A Really Good Log Interpretation Program Designed to Honour Core

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Summary: Montney example illustrates methodology

We have unique, focussed, log interpretation program developed to:

1) Use one program for all lithologies to obtain Sw, porosity, perm, net pay, net to gross.
2) Use elements to describe lithology and interpret mineralogy: sandstone, carbonate, shale, and everything in between.
3) Use the SP to propagate Rw from one known-Rw zone to all zones in the well.

- Inputs: resistivity, sonic, dipmeter imager, elements-density-Pe, neutron, gamma ray, free fluid, TCMR, T2LM, SP and Rw for one interval.
- If missing any above input curves, predict from offset well before entering computation program. The predictions simply enable the programs to run; they do not have to be exact at this point.
- There are two related programs 1) Petrophysics Designed to Honour Core (PDHC) and 2) Element to Mineral program (ELM-GAMLS). One can use either or both. We usually start with PDHC and if necessary to fit core, use ELM.
- Calibrate computation output to core, when available, using revised input parameters. If much core, use it to generate core to lithology to mineralogy automatically using element to mineral program (ELM). If little core, run without core, make a dummy fake core and run using ELM to see if both methods agree.
- Both programs evolved from Excel™ MICROSOFT programs which grew too large to be manageable. They were then converted to JAVA code so they could be managed. For the PDHC, there is a master Excel program. Changes are input to this Master program and then easily converted to code: Excel can be used to experiment and develop ideas and it then can be turned into a more efficient JAVA program "semi-automatically". Any program you want to use can be converted in this manner. Rather than a user developing script just for a special equation, the entire JAVA program can be changed after the user has made the changes in Excel.
- Normally, changes to the PDHC program are implemented in a day to a week and then tested to ensure they really do what we want. For the ELM, Eric Eslinger maintains it via the Geological Analysis using Maximum Likelihood Systems. Since ELM is part of a huge system of programs, changes are continuously evolving and take longer to see results.

- We input parameters for pay, reserves, mineralogy, elements via an input list that is either a constant or is zonable, as required. The program, PDHC, is continuously evolving to meet our and customer requirements. Bob Everett, with input from all of his friends, has a personal programmer, his son, Jamie. Together log interpretation is straightforward, upgradable and wonderfully easier than any other method that Bob has used ☺
- The presentation illustrates how the programs are applied to minimize logging expense in new wells via a priority system for logging runs.

Introduction

Programming supports a flexible and adaptive petrophysical service – that service is the primary objective. One may not have the budget to hire a programmer or may be more of the do it yourself type. The point is that you do not want to be stuck with canned software one cannot manipulate so one needs to do some "programming" to keep responsive.

"Programming" can be achieved in many ways: one can "program" in Excel to some degree. There are scripting languages within the tools one may currently use to do similar things. Alternatively, one can choose to learn a programming/scripting language to help or they can hire a programmer. So 'a programmer' is not the only option – "programming" is. An important point is that Excel can be used to experiment and develop ideas and can be turned into a more efficient program "semi-automatically".

Theory and/or Method

Nearly all available programs have some method of providing user input. Often the user supplies the script and the equation is solved outside the main program but not integrated into the main program. For example, one may want to use Waxman-Smits-Thomas (W-S-T) for Sw instead of Dual Water (DW). One provides the script and gets a result. But this result is not integrated into all of the equations that use Sw. Using our method, one provides a switch in Excel that asks if you want to use W-S-T or DW. Then one provides in Excel, an 'If-Then-Else' statement to use what is wanted. The output for Sw is then thoroughly integrated in all calculations that use Sw. We 'semi-automatically' convert it to Java code. The result is timely and all-encompassing. The main point is the Excel to Java conversion has been fully tested and is operational.

Included logs are:

- Resistivity-Sonic Logs for Pass 1, a 'Quick look' pass.
  - Resistivity, sonic, Lithology description.
  - Strip Log digits of lithology.
- ADD if hydrocarbons:
  - Magnetic Resonance Porosity/perm for Pass2, another 'Quick-look' pass
  - Elemental Spectroscopy for pass3, a detailed pass:
    - Si, Ca, Ti, S, Fe, Mg, Al, K, Na, Cl, C
  - Density-Neutron-GR in High Resolution.
  - Other advanced logs:
    - Formation Test
    - Formation Imager- pad resistivity

- Quick Look Pass 1:
- For educational purposes:
    - We will ‘cheat’ and compare our Quick look results with already-measured lithology and mineralogy.

Naturally, one does not already have measured mineralogy to compare to newly-logged data.

Examples

Examples / Goals are:

- variable amount of Ca/denominator when dolomite is dominant.
- addition of muscovite when program doesn’t find it and core does.
- addition of kspar when program doesn’t find it and core does.
- addition of a summary to provide averages for a simulator. Request by Serinus , 2012.
- upgrade of the summary. Request by Mazarine in 2015.
    - volume of BVW/porosity for Sw_averaged, not average of Sw..
    - Net to gross added.

