Abstract
Here is a method for qualitative analysis of Electrical Survey (ES) logs. The basis of the method is detailed in[1], "Water Saturation & Productivity Estimates from Old Electrical Survey Logs of Clean & Shaly Sections"(www.oiljetpump.com). Systems of interpretation for ES logs (SP, Rn, Rlat, typically SP, R16, R64, R18-8") are sparse. Mainly due to advances in logging systems to overcome inherent problems of the ES system. However, many (perhaps[6] 40%) of American wells were logged using the ES system. The analysis method is to plot log(R16/R_d) vs PSP, with Rd as an interpolated value from either Long Normal or Lateral. This is similar to analysis by plotting log(R_{xo}/R_t) vs SSP. However many old wells were not logged with a R_{xo} tool, subsequently R_{xo} is indeterminate from ES data, but R16/R_d is available from the ES log. A Neural network was used to map charts in place of using least squares regression.

Background
Schlumberger[2] presents Chart D12, "Saturation Determination 5FF40 - 16" Normal, Thick Beds of Low and Medium Resistivity". Schlumberger used a modification of the SP equation as their basis of analysis. The shale PSP equation is:

$$S_w = \{(R_{xo}/R_t)/(10^{(PSP/K)})\}^{(5/\alpha 8)} \quad \& \text{ PSP} = \alpha(\text{SSP}) \ \& \text{ if } \alpha = 1, \text{ PSP=SSP}$$

This equation plots linear with R_{xo}/Rt plotted on a log scale vs inverse PSP on a linear scale: PSP = Klog(R_{xo}/R_t) - K1.6$\alpha \log(S_w)$ This plot is linear passing thru the point PSP=0 & R_{xo}/Rt=1, with a series of S_w lines thru same point.

With the ES, R_{xo} is not generally available. The invaded zone resistivity, R_i, can be used instead to calculate Sw by inclusion of mixing factor[1], z,

$$S_w = \{(R_i/R_t)[Z + (1-Z)/(10^{(PSP/K)})]\}^{(5/\alpha 8)}$$

A plot of log(R16/R_t) is not linear against PSP but an alternative is feasible, given the nearly linear nature of log $[Z + (1-Z)/(10^{(PSP/K)})]$, plot 1.

Schlumberger's approach[2] in Chart D12, plots log(R16/R_d) vs PSP, allowing the S_w line to curve rather than be linear, as would be the case for a SP plot. The S_w curvature accounts for mixing and invasion effects. In chart D12 R_d is R(5FF40) and in chart D14, R_d is R(6FF40), p254 Pirson[3].

In analysis of ES logs, it is proposed to use R_d evaluated from long normal or lateral values in place of the induction value. Using the best response of either R64 or R18-8", should give a qualitative analysis of S_w. False positives are reduced by consideration of ES response properties.

The depth of investigation for R5FF40 is similar to R64, and R6FF40 closer to R18-8. This is seen by looking at Lane Wells interpretation charts for R16 vs R64 and R16 vs R18-8

and comparing to similar charts for R16 vs 5FF40 and 6FF40, pp89-92, 105-108, 169-172 of Pirson. This comparison is shown in Appendix 1, 2.
All other factors being equal invasion diameter, D_i, is related to porosity. Pirson's interrogatory is: " invasion distance depends not just on porosity but mud filtrate rate, differential pressure, time of exposure & back diffusion." When using only two logs, (thin beds e<72 inches) a porosity balance gives additional check on analysis validity.

Critical line

The Critical line is Schlumberger's production cut-off limit for sandstone. It corresponds to a water saturation of 50% for Di/dh between 3 and 5, and 60% for Di/dh<3.

Use 5FF40 critical line for Long Normal, R64, and 6FF40 for Lateral resistivity, R18-8 deep resistivity, see Appendix 1. The critical line is calculated by regression equation: If $R16/R_d$ > Critical, then likely condition is water, at given PSP. The critical ratio at SSP of -55 & 100F, for R16/5FF40 is 1.55 and for R16/R6FF40, is a ratio of 1.8.

Tool	Critical Lines at 100F, other T use Rmf/Rw=	PSP range	Tool=
R16/R5FF40	-0.5+10^(0.00005*PSP^2 + 0.0001*PSP + 0.1635)	>-140 & <0	R64
R16/R6FF40	10^(5/100000*PSP^2 - 0.0028*PSP - 0.053)	>-140 & <0	R18-8

APPLICATION

For Shaly sands Schlumberger method draws a line from PSP=0, $R16/R_d$ =1 to PSP and $R16/R_d$. A projection of this line, on semilog grid, intersecting with SSP indicates water saturation, in terms of effective porosity. An example is shown in Graph 2 at PSP of -30 and SSP of -90. In shaly sections, this water saturation in terms of effective porosity is always less than that calculated on total porosity. For the example line of Graph, indicates a productive section, provided SSP exceeds -80 for the 6FF40 and -100 for the 5FF40 line. Analytical solution of the method is made by application of similar right triangles principle, $(A/C)_1=\cos^{-1}(\theta)=(A/C)_2$

Water Line

An SP's plot of water line is linear, shown on Graph 2. However, the water line plot of $R16/R_d$ vs. PSP is curved. Such a water line (not shown on Graph 2) corresponds to $R16/R_d$ approximately 1.4 times greater than the critical value.
Additional qualifications given for the method of Schlumberger are

- for $R16/R_d$ <1.2 use Archie equations[1]
- method applies only to permeable beds,
- do not use method if Rmf/Rw is less than Di/dh.

