

TUFFY

Exercise TUFFY:

How to square log readings and define the lithology with the help of various logs.

Objectives:

- Getting acquainted with the relations between FDC-CNL, CNL-SONIC, FDC-SONIC, MID- and M-N plot and their relations to lithology definition.
- In this exercise correlating and squaring of logs is an important purpose for the determination of porosity .
- A comparable evaluation can be made for:
 - . porosity of surrounding rocks around coal seams and ore bodies.
 - . determination of the vertical lithology in fresh water reservoirs.

Well TUFFY-3

The well has encountered two possible reservoir sections, the Sollingen sandstone and the Detfurth. These formations are found in wide areas of Northern-Germany, The Netherlands and the North Sea as:

- Marker seams.
- Potential reservoir sands for oil, gas and water.

Reservoir characteristics:

- BHT = 83°C (at reservoir depth)
- Petrophysical parameters: $m = 1.8$, $n = 2.0$.
- The formation water has been assumed to be fully salt saturated (250000 ppm) with the $R_w = 0.016$ ohm.m at FT.

Production test results:

- Detfurth : 158106 m³/day gas at 50 bar draw down,
- Sollingen: not tested

Mud characteristics

- Mud type: salt water mud
- $R_m = 0.076$ Ohm.m at 22°C = 105000 ppm = 0.030 Ohm.m at BHT
- $R_{mf} = 0.046$ Ohm.m at 22 °C = 210000 ppm
- $R_{mc} = 0.26$ Ohmm at 22 °C

General information

Bit size = 12 1/4 inch

QUESTIONS

Sollingen Sandstone:

- Correlate and square the logs of the Sollingen Sandstone section.
- Correct the resistivities for borehole and invasion effect.
- Determine the lithology, using FDC-CNL, SONIC-CNL, MID- and M-N plot.
- Explain the position of the plotted points.
- Calculate S_w using Archie.
- What would be the effect when the pores are filled with salt water and how can it be observed?

