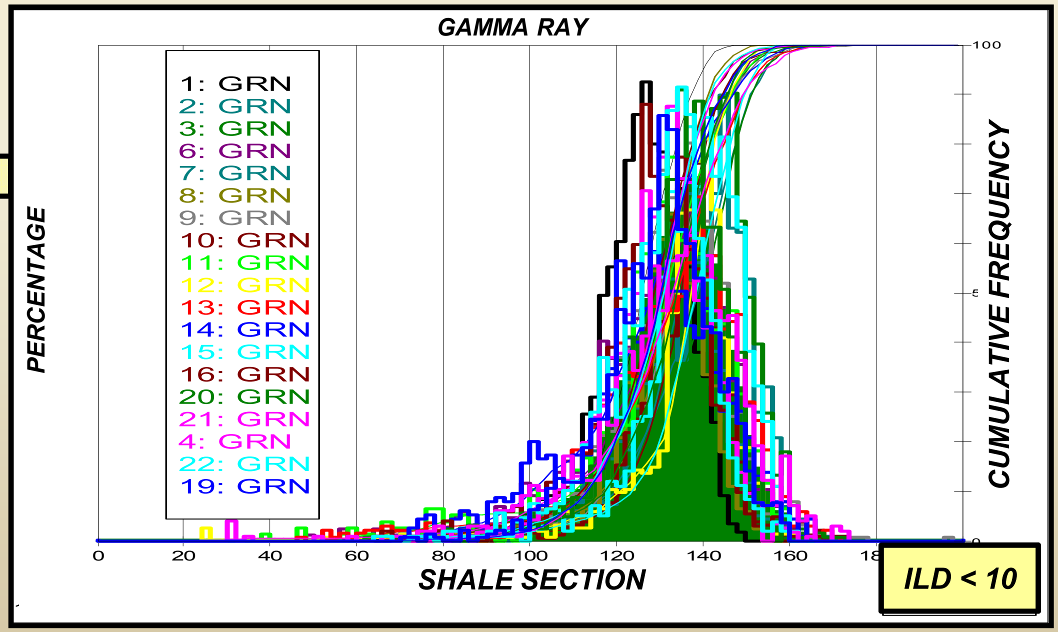
Log data normalization is critical because:

- ***There are several historical logging companies***
- ***Different vintages of logging tools-even within the same company***
- ***There are differing degrees of calibration of logging tools as well as engineer experience***

before



after



Petrophysics- Derivation of Play Drivers

Petrophysical Interpretation

*(Arps,1953) *(Asquith & Krygowski, 2004)

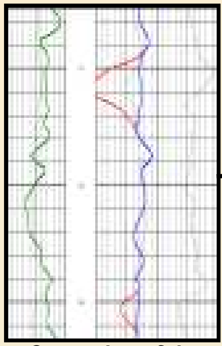
Petrophysical Interpretation

After preparation….

*(Arps,1953) *(Asquith & Krygowski, 2004)

Petrophysical Interpretation

After preparation….

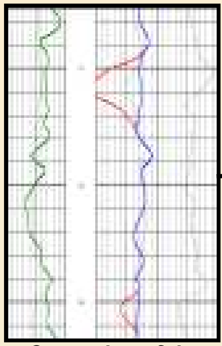


Correction of the Density

*(Arps,1953) *(Asquith & Krygowski, 2004)

Petrophysical Interpretation

After preparation….



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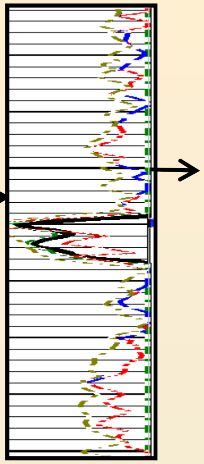
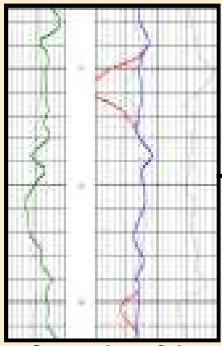


VCLAY from several indicators

*(Arps,1953) *(Asquith & Krygowski, 2004)

Petrophysical Interpretation

After preparation….



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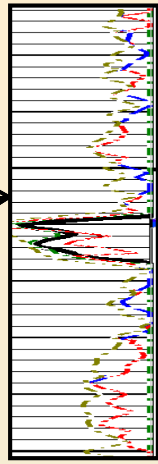

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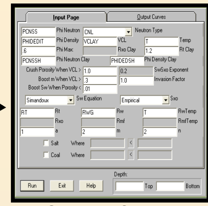
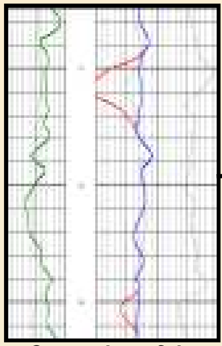


VCLAYs fed into proprietary models

*(Arps,1953) *(Asquith & Krygowski, 2004)

Petrophysical Interpretation

After preparation….



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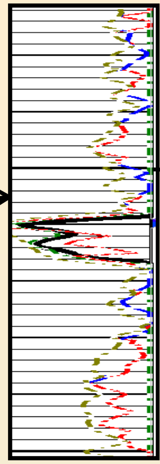

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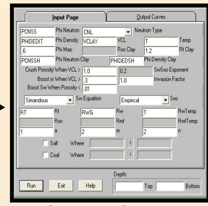

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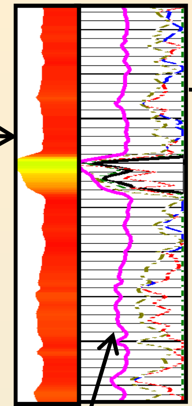
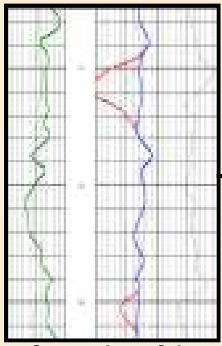


Final VCLAY

**(Arps,1953) *(Asquith & Krygowski, 2004)*

Petrophysical Interpretation

After preparation….



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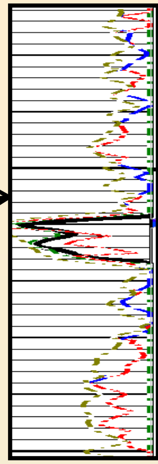

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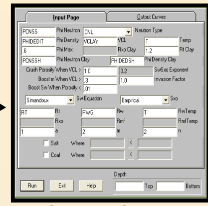

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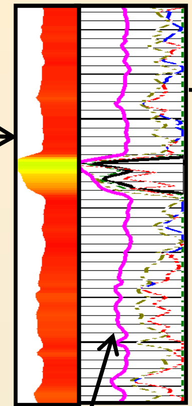


Final VCLAY

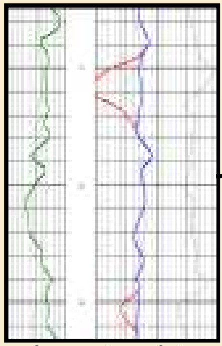
$$R_w = \frac{R_o \times \phi^m}{a}$$ *

Rwa calculation

*(Arps,1953) *(Asquith & Krygowski, 2004)

Petrophysical Interpretation

After preparation….



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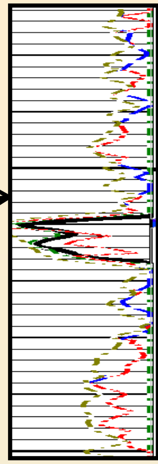

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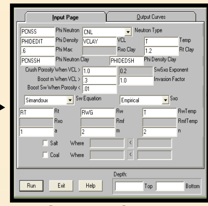

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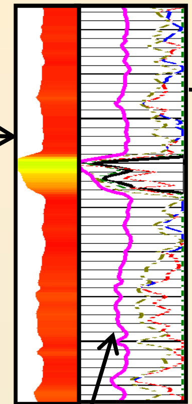


Final VCLAY

$$R_w = \frac{R_o \times \phi^m}{a} \; *$$

Rwa calculation

OR

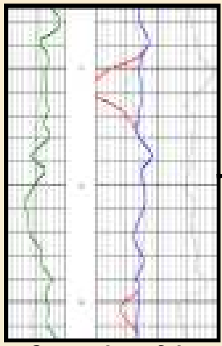
$$R_w = \frac{R_{we} + 0.131 \times 10^{\left(\frac{1}{\log(BHT/19.9)}\right)-2}}{-0.5 \times R_{we} + 10^{\left(\frac{0.0426}{\log(BHT/50.8)}\right)}} \; *$$

Rw from SP

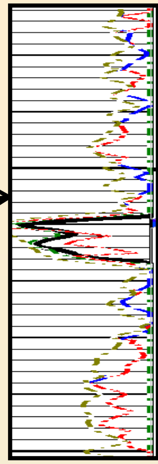
*(Arps,1953) *(Asquith & Krygowski, 2004)

Petrophysical Interpretation

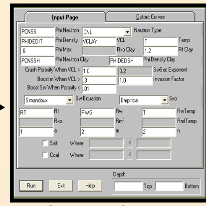
After preparation….



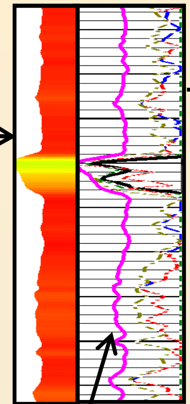
Correction of the Density



VCLAY from several indicators



VCLAYs fed into proprietary models



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OR

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Petrophysical Interpretation

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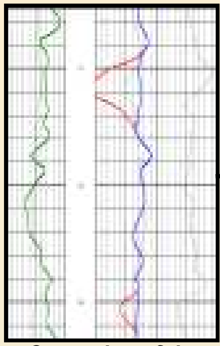

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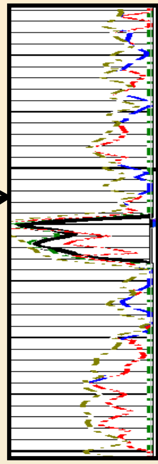

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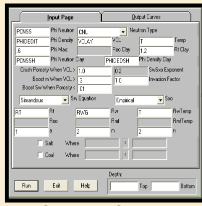

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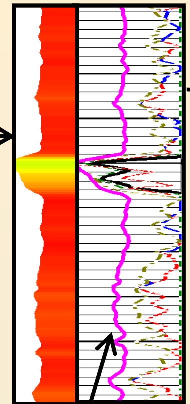

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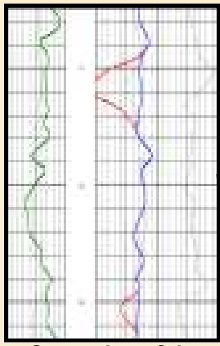
Petrophysical Interpretation

After preparation….



