Detection of Shaly Gas Reserves using Pulsed Neutron Neutron Logging
A Case Study

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Introduction

Shale-gas reserves are characterized by their shallow depths, low permeability clay-rich sands, and immature locally generated biogenic gas. Clays are reducing permeability and hydrocarbon pore volume. The main problem is the difficult evaluation in these thin, discontinuous, clay-rich reservoirs. Sand-layers in such conditions can not or hardly be detected by GR or SP and on Density/Neutron logs no gas effects are shown.

Hotwell's gas processing method uses 4 different markers for gas-detection. The more markers present, the higher the possibility for gas-presence in the reservoir.

Figure 1. Gas Fields in Canada and the USA (modified from "Shallow Gas in the Western Plains", Rakhit Petroleum Consulting)

Processing

PNN - Pulsed Neutron Neutron is a thermal neutron capture tool. The PNN system contains two detectors (near and far detector) which measure thermal neutrons, which are not captured by the formation. The rate of thermal neutron decay in the formation can be used to differentiate between hydrocarbons in the pore space and water, in particular salt water. A mineral's ability to absorb thermal neutrons is defined as its capture cross section, SIGMA. The higher the value of Sigma, the greater the ability of the formation and its fluid to capture thermal neutrons.

Utilizing different processing modes and count-rate images, gas bearing zones can be identified within shaly sequences. 4 qualitative gas saturation indication markers indicate the presence of gas in the reservoir, as follows:

Indicator 1: The first gas indicator is the short space detector and long space detector overlay. The curves are selected from count rate images. SSNM (short space) and LSNM (long space) curve overlay is done by using compatible scales to make the two curves stack in a shale-zone. Gas indication is strictly seen as separation between the short and long space detector, using total or partial count rates. This separation is shaded on the processed log

Indicator 2: The second gas indicator is the SIGMA curve. On the processed log, SIGMA is shaded for SIGMA values less than 27 capture units. This value is selected from local experience in such kind of lithologies. In clean sand conditions, typically, a processed SIGMA curve lower than 18 capture units would indicate good gas saturation.

Indicator 3: The third gas indicator is the crossover between the RATIO (Short/Long space detector partial or total count rates) curve and the RATSNSF (Ratio of Short space detector near counts/Short space detector far counts). RATIO itself is a good gas indicator, although it can be influenced with the presence of gas in the borehole. The presentation in opposite scales shows gas saturation where the two curves crossover. This crossover is shaded on the processed log.

Indicator 4: The fourth gas indicator comes from SGM2_12 & SGM2_23. These curves are mode two processed Sigma curves. They deflect in opposite directions due to different shape of the thermal neutron decay (convex or concave) in non gas and gas saturated formations

Presentation

GRPNN curve on the presented log (figure 2) shows little change in lithology whereas the processed neutron curves detected the presence of gas. All 4 gas indicators are shown as yellow highlighted areas. If gas presence is visible on all 4 indicators there is a high confidence for good gas saturation in the reservoir.

With this Quick-look method determination of gas-layers within shaly sand sequences is very fast and easy; especially if combined with Fast Fourier Transformation to differentiate between tight and gas zones.
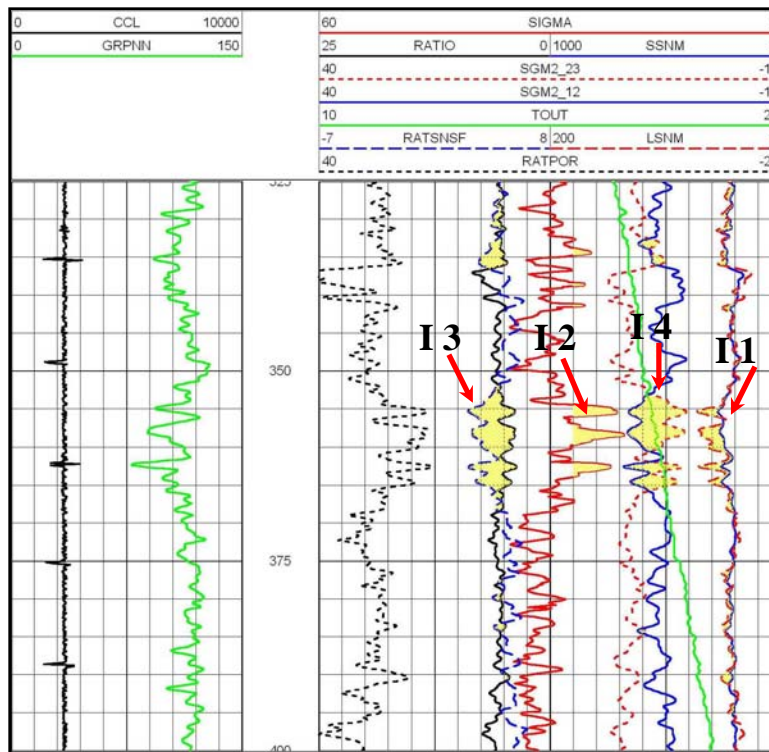

Figure 2.

References

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