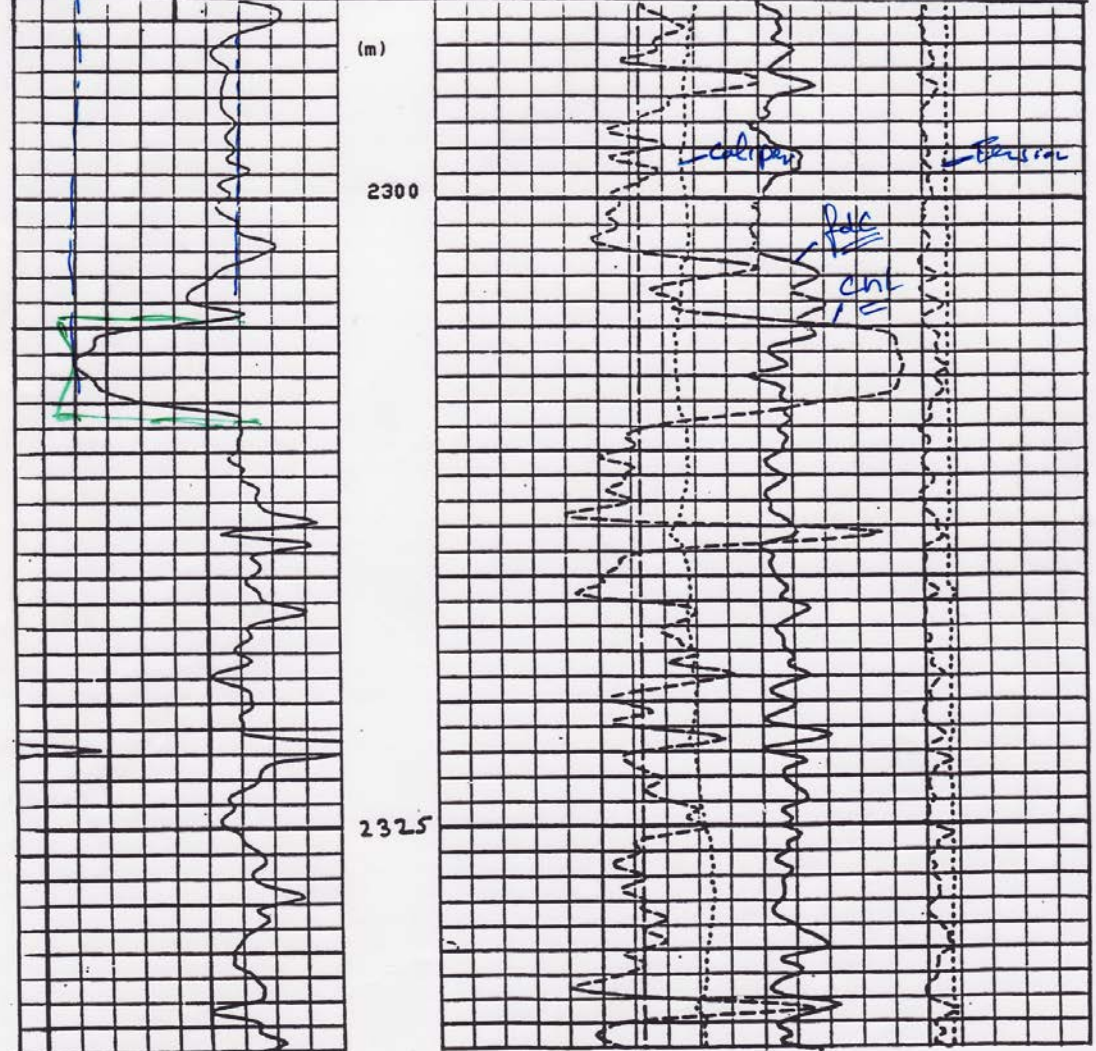
Table 1, Tuffy-3

Layer	Depth	Density	Neutron	RLLd	Sonic	RLLd	Ø	Shc
No.	(m)	(g/cc)	(p.u.)	(ohm.m)	(:s/ft)	(ohm.m)		
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

TUFFY-3
SOLLINGEN
FDC - CNL

		NPHI () <i>Correction</i>	
		0.720	0.420
		RHOB(G/C3) <i>Correction</i>	
		1.500	2.000
		TENS(LB) <i>Tension</i>	
		0.0	5000.
		DRHO(G/C3) <i>dens corr</i>	
		-0.250	0.250
		NPHI () <i>ML</i>	
		0.12	-0.180
		RHOB(G/C3) <i>FDC</i>	
		2.5	3.000
6.000	BS(IN)	16.00	
6.000	CAL(IN)	16.00	
0.4200			
2.000			

