Oil Saturation Determination- Lab & Logging difficulties & a Hybrid Approach

Matt Blanch, AGAT Laboratories, Calgary, Alberta
mblanch@agatlabs.com

Summary (Arial 12pt bold)

The extensive Athabasca Oil sands are gaining importance as a largest resource of liquid hydrocarbon in Canada. Oil sand is a mixture of three different types of constituents namely, bituminous organic matter, water and inorganic matter or minerals. They vary widely in composition. The oil sand that contains 6% or more bitumen is technically and economically viable as process feed for the extraction of liquid hydrocarbon. It is therefore necessary to find a reliable bitumen determination technique. The higher the reliability in analysis the higher the level of accuracy results in estimating the available oil sand reserves. This is similarly true to develop and optimize process parameters especially for the design of a prototype extraction plant and for the efficient operation of the process of extraction of liquid hydrocarbon from oil sand

There are various methods that have been used for the determination of bitumen, water and minerals from conventional core or oil sand. The examples of some of these methods are: i) Dean-Stark, ii) Modified Dean-Stark, iii) proton NMR, iv) Retort and v) Pressure Elusion-Fisher titration techniques. Since bitumen is defined as toluene extractable soluble part of an oil sand sample and it itself is a complex mixture of a large number of organic molecules, mass was identified as the only reliable parameter by which bitumen content could be measured [1]. The choice of this parameter to assay bitumen demands an initial separation of the bitumen of interest from the oil sand sample

This Presentation will cover the Dean Stark procedure in detail. It will cover the accuracy and repeatability of the analysis, range of grade specifications, and define the sources of error and mitigation techniques that have been developed and be applied both in the field and at the laboratory. The presentation will show the variations in log responses in comparison to the calculated porosity and saturations from the laboratory and explain the variability in both analyses and propose a hybrid method of analysis.

Theory and/or Method

Core analysis is an essential component in determining bitumen saturation and reserve estimation. The fundamental problem is that during the coring process, core is disturbed and drilling fluids invade the core. Moreover, during the core retrieval process due to the pressure variations, the core expands within the core barrel, allowing these fluids to accumulate within the core. The addition of drilling fluid into the core will cause the calculated porosity to increase, and effectively reduce the amount of oil saturation measured in the lab.

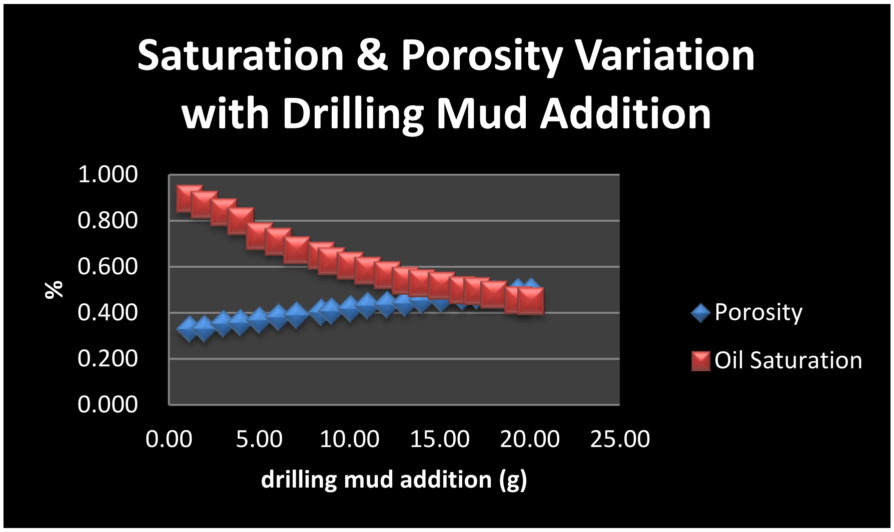

Figure 1- Drilling Mud Effect

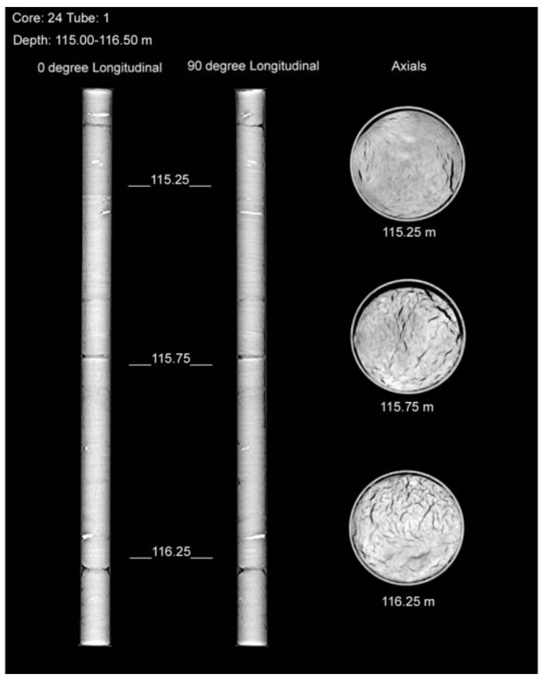

Figure 2- Disturbed Core CT SCAN

The dean stark process will measure accurately within 0.5% the fluid volumes present within the core, but it is unable to distinguish the discrepancy between formation water, and water that is contributed from the drilling process. Nevertless, due to the variability in Water resistivity, logging tools have difficulty in accurately measuring the water resitivity of the formatiion and the resulting saturations from the Archie Equation can vary significantly across a given zone of interest. In essence, this has contributed to some zones being indentified as being 100% water saturated.

Figure 3- Core logged as SW=1

In essence – a hybrid method has been evaluated to correct for the invaded fluid, using the log calculated porosity, and the fluid volumes determined within the lab.