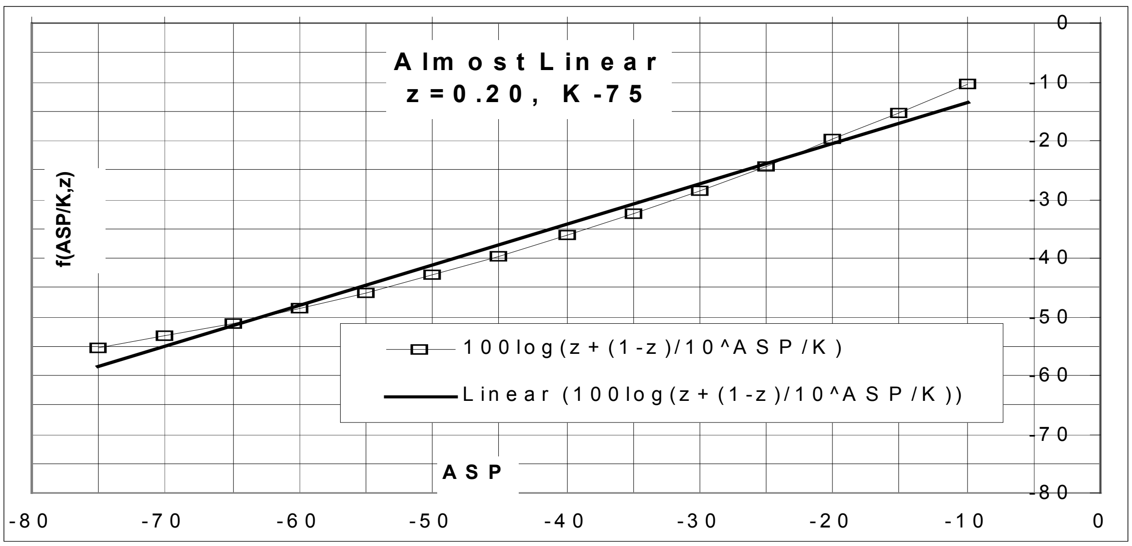
Comparison of Ri/Rt of ES Tool and FF40 Tool

A set of analytical equations for Sw using ES log was proposed by Armstrong[1], using Lane Wells invasion charts[2] 89-105 to solve Ri and Rt. Table 1, below provides a summary of these equations. Details of the quantitative method, and a calculation spreadsheet are given in the reference 1. A similar set of Lane Wells invasion charts[2] pp 169-171 are available for R16 and RFF40 and the equations are also valid for these charts.

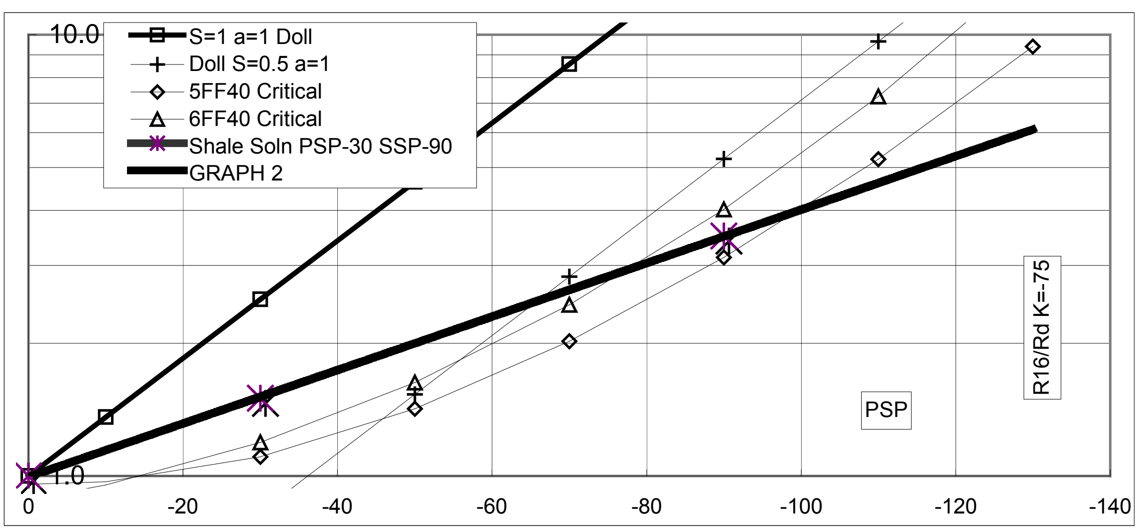
TABLE 1

$S_w = \{(R_i/R_t)[Z + (1-Z)/(10^{(\alpha SSP/K)})]\}^{(5/\alpha 8)}$	Eq.1
$[Z^{2.62}(10^{(SSP/K)}-1)+Z^{1.62}](1-2Z)^2 - Rmf/[(Ft/Fa)2.5Ri] \equiv g(Z)=0$	Eq2
$F_t/F_a = 10\hat{}[(\alpha - 1)SSP/K]$	Eq3
$F_t = \{F_t/F_a\}[Ri\ (1-2Z)^2]/(R_z)$	Eq4
$R_z = R_{mf}/\{(10^{(SSP/K)})Z + (1-Z)\}$	Eq5
$\alpha = PSP/SSP \quad K=-(^{o}F/7.6 + 60.5)$	Eq6

PSP is (α * SSP) and if log$[Z + (1-Z)/(10^{(\alpha SSP/K)})]$ vs PSP is close to linear scale then plotting PSP vs. log(R_i/R_t) will allow a qualitative analysis of ES data. The below plot shows near linear fit at maximum expected Z, and as Z decreases, the linearity also increases. This concept is used in Schlumberger method for R16/R_{FF40}.



The effect of decreasing water saturation is seen in the below plot of PSP and Ri/R_d vs PSP for S_w=1 and S_w=0.50, as are the critical lines of Schlumberger.