GR (GAPI)
0 *sand* 75 *shale* 150



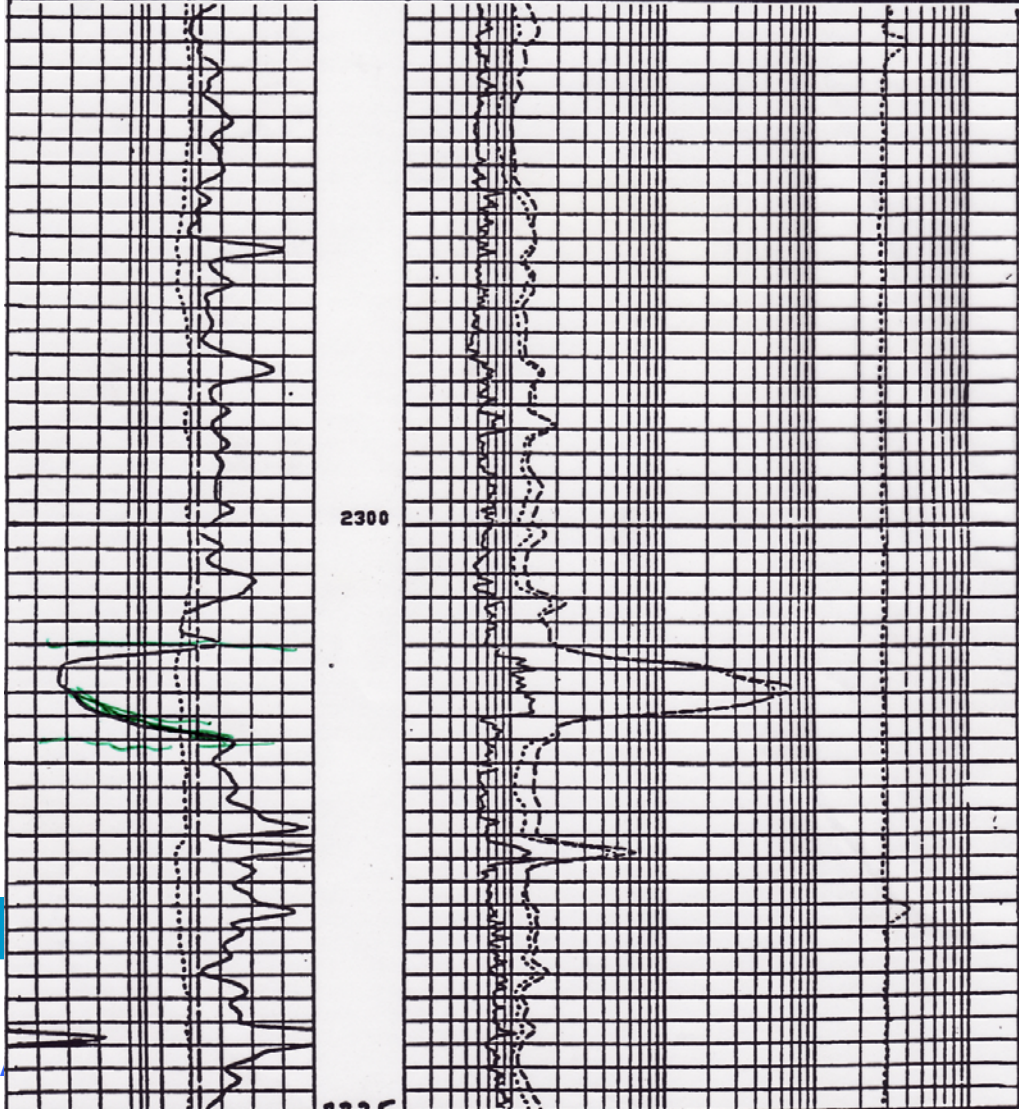
ation

TUFFY-3
SOLLINGEN
LATEROLOGS

LLS (OHMM) 2000. 200000
LLD (OHMM) 2000. 200000

BS(IN) 6.000 16.00
CALI(IN) 6.000 16.00
GR (GAPI) 0 75 150

MSFL (OHMM) 0.2000 2000.
LLS (OHMM) 0.2000 2000.
LLD (OHMM) 0.2000 2000.
10 100

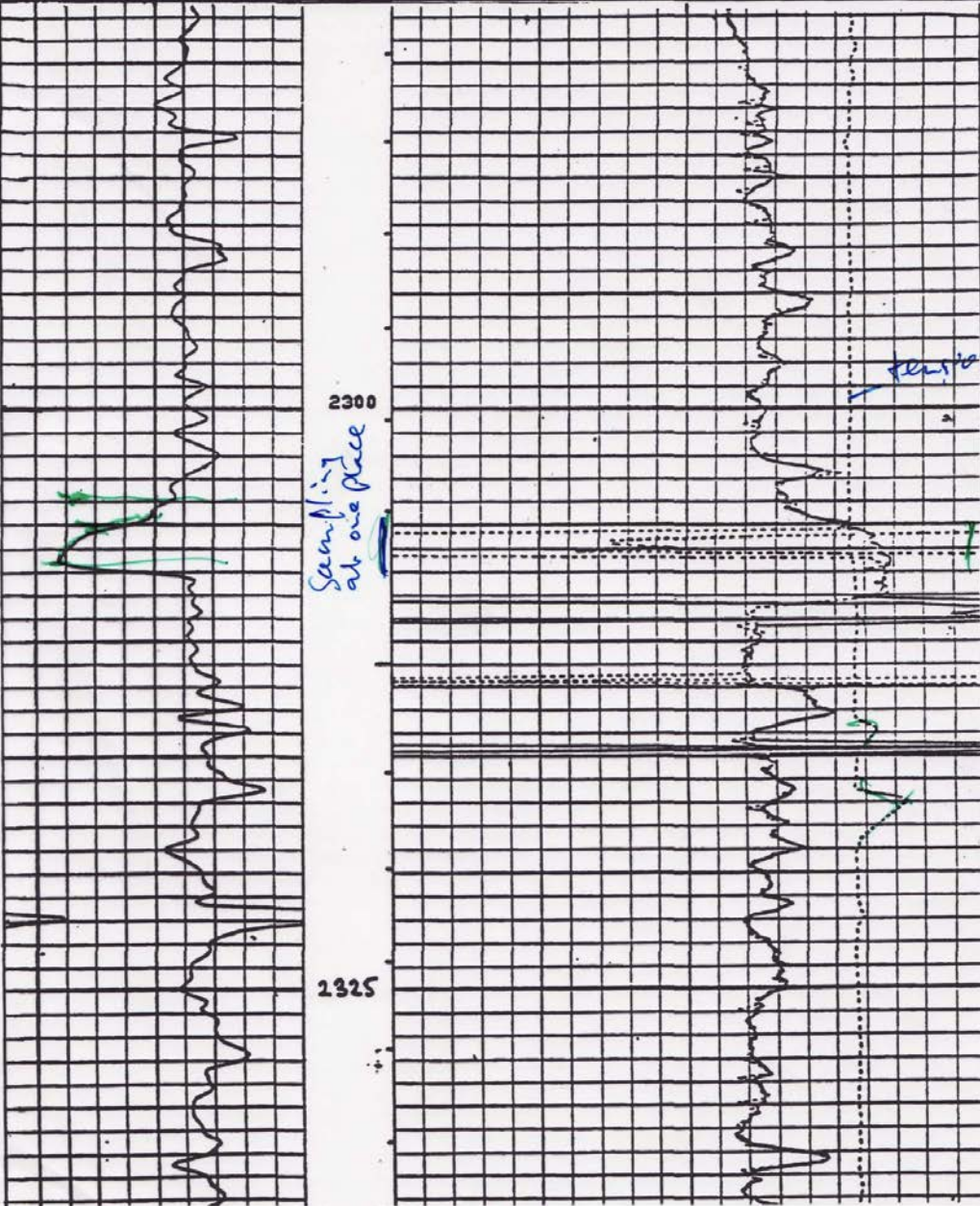


TUFFY-3
SOLLINGEN
SONIC
GR (GAPI)

