Petrophysical Interpretation on Six Shallow Wells in the Peace Region of BC

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Introduction.

This work was conducted on the request of Geoscience BC. Six wells were analyzed with HDS 2008™ software, and three petrophysical curves V_{SH}, PhiE, S_W were generated. The result of the work was submitted in digital (las-file) and image (pdf-file) format to the client.

Procedure Description

Data.

All information was received from the client. The information includes digital and image logs on six wells and project description which includes wellbore core description. The following logs were run in each well:

GR spectral
Caliper
Resistivity (different depth sondes)
Neutron
Density
PE
Density correction
Sonic

In general the logs are of good quality except sonic logs on wells Area-7 and Area-12. These two logs can not be used for processing. Also there are three wells (A-6a, A-10b, A-13) with bad sonic signal and one (A-10b) with unacceptable neutron/density logs in some zones due to bad borehole conditions.
No core or fluid analyses are available.

V_{SH} calculation

V_{SH} was derived from GR applying linear equation:

$$V_{SH} = (GR_{SH} – GR_{Log})/(GR_{SH} – GR_{Clean})$$

Where

GR_{SH}, GR_{Clean} – GR readings opposite shale and “clean” sand respectively

GR_{Log} - Log reading

All values GR_{SH} and GR_{Clean} were taken by well.

Porosity Calculation

Porosity was derived from neutron/density cross-plot and corrected for shaliness (V_{SH}). There was some complication for porosity calculation, since all wells were lined with PVC pipe and grouted. The additional distance between borehole walls and density tool pad impacts the density calculation. Because of this distance density correction curve reached value close to 400kg/m^3 which is unacceptable in standard (open hole) conditions. The only way to validate porosity calculation was to compare calculated porosity to porosity derived from other type of log (sonic) which were not affected by borehole conditions. The comparison showed good correlation (Fig.1).

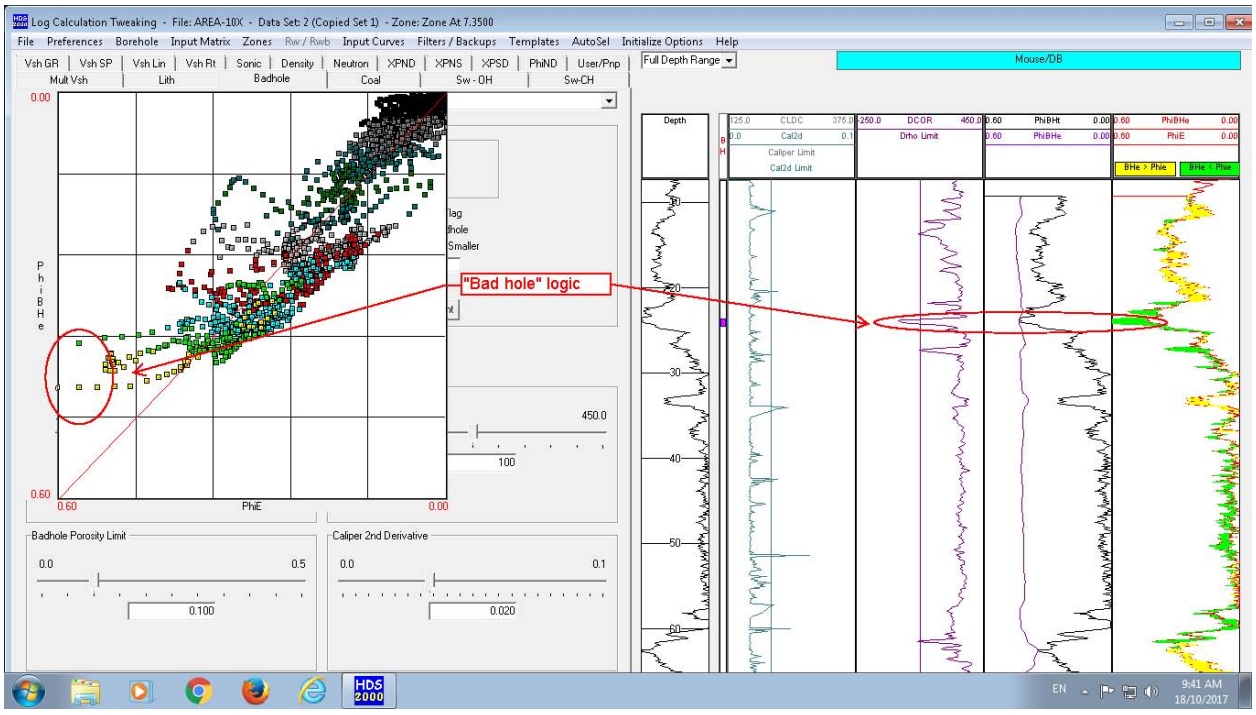

Figure 1. Good correlation between neutron/density cross-plot and sonic derived porosities and example of "bad hole" logic application.