Considerations in plotting R16/R64 or R16/R18-8

R16 is not same as R_i (invaded zone resistivity), it can read anywhere between R_t and R_{xo}, depending on type of formation. In the case of low porosity formations R16 will read closer to R_{xo}. In the case of very low resistivity formations R16 will read closer to the deep resistivity. If R16 approximates R_{xo}, then plotting $R16/R_d$ vs PSP imposes no special considerations, as the plot reverts to a classic SP plot. Use of $R16/R_d$ vs PSP as a qualitative tool requires only a reasonable contrast between R16 and R_d. The more serious drawback is associated with reading R_d by the Long Normal, R64. There are fewer considerations in reading R_d with the Long Lateral R18-8 due to the increased reading depth of electrical signals with this tool. Considerations for borehole and bed thickness are provided in the spreadsheet. For R16, chart B12 Borehole and Bed Thickness correction factor was mapped by neural network. Chart B12 applies for Di/dh between 2 and 10, as is typical of medium to high porosity beds.

Long Normal, R64. (AM typically 64 inches)

If resistive bed thickness is less than AM (64 inches), the tool records an inverse crater. The distance between the crater rims being bed thickness plus electrode spacing, (e+64, for R64 inch normal and e+16 for the short normal). When bed thickness is greater than AM, normal tool readings are distorted in the area +/- (½AM) from both actual bed top and bed bottom. Borehole and thickness factors are provided in the spreadsheet, using either Hilchie method or Guyod charts to correct bed thickness and Schlumberger charts for borehole effects.

Deep Lateral, R18-8, (AO typically 18'-8"), also called R19 or R20

The conventional lateral responds to beds as thin as 16 inches. In resistive beds less than AO a nick 16 inches above bed top and a reflection peak located at e+18'-8" below bed top will be present. Also for thin beds there is a dead zone for 18'-8" below the bed top, in which zone the lateral reading is not analytical. For e> 19-20 feet, a decay zone exist AO feet from bed top. Borehole and thickness factors are provided in the spreadsheet, using either Hilchie method or Guyod charts to correct bed thickness and Schlumberger charts for borehole effects.

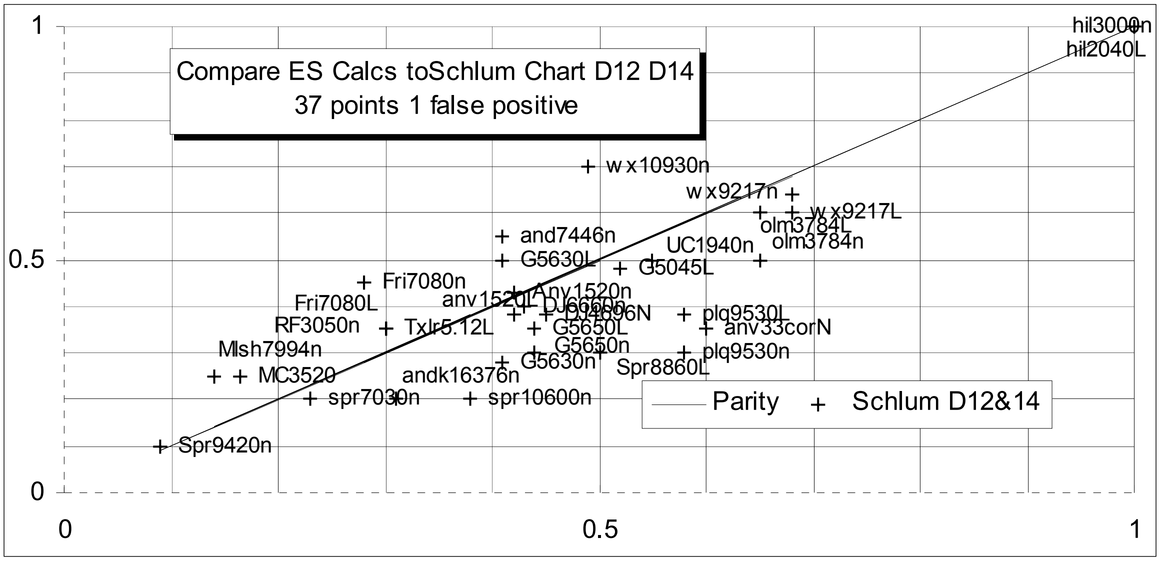
In overcoming the various problems of the ES tools, it is chosen to use the max value from R64 and R19. After plotting, eliminate those points associated with tool anomalies, as mentioned above.

Porosity Balance

A porosity balance is recommended to confirm result. The porosity balance consist of determining formation factor, F, by the equation: $F = (F_t/F_a)R_tS_w^2/R_w$. The porosity balance is essentially a consistency check, for S_w results of the ratio method, the essence of Charts D12 and D14. If a formation is clean, PSP=SSP, and (F_t/F_a) is unity. Various accessory routines are given in the workbook "CF_Conv_Sw(F)", to assist in calculation of F, provided R16 reads Ri and Rd reads Rt. Evaluation of this last assumption is given in the spreadsheet dealing with invasion charts for ES logs.

Summary

Plot of R16/R_d of ES logs vs. PSP will compare favorable to a similar plot using R16/FF40 because investigation depths of the FF40 tool compare to Long Normal, R64 and Lateral R18-8. However unique features of response signatures for R64 and R18-8 tools must be reconciled for a best evaluation.