Vent. res: 2 ft
Fluv. res: few ft

0.0	TENS(LB)	5000.
140.0	DTL (US/F)	40.00
90.0	DT (US/F)	40.00

0 75 150



Sampling
at one place

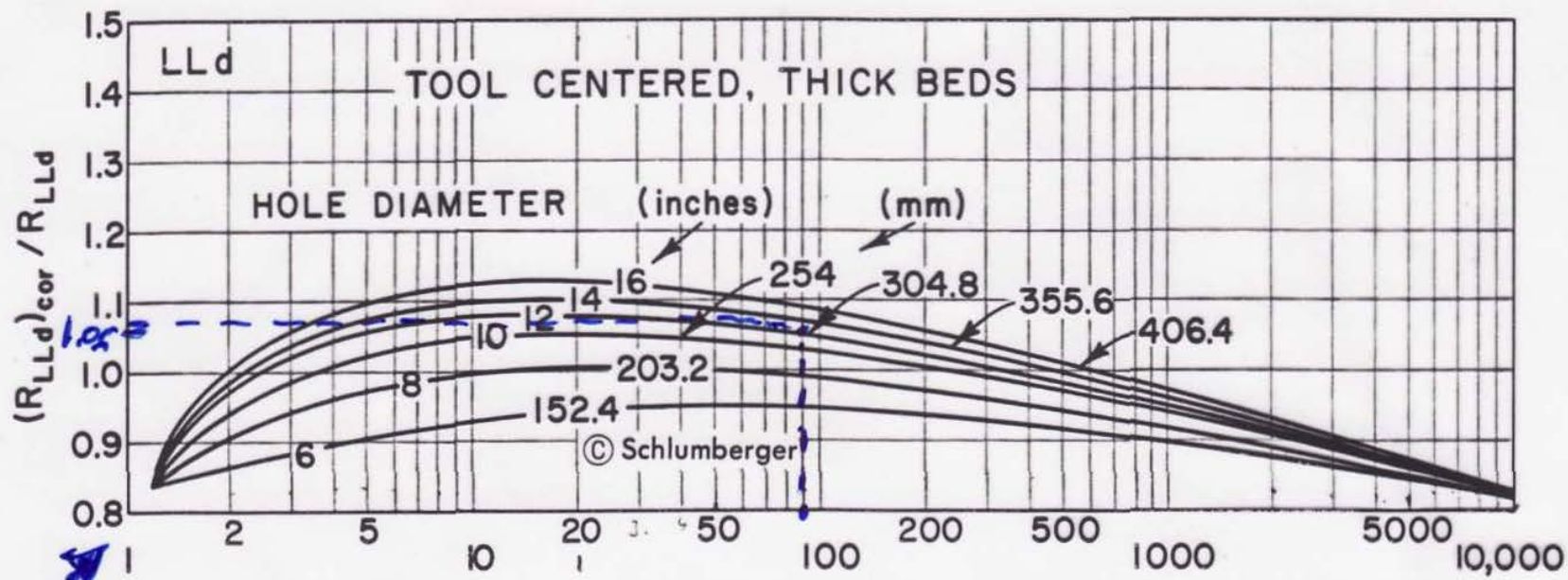
Cyclic skipping log stuck

uation

DUAL LATEROLOG* CORRECTION CHARTS

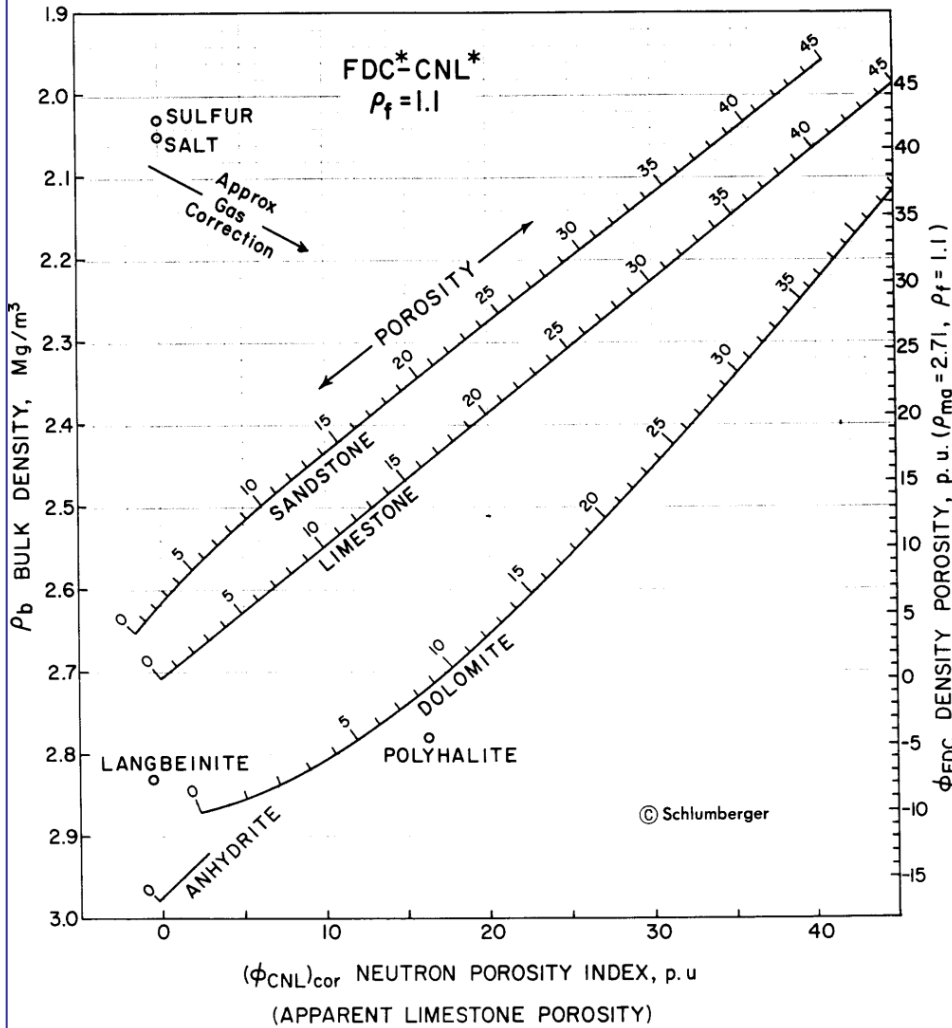
SONDE CENTERED

DEEP LATEROLOG* BOREHOLE CORRECTION