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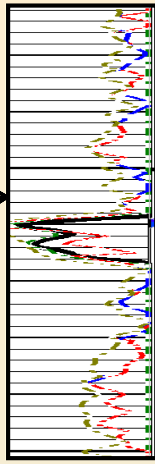

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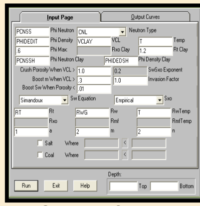

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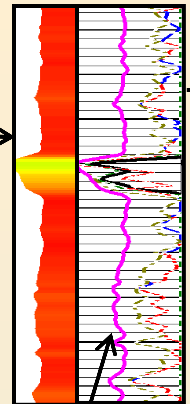

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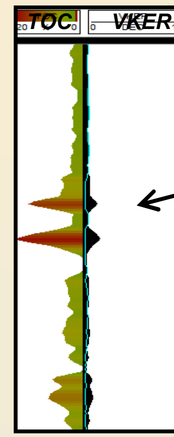

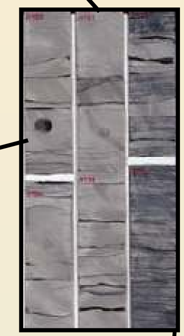

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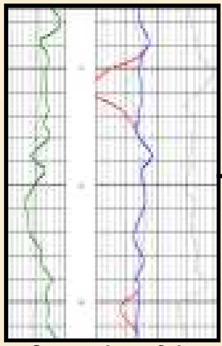
Petrophysical Interpretation

After preparation….



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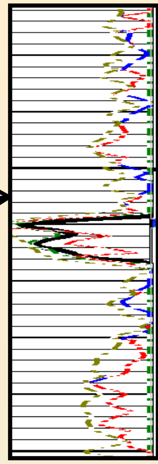

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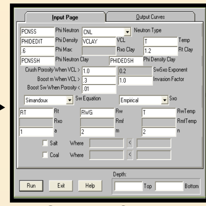

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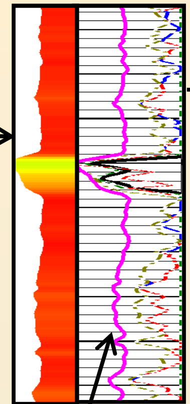

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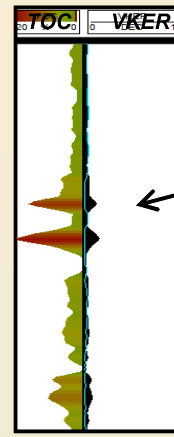

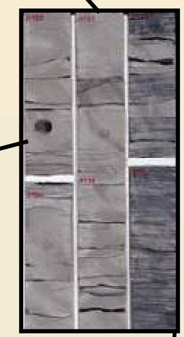

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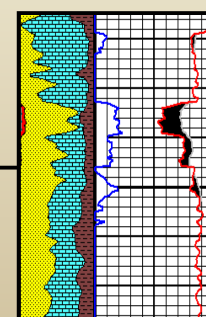

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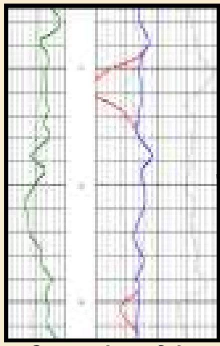
Petrophysical Interpretation

After preparation….



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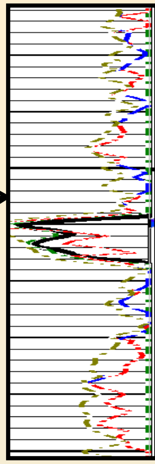
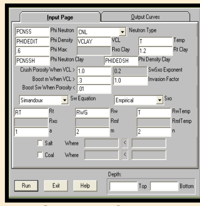
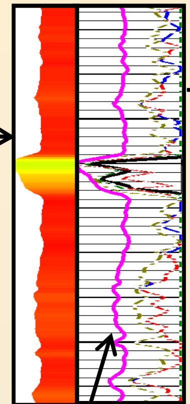


VCLAY from several indicators



VCLAYs fed into proprietary models



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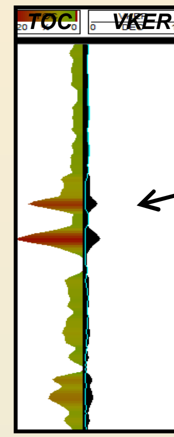

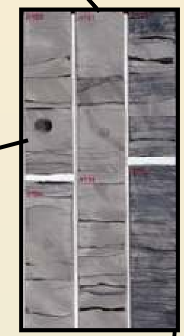

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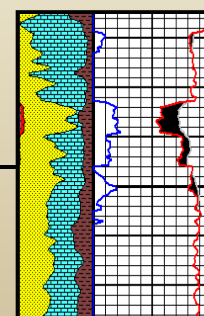

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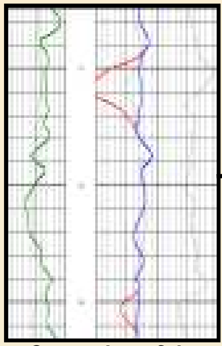
Petrophysical Interpretation

After preparation….



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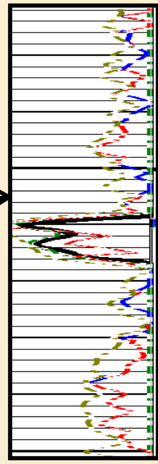
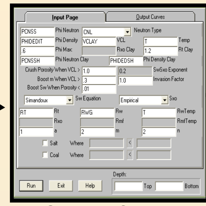
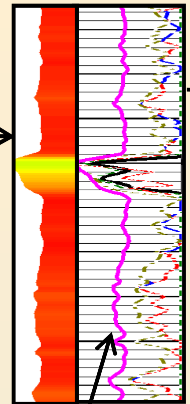


VCLAY from several indicators



VCLAYs fed into proprietary models



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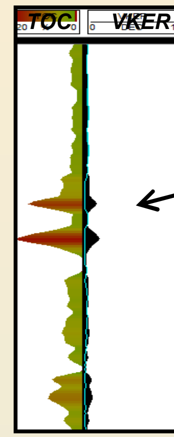

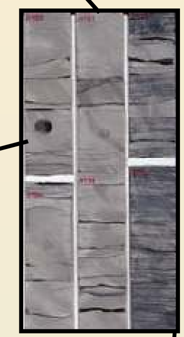

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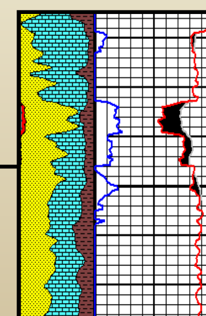
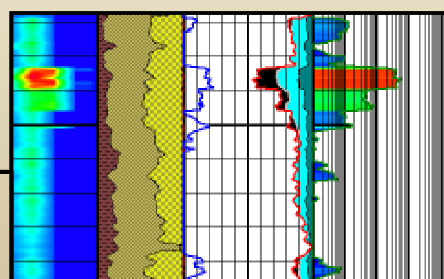


Regional, field or formation specific <u>textural models yields</u>: BVI, PERMIABILITY & GRAIN SIZE



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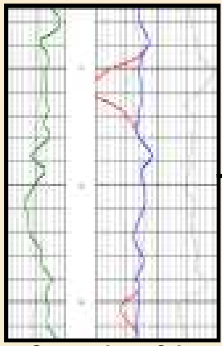
Petrophysical Interpretation

After preparation….



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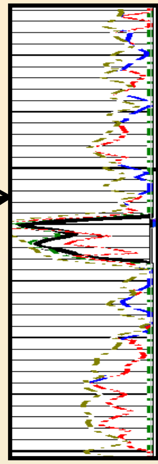
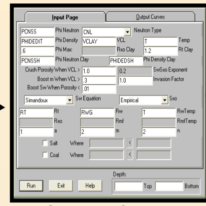


VCLAY from several indicators



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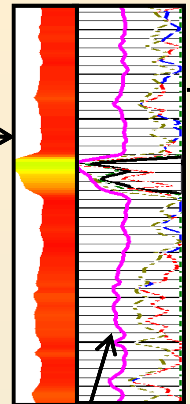

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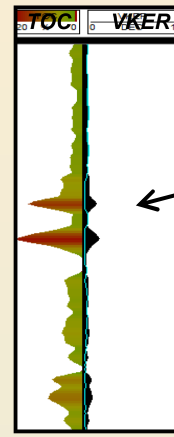

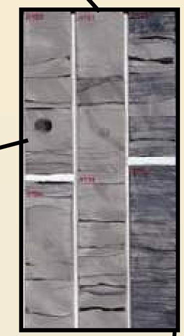

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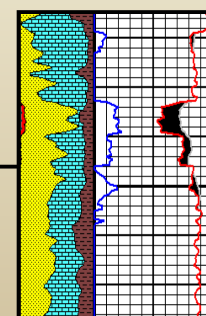
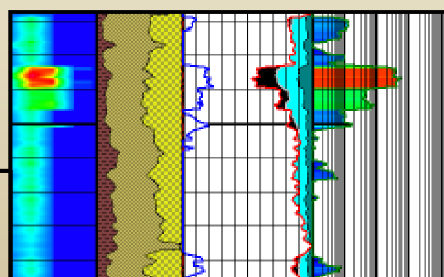
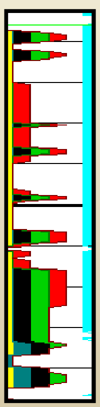


Regional, field or formation specific textural models yields:
BVI, PERMIABILITY & GRAIN SIZE



Flags indicate the quality and productivity of zones



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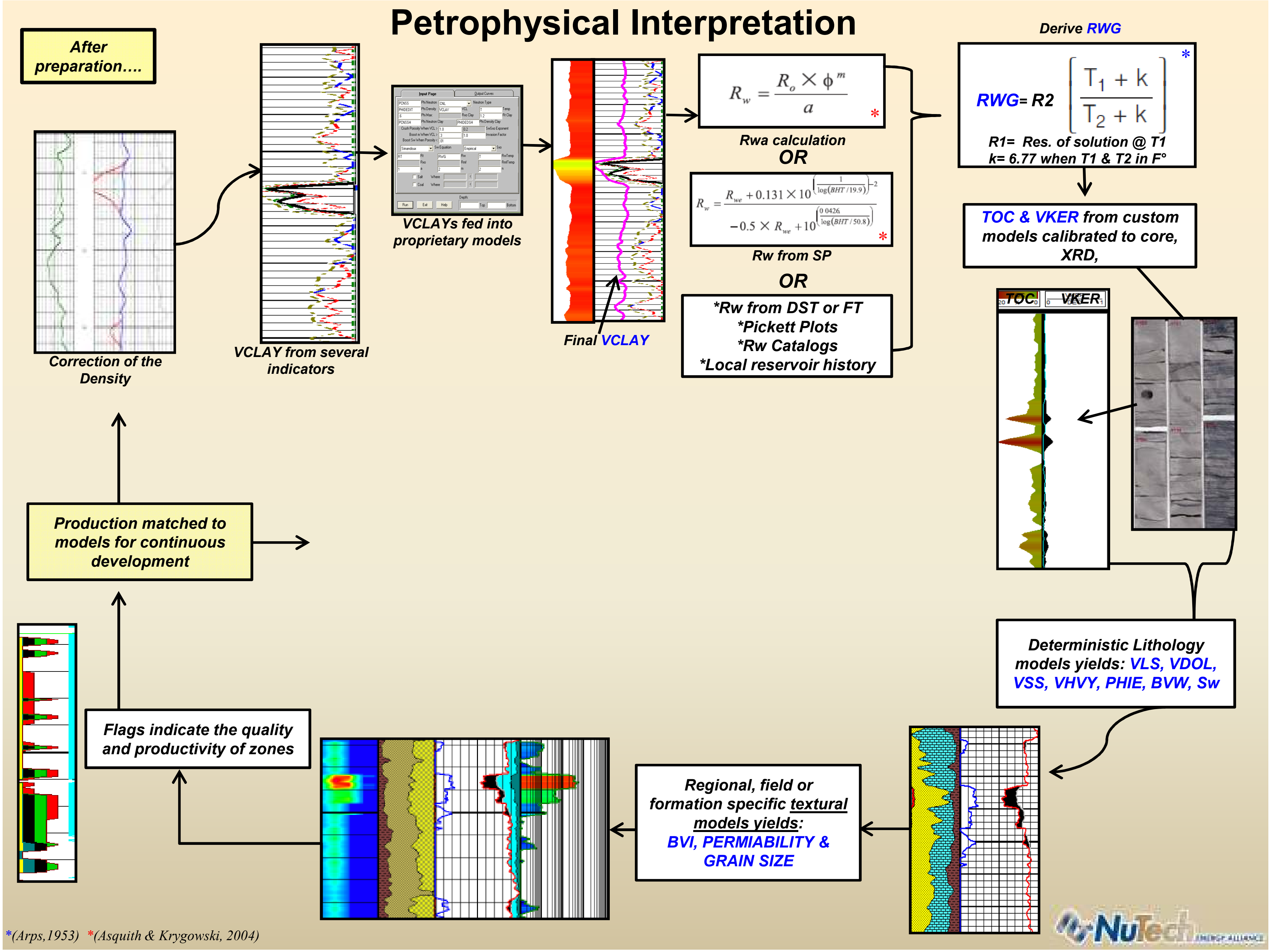
Petrophysical Interpretation
After preparation….
Correction of the Density
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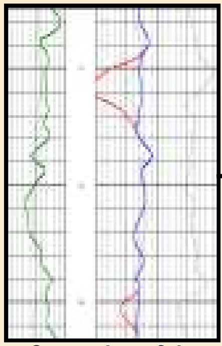
NuTech