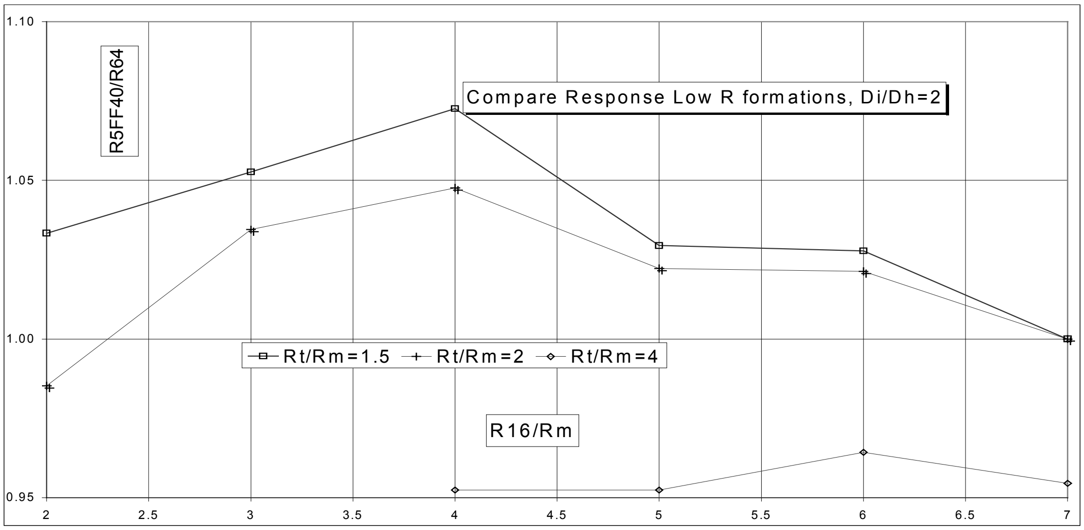
Additional sections were added into the spreadsheet to make ancillary calculations related to porosity balance given in the workbook "CF_Conv_Sw(F)".

References

1. Armstrong, O.P. 2005, Water Saturation & Productivity Estimates from Old Electrical Survey Logs of Clean & Shaly Sections" www.oiljetpump.com
2. Schlumberger, 1966, Log Interpretation Chart Book. Schlumberger Well Surveying Corporation, Houston TX
3. Pirson, S.J., 1963, Handbook of Well Log Analysis, Prentice Hall, NJ
4. Pirson, S.J., 1957 Formation Evaluation by Log Interpretation, World Oil GPC, Houston Tx April/May /June 1957, wide range of topics relative to older logs & oil/water mobility in various reservoir rock types, including shaly reservoirs
5. A2D.com source of well logs reviewed for this study
6. Hilchie DW 1979 Old E.Log Interpretation, pre1958, AAPG reprint 2003 Tulsa, p2
7. Guyod,H. 1945, Location of Sand type Reservoirs Oil Weekly Vol.120 No.1, Dec.3, reprinted in Guyod, H. 1952 Electric Well Logging Fundamentals, p132 , Widco Instrument. Houston TX

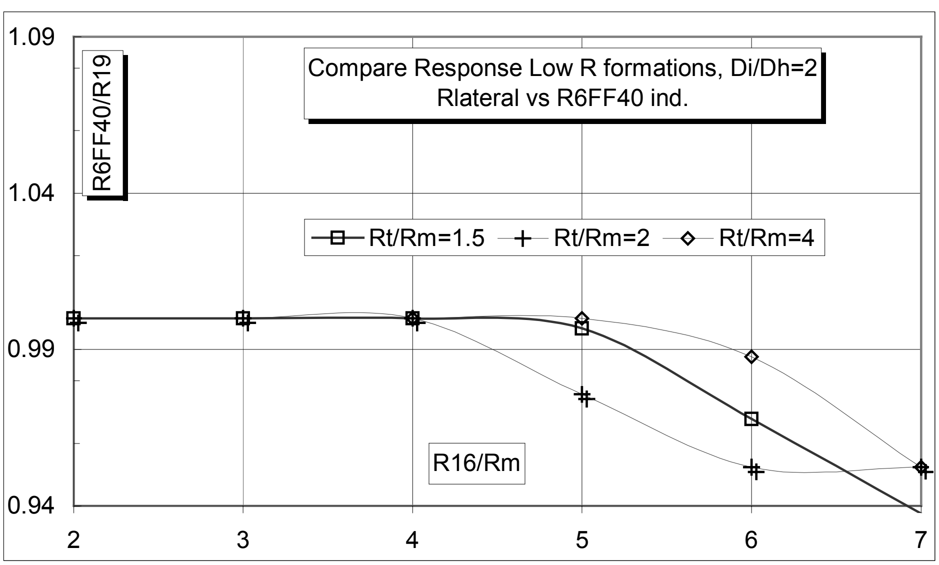
Appendix 1

Since true resistivity is a property of the formation, a comparison of apparent tool resistivity to Rt will show difference in Ra for various tools. Here are comparisons of tool response of R64 to R5FF40, Low Resistivity Formations using Lane Wells invasion charts, p169, p89 Pirson. The response of these tools typically differ by less than 5% in most conditions. The comparison result is not surprising as 5FF40 tool was actually designed to mimic R64 investigation depth.