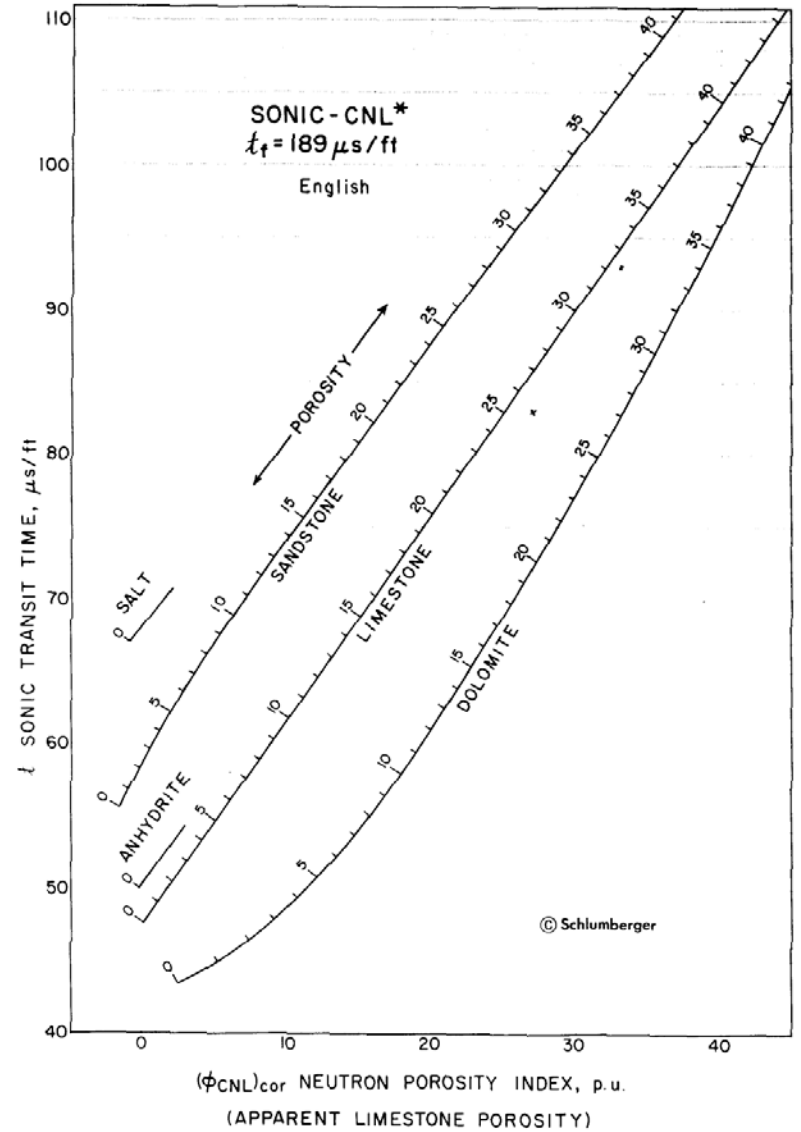


$R_m = 0.076 \text{ (22°C)} \rightarrow \text{hadu } 83^\circ\text{C } h_{\text{branger}} = 0.03 \text{ } \Omega\text{m}$
 $R_{LL} = 26 \text{ } \Omega\text{m} \rightarrow 26/0.03 \approx 90 \rightarrow 12\frac{1}{4}'' \rightarrow 1.05 \text{ } R_{LLcor} = \frac{R_{LL}}{1.05}$
 $= 25.22 \text{ } \Omega\text{m}$

