DETERMINATION OF MOVABLE HYDROCARBON BY GEOLOG

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Abstract: ***Well logging a special technique used in the oil & gas industries to find out the subsurface formations. After getting the information of subsurface formations petro physical studies were used to determine the availability of Hydrocarbon in that formation. Petro physical properties such as shale volume, effective porosity, water saturation, Movable Hydrocarbon Index can be used to determine the Hydrocarbon occurrence and movability in the reservoir. In this article using a case study of assumed values on Geolog Software to predict the movable Hydrocarbon in a reservoir.***

IndexTerms: Drilling parameters, petro physical property Analysis, HCM, Low Permeability

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Introduction:

As the oil & gas industry emerges to growth, finding more hydrocarbon are essential to fulfill the requirements. As many techniques were used to find out hydrocarbon in the subsurface formation. Here a case study with assumed values were taken to find the movable hydrocarbon in a reservoir using Geolog. The petro physical properties were used for calculation purpose and the final result were acquired by the software. In the Log sheet the Zone of interest is pointed out at the final stage which the movable hydrocarbon are occurred.

Well Data & Pre-calculation:

Run no- suite 1
Depth-914 meters or 3000 feet
Types of fluid system- KCl polymer
Mud weight-1.48
Rm= 0.866@87 ˚F
Rmf= 0.575@87 ˚F
Rmc= 1.295@80 ˚F
Maximum recorded temperature - 315 ˚F @ 3000 feet
Reservoir depth= 3000 feet
THT= 188 ˚F
BHT= 315 ˚F

Methodology:

Shale volume (Vsh)

Shale volume was calculated using the Gamma Ray. For each method, shale and clean point values were determined by controlling the overall log responses. The Gamma Ray method can be expressed by the following equation;

$$Vsh = \frac{GR\log - GR\min}{GR\max - GR\min}$$

Where:

Vsh is the shale volume,
GR_{log} is the gamma ray reading value,
GR_{max} is the gamma ray log value for shale zone and
GR_{min} is the gamma ray log value for clean zone.

Effective porosity

At first porosity was calculated from the density log by using the following equation Porosity $\phi_D = (\rho_{ma} - \rho_{b)} / (\rho_{ma} - \rho_f)$
Then, porosity was calculated from neutron log. ρ_{ma} and ρ_f values are 2.65 and 1 gm/cc respectively were used to calculate ϕ_D values. Effective porosity was than calculated using ϕ_D and ϕ_N values by the following equation
Effective **Porosity** = ϕ_D X 0.7+ ϕ_N X0.3
Where,

ϕ_e = Effective Porosity
ϕ_D = Density Porosity

ϕ_N = Neutron Porosity

Water Saturation (S_W)

Indonesian equation was used to calculate S_w. This equation includes a correction for clay content and is used for reservoir with shale volume > 5%.

The calculation of S_w based on effective porosity deep formation resistivity, shale volume etc. LLD reading were used as formation true resistivity (R_t).

$$Sw = \frac{1/\sqrt{Rt}}{\frac{Vsh(1-\frac{Vsh}{2})}{\sqrt{Rsh}} + \frac{\Phi}{\sqrt{aRw}}}$$

Where,

R_t = True resistivity (LLD Value)
S_W = Water Saturation
R_{sh} = Resistivity of shale
V_{sh} = Shale Volume
R_w = Formation water resistivity
Φ = Effective Porosity

Movable Hydrocarbon Index (MHI) = S_W / S_{XO},

As per the ratio method (Schlumberger, 1989), published in AAPG methods in Exploration Series 16, 2003,

If MHI ≥ 1 then, this represent – Hydrocarbon were not moved during invasion.

MHI < 0.7 for Sandstone - Movable Hydrocarbon Indicated.

MHI < 0.6 for Carbonate - Movable Hydrocarbon Indicated.

When MHI is less then 0.25 is movable gas and 0.25-0.75 is movable oil (Hamada, 2006)

In the flushed zone of formations with moderate invasion and average residual hydrocarbon saturation, the following relation normally works well (Krygowski, 2003).

$$\mathbf{S_{xo} = (S_W)^{1/5}}$$

Where,

S_{XO} = Water saturation for flushed zone.
S_w = Water saturation of the uninvaded zone.

Case study

1. Temperature Gradient = $\frac{\text{B.H.T- Surface temperature}}{\text{Total depth}}$

B.H.T=315˚F

= 315-85/3000= 150/6364= 0.076˚F/ feet

Formation Temperature at 3000 feet = Depth X geothermal gradient+ surface temperature

= 3000X0.076+85 = 313˚F

At 3000feets Temperature= 313˚F.