Petrophysical Interpretation

After preparation….



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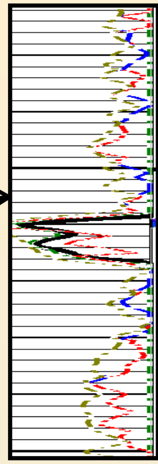

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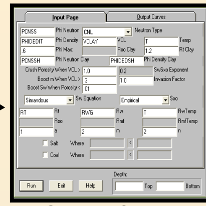

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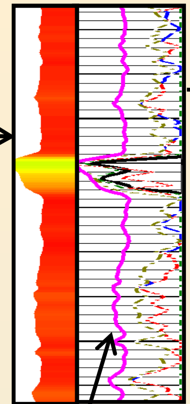

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OR

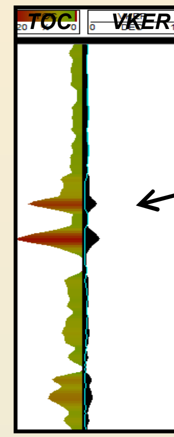
****Rw from DST or FT***
****Pickett Plots***
****Rw Catalogs***
****Local reservoir history***

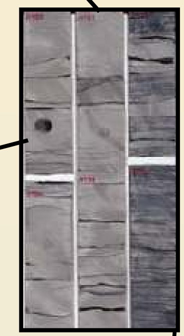
Derive RWG

$$RWG = R2 \left[\frac{T_1 + k}{T_2 + k}\right] \; *$$

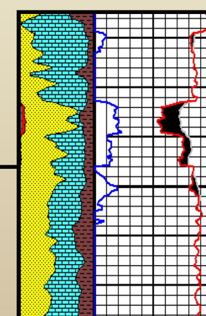
R1= Res. of solution @ T1
k= 6.77 when T1 & T2 in F°

TOC & VKER from custom models calibrated to core, XRD,

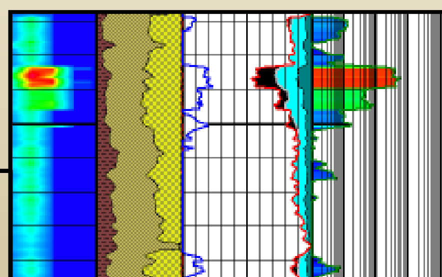




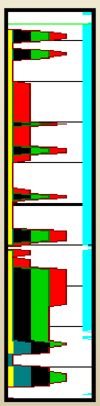
Deterministic Lithology models yields: VLS, VDOL, VSS, VHVY, PHIE, BVW, Sw



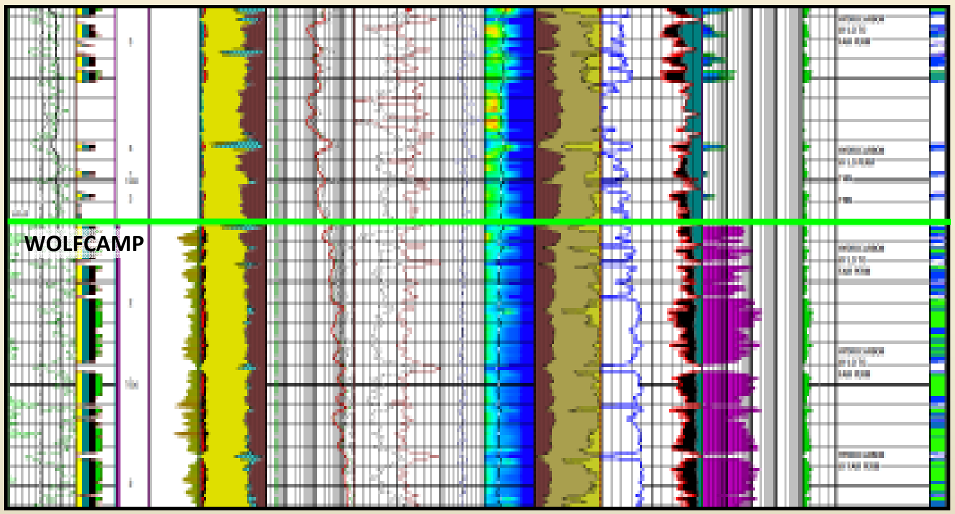
Regional, field or formation specific textural models yields: BVI, PERMIABILITY & GRAIN SIZE



Flags indicate the quality and productivity of zones



Production matched to models for continuous development



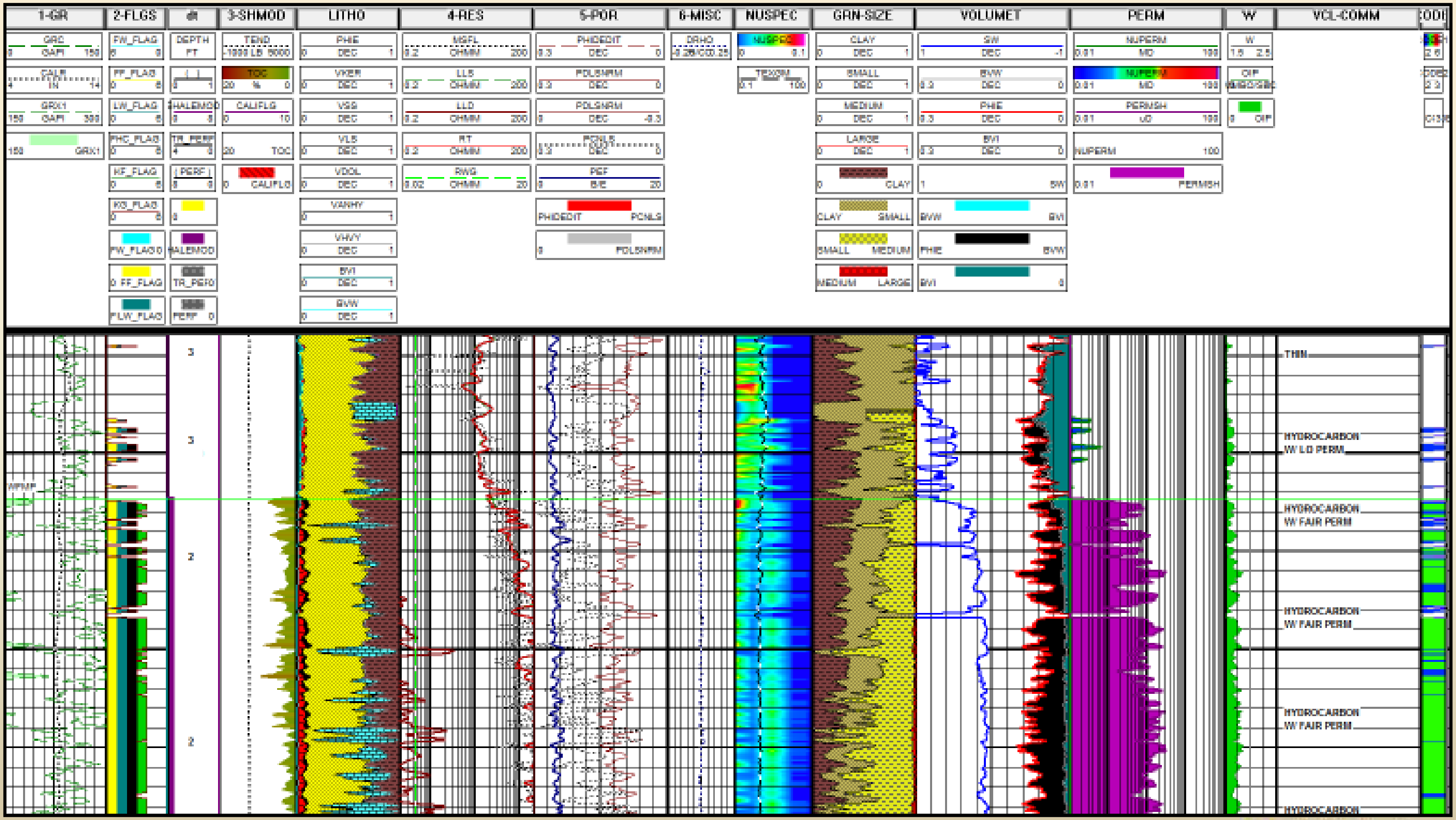
*(Arps,1953) *(Asquith & Krygowski, 2004)

NuTech

Petrophysical Interpretation

Recap…

- ***From the petrophysical analysis, the <u>play drivers</u> we derive are: VCLAY, RWG, TOC, VKER, LITHOLOGY, PHIE, BVW, BVI, SW, & PERMIABILITY***



Gas in Place/Oil in Place

Calculation of gas in place and oil in place…

**(Seungman & Dongsu, 2005)*(http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/maps/maps.htm) *(Asquith, 2005)*

Gas in Place/Oil in Place

Calculation of gas in place and oil in place…

Establish the relationship between gasses adsorbed to solids

*

Langmuir's Equation:

$$\theta = K*C/(1+K*C)$$

θ=fractional coverage of the surface
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Calculate Original Oil in Place & Original Gas in Place