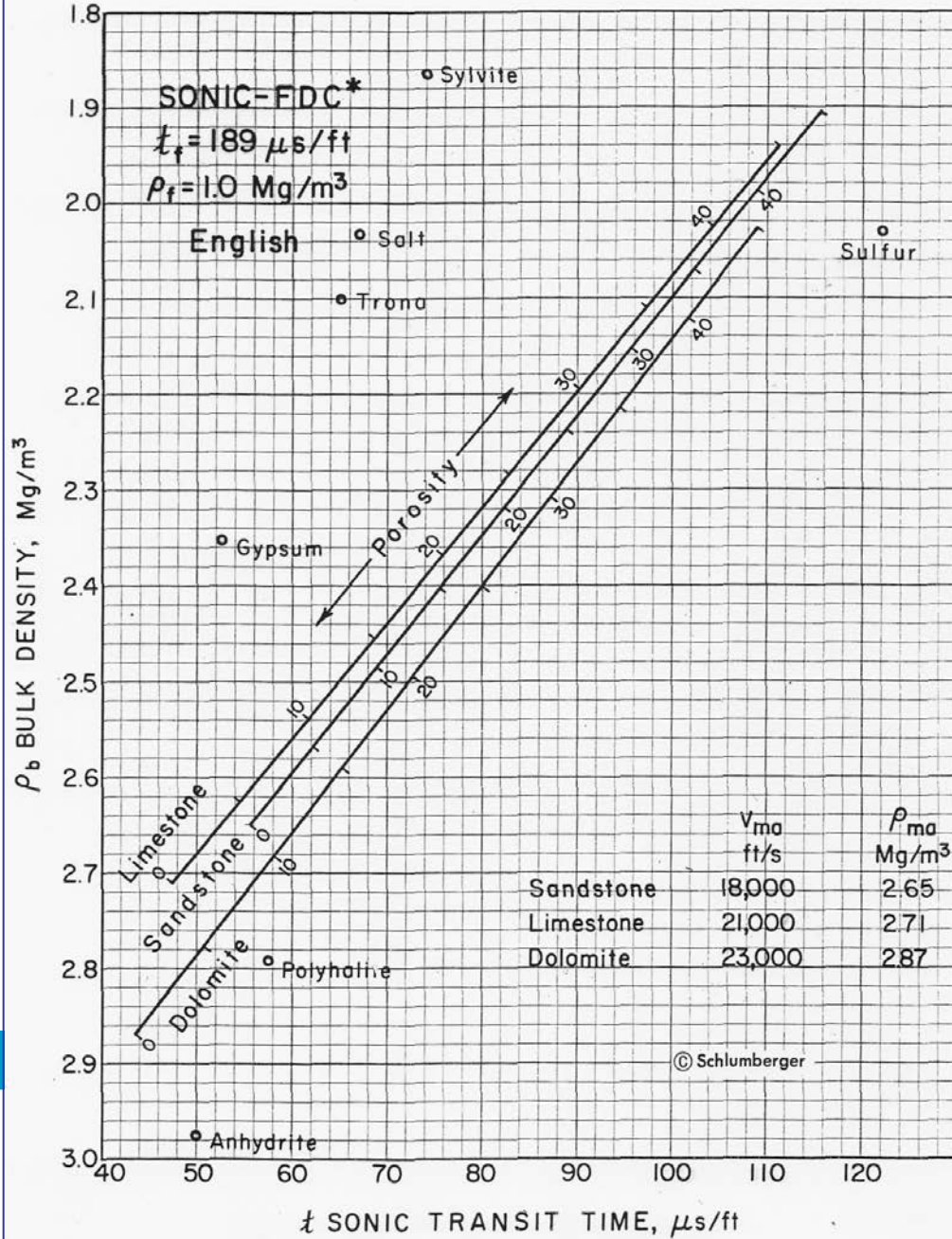
POROSITY AND LITHOLOGY DETERMINATION FROM
FORMATION DENSITY LOG AND
COMPENSATED NEUTRON LOG (CNL*)
SALT WATER, LIQUID-FILLED HOLES



POROSITY AND LITHOLOGY DETERMINATION FROM SONIC LOG
AND COMPENSATED NEUTRON LOG (CNL*)