The average temperature at pay zone 313˚F.

Rmf 0.866 at 87 ˚F temperature.

2. Rmf at formation temperature

R2=R1 (T1+6.77)/T2+6.77

Here R1= 0.866, T1=87˚F, T2= 313˚F.

R2= 0.866(87+6.77)/(313+6.77)

=0.2539

Rmf = 0.253(Ω-m) at 313˚F

Rw= 0.16 (Ω-m) at 200˚F from HLS Report.

Calculation for volume of shale:

$$*V_{sh} = \frac{GR_{(zone)} - GR_{(clean)}}{GR_{(shale)} - GR_{(clean)}}$$

GR (zone) =45 (average)
GR (shale) = 140 GR(clean)=28
Vshale= 45-28/140-55=0.2
For Tertiary rocks Vsh = 0.083 ($2^{3.7} \times I_{GA} - 1.0$)
$= 0.083(2^{3.7x0.2} - 1.0)$
$= 0.083(2^{0.74}-1)$
$= 0.083(1.6701-1)$
$= 0.083x0.6701$
$= 0.0556$

3. Porosity Calculation

Porosity $\phi_D = (\rho_{ma} - \rho_{b)} / (\rho_{ma} - \rho_{f)}$
ρ_{ma} = 2.65 for Sand stone
ρf = 1.0 usually water or mud filtrate in the zone investigated by density log.
Average ρ_b = 2.4 (gm/cc)

$\phi_D = 2.65-2.1/2.65-1$
$= 0.333$

Porosity ϕ_N from log = 0.54
Average Porosity = ϕ_D X 0.7+ ϕ_N X0.3
= 0.33X 0.7+0.54X0.3
= 0.39 = 39%

Parameter	value
A	0.81
M	2
N	2.0
Rw(Ω-m) at 200˚F	0.16
Rho matrix(gm/cc)	2.65 For Sandstone
Rho fluid(gm/cc)	1.0

CALCULATION OF HYDROCARBON SATURATION (Sh) FOR SILTY SHALY RESERVOIR

CALCULATION

The water saturation (Sw) is calculated using the following Indonesian equations (Richard piggin).

Here m=2 and n=2

$$\frac{1}{\sqrt{R_t}} = \left[\frac{V_{sh}^{(1-Vsh/2)}}{\sqrt{R_{sh}}} + \frac{\Phi}{\sqrt{aR_w}} \right] Sw$$

Parameter	Value
A	0.81
M	2
N	2.0
Rw(Ω-m) @200F	0.16
Rho matrix(gm/cc)	2.65 For Sandstone
Rho fluid(gm/cc)	1.0
Average Rt	9
V shale	0.066

Where,
Sw: Water saturation
Rt: Resistivity value of Later log Deep (LLD)
Rcl: Resistivity of clay

Vsh: Volume of shaliness
Rw: Resistivity of formation water
a: Archie's constant/ Tortuosity factor
m: Cementation exponent
n : Saturation exponent

$$\frac{1}{\sqrt{R_t}} = \left[\frac{V_{sh}^{(1-Vsh/2)}}{\sqrt{R_{sh}}} + \frac{\Phi}{\sqrt{aR_w}} \right] Sw$$

1/√8= { (0.055(1-0.055/2)/√7+0.43/√0.81x0.22}Sw
1/√8= { (0.055(1-0.055/2)/√7+0.43/√0.1782}Sw
1/√8= { (0.066(1-0.066/2)/√7+0.25/0.422}Sw
0.35 = (0.09+1.01) Sw
0.35= (1.1) Sw
Sw= 0.35/1.1=0.31
So = 1-Sw
So =1-0.31
So = 0.69
So = 69% of Hydrocarbon Saturation

Movable Hydrocarbon Index (MHI) = S_W / S_{XO},

In the flushed zone of formations with moderate invasion and average residual hydrocarbon saturation, the following relation normally works well (Krygowski, 2003).

$S_{xo} = (S_W)^{1/5}$

Where,
S_{XO} = Water saturation for flushed zone.
S_w = Water saturation of the uninvaded zone.
Sxo = $(0.69)^{1/5}$
Sxo =0.92
Movable Hydrocarbon Index (MHI) = S_w / S_{xo}
MHI =0.31/0.92
MHI =0.33
When MHI is less than 0.25 is movable gas and 0.25-0.75 is movable oil (Hamada, 2006).
In this case MHI is 0.53 so the hydrocarbon is movable.