OOIP = 7758*Φ*(1.0 - Sw)*h*DA

OGIP = 43560*Φ*(1.0 – Sw)*h*[(0.43*depth)/14.7]*DA

where:
OOIP = original oil-in-place
OGIP = original gas-in-place
Φ = porosity
h = reservoir thickness
DA = drainage area
depth = depth of reservoir
7758 = barrels of oil in an acre-foot
43560 = cubic feet of gas in an acre-foot
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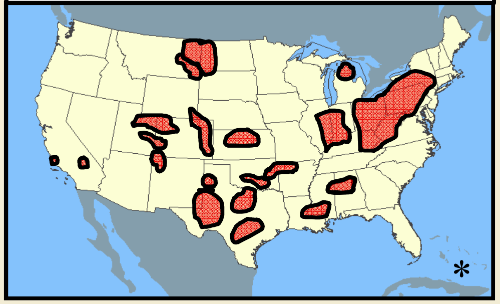
Lower 48 States Shale Plays



Inputs entered into basin specific models

**Vertical wells only*

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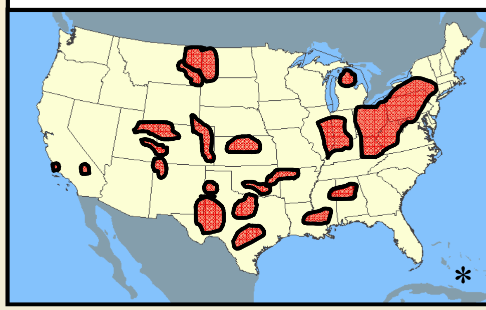

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Yields

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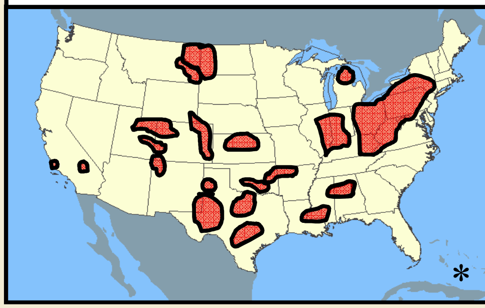

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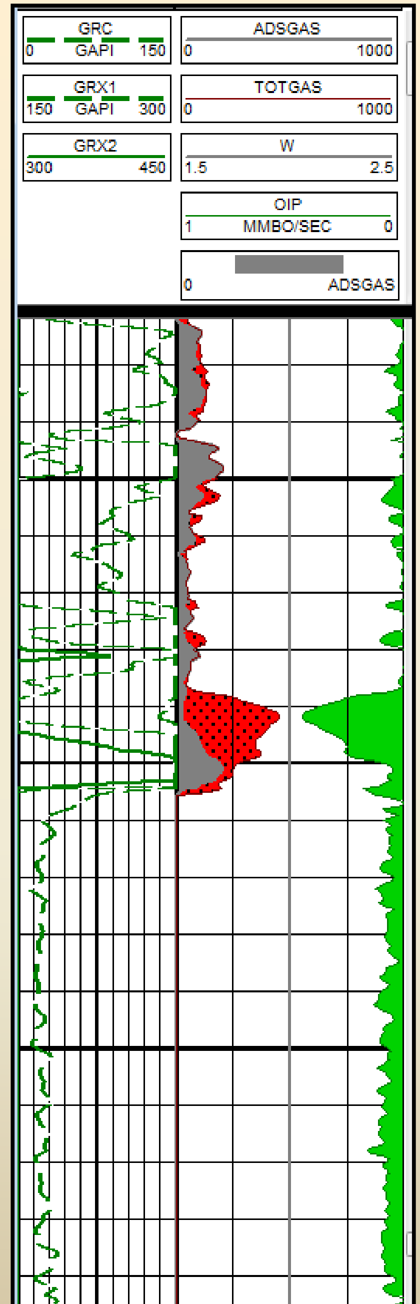

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Play Drivers from Engineering Summary

Finally, derivation of some final Petrophysical <u>play drivers</u>…..

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Finally, derivation of some final Petrophysical <u>play drivers</u>…..

DEPTH FT	GROSSFT	PAYFT	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorFT POR-FT	PERMSHFT uD-FT	TOC %	OIP MMBO/sec
-----											
	1	–	–	0.37	0.059	0.81	0.0098	9.846	52.9508	0.364	0.042
	1	–	–	0.36	0.052	0.92	0.0012	9.85	52.952	0.346	0.016
	1	–	–	0.37	0.039	1	0	9.85	52.952	0.325	0
	1	–	–	0.39	0.04	1	0	9.85	52.952	0.308	0
	1	–	–	0.41	0.048	0.96	0.0002	9.852	52.952	0.28	0.007
	1	–	–	0.38	0.053	0.87	0.0035	9.859	52.9555	0.351	0.027
	1	–	–	0.35	0.058	0.82	0.0084	9.869	52.9639	0.42	0.04
	1	–	–	0.33	0.057	0.85	0.0055	9.878	52.9694	0.431	0.033
	1	–	–	0.29	0.047	1	0	9.878	52.9694	0.438	0
	1	–	–	0.28	0.048	0.97	0.0001	9.879	52.9694	0.485	0.006
	1	1	3	0.35	0.068	0.45	0.1401	9.916	53.1095	0.433	0.142
	1	1	3	0.41	0.086	0.39	0.298	9.969	53.4075	0.917	0.2
	1	1	2	0.31	0.097	0.26	0.5997	10.041	54.0072	3.564	0.275
	1	1	2	0.21	0.098	0.15	0.8257	10.124	54.8329	4.731	0.318
	1	1	3	0.23	0.075	0.23	0.374	10.182	55.2069	3.517	0.222
	1	1	3	0.27	0.069	0.37	0.1974	10.226	55.4043	1.966	0.166
	1	–	–	0.34	0.058	0.6	0.0498	10.249	55.4541	0.12	0.089
	1	–	–	0.27	0.024	1	0	10.249	55.4541	0.32	0
	1	–	–	0.27	0.027	1	0	10.249	55.4541	0.341	0
	1	–	–	0.25	0.048	0.6	0.0321	10.268	55.4862	0.382	0.073
	1	1	3	0.25	0.068	0.53	0.0975	10.3	55.5837	0.386	0.121
	1	1	3	0.32	0.068	0.57	0.083	10.329	55.6667	0.501	0.112
	1	1	3	0.35	0.062	0.59	0.0606	10.354	55.7273	0.822	0.097
	1	1	3	0.4	0.079	0.49	0.166	10.395	55.8933	0.335	0.154
	1	1	3	0.33	0.09	0.43	0.2859	10.446	56.1792	0.149	0.197
	1	–	–	0.19	0.046	0.81	0.0055	10.455	56.1847	0.476	0.033
	1	–	–	0.12	0.013	1	0	10.455	56.1847	0.417	0
	1	–	–	0.1	0.003	1	0	10.455	56.1847	0.369	0
	1	–	–	0.14	0.013	1	0	10.455	56.1847	0.455	0
	1	1	3	0.2	0.062	0.41	0.1331	10.491	56.3178	0.607	[illegible]
	1	1	3	0.24	0.061	0.57	0.0676	10.518	56.3854	0.413	0.102
	1	–	–	0.21	0.057	0.62	0.0412	10.539	56.4266	0.455	0.082
	1	1	3	0.19	0.058	0.42	0.1101	10.572	56.5367	0.665	0.127
	1	1	3	0.23	0.063	0.48	0.1069	10.605	56.6436	0.563	0.126
	1	1	3	0.27	0.073	0.48	0.142	10.643	56.7856	0.328	0.143
	1	1	3	0.26	0.084	0.37	0.3038	10.695	57.0894	0.766	0.202
	1	1	2	0.28	0.105	0.37	0.5	10.762	57.5894	0.772	0.253
	1	1	3	0.3	0.103	0.4	0.4344	10.824	58.0238	0.682	0.238
	1	1	3	0.29	0.104	0.4	0.4363	10.886	58.4601	1.08	0.238
	1	1	3	0.35	0.092	0.43	0.2981	10.939	58.7582	0.215	0.2
	1	–	–	0.27	0.032	0.93	0.0003	10.941	58.7582	0.333	0.009
	1	–	–	0.23	0	1	0	10.941	58.7582	0.414	0
	1	–	–	0.3	0.035	0.86	0.0017	10.946	58.7599	0.226	0.019
	1	1	3	0.4	0.093	0.45	0.284	10.997	59.0439	0	0.196
	1	1	3	0.39	0.078	0.6	0.0944	11.028	59.1383	0.349	0.119
	1	–	–	0.42	0.063	0.73	0.0258	11.046	59.1641	0.28	0.066
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	362 TOT	195 TOT	2.8 AVGX	0.314 AVGX	0.068 AVGX	0.615 AVGX	0.163 AVGX	11.046 CUM	59.1641 CUM	0.712 AVGX	42.188 CUM

Cumulative permeability over specific formation

Play Drivers from Engineering Summary

Finally, derivation of some final Petrophysical <u>play drivers</u>…..

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	1	–	–	0.23	0	1	0	10.941	58.7582	0.414	0
	1	–	–	0.3	0.035	0.86	0.0017	10.946	58.7599	0.226	0.019
	1	1	3	0.4	0.093	0.45	0.284	10.997	59.0439	0	0.196
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Cumulative permeability over specific formation

<u>Total</u> cumulative hydrocarbon porosity-feet over specific formation

<u>Total</u> cumulative permeability-feet (kh) over specific formation

Zone	Summaries										
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-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
formation 1	139	94	2.5	0.336	0.073	0.585	0.407	4.526	56.5355	2.210	17.287
formation 2	517	254	2.7	0.262	0.068	0.658	0.273	13.225	140.9915	1.848	50.508
formation 3	877	317	2.7	0.232	0.053	0.692	0.188	16.269	164.892	1.963	62.138
formation 4	1860	1324	2.2	0.216	0.070	0.437	1.018	82.876	1893.452	2.253	316.536
formation 5	362	195	2.8	0.314	0.068	0.615	0.163	11.046	59.1641	0.712	42.188
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX	CUM

NuTech ENERGY ALLIANCE

GeoTextural Play Drivers: Brittleness & Competency

Next, the petrophysical solutions drive the GeoTextural log properties…

*(Davis & Reynolds, 1996)

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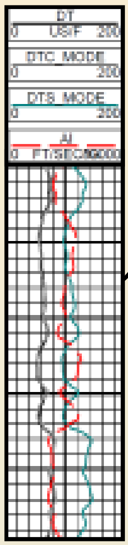

Delta-T Compressional & Delta-T Shear wave <u>modeled</u> if not acquired

*(Davis & Reynolds, 1996)

NuTech ENERGY ALLIANCE

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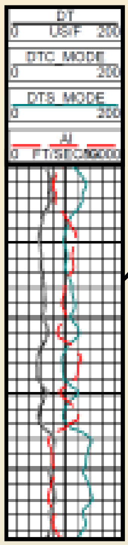


Delta-T Compressional & Delta-T Shear wave <u>modeled</u> if not acquired

$$E = \frac{\Delta \sigma}{\Delta \varepsilon} \quad *$$

$\sigma =$ Axial stress

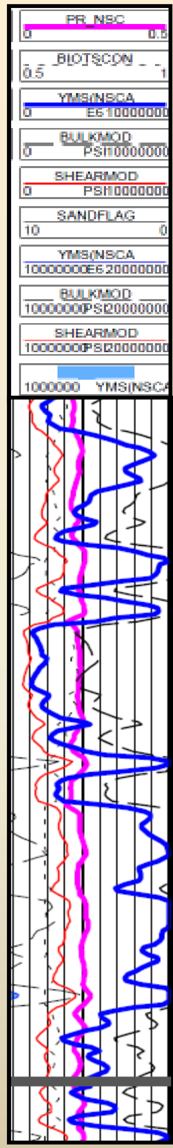
$\varepsilon =$ Axial strain

Young's Modulus

$$\nu = \frac{\varepsilon_{lateral}}{\varepsilon_{axial}} \quad *$$

Poisson's Ratio

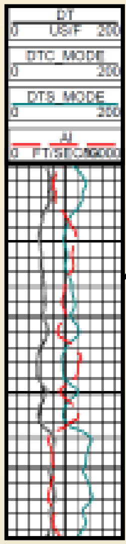
Derivation of elastic properties



*(Davis & Reynolds, 1996)