Appendix 2

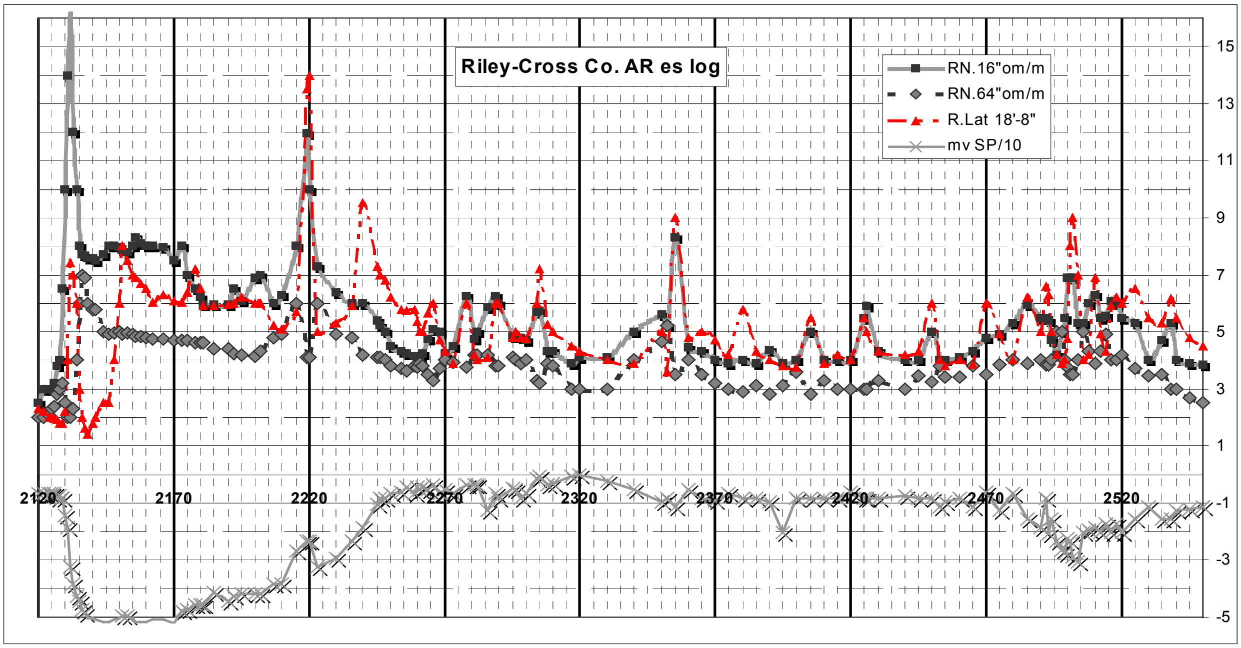
Compare tool response of R18-8 to R6FF40, Low Resistivity Formations using Lane Wells invasion charts, p171, p105 Pirson. The response of these tools typically differ by less than 5% in most conditions. The 6FF40 tool was actually designed to mimic R19 investigation depth.

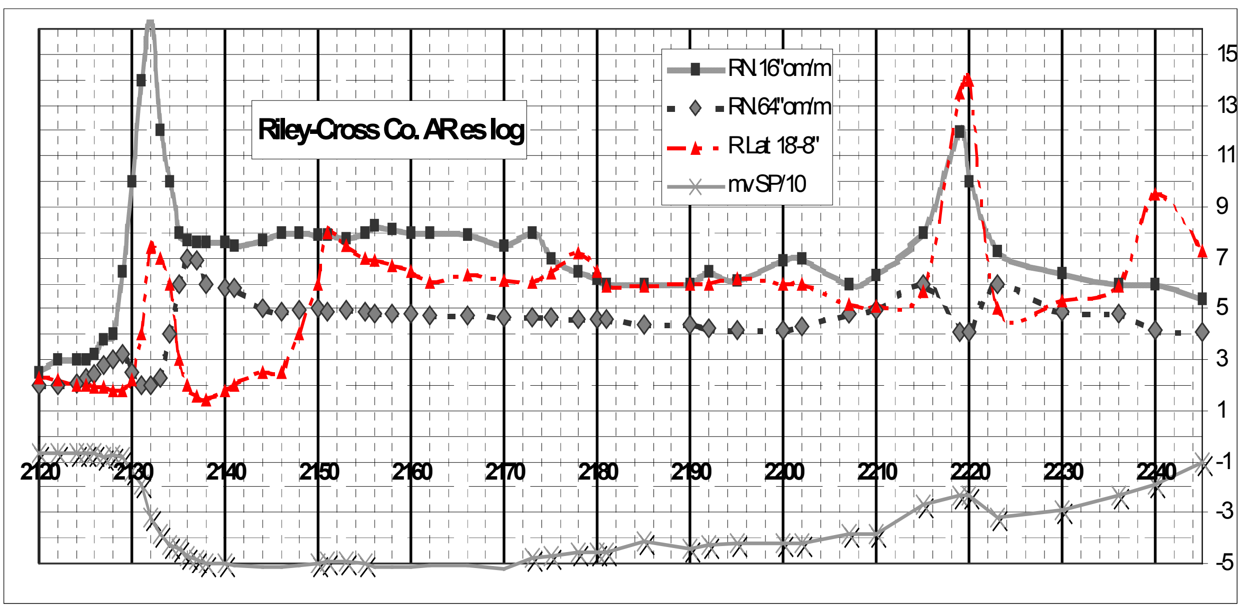


These graphs indicate an error of less than 3% is expected if charts D12 & D14 are used with the corresponding ES tools to calculate Sw. This is because Sw is nearly proportional to square root of Rt and the 6&5-FF40 tools respond to within 5% of ES deep tools. The root of 1.05 is about 1.025.