Interpretation Using Geolog Software

For interpreting the potential zone for hydrocarbon and for calculating the porosity, shale volume & water saturation of the formation Geolog 6 software has been used. In software analysis has been done by the following steps-

Project creation
⇩
Data Loading in GEOLOG software
⇩
Data editing & correction

Resistivity, Gamma, Density and Neutron log has been used for the analysis:

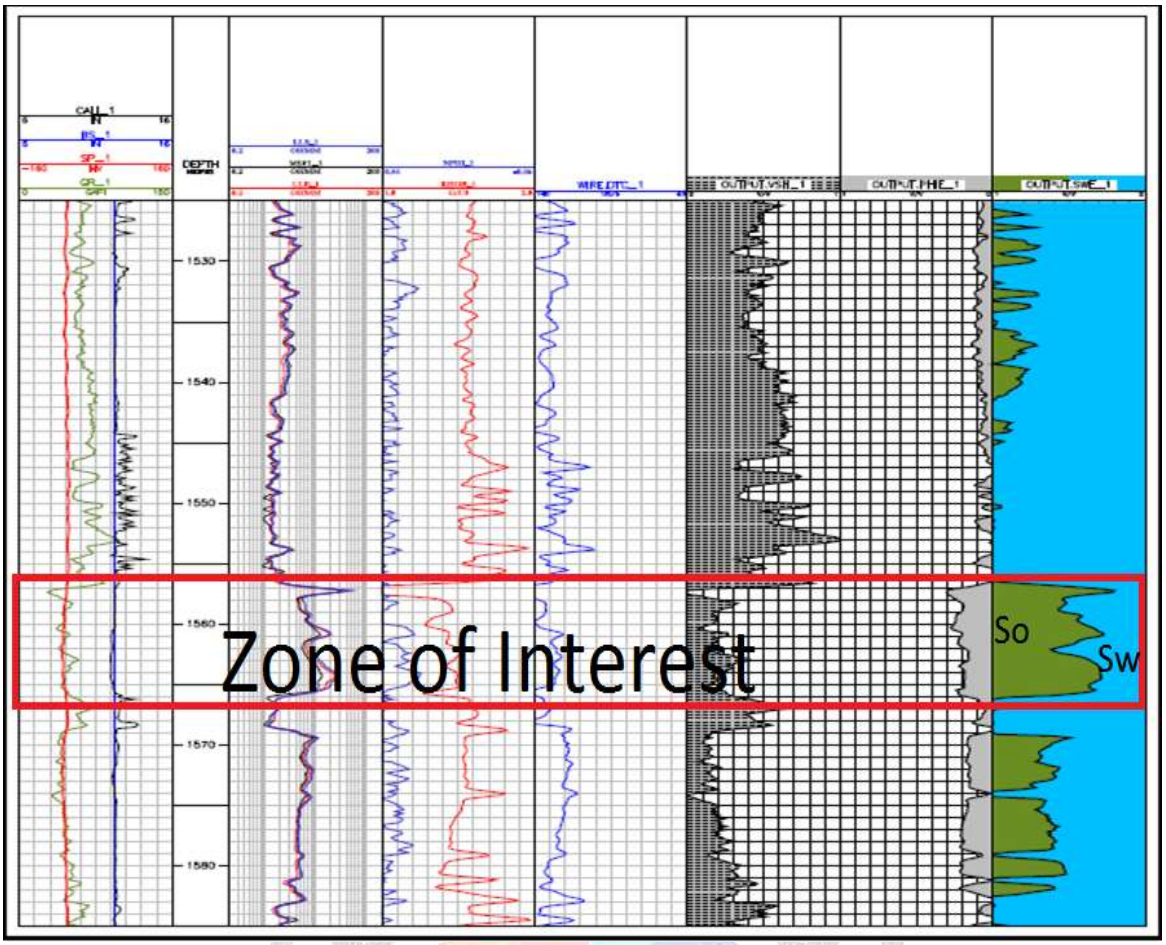

Fig :Final result of log sheet determined Zone of Interest

Conclusions:

- From petrophysical evaluation from the study well the zone of interest for perforation is from 1556 feet to 1567 feet.
- Porosity of the reservoir is 39 %.
- Hydrocarbon saturation of the interested zone is 69%.
- Movable Hydrocarbon Index (MHI) is 0.33 which indicates the hydrocarbon in this zone is movable.

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