GeoTextural Play Drivers: Brittleness & Competency

Next, the petrophysical solutions drive the GeoTextural log properties…



Delta-T Compressional & Delta-T Shear wave <u>modeled</u> if not acquired

*

$$E = \frac{\Delta \sigma}{\Delta \varepsilon}$$

$\sigma =$ Axial stress

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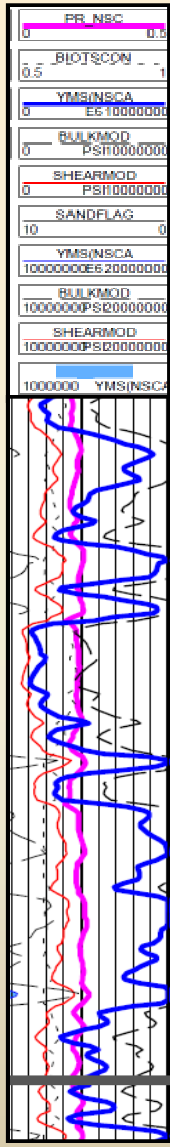

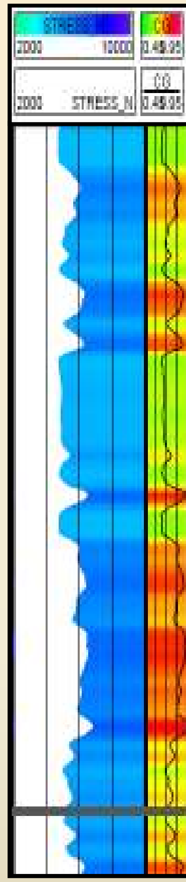

In-situ stress indicates the minimum least principle stress of the formation

Closure stress gradient

****Validated & calibrated to injection tests & fracture treatments***

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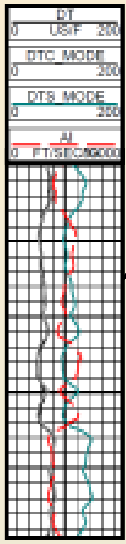

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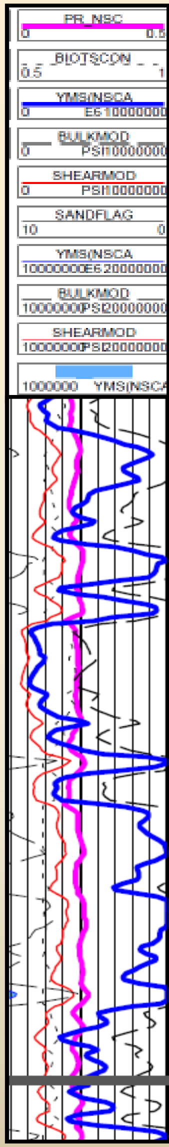

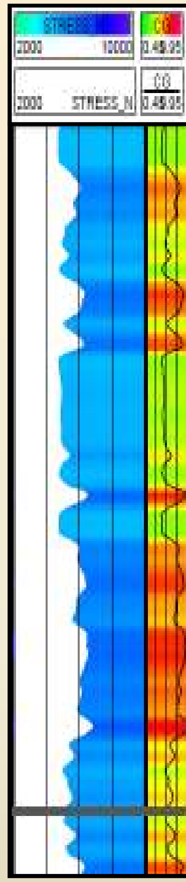

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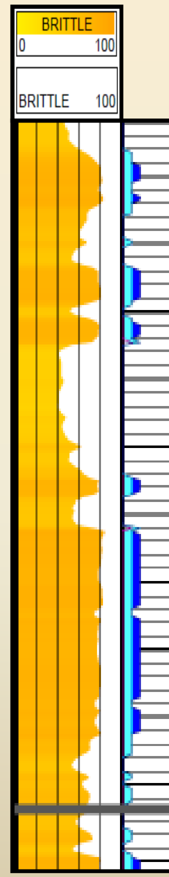

Brittleness coefficient (%)

*(Davis & Reynolds, 1996)

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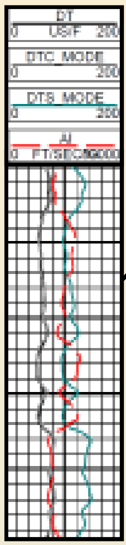

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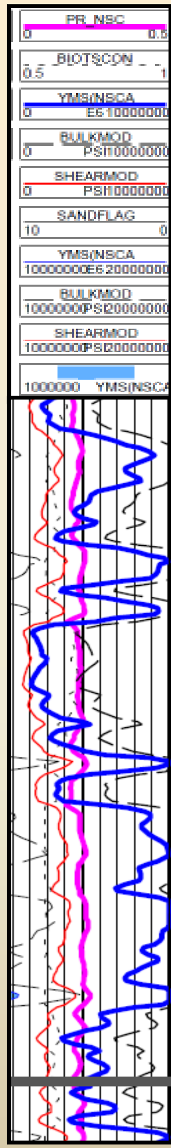

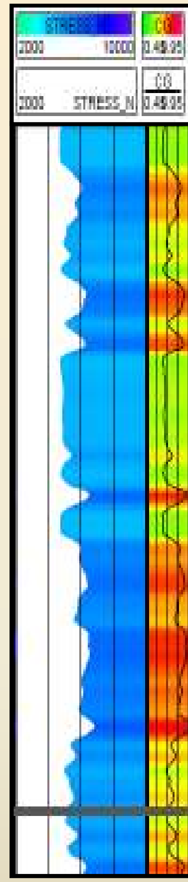

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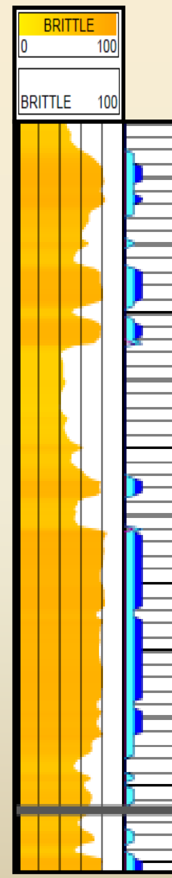

Brittleness coefficient (%)

Competency = E / stress

**In terms of mechanical strength, the resistance to either erosion or deformation.*

*(Davis & Reynolds, 1996)

GeoTextural Interpretation

Recap…

- ***The petrophysical analysis drives the GeoTextural results and the play drivers we derive are: Brittleness & Competency***

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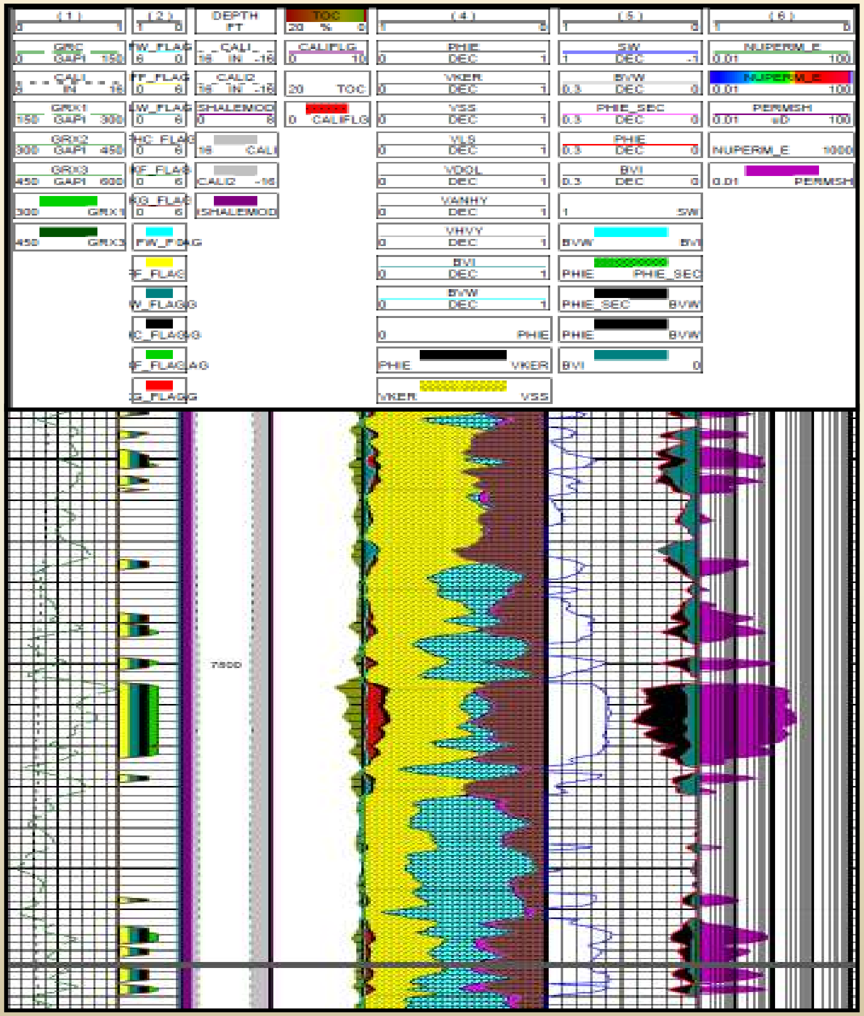