Appendix 3 Application to ES of Riley-Surrat of Cross Co. AR

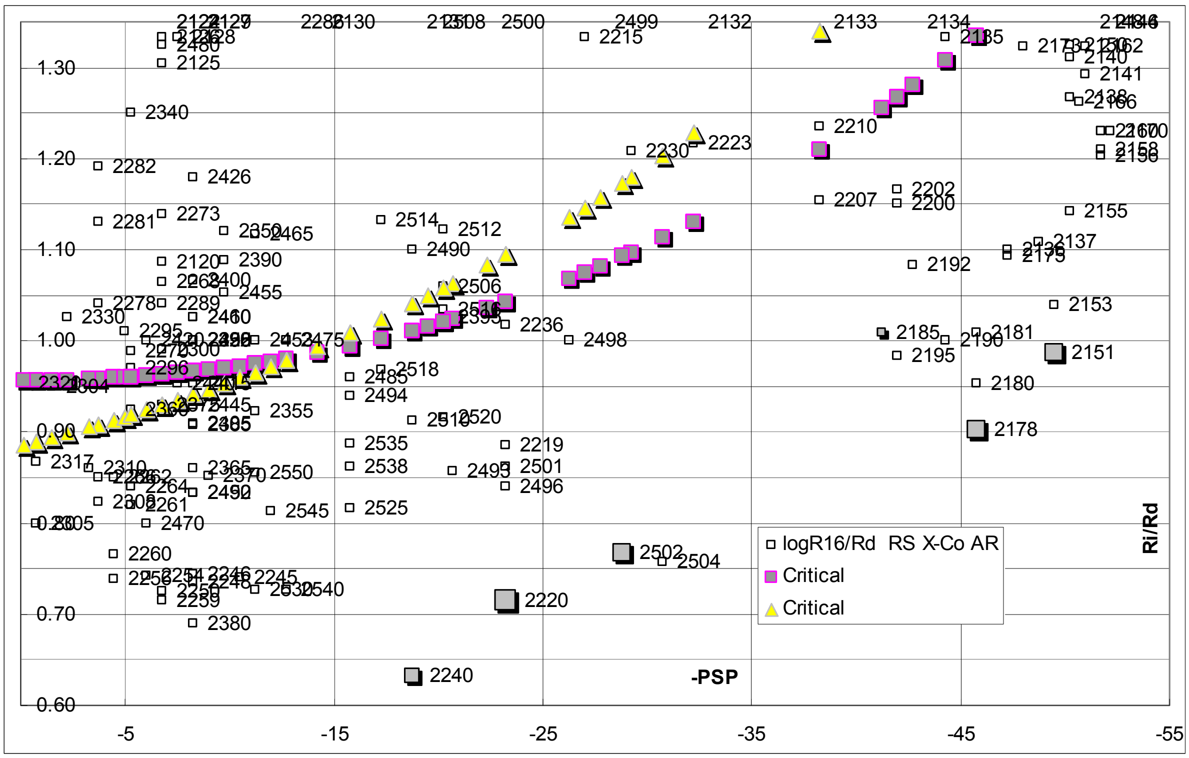
Riley Surrat Well Log Plotted vs depth





A plot of the well log for Riley-Surrat is used for illustrative purposed. At 2220 a classic thin high resistive bed appears, with 96" separation between LN crater rims. Bed thickness is 96 less 64 or 32inches. The reflection peak appears at 2240 on lateral. Symmetrical properties of normal curves indicates bed center at 2219, bed top 2217.5, base 2220.5. Inflection of SP curve is noted at 2217.5, 2219, 2222. Another anomaly appears at 2502, LN crater rims are at 2497 and 2505, t =24 inch.

Plot R16/R_d vs PSP for Well Riley Surrat



Appendix 4

In case presented here, it is not possible to reach an exact solution using one set of invasion charts (either 2 normal or R16 and deep Lateral). For this case, solving Formation Factor, (F porosity balance), and Sw for each value of Ri and Rt does give insight into validity of data, if some idea of lithology is understood. The most direct method is solving F based on deep resistivity. The method gives additional insight when only one set of invasion charts can be used, such as in thin beds with Electrical Survey tool.

1) Solve z_n using Newton-Ralphson iteration

Assume ROS is not dependent on Z, as used by Pirson, then **g**(Z) and g′(Z) allow implicit evaluation of Zn, given, chart value of Ri/Rm, alpha (determines Ft/Fa), SSP, Rmf/Rm and temperature.

$$g' = [2.6Z^{1.6}(R_{mf}/R_w - 1) + 1.6Z^{0.6}](1-ROS)^2 \quad \text{Eq.2c}$$

$$\mathbf{g}(Z) = [Z^{2.6}(R_{mf}/R_w - 1) + Z^{1.6}](1-ROS)^2 - (R_{mf}/R_m)/[(F_t/F_a)2.5(R_i/R_m)_n] = 0 \quad \text{Eq.2b}$$

Take initial value of Z as $0.41/[abs(R_{mf}/R_w-1)^{0.26}(1-ROS)(SQRT(R_i/R_m F_t/F_a)]$ and solve forward until **g**(Z) approaches zero. In this instance. n refers to the values of Z and Ri/Rm for each invasion chart. A neural network map of invasion charts is provided in spreadsheet1, for $R16/R_m$ less than 25.

2) Solve $S_w(n)$

$$S_w(n) = [(R_i/R_m)_n\{[z_n + (1-z_n)/10^{(PSP/-K)}]/(R_t/R_m)_n\}]^{1/(1.6\alpha)}$$

Where n, represents the invasion chart, Di/Dh of 2,5,10 or 15.

3)Check value of F

$$Fd = (Ft/Fa)(S_w)^2 R_t/R_w \quad \text{and} \quad Fi = (Ft/Fa)(1-ROS)^2 R_i/R_z$$

If a reasonable solution is provided, the ratio of deep formation factor, F_d to invaded formation factor. F_i will be close to 1 and F_d will be close to anticipated value.

For high porosity formations R_d approximates R_t and porosity balance is effected using R_d, thereby eliminating evaluation of Ri and z.

Appendix 5 Discussion of spreadsheets

MID Plots,

The purpose of mineral identification is to better ascertain mineral bulk property for calculating porosity and formation factor, F. These systems are best expressed in Matrix form. The Gypsum, Anhydrite, Dolomite, system is shown below as a matrix form, from Wylie p178:

Φ	G'	A'	D'	RHS	<=Variable/Description
τ_Γ	τ_g	τ_a	τ_d	τ bulk	Sonic Matrix Coeff
ρ_Γ	ρ_g	ρ_a	ρ_d	ρ bulk	Density Matrix Coeff
1	0.49	0	0	Φ_N	Hydrogen Matrix Coeff
1	1	1	1	1	Mass Matrix Coeff

Systems of two components may be expressed in similar way, i.e. Limey-Sand:

Φ	Σ'	L'	RHS	<=Variable/Description
τ_Γ	τ_δ	τ_L	τ bulk	Sonic Matrix Coeff μSec/ft
ρ_Γ	ρ_δ	ρ_L	ρ bulk	Density Matrix Coeff g/cc
1	1	1	1	Mass Matrix Coeff v/v