From

$$\phi 1 = \frac{PV1}{PV1 + GV1}$$

$$\phi 2 = \frac{PV2}{PV + GV2}$$

where $\phi 1 = $ log porosity, and $\phi 2 = $ lab porosity.

We know PV2=Bit +Water+ Winv and PV1= Bit + Water.

Assuming GV1=GV2=GV (grain volume), and there is no gas component. We can solve the above equations to determine :

$$Winv = PV2 - GV * \frac{\phi 1}{(1 - \phi 1)}$$

Using the above equation, a model was developed using Dean stark lab data to determine the correct amount of water to use, correlating them to Log Saturations. The water calculated from invasion needs to be analyzed, as it cannot be taken 100% of the time at face value. Hence, a correction and cut off value has been modeled, and optimized at 65% dependent upon a series of criteria.

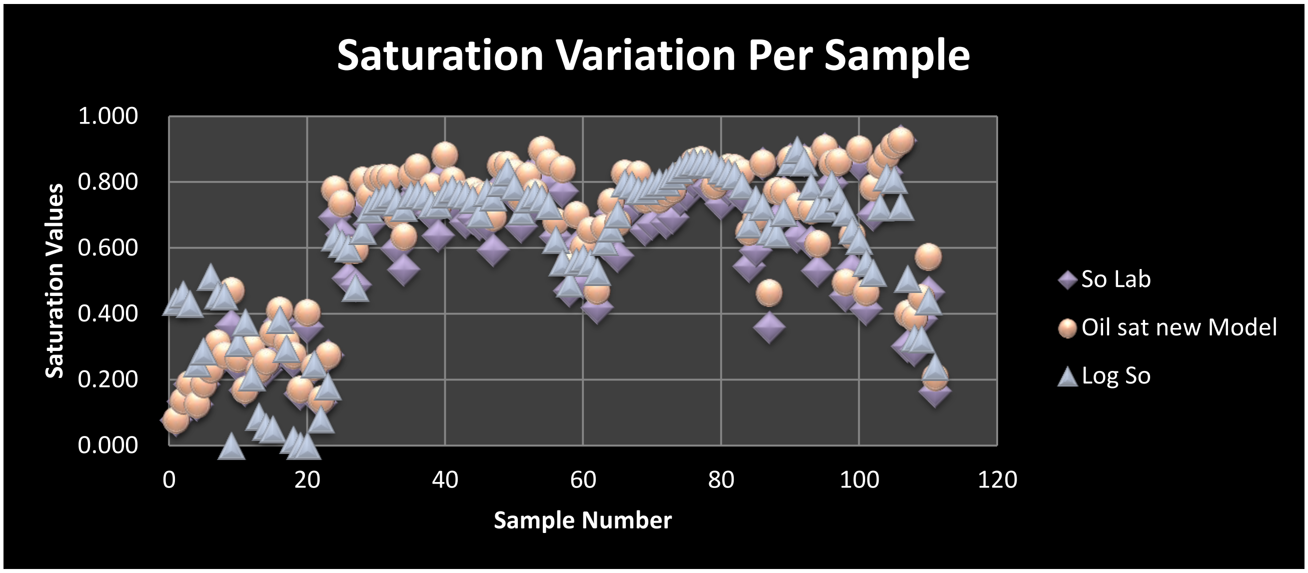

Figure 4- Modeled So, Log So, and Lab So

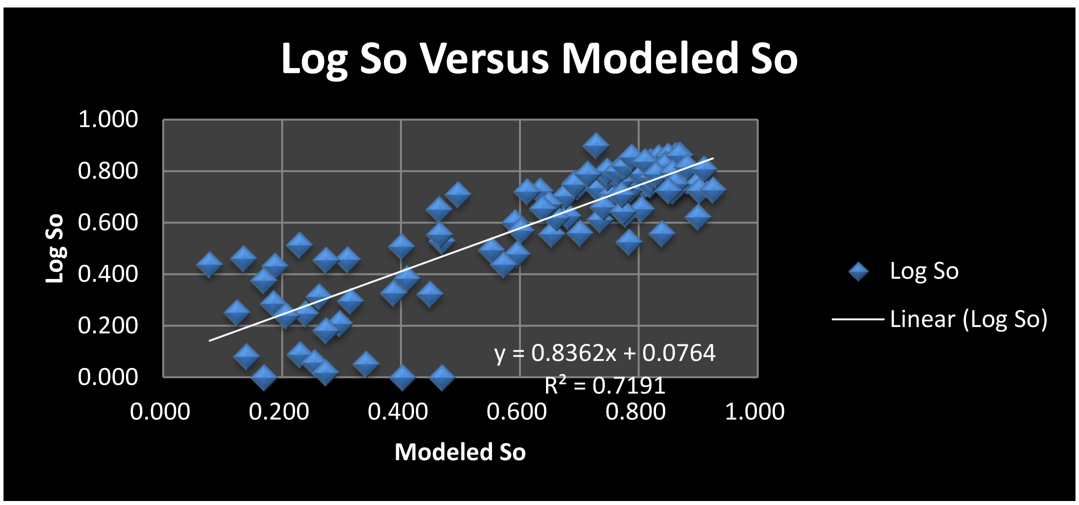

Figure 5- Correlation of Log So versus Modeled So

Conclusions

Due to field variations and log response variations, a hybrid approach has been proposed, and has increased the correlation between the lab data and the log data. Tracers in field applications can be used to enhance the water determined within the core; however, discrepancies still persist as drilling fluid can flush out formation water. A combined analysis between logging data and lab data is essential in the evaluation of the reserves in order to best interpret the variability in both analyses.

Acknowledgements

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