Porosity from sonic log was derived by employing Raymer-Hunt equation:

$$PhiS = (DT_{Log} - DT_{max}) / DT_{Log} * C_p$$

where

DT_{Log}, DT_{max} - DT from log and matrix DT respectively

$C_p = 0.625$ - User defined constant

Finally, the "bad hole" logic was applied when calculated porosity exceeded logical values (55%). In that case sonic porosity was used or, if sonic was unavailable, porosity was limited.

Saturation Calculation

Saturation was calculated by employing Modified Simandoux equation with the following parameters:

a = 1
m= 1.4
n= 2

The approximate formation fluid resistivity was obtained from Pickett plot created on well area-10x data (Fig.2). Based on the project description this well penetrated water saturated sands. So the value for formation fluid resistivity was figured out as R_W =30 Ohmm.

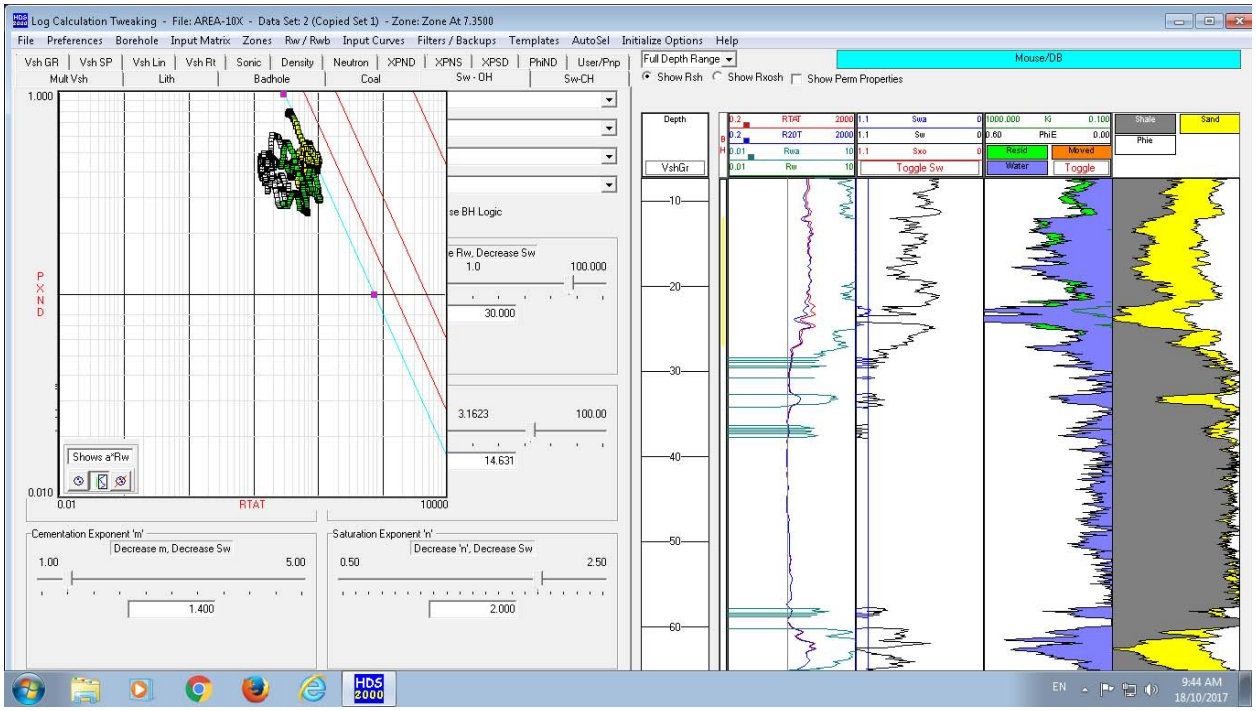

Figure 2. Pickett plot on well Area-10x

Final Notice

Despite of good correlation between neutron/density and sonic derived porosities, the obtained porosity is not recommended for use in work that requires precise porosity calculation (reserve calculation, etc.), since there is no calibration to core data analysis.

Petrophysical characteristic of rocks penetrated by wells

All average values of pores zones on each well are accumulated in the following table.

Table 1.

Well	Thickness (m)	PhiE (%)	V_{SH} (v/v)	Saturation	Comments
A-6a	9.5	22.5	0.067	Dry/Water	No obvious air/water contact
A-7	26	35.3	0.234	Water	
A-10b	35.7	35.2	0.218	Dry/Water	Air/water contact at 45m
A-10x	24.6	26.1	0.338	Water	
A-12	24.3	35.5	0.271	Dry	
A-13	15.4	23.3	0.284	Dry	

Detailed petrophysical descriptions on each well are given below.