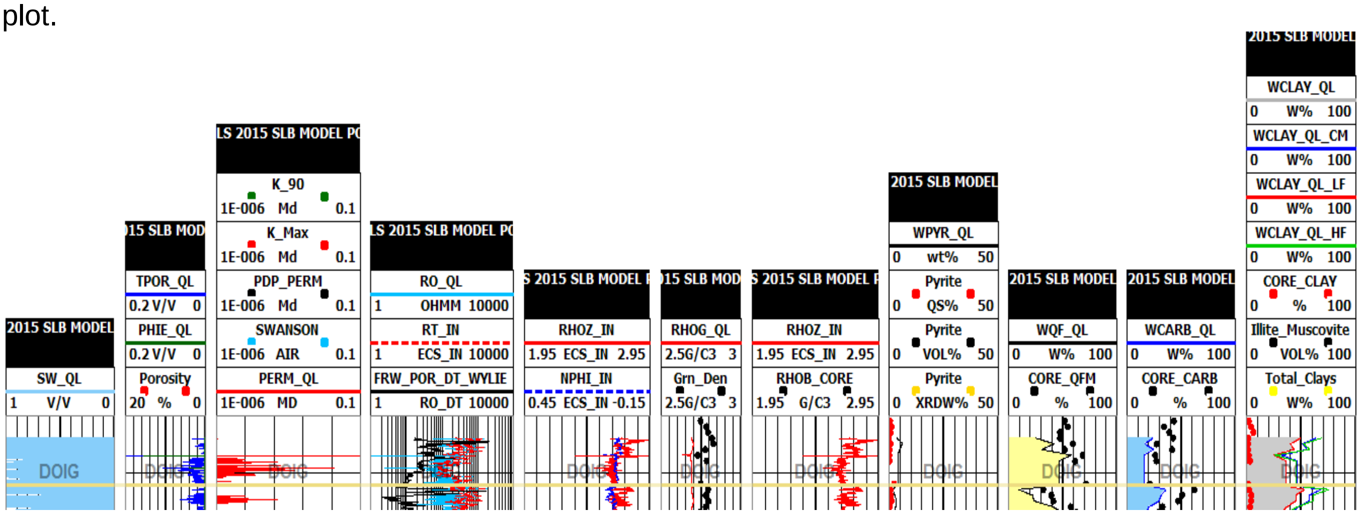
Plots, after the conclusion, show quick look and detailed passes.