- τ_Γ sonic travel time of liquid, μSec/ft
- ρ_Γ density of liquid g/cc
- Φ total porosity & open pore = Φ - SΦs, Φs-> shale porosity
- Σ Sand L Lime S Shale G Gypsum
- τ_δ time Sand τ_L time Lime τ_S time Shale)
- ρ_δ Den Sand ρ_L den Lime ρ_S Den Shale)
- τ bulk sonic time μSec/ft ρ bulk den g/cc
- k Factor of neutron porosity increase for Shale Volume due to chemical hydrogen. Approximately 14 percent shale volume is taken to add 2% to hydrogen porosity. Pirson p28, 180, 201.
- $\Sigma' = (1-\Phi)\Sigma$ $L' = (1-\Phi)L$ $S' = (1-\Phi)S$ $G' = (1-\Phi)G$

Sand Lime Shale System

Φ	Σ'	L'	S'	RHS	<=Variable/Description
τ_Γ	τ_δ	τ_L	τ_S	τ bulk	Sonic Matrix Coeff μSec/ft
ρ_Γ	ρ_δ	ρ_L	ρ_S	ρ bulk	Density Matrix Coeff g/cc
1	k	0	0	Φ_N	Hydrogen Matrix Coeff Hpor
1	1	1	1	1	Mass Matrix Coeff v/v

These are linear systems, solved by inversion of Left Hand Side, as $\mathbf{V}=(\mathbf{LHS})^{-1}(\mathbf{RHS})$

Plots of M-N, por-N vs either density or sonic time, and density vs sonic time may be used for mineral identification. Options provided for common combinations of sediment rocks are GAD, Shale-Limestone-Sandstone, Shale-Lime-Dolomite, Lime-Sand, Lime-Dolo.

Appendix 6 Details of Shale Properties

Shale properties are highly variable, but for purposes of these calculations divisions are given by following Table: Shale Formation Factor were taken from Guyod p77 and sonic times by Pirson formula p226, F=500/(dt-70).

Type	Density	F=Rs/Rw	dt, µSec/ft
Gumbo	2.1	5.0	170
Gulf 6k'	2.35	11.6	113
MidCont	2.45	62.5	78

Shale density were taken from excess pore pressure studies, but overlap of properties may occur. A conversion from Porosity method to F is made using inverse square rule for carbonates and Humble formula for sandstones. Shale volume, S or Vs, porosity, if any, is subtracted from total porosity with open porosity based on: $\Phi_o=\Phi_T$ - SΦs, Φs-> shale porosity, with shale porosity taken from drop down menu of L43 in sheet 3, Pirson p203. The shale volume, S, used for correction of open and total porosity is taken from selection of PSP and SSP

Appendix 7 Reference to Calculation Calibration Data Sets

Below is list of calculation and calibration data sets given used in the spreadsheets. Following these examples will assist the user to grasp program methods, limitations, and capacity.

Example Calibration	Source	Page	Sheet	Cell	Example Calibration	Source	Page	Sheet	Cell
GAD Matrix calc	Asquith	161	4	Q1	F Cssp	Schlumb.	B1	3	T71
Shale Vol	Meehan	217	4	Q19	Fsonic	Schlumb.	D19b	3	W72
Por & M-N	Meehan	223	4	W1	Fsonic Sch D19-a	Schlumb.	D19a	3	W82
Vshale	Asquith	91	4	W25	F neutron	Schlumb.	C15	3	T78
Matrix Prop (dt den por-n)	OPA	Matrix clc	4	AA2	F by Den	Schlumb.	C15	3	Q77
Open Porosity	Asquith	193	4	AA12	Sonic p	Schlumb.	D21c2	3	Q84
ND Por eval	Asquith	85	4	W33	Sonic por	Schlumb.	D23	3	T95
Por by ND	Asquith	87	4	w41	Fsonic	Schlumb.	D19c	3	W92
Por-n-d Method	Schlumb.	C27	4	T43	Sonic p	Schlumb.	D21b2	3	Q104
Por-n & dt Method	Schlumb.	C23	4	T34	Sonic p	Schlumb.	D21c2b	3	Q94
Por-n & Den Method	Schlumb.	C21	4	Q34	F(Ro)	Pirson	93	3	J71
Por-n-d Method	Schlumb.	C25	4	Q41	Implicit Solve Sw(Ro)	Pirson	93	3	M71
Rw(SSP Rmf T)	Asquith	33	3	Q20	Gas sat n-por g-hole	Pirson	259	3	A73
SP->SSP	Asquith	33	3	T20	Gas sat n-por g-hole	Schlumb.	D25-A	3	B73
R64 corr'd	Guyod	139	3	W20	Gas sat n-por g-hole	Schlumb.	D25-B	3	C73
Depth T corr & R Tcorr	Schlumb.	A3	3	Q28	Gas sat n-por g-hole	Schlumb.	D25-C	3	D73
R16 corr'd (Rs Rm e)	Schlumb.	B11	3	T28	R16.dh.RmCF	Schlumb.	B1	3	w41
R19 corr'd for e	Guyod	140	3	W27	R19.dh.Rm CF	Schlumb.	B1	3	w49
R Lateral e CF	Guyod	39	3	W34	R64 dh.Rm CF	Pirson	Fig 7.9	3	T46
R16 corr'd (dh Rm)	Schlumb.	B1	3	W41	Rw(SSP Rmf T)	Schlumb.	A9-12	3	Q48
R19 Dh Rm	Pirson	Fig8.9	3	T37	R16 corr'd (dh Rm)	Hilchie	Fig3.8&3.9	3	Q55
Rw(SSP Rmf T)	Schlumb.	A9	3	Q41	Sw F R16 R64 SSP	Hilchie	71	3	w58
Hilchie Corr'd R18-8	Hilchie	38-39	3	Q63	Hilchie Corr'd R64	Hilchie	71	3	T63
Fmicrolog	Schlumb.	C2	3	Q71					

Data for another 53 Sw calculations are given for comparison to the proposed method in Sheet 2

APPENDIX 8

Examples Sw & Rw by Implicit Solution via F method, use sheet3 of spreadsheet. For estimation of matrix property, use linear relation of d(por) with either d(usec or SG) to estimate at por=0.

