Recent Advances in Borehole Resistivity Logging

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In locating hydrocarbons in a borehole, electrical logging techniques play a key role since they can distinguish between oil and water saturated rocks. During the past 5 years, numerous new electrical logging technologies were developed based on integrating state-of-the art geophysical technology into borehole logging. The technologies selected for this presentation include shallow imaging devices as well as deep array resistivity tools and a through casing resistivity device. Geophysical hardware design, acquisition principles, data processing and interpretation all together result in better signal-to-noise measurements and more accurate interpretation results which translate directly into more hydrocarbon reserves. Recently available 3D numerical modeling capabilities support all phases of tool design and interpretation. Here, using case histories, we illustrate how geophysical concepts go hand in hand with the advances in electronics hardware and information technology to get better hydrocarbon reserve estimates.

Two hardware changes represent the major contributing factors: small signal measuring devices such as sigma delta converter and resulting multi-sensor arrays providing multiple depths of investigation. These electronic advances have lead to a compact hybridization of the receiver amplifier and A/D circuitry. As one of the results, the STAR resistivity imager now measures calibrated values, which allow to successfully relating and comparing resistivity images measurement with a micro resistivity log.

Data processing starts with the acquisition of the complete waveform, which is then stacked for signal-to-noise ratio improvement and inverted to obtain the best possible match between the measurements and the synthetic curves. In addition, the inversion gives numerous quality control indicators, which allow the comparison between different inversion runs. Two-dimensional inversion delivers not only a two-dimensional distribution of the formation parameters but also statistics that are essential for estimating the reliability of the results. In a more complex environment such as dipping beds, deep invasion and thin beds more complex models are used on a selective basis.

Array resistivity measurements from array induction to array laterolog tools can be interpreted with higher vertical resolution. In most cases, this potentially results in an increase in hydrocarbon reserves. Case histories for different tools and applications clearly demonstrate the benefits of the new concept of integrating multiple resistivity logs interpretation.