LITHOLOGY IDENTIFICATION FROM FORMATION DENSITY LOG AND SONIC LOG



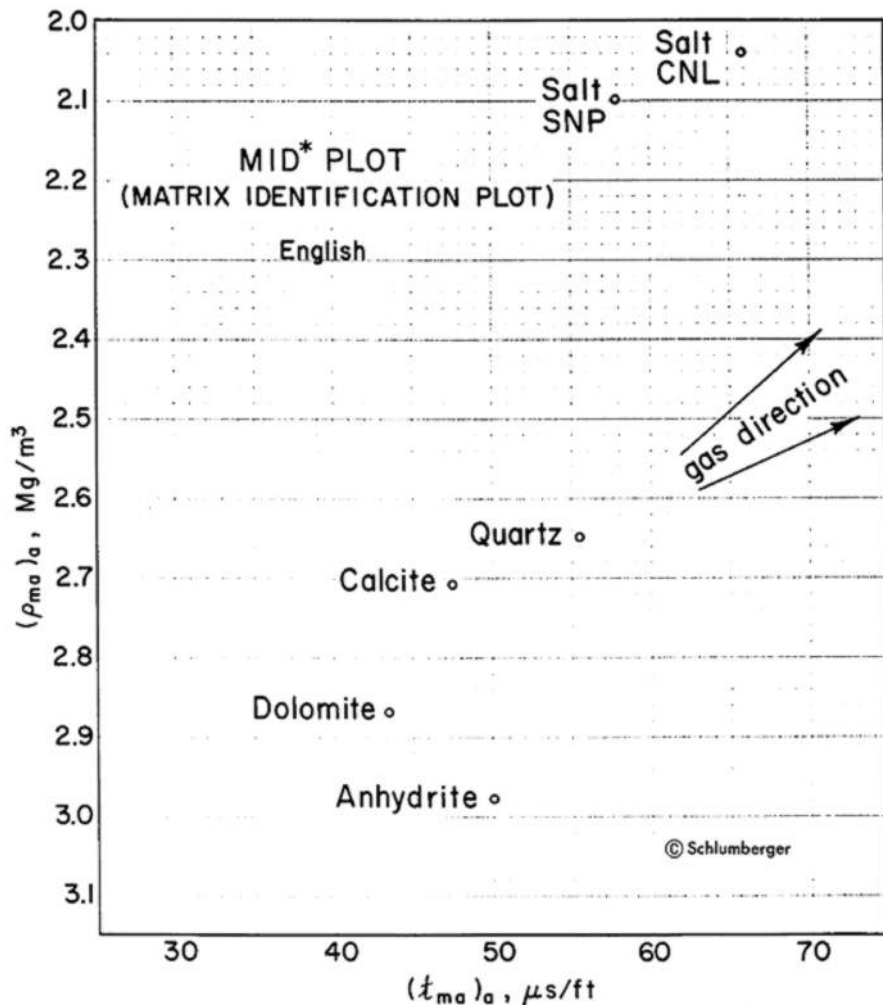
HOW TO USE THE MID PLOT*⁸

Select the $(t_{ma})_b$ and $(\rho_{ma})_a$ charts for your Neutron-log type, borehole-fluid salinity, and measuring system (English or metric).

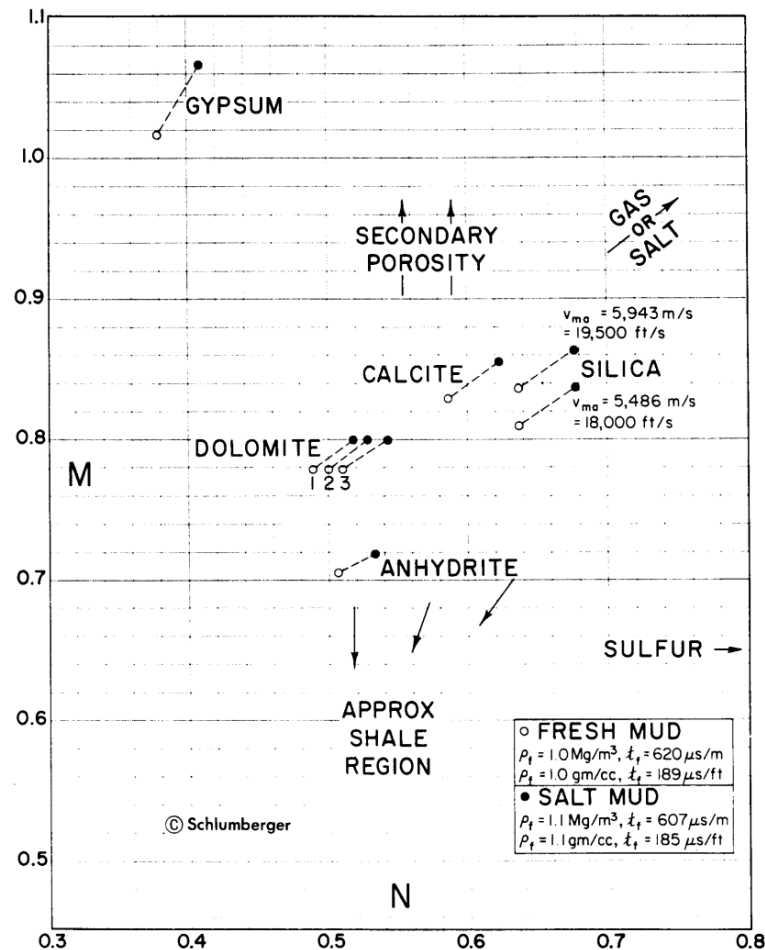
Tabulate t_r and ρ_b and ϕ_N (limestone) by depths for each chosen station and the resultant $(t_{ma})_a$ and $(\rho_{ma})_a$ from the appropriate chart. Plot the points on the MID-Plot grid. The plot will generally form a pattern which identifies the major reservoir rock by its proximity to the labeled points on the plot.