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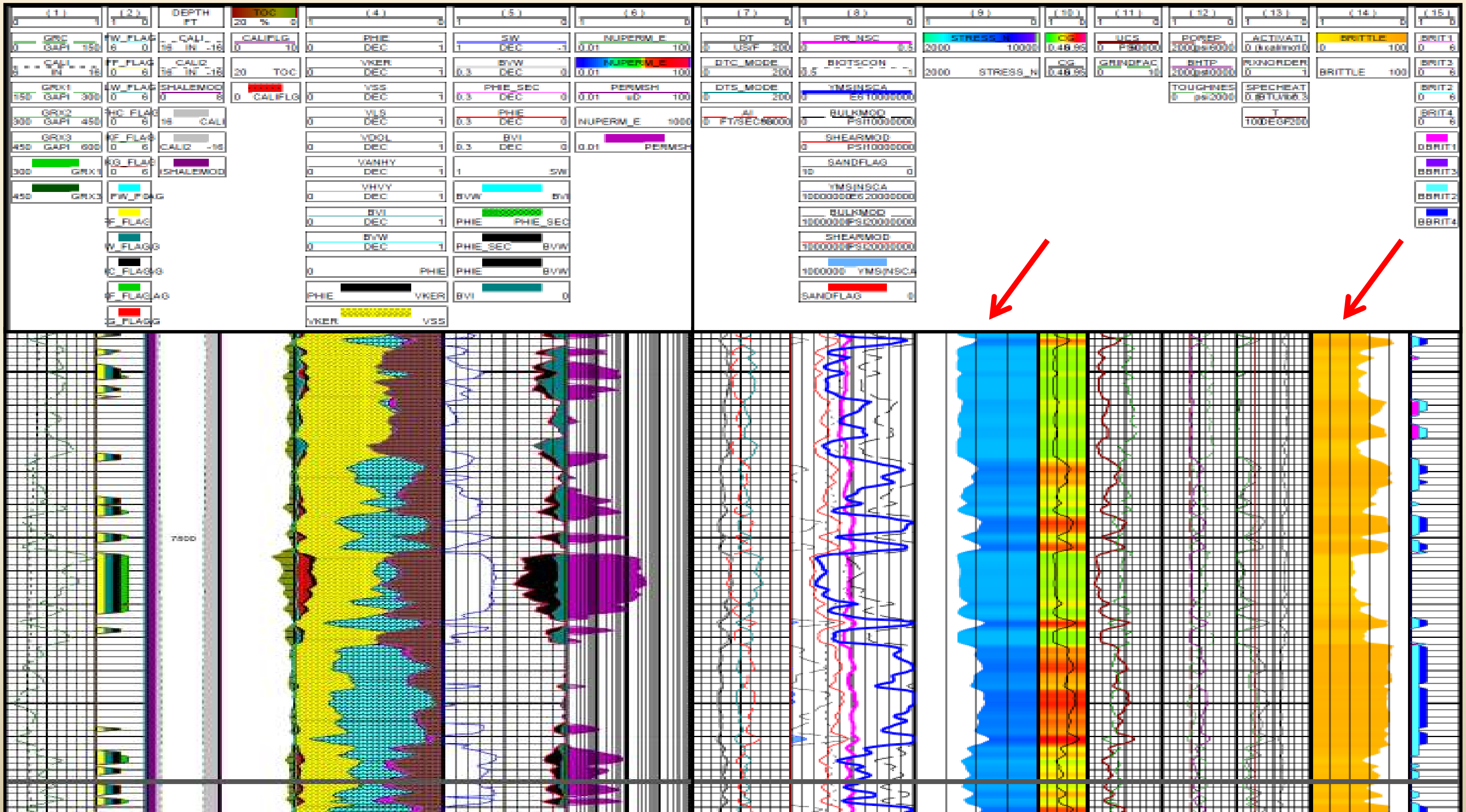

Geologic Attribute Mapping

Data Collection & Conditioning

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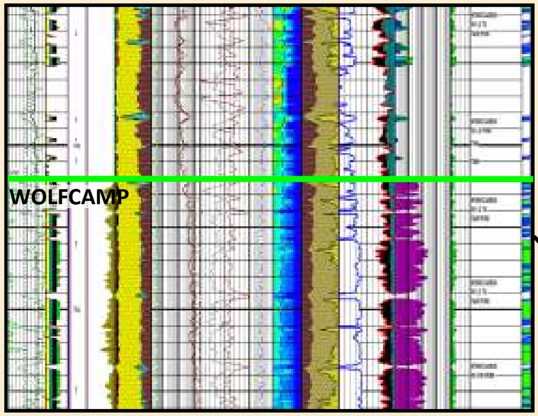

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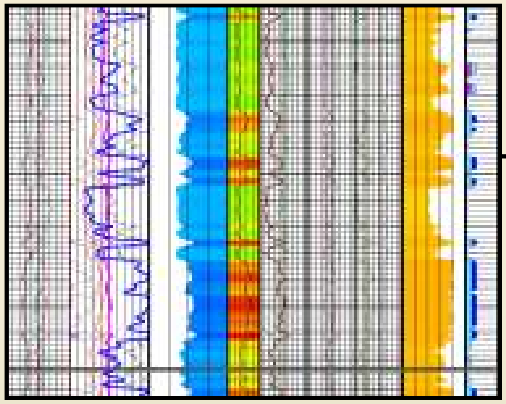
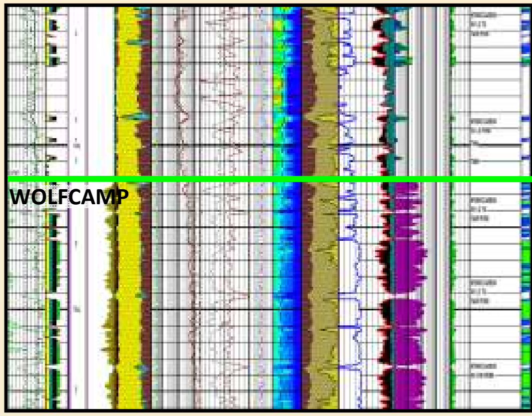


Geomechanical properties collected

Zone	Summaries										
DEPTH FT	GROSSFT	PAYFT	RANK	CLAY DEC	PHIE DEC	SW DEC	PERMSH uD	HydPorFT POR-FT	PERMSHFT uD-FT	TOC %	OIP MMBO/sec
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
formation 1	139	94	2.5	0.336	0.073	0.585	0.407	4.526	56.5355	2.210	17.287
formation 2	517	254	2.7	0.262	0.068	0.658	0.273	13.225	140.9915	1.848	50.508
formation 3	877	317	2.7	0.232	0.053	0.692	0.188	16.269	164.892	1.963	62.138
formation 4	1860	1324	2.2	0.216	0.070	0.437	1.018	82.876	1893.452	2.253	316.536
formation 5	362	195	2.8	0.314	0.068	0.615	0.163	11.046	59.1641	0.712	42.188
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
	TOT	TOT	AVGX	AVGX	AVGX	AVGX	AVGX	CUM	CUM	AVGX	CUM

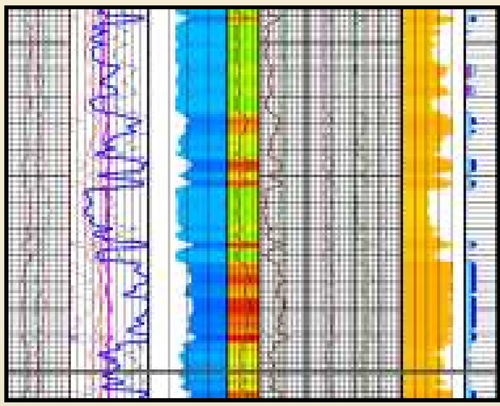
Listing of data

Data Collection & Conditioning



Petrophysical drivers collected

Petrophysical play drivers are further conditioned into mappable attributes (EX: accumulations, net cutoffs & averages)



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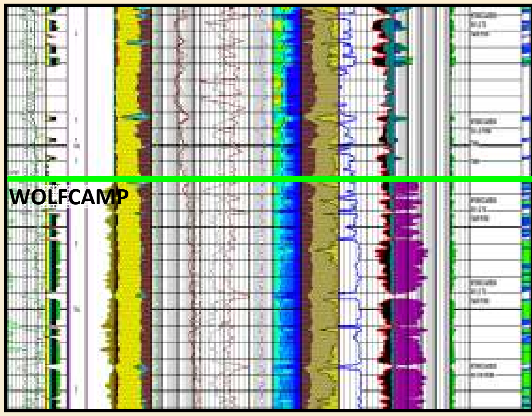

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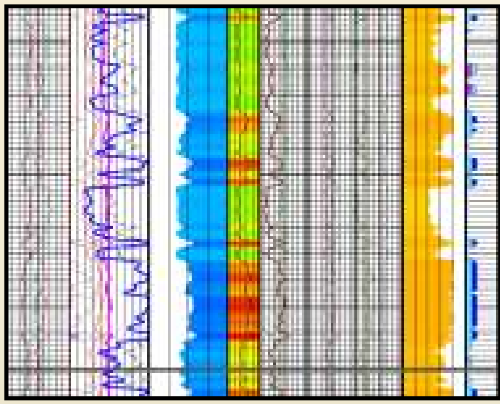

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FINAL MAPPABLE ATTRIBUTES:

Net PHIE-ft (> 7.5%)
Net Permeability-ft (> 100 uD-ft)
Mean Brittleness (dimensionless)
Mean VCLAY (%)
Net TOC (%) (> 2%)
Summation of OIP (MMBO/SEC)

Next…

Cross-Sections

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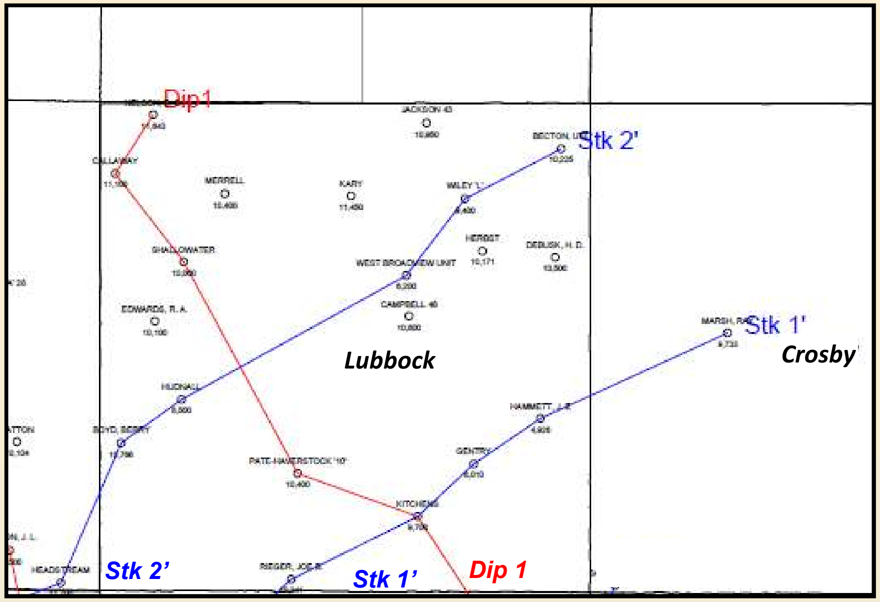

Revisiting the original base map, cross-sections are developed that will give us an inference of the strike and dip of the study area

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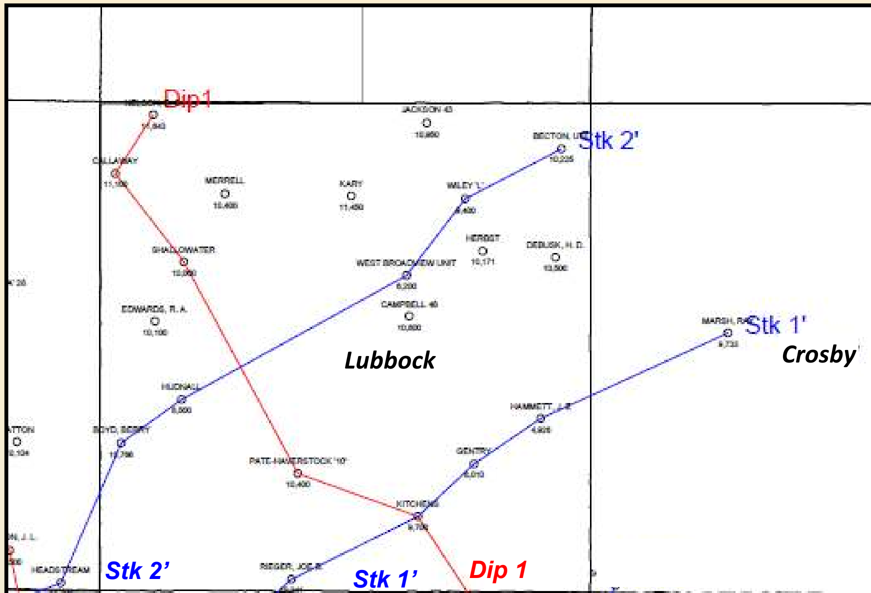