Area -6a

Only a short part of the well (~15m) is covered with logs.

The section of the well can be divided into three zones: upper and lower sandy zones and one shaly layer (~1.5m) in the middle. Average porosity of the sandy parts at 15% cut-off[1] is 22.5%.

Upper sandy zone is dry, and water was observed in the lower zone while drilling.

Area -7

Approximately 47m of the well are covered with logs.

Based on GR log there are three sandy intervals divided by three shale layers. All sands are water saturated. The average petrophysical properties of the sands are as follows:

Table 2

Depth[2] (m)	V_{SH} (v/v)	PhiE (%)	Comments
6 – 18.5	0.08	40.9	
21.5 – 31.5	0.31	34.9	Including shaly zone at 23-26m
35.5 – 40.0	0.594	17.5	

Core description[3] of depth interval 21.5 – 27m is “Interbedded silt, clay and vary fine sand”. GR reveals that probably only the upper 1.5m are actually sand. The rest is clay and silt and very little sand.

Average values on well are: V_{SH}=0.234, PhiE=35.3%

[1] All average values in this report calculated at 15% PhiE cut-off
[2] All depths in this report were taken from logs, so they can differ from depth in the lithological column.
[3] Core description taken from “NE BC Sonic Drilling Project, Physical Log Description and Interpretations”, Gescience BC Report 2017-XX

Area– 10b

Approximately 55m of the well are covered with logs. However, there is a break in log data in the depth interval 14.3 – 20.6m due to cavity behind the PVC tube.

The rocks penetrated by the well are described as interbedded silty from fine to course sand with silt and clay layers. V_{SH} increases in the uppermost part (above 10m) and at the bottom (below 52.5m, "Silty Clay Diamict"). Average values on the well are V_{SH}= 0.218, PhiE= 35.2%.

High resistivity value and low neutron porosity means that major part of the rock is dry. The air water contact located at 45m

Area -10x

Approximately 65m of the well are covered with logs.

Based on GR (V_{SH}) the rocks can be divided in the upper sandy part (above 24.8m), middle shaly part (24.8m – 60.2m) and bottom sandy part (60.2 – 64.9m).

The average values of sandy zones are as follows:

Table 3

Depth (m)	V_{SH} (v/v)	PhiE (%)	Core description	Comments
7.5 – 11.6	0.447	20.2	Sandy Silt Diamict	
11.6 – 22.3	0.282	28.7	Fine to very Sands overlying Pebbly Silt and Silty very Fine Sands	Porosity increases upwards
22.3 -24.8	0.093	39.5	Pebbly Fine Sand	
60.2 – 64.9	0.294	23.9	Pebbly Silt and very Fine Sand	

Within shaly part there are two pores intervals : upper part of "Silty to Silty Clay Diamict" (22.3 – 27.1m) with porosity up to 25% and 32.8 – 33.8m interval of "Sandy Silt Diamict" with porosity up to 20%.

All sands are water saturated.

Area -12

This well covered with all logs to the depth of 43m.

There is not as good correlation between logs and lithology column as in some other wells. Based on logs there are two pores zones with different properties: 17.4 – 25.6m with average PhiE = 22.3%, V_{SH} =0.256 and 25.6 – 42.5m with PhiE = 41.5%, V_{SH} = 0.279. The porosity below 32.4m (described as "Laminated Clays and Silt with Fine Sand Beds") is possibly overestimated. The reason for this statement is core description, low resistivity indicating possible high water (clay) content and high neutron porosity (high clay content or cavity). The overestimation could be caused by some cavity behind the PVC tube. Since sonic is of not acceptable quality we can not proof the calculated porosity or deny possible cavity as caliper was run in a PVC tube.

All pores zones above 32.4m looks as dry.

Area-13

The well is covered with all logs from 6m to 45m

There are several pores zones in the well:

- 8 – 10m. Average values are PhiE =20.4%, VSH=0.483. Spike of porosity (32.2%) at 8.6m probably not real, since sonic porosity in this zone is balancing within range of 13 – 19%.
- 21.2 – 26.5m described as “Interbedded Pebble to Cobble Gravels” are of average PhiE=18.6%, V_{SH} =0.264. These values calculated only for lower ~3.5m, since the upper 1.7m are not pores (PhiE<15%).
- 26.5 – 28.6m described as “Cobble gravel” are of average PhiE = 28.8%, V_{SH} = 0.163.
- 30.8 – 35.8m described as “Interbedded Mud, Gravely Mud and Gravel” are of average PhiE=29.6%, V_{SH} =0.236.
- 35.8 – 44.5m described as “Interbedded Gravely Diamict, Pebbly Muds and Pebbly Sands” are of average values PhiE= 19.1%, V_{SH}=0.317. Some layers within depth interval are not pores.

All pores zones are dry.

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