Note that F(por) is based on total porosity but open porosity is (total porosity)(1-Vsh) and is used in shaly method, Simandoux and duel water.

Additional examples are found in sheet 3 at cell Z1. These examples detail Pickett Cross plot and Hingle Cross plot methods. The crossplot methods relate to Matrix identification (MID), Rw, and Sw.

Ref/page	D. ft	Sw	Sw calc	Set Cell	#	Chg cell
P.291		0.66	0.66	H53	E59	H52
P273		0.52	0.50	H53	E59	H52
p298	7080	0.54	0.54	H53	E59	H52
p297	9868	0.21	0.21	H53	K68	H52
p291	9425	0.09	0.09	H53	H47	H52
p289	3050	0.27	0.21	H53	K39	H52
p289	3050	0.27	0.17	N40	K39	N39
p289	3050	0.27	0.27	H53	E59	H52
M229	ex#1D	0.99	1.00	H53	B61	H52
M229	ex#2b	0.37	0.39	H53	B61	H52
M230	ex#3a	0.26	0.29	H68	B61	H67
M230	ex#3a	0.26	0.26	e68	B61	e67
M230	ex#3a	0.19	0.19	h68	B61	h67
A193	1926	0.67	0.65	h68	B61	h67
W124	Fig21	1.00	1.00	H53	K46	F38
W124	Fig21	0.52	0.52	H53	K46	H52
W184	Fig34	1.00	1.00	H53	K56	F38
W184	Fig34	0.45	0.49	H53	K56	H52
W189	Fig35	1.00	1.00	H53	H60	F38
W189	Fig35	0.63	0.62	H53	H60	H52

	P=Pirson Well Logs, p=Pirson Resvr Engi M_Mehan A_Asquith
Ref/page	W=Wyllie
P.291	psp=-50, ssp-117, Rxo3.65, Rw=0.035,ROS0.15,Rt=1.67Rmf=0.65
P273	SSP=PSP=-77 Rxo32.4, Rw0.40,Ros=0.15Rmf2.35Rt16
p298	psp=-20,SSP=-69 ROS=0.25 Rt=2.25 Rw=0.06Rxo=2.06Rmf=0.42
p297	SSP=PSP=-100 Rt=125,Rw=0.02 Ro=5.6
p291	SSP=PSP=-92Rt=112Rw=0.033R2"=4Rm=0.70
p289	ssp=psp=-92Rt=17Ri=40Rw=.042Rmf=1.12Rm=1.4
p289	ssp=psp=-92Rt=17Ri=40Rw=.042Rmf=1.12Rm=1.4
p289	ssp=psp=-92Rt=17Ri=40Rw=.042Rmf=1.12Rm=1.4Ro=1.15
M229	por=.091Rt=4.2Rw=0.039
M229	por=.154Rt=6.7Rw=0.029, Mehan selected Consol SS this routine has only generic sandstone
M230	por=.154Rt=7.5Rw=0.018, Rsh=1.1 Vsh=0.15(setsPSP=85SSP=100) F2w method
M230	por=.154Rt=7.5Rw=0.018, Rsh=1.1 Vsh=0.15(setsPSP=85SSP=100) Fsimdx snd method
M230	por=.154Rt=7.5Rw=0.018, Rsh=1.1 PSP=-20SSP=-48 F_2w snd method
A193	por=0.18Vsh_0.09Rsh4Rt11Rxo16PSP-52SSP-57 avg Simdx&2W
W124	Rw(ND 35/1) Ndmin=100NDmax=1300ND(S=1)=300,R(S=1&300ND)=2.5 Get Rw=0.092
W124	Sw(w/Rw above35/1carb) Ndmin=100NDmax=1300ND(min)=300,R(S&500ND)=30 w/Rw=0.092
W184	Rw(dtmax) dt=62 R=18 Get Rw=0.105
W184	Rw=0.105 Rt=6 dt=87
W189	Rw(Sw=1,Sg=2.49)Rt=5.5=>Rw=0.066
W189	Sw(SG=2.4 Rt=5.5, Rw=0.066) NaCl SS

Definitions

PSP, psuedo static potential of a thick shale-sand sequence, PSP=ASP(CF)
CF SP generic correction factor for bed thickness = 1/(0.2933Ln(e'-feet) + 0.0622), valid e>2feet and <20feet, chart developed for Gulf Coast type sands[7]. A neural network model is included but user must have some idea of lithology or Ri/Rm.
e bed thickness
R16a, apparent value of 16" normal tool at bed center valid e>AM=16"
R16c, corrected R16 for borehole based on 8"hole and shoulder effect by neural network.
R64a, apparent value of 64" normal tool at bed center valid e>AM=64"
Rnc Normal sonde corrected for bed thickness
=Rn[1+(ln{Ra/Rs})/(e/AM-1)], valid Rm>Rs/3 & <5Rs, e>2AM
R18-8a, apparent value of 224" lateral tool AO=224", AN is 20 feet
R19, another short name for R18-8 since 18 ft 8 inches to closest foot = 19 feet

Sonde	CF type	Equation	
N_{ormal}	shoulder	$R_t/R_a=[1+(\ln(R_a/R_s))/(e/AM-1)]$ e/AM>2	Guy. Fig3p139
Lat		$R_t/R_a=(a)e^{(bRa/Rs)}$ a=1.18-0.376$e^{(b)}$, b=0.83$(e/AO)^{0.56}$. valid: 0.1>e/AO <1	Guy. Fig6p140

Other correction factors either by regression or by Neural Network model. Confirmation data given in spreadsheet and referenced by Table of appendix
Additional details of variable names may be found in reference 1.