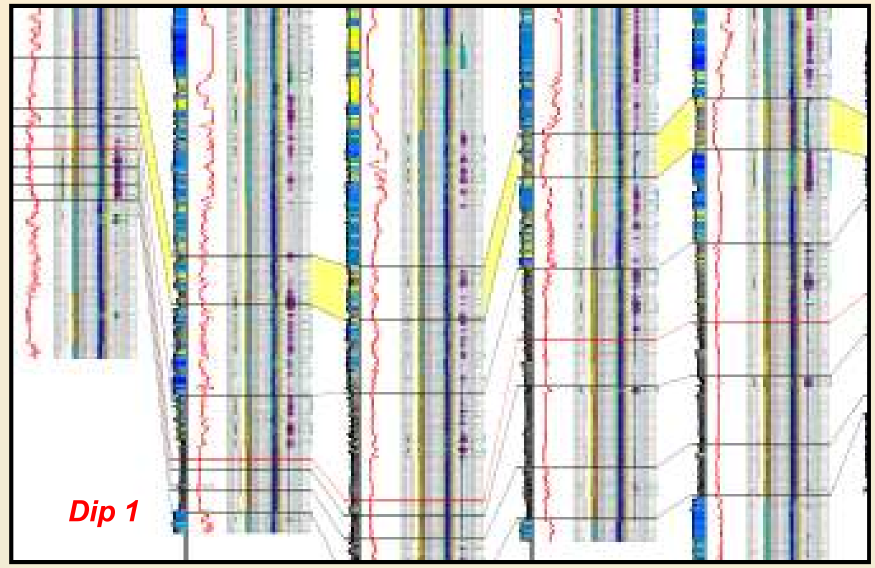

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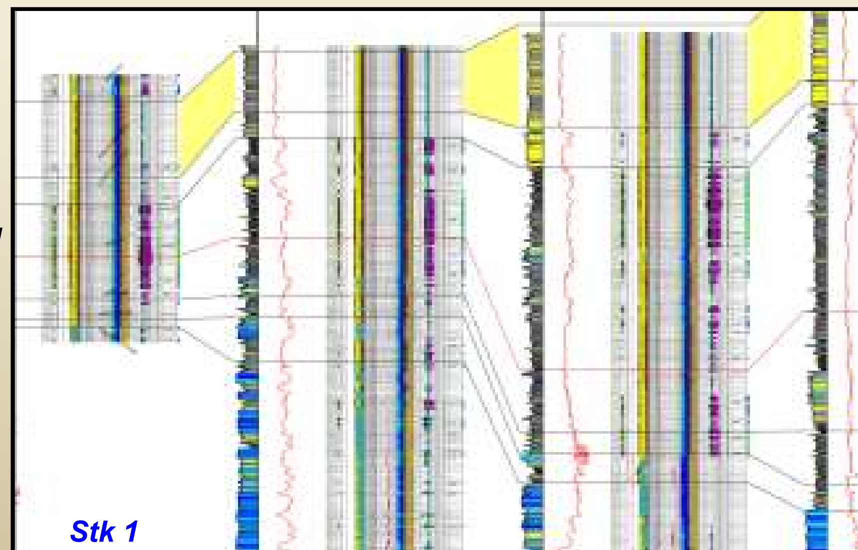
Cross-sections are generated along strike and dip from the petrophysical interpretations



Research & Respect for the Paleogeography

*(Modified from Dutton ,et al., 2005) *(Modified from Blakey, 2011)

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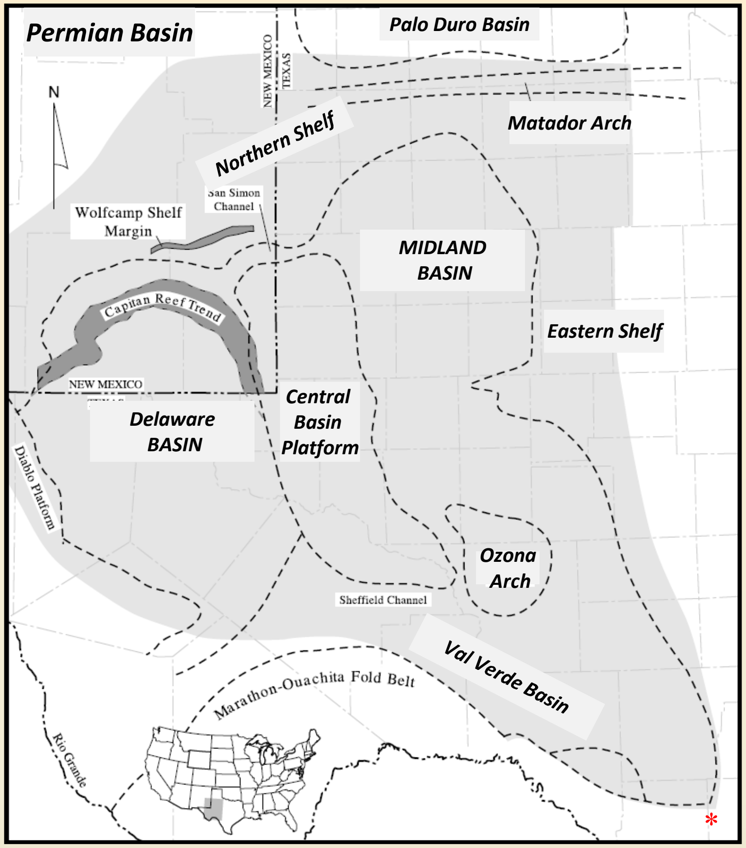

Extensive research helps to define basin outlines, structural features, depositional systems, and facies changes

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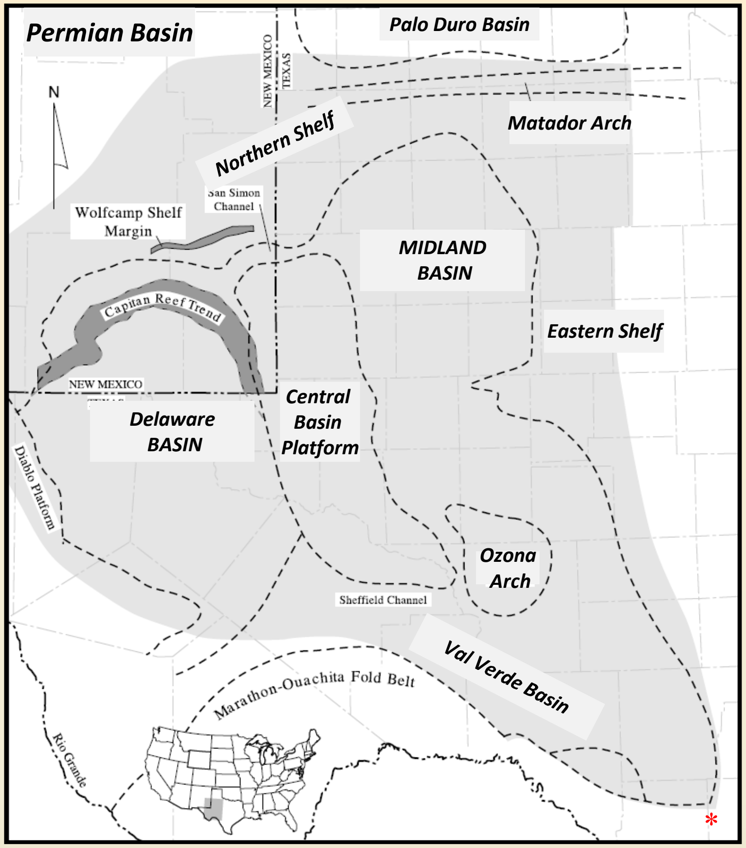

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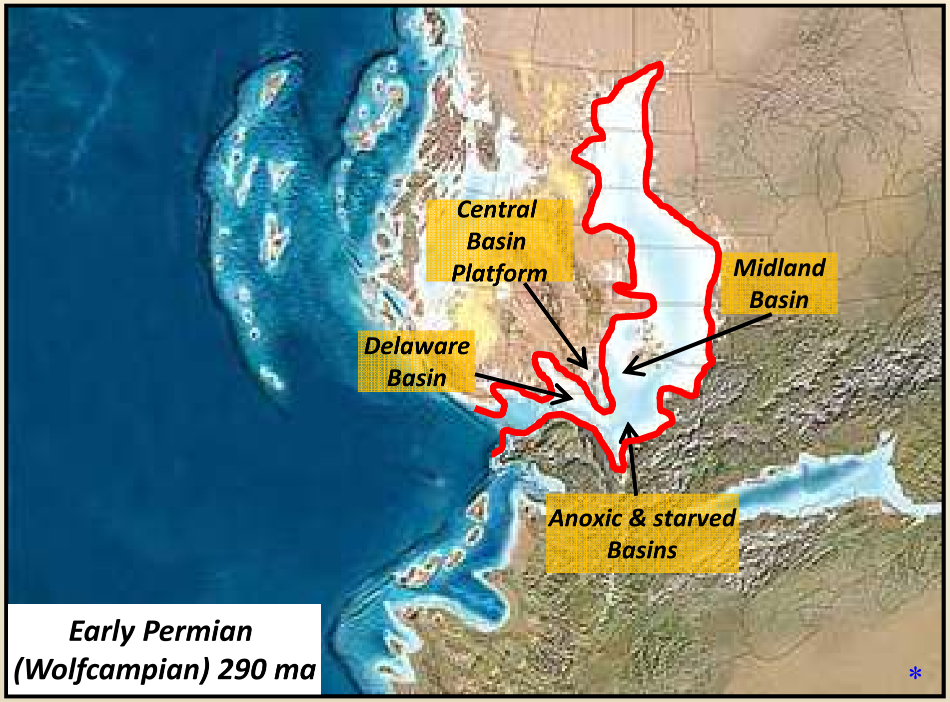

Respect for the paleogeography helps to drive the contoured attribute maps of the study area

*(Modified from Dutton ,et al., 2005) *(Modified from Blakey, 2011)

Finally…

MAPPING

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- ***Final mappable attributes are distributed over the study area.***
- ***Contoured maps are generated in accordance with basin structure, facies relationships, depositional systems and paleogeography.***