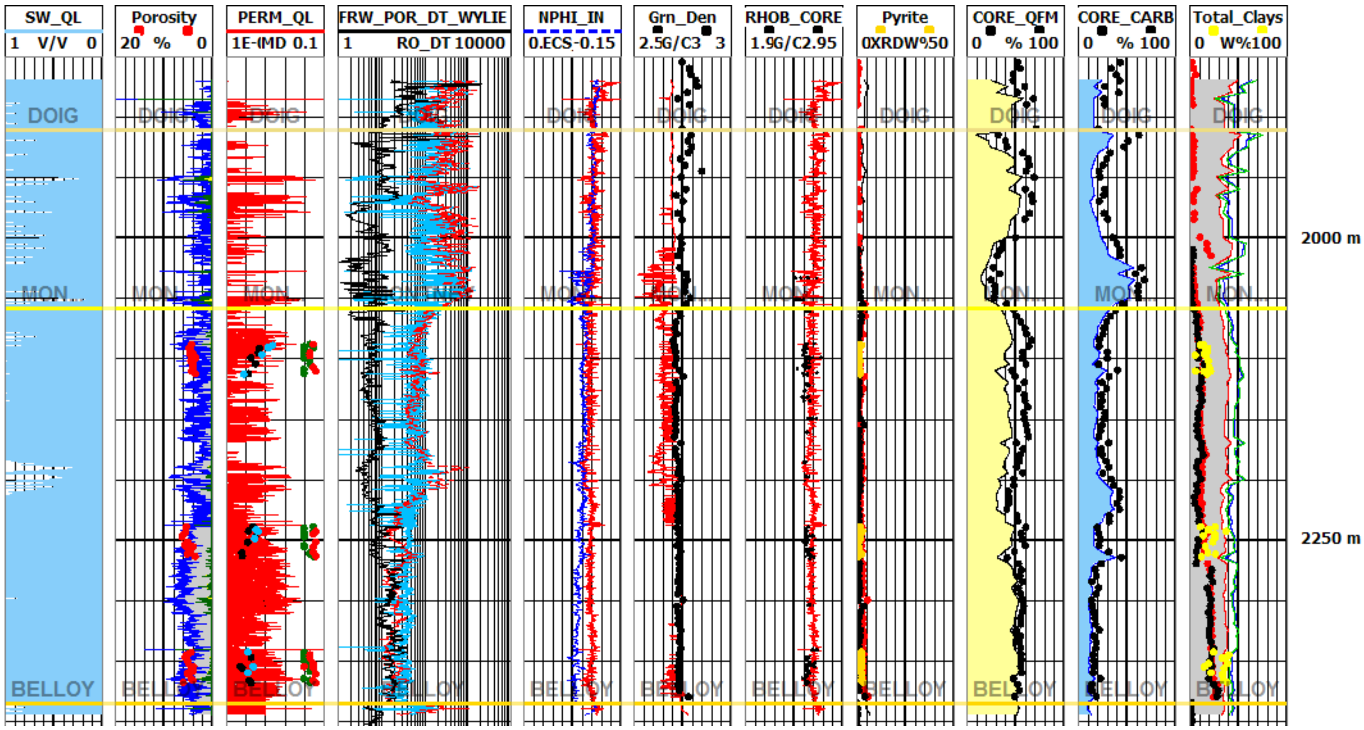
Conclusions

- Montney formation is rich in hydrocarbons with a complex mineralogy.
- Formation evaluation from advanced logs, including NMR and elemental spectroscopy, is best.
- Quick Look Pass1 may be misleading since F-log is optimistic
    - Formation volumes from resistivity-sonic & predicted logs
- Quick Look Pass2 Improved when NMR included (TCMR, KSDR, free fluid)
- Detailed methods Pass3, with elements/NMR/density is best.
    - Density and Magnetic Resonance porosities.
- Objective achieved: flexible / adaptive service via programming and a priority method designed to save logging dollars has proven itself.

Plots

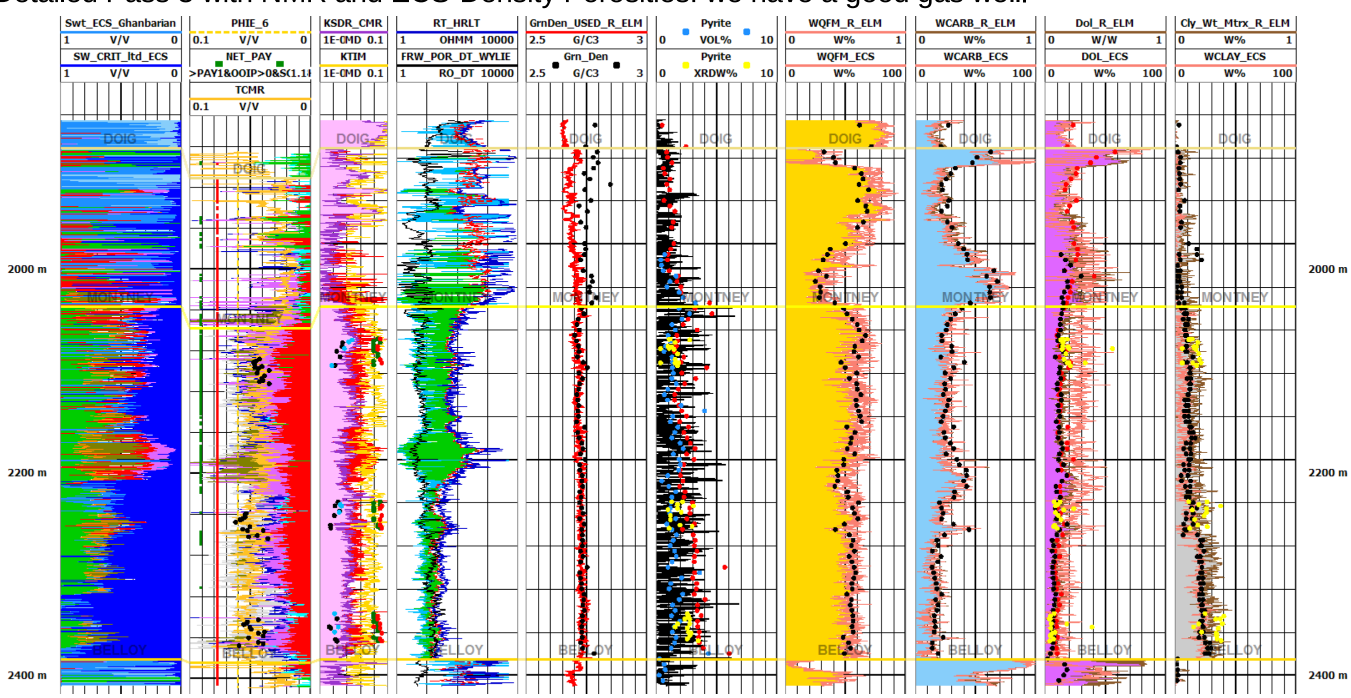
Quick Look Pass 1 with F-Log says there are probable hydrocarbons. The heading is followed by the plot.





Quick Look Pass 2 with NMR for porosity: Definitely Hydrocarbons (not shown for space limits)

Detailed Pass 3 with NMR and ECS-Density Porosities: we have a good gas well.



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