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Cased Hole Dual Physics Nuclear Measurement - Opportunities Created Through Measurement

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Summary

Reservoir surveillance is the key to optimation. Through lowing operational expenditures by reducing the amount of unwanted fluid handled and disposed of by identifying what intervals of the reservoir are culprit, or placing efforts into adding production by identifying bypassed pay through unmasking of environmental conditions for near term exploitation or future play delineation. The first step in optimation is measurement.

Open hole logging data is the usual starting point. After all the most inexpensive hydrocarbon is in your well logs. However once a well is cased and cemented the environment is changed and variables are introduced by the well construction alone. The matrix and fluid properties also change after a period of production. Depletion or induced activity changes the orgional state of the well. Additional logs need to be continuously run to provide an up to date assessment of the well.

There is power in knowledge. Knowing the current state of your reservoir will help achieve maximum value from that asset during the operating life time. Being able to articulate and support with concrete data the upside potential beyond a current producing asset will help realize value when additional production is needed or at time of asset sale aiding in the avoidance of costly missteps.

Theory

Cased Hole Saturation logs are one type of tool to quickly and efficiently achieve this level of understanding. While these tools are effective they do come with their limitations and require certain inputs and conditions to be successful. These tools are mostly nuclear based although there are through casing sonic and resistivity tools available. For the purpose of this paper focus will be placed on the dual physics combination of both Thermal Neutron (NN) and Neutron Gamma (NG) dual physics nuclear measurement in comparison to more common Pulsed Neutron and Compensated Neutron Logs. Several case studies will be used comparing the results of common measurements such as saturation, porosity, and hydrogen index but also the unique measurements in dealing with dual physics nuclear tool such as Relative Bulk Density and Thermal Neutron Nuclides “Clay” measurement. Tying back to ultimate production results in both carbonate and clastic rocks.

Conclusions

Logging through several strings of casing presents special challenges after the well construction. The logging tools can no longer directly measure the formation. As steel casing / tubing and cement sheath is now in the way. That creates variables on its own as conditions are not always uniform. Sensors and mathematics to compensate for these variables or at least be able to identify, are critical. Accessing the deeper, undisturbed reservoir is also critical as a true measure. Measurement dominated by irregular cement sheath, pipe corrosion or deformation and mud invasion will result in erroneous through casing shows and may mask a potential resource. Ensuring the right complementary information is available and the logging equipment is appropriate for the desired out come for the wellbore environment is critical. Clear objectives and proper planning will not guarantee success but will lead down the path of understanding and value more often than not.

Novel/Additive Information

By leveraging the unique measurements of the dual physics nuclear measurement, formation conditions can be unmasked or false positives can be de bunked

1) Thermal Neutron Nuclides “Clay” for drilling mud invasion identification through casing vs. Natural Gamma Ray measurment alone VSh_gr vs. VSh_Nuclear
2) Thermal Neutron Nuclides “Clay” for NORM contamination or “HOT” sand discriminator vs. Natural Ray measurment Gamma alone VSh_gr vs. VSh_ Nuclear
3) Thermal Neutron Nuclides “Clay” for Dolomite Porosity Identification in carbonates
4) Relative Bulk Density to assist with discriminating porus vs clean yet highly cemented intervals.

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References

1. https://roke.ca/#!oil/c1oa0
2. https://patents.google.com/patent/US20170176635

Figure 1: Invasion Masking Saturation Time Lapses 22 years later

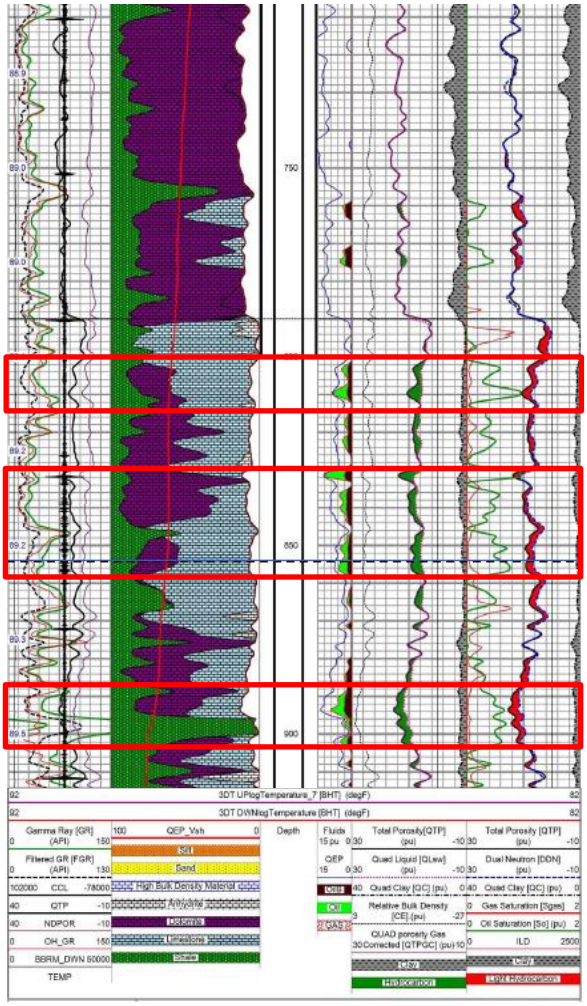

Figure 2: Thermal Neutron Nuclides “Clay” for NORM contamination or “HOT” sand discrimination