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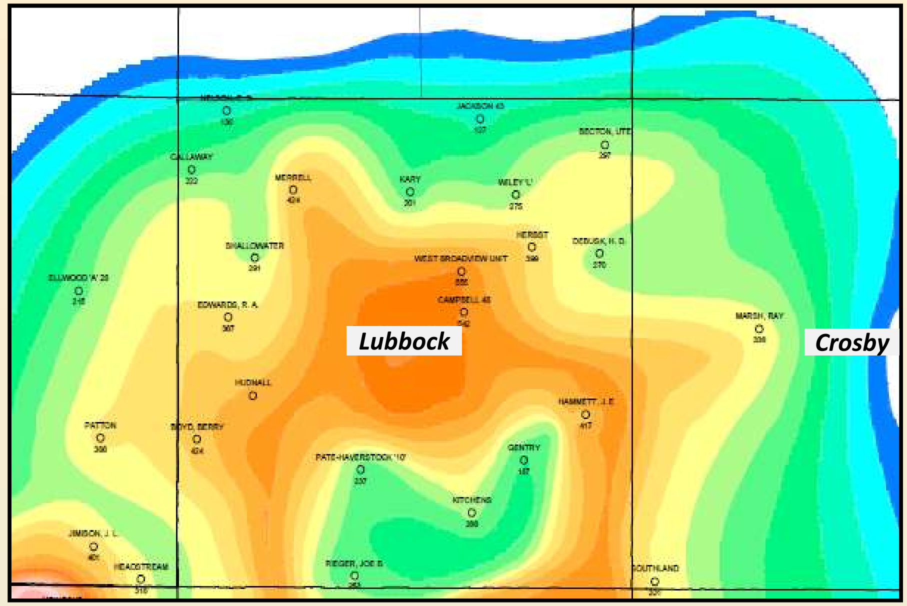
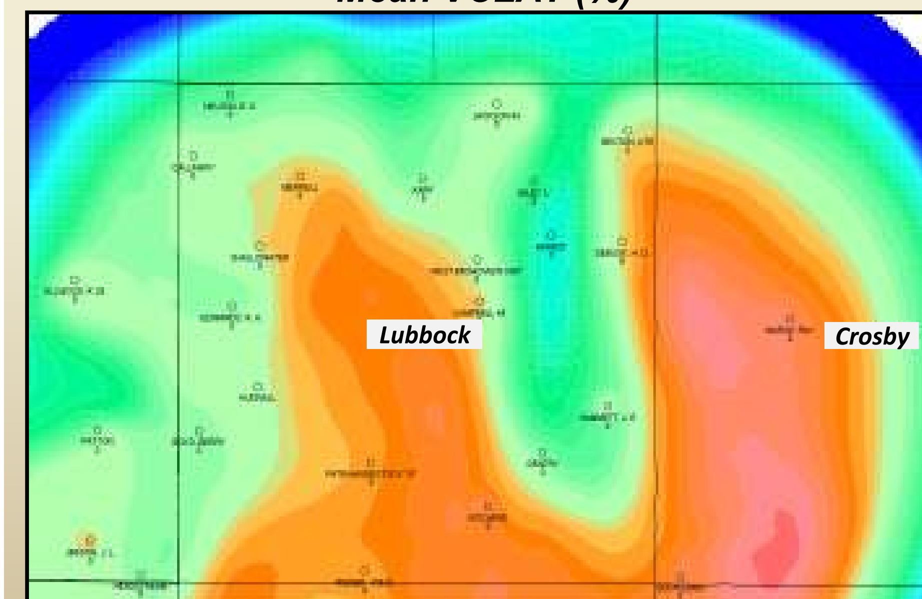
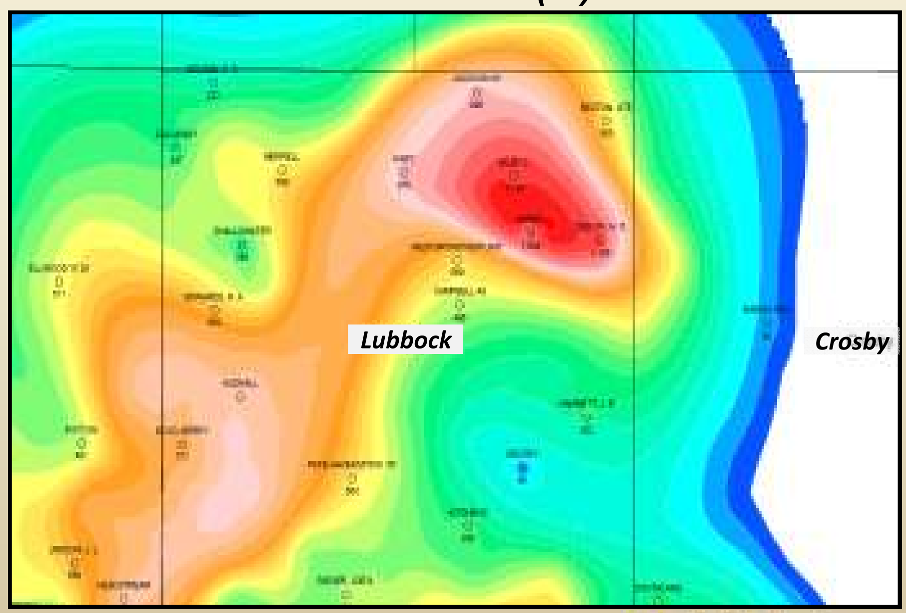


Mean VCLAY (%)



Net TOC (%)



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- ***Evaluating the final maps of the study area answers our initial questions before entering into the play.***

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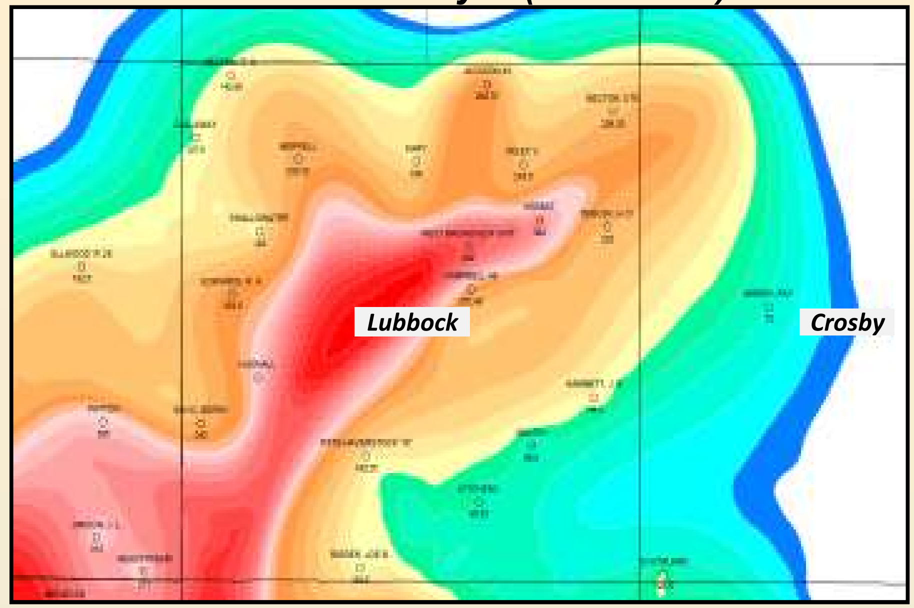
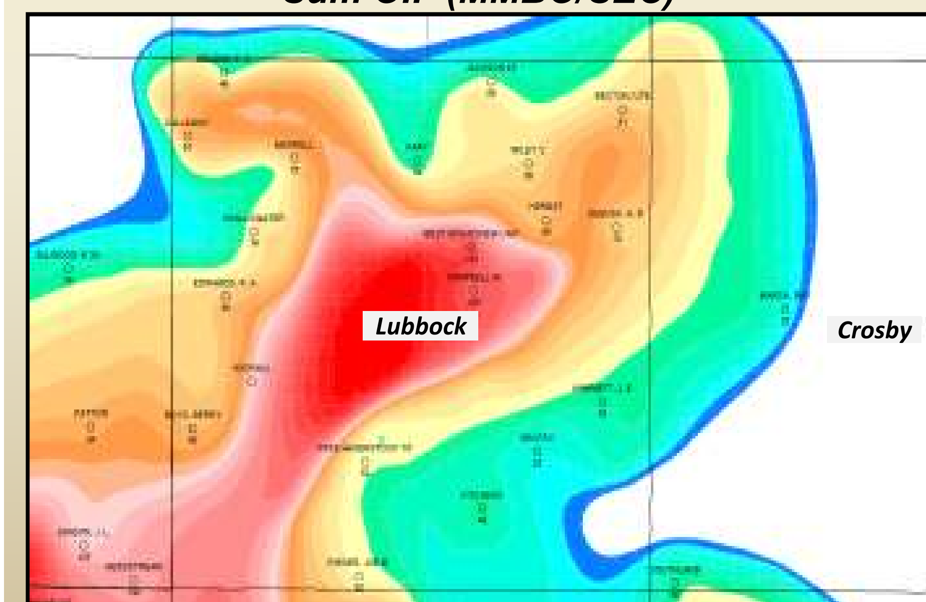
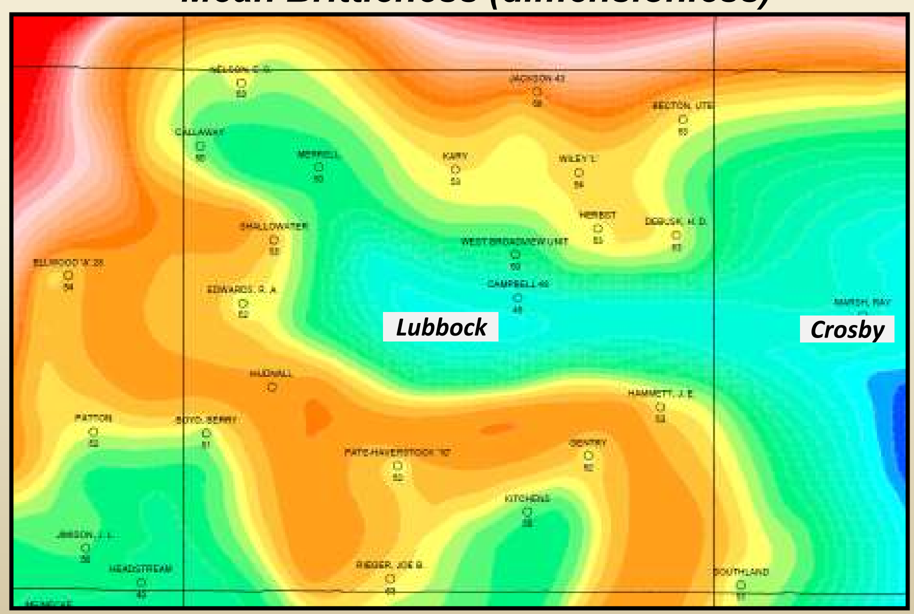
Net Permeability-ft (>100 uD-ft)



Sum OIP (MMBO/SEC)



Mean Brittleness (dimensionless)



Summary

A proper methodology is crucial to gathering petrophysical attributes that can be mapped with respect to the paleogeography and depositional systems. Employing this methodology can allow for an advanced "reconnaissance" of an area and help to answer some initial questions before entering into a play.

Typical data sets are sparse on petrophysical and geomechanical (textural) data. The ability to utilize public data systems and apply petrophysical processing can significantly decrease the time expended on in-house petrophysics. Utilizing public data systems also greatly expands the interpretation and confidence of any given play.

With the integration of petrophysics and attribute mapping, one can evaluate large areas for play viability, understand the regional aspect of the unconventional play and delineate the smaller conventional anomaly. Mapping the petrophysical attributes gained from region specific models gives the geoscientist conceptual proof and delivers an enhanced data set within the area of interest.

The ability for an experienced team to integrate petrophysics with geologic attribute mapping can justify the economic aspects of play analysis. The ability to execute this process expeditiously will lead to successful leasing of acreage *ahead of the stampede*.

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