The presence of secondary porosity in the form of vugs or fractures produces displacements parallel to the Sonic-sensitive axis.

The presence of gas will displace points as shown on the basic MID Plot. Identification of shaliness is best done by plotting some shale points to establish the shale trend lines.



M-N PLOT* FOR MINERAL IDENTIFICATION⁷



This crossplot may be used to help identify mineral mixtures from Sonic, Density, and Neutron logs. (The Neutron log used in the above chart is the CNL*.) Except in gas-bearing formations, M and N are practically independent of porosity. They are defined as:

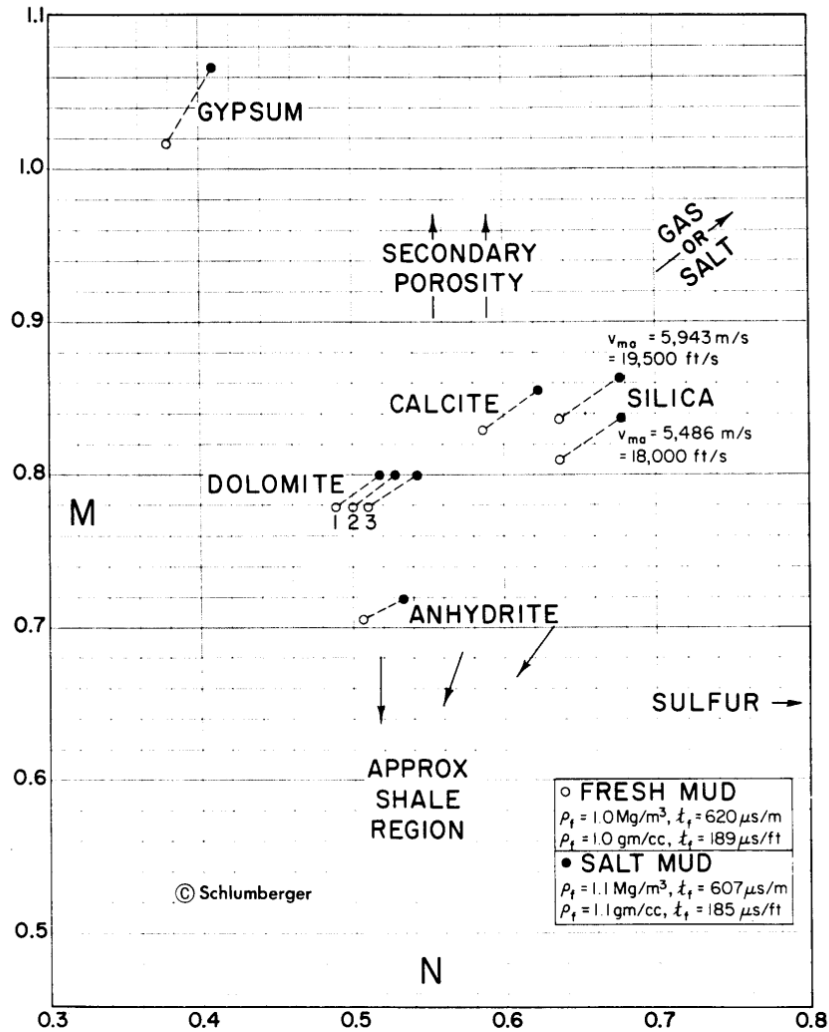
$$M = \frac{t_r - t}{\rho_b - \rho_f} \times 0.01 \text{ (English)}; \quad M = \frac{t_r - t}{\rho_b - \rho_f} \times 0.003 \text{ (Metric)}; \quad N = \frac{(\phi_N)_r - \phi_N}{\rho_b - \rho_f} \text{ (Either)}$$

Points for binary mixtures plot along a line connecting the two mineral points. Ternary mixtures plot within the triangle defined by the three constituent minerals. The effect of gas, shaliness, secondary porosity, etc. is to shift data points in the directions shown by the arrows.

The dolomite lines are divided as to porosity as follows:

- 1) $\phi = 5.5$ to 30 p.u.
- 2) $\phi = 1.5$ to 5.5 p.u. and $\phi > 30 \text{ p.u.}$
- 3) $\phi = 0$ to 1.